Long-distance dispersal to the mining frontier in late 19th century Colorado

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(Accepted: 28 November 2008)

Summary

Leading edges of population expansion provide unique opportunities for individuals to elevate their social and economic status. However, dispersal into unknown areas may have high costs such as violence associated with conflicts over resources, unfamiliar and harsh ecological conditions, and a loss of social networks. We investigate the background of men who dispersed to Gothic, Colorado during the late 19th century to prospect for silver ore. We find support for the hypothesis that men who chose to disperse to the frontier and endure such costs were on average those who lacked access to critical resources in their childhood homes. Yet contrary to this hypothesis and previous dispersal research, some migrants came from very wealthy and high status families. The incentives of long-distance dispersal to ephemeral mining towns with potentially high payoffs are different from the incentives of dispersal sites examined in previous literature. This project draws attention to the need to study heterogeneous incentive structures for dispersal and is also a small piece of understanding the larger puzzle of the colonization of frontiers and population expansion.

Keywords: dispersal, life-history strategies, frontier, 19th century, silver prospecting.

Introduction

Like non-human primates, humans disperse as a facultative response to increase their reproductive success. Individuals will choose to disperse when the expected rewards for dispersing outweigh the costs. Thus, rates of dispersal should vary within a population based on differential access to mates

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DOI:10.1163/156853908X395558

Behaviour 146, 677-700
Also available online - www.brill.nl/beh

and resources (Isbell & Van Vuren, 1996). Access to resources and economic opportunities vary by both the natal area and the dispersal site. Thus, motivations for dispersal are expected to vary as both the natal and dispersal site vary. Unfortunately, the multiple individual level incentive structures within populations and between regions are not well understood for either human or non-human primates.

Unlike non-human primates, human primates must also weigh the cultural aspects of the costs and benefits of dispersal. Long-distance dispersers experience cultural and technological boundaries, which will alter the potential costs and benefits (e.g., cultural persecution, technology to exploit a previously untapped resource). Frontiers, or edges of an expanding cultural group, are characterized by low population densities, social flexibility, and relatively unexploited resources. Logically there should be opportunities for upward social mobility, an popular theme first championed by Turner (1920). The rewards of dispersal to the frontier, however, are not as clear as originally conceived. The actual degree of social mobility on the frontier as well as the specific social and economic factors that impede or enhance social mobility are debatable (Peterson, 1975; Guest, 2005). Also, there are potential dispersal costs imposed by the dangers of traveling in unknown areas, uncertainty of environmental quality and potential economic rewards, and the lack of formal social institutions to deal with interpersonal conflict. Given these complications, the factors that might drive the settlement of the frontier are not immediately obvious. Since decisions to immigrate to frontier regions are based on individual-level incentive structures, a profitable way to investigate the decision to migrate to the frontier is to understand the costs and benefits experienced by individual immigrants.

This paper investigates the factors that may have inspired long-distance migration to the mining frontier by investigating the life histories of a cohort of men who migrated to Gothic, Colorado in the late 19th century to prospect for silver ore. Investigating the natal histories of long-distance migrants will add to the general understanding of individual-level incentives for dispersal as well as the settlement and development of frontier regions.

This project expands previous dispersal research by addressing the lack of understanding of long-distance dispersal and of multiple types of dispersal. Previous research has assumed that dispersal sites were much like natal sites, if perhaps with less competition for mates and resources. This is a reasonable

assumption, if migrants are moving short distances. It is likely that neighboring communities are very similar in economic niche (e.g., farming, fishing, wool production). However, long-distance migration could take migrants to very different types of communities. Also, migration does not have to be from one permanent residential settlement to another. It is likely that dispersal to ephemeral boomtowns was a high-risk, high-gain strategy to obtain resources but was not a permanent home. Dispersers to Western boomtowns are likely to undergo different pressures than dispersers who go to frontiers to permanently settle with family to farm.

From an evolutionary point of view, competition for resources may explain why individuals of any species disperse. Staying in the natal area has many benefits (kin interactions in social species, known food sources, and known sources of danger; Greenwood, 1980). Dispersers to an unknown area face high costs (e.g., metabolic costs, economic loss, or increased risk of mortality from predation; see review in Isbell & Van Vuren, 1996). Individuals should disperse when the expected benefits they gain by moving to a new territory outweigh the costs of dispersal and the opportunity costs of what they leave behind. Thus, as Hamilton & May (1977) demonstrated in a series of mathematical models, it may be advantageous to have progeny disperse if the natal environment provides no vacant sites for colonization, even if immigrant mortality is high. Waser's (1985) models investigated the distances individuals would disperse with the rule that they will move to the first uncontested site and no farther, under assumptions of perfect information or straight-line travel. As site turnover slows (i.e., competition for resources increases), individuals will have to move farther away to find an uncontested site. Therefore, when competition is high, individuals who are less competitive must disperse farther to gain access to critical resources or mates (Greenwood, 1980).

In humans, access to resources is influenced by cultural factors such as parental wealth and status. Parents with limited wealth and status will have little to give their offspring, and it is often difficult for their offspring to move up the socioeconomic ladder (Bowles & Gintis, 2002) or find marriage opportunities (Pollet & Nettle, 2007). Therefore, offspring of low wealth and status parents should be more likely than average to disperse to frontiers to take advantage of the potential upward mobility on the frontier. Empirical evidence supports the hypothesis that individuals are most likely to disperse when the natal site offers few high quality economic opportunities (Clarke &

Low, 1992; Strassmann & Clarke, 1998; Herscovici, 1998; Hitztaler, 2004) and when their families are poor relative to the rest of the community (Voland & Dunbar, 1995; Towner, 2000). However, although poorer men can increase fitness by dispersing, the poorest may not be able to afford dispersal costs at all (Towner, 1999).

Chances of dispersal may also be influenced by the degree of family competition. When parents have limited energy and resources, they should strategically distribute their resources in order to maximize the collective success of their offspring (Trivers, 1972; Trivers & Willard, 1973). This helps explain why parental investment patterns are often biased by gender, birth order, number of offspring, and paternity certainty (examples in Dickemann, 1979; Hartung, 1982, 1985; Mealey, 1985; Hrdy & Judge, 1993; Bereczkei & Dunbar, 1997; Holden et al., 2003). If an individual is part of a large family, the parents may encourage him or her to leave home so that there are more resources for other children. Also, parents may strive to increase long-term fitness (lineage survival) by investing the majority of their wealth in one heir (Hrdy & Judge, 1993; Voland & Dunbar, 1995). Thus, individuals who have many same-sex siblings may experience more competition for resources (dowry, inheriting family farm, etc.: Mace, 1996; Borgerhoff Mulder, 1998). Empirical evidence from populations in Sweden and Germany supports that poor access to resources encourages individuals with many same-sex siblings to disperse (Clark & Low, 1992; Voland & Dunbar, 1995). Parents may choose to invest in one older sibling to have a longer time to watch out for their investment, and in an expanding population, older children may experience less competition (Hrdy & Judge, 1993). Thus, later-born children of large families with many same-sex siblings are more likely to disperse.

Such patterns of differential parental investment should be most apparent when families own impartible wealth (Hrdy & Judge, 1993). For instance, a family farm is difficult to split between multiple siblings for many generations and remain above the minimum size needed to support a family. Thus, individuals from farming families probably experience different dispersal pressures than individuals from non-farming families. In addition to investigating wealth and family competition for the whole cohort, cohort members from farming families are compared to cohort members from non-farming families.

Previous research demonstrates that dispersers are most often from relatively poor families and families with high levels of intra-familial competi-

tion. If long-distance dispersal to the boomtown of Gothic is similar to short-distance dispersal, Gothic migrants should also come from poorer than average families and families with high intra-familial competition. We explore these hypotheses using longitudinal data collected for a cohort of unmarried US-born prospectors who lived in Gothic in 1880.

We predict that since the costs of long-distance dispersal are high, those who migrated to Gothic should be those who would benefit the most by the potential social and economic mobility of the frontier. We expect those who migrated were inspired by poor economic opportunities (Hypothesis 1) and high intra-familial competition (Hypothesis 2) in their childhood homes. In addition, we predict that the particular inheritance system associated with farming families compared to non-farming families will produce different patterns of intra-familial competition and subsequent dispersal (Hypothesis 3).

Historical background

The discovery of gold in 1858 and subsequent claiming of the Colorado territory in 1861 first put pressure on the territories of Native Americans, the Utes. However, the Utes were able to defend their lands in the high Elk Mountains until the Brunot Treaty in 1873, which forced Utes off four million acres, including the Gunnison area (Wirth, 1996). In late May of 1879 the Jennings brothers discovered the Sylvanite lode, which drew prospectors into the high Elk Mountains of Gunnison County Colorado (Vandenbusche, 1980). Since Gothic was near the border of Ute territory, there were numerous 'Indian scares' until the Utes were forced entirely out of Colorado in 1881 (Vandenbusche, 1980). Despite the risks of encountering Utes and the physical dangers of rough terrain and wild summer storms, prospectors flocked to the newly protected areas to search for gold and silver. Most set up tents on the confluence of the East River and Copper Creek (Vandenbusche, 1980), where the town of Gothic was soon incorporated (July 17, 1879; Vandenbusche, 1980). Gothic quickly became the main supply center for prospectors and miners, especially those in the Elk Mountain Mining District (Figure 1). By 1880, at least 1225 people were town residents, most of who were involved in searching for and extracting silver ore (United States Bureau of the Census, 1880). Gothic's economic boom peaked in 1881, supporting over 30 businesses, but by 1885 the town was all but deserted and

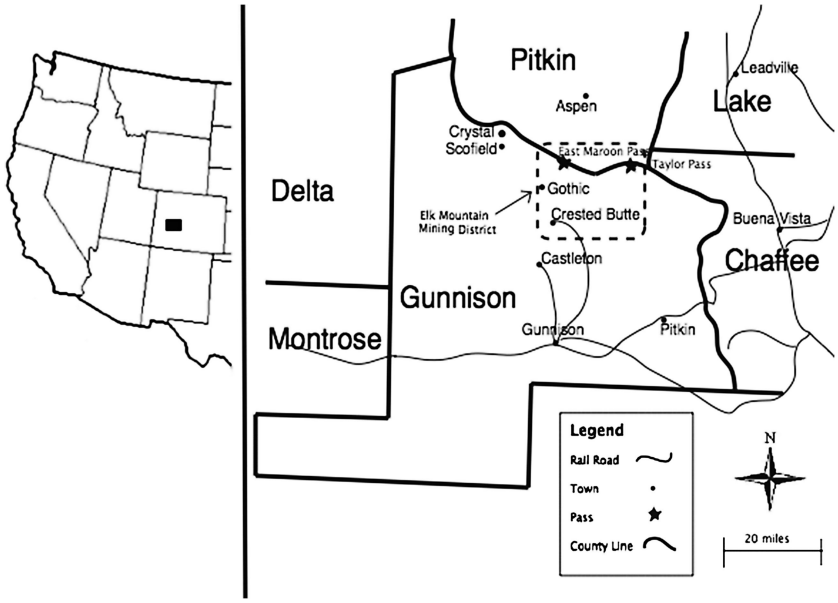

Figure 1. (Left) Map of the western United States. The black rectangle is the general area of Gunnison County, CO. (Right) Map of Gunnison county, CO (circa 1885). The Elk Mountain Mining District is enclosed with a dotted rectangle.

only eight registered businesses remained (Colorado State Business Directories 1880, 1885). By the 1900 US census, only 50 people remained in Gothic.

Most immigrants to the Gothic area were of northern European descent. The 1880 Census classified 97% of Gothic residents as 'white', just over 1% of residents as 'black', and one resident as 'mulatto'. According to the 1880 US Census, 18% of migrants to the Gothic area were born abroad. Most foreign-born immigrants were born in Canada (25%), Ireland (17%), England (16%), Germany (10%), Scotland (9%) and Wales (9%). Over half (58%) of the native born migrants came from Pennsylvania, New York, Ohio, Illinois, Indiana and Missouri. Only around 3% were born in Colorado and other western territories.

Gothic immigrants were predominantly male and unmarried, and largely without local close kin networks. Only 9% of Gothic immigrants were female (101 of 1124 people). Although 30% of male immigrants to Gothic were married by 1880, only 18% of those brought their wives to Gothic with them. Women and families are not the only possible kinship network, but only 30% of single men who declared their occupation as prospector had

even one known kin member in Gothic (if a kin member was present it was usually a brother, but in one case it was a father). Only one unmarried man came with his parents and multiple siblings. In sum, the Gothic population primarily consists of unmarried 'white' males without kin networks.

Mating and social costs of migrating to Gothic

Women were scarce in Gothic, making the potential reproductive costs of dispersal to Gothic by unmarried men high. The lack of women was bemoaned in the local newspaper, "Gothic possesses her full share of the beauties of nature. All saving women" (Silver Record 1 July 1882). Among Gothic migrants, there were 12 unmarried women to 799 men between the ages of 14 and 50 years of age, and there were only eight locally documented marriages of Gothic men during the boom years. There was little hope of even paying for female attention because of a town ordinance published in the Elk Mountain Bonanza on 10 July 1880 that declared a ban on 'bawdy houses'. Thus, there is little evidence that migrants to Gothic were attracted by the possibility of directly enhancing their reproductive success.

Risk of violence

In frontier towns far away from central governments, citizens often feel compelled to dispense their own justice (Nisbett & Cohen, 1996). Gothic was no exception, and violent conflict over resources appears to have been common. The most famous conflict over resources was the murder of Joseph Thompson by Jim J. Jennings over a town lot property (Elk Mountain Bonanza 10 July, 1880). A year later the Gothic Miner reports that Jennings escaped the jail in Gunnison (9 July 1881). So, it is not surprising the Gothic Miner (9 July 1881) questions the use of formal government and legitimate methods of conflict resolution; "can the east blame our frontier towne (sic) for lynching?"

As is typical of vigilante justice, conflict between two individuals can escalate, eventually involving the whole town. This meant the risk of violence was not limited to only a few drunken brawlers, but was a risk every citizen took. For example, the Gothic Miner (4 June 1881) reported that J.C. Crowles was stopped by a robber on his way home. Fortunately, Mr. Arch Davis intervened and recruited others from street corners and saloons to horsewhip the robber for a quarter of a mile.

Since Gothic residents lived near the border of Ute territory in 1880 (Wirth, 1996), residents were particularly concerned with potential massacre by Utes. The Rocky Mountain News (10 February 1880) demonstrated the strength of this concern after rumors of an impending massacre "the town was deserted by all the inhabitants by 10 o'clock, save three or four men". Gothic remained deserted that winter, but the Rocky Mountain News (10 February 1880) hoped future Gothic residents were men, "who cannot be scared off by every little Indian rumor". These 'Indian scares' continued until the Utes were forced completely out of Colorado in 1881 (Vandenbusche, 1980).

Prospecting costs

Due to the high altitude (9483 ft), prospecting season in Gothic was short, typically from June to early August (Gothic Miner, 17 September, 1881). The Rocky Mountain News reported snow in Gothic in both April and May (25 April 1884 and 8 May 1884) and by August the Gothic Miner reported that "saloons close up on account of there being only half a dozen men its about time for snow-shoes" (27 August 1881). This short summer alone would make it difficult to make a living by silver prospecting in Gothic.

Even during the best summer weather, however, there were high costs for prospectors. The Gothic Miner described the life of a prospector as "working with death in climbing, hardship through day and night, no social communing with mother or sister, and lies there fallen from a cliff accidentally shot, hungry, cold or lost" (9 July 1881). Accident reports compiled from local papers indicate that the most common sources of injury were from rock falls and dynamite (S.M. Glover, unpublished data). Pomeroy's (1881) pocket manual for prospectors warns against claim jumpers, respiration problems and rapid temperature shifts at high altitude, mountain fever, and giant powder (nitro-glycerin). In addition to these dangers the Gothic area experiences frequent magnificent summer storms, and it is not uncommon for a few hikers each year to be struck by lightning (S.M.G., pers. obs.).

Prospecting rewards

The newspapers were full of articles extolling the virtues of the rich veins of ore and promising great cultural, spiritual, and recreational opportunities in the town of Gothic. A particularly dramatic article from the Gothic Miner

even described the future of the area with the metaphor of a "wave of capital" which would rise "to swell and break of the Rocks (sic) of our habitation" (8 October 1881). Newspapers remained hopeful even past the peak of the mining boom. The Silver Record reported that "for the capitalist and the prospector no camp in the state possesses greater advantages than Gothic" (24 June 1882).

However, there are signs that the reality of mining in the Gunnison region may not have met these high expectations. For instance, the Gothic Miner reported during the second year of prospecting that "all the fictitious booms that have been generated in the minds of imaginative speculators during a hard winter have been sprung" (16 April 1881). One article asserted that Gothic had "quieted down and boomed out. It is not a healthy state" (Elk Mountain Bonanza, 19 March 1881).

In fact, it is likely that prospecting was not particularly profitable anywhere in Colorado. According to The Rocky Mountain News (21 January 1881), the Griffith mountain debating club decided that prospecting for gold and silver was the poorest business in America, and the average amount of money made by prospecting in the state did not exceed 5 cents per day. By comparison, a miner's wages were three dollars a day plus board, and carpenters made 4–5 dollars (Rocky Mountain News, 11 May 1881). These debaters estimated that in the local Gunnison area, only 25 of the 10 000 local prospectors made three dollars a day for their labor.

Methods

We used a variety of historical records to evaluate the hypothesis that poor economic opportunity and high intrafamilial competition provided motivation to disperse to Gothic. The 1880 US Census record provided the names, occupations, birth dates, birthplaces, and parental birthplaces for individuals residing in the Gothic area (town and nearby mining camps). We used the cohort of all unmarried, US-born prospectors (232 individuals) to investigate what childhood factors may have inspired dispersal to Gothic. Because the primary lure of Gothic was silver ore, the focus of this study is on those who declared their occupation to be 'prospector' (413 individuals). Prospecting is the process of searching for areas where rich silver ore can be potentially mined, and is distinct from those who declared their occupation

to be 'miner'. Miners were more likely those who worked at extracting silver ore from the ground and developing mines. All prospectors in Gothic were male. Married men may have had different motivation than unmarried men, and because of poor information on birth locations (census only records a country) foreign-born Gothic residents are next to impossible to trace back to their natal site. We focus on what factors may have inspired the unmarried US-born prospectors to migrate to Gothic (232 individuals). Cohort members were 28.9 years old, on average (range 16–56). Most cohort members (61%) came from Pennsylvania, Ohio, Missouri, or Illinois.

We searched historical records for information about the childhood situation for all 232 individuals in the cohort. We used the website ancestry.com to access a database of historical records, which allows the user to search using multiple input fields such as name, birth date, and birth place. The records in this database that are of greatest interest to this project are state and national census records, family history records (birth, death, marriage), and genealogies. Since most cohort members were in their late 20s in 1880, the 1860 US Census records provided the majority of information on the childhood situation (family name, ages, wealth and occupations) of cohort members. In order to compare wealth and family composition of cohort families to other families in their county, we used the Library of the University of Virginia's historical census browser to access summary statistics from the 1860 US Census by county and state (e.g., population and wealth).

There was no fixed rule, but a match was initially considered 'good' when most of the following matched: name, birth date, birthplace, and parents' birthplaces. Then these matches had to survive the test of any additional records that were discovered. Parental birthplaces and birth date ($\pm$5 years) were the most flexible categories. Although most of the data presented in this paper rely on the 1860 US Census records, the 1850 and 1870 US Census records provided invaluable information for tracking individuals to their childhood homes.

Typically, a random sample is used to make estimates of some property of a larger population. Tests of statistical significance incorporate uncertainty due to sampling in decisions about hypotheses. The data set in focus here, produced by investigating all members of the Gothic cohort, is not a random sample from a population, and is not subject to conventional sampling uncertainty. Thus, the toolkit provided by inferential statistics to estimate population level parameters from a sample and test hypotheses is not appro-

priate. These data are subject to another type of uncertainty: censoring. Data sets affected by censoring are analyzed with a different set of tools (Little & Rubin, 2002). In this paper we dealt with censoring by considering the potential mechanisms that caused data to go missing, and how these mechanisms might affect decisions about hypotheses. The potential effects of censoring mechanisms are discussed throughout the paper.

We found at least one piece of information for 76 (33%) cohort members. One concern is that life-history data of cohort members may be censored by age, birth state or ethnicity. We checked for systematic differences between those cohort members who were matched (at least one life-history variable was observed) versus unmatched. The 'good' matches were not disproportionately born in different years, in particular states, or to parents of particular ethnicities (e.g., Irish, determined by information on father's birth place). The US Census instructions in 1860 emphasized the need to include those who did not live in official housing (such as those who live in shacks, huts, and abandoned buildings). Thus, the census aimed to include individuals of all wealth levels. In sum, we believe that those individuals who were not matched were likely lost at random with regards to crucial variables such as age and ethnicity. While the census takers made every effort to include households from all economic classes, it is possible that those individuals they did not enumerate were predominantly the very poorest members of society. In this paper we will examine this possibility for relevant hypotheses.

Poor economic opportunities (Hypothesis 1)

Hypothesis 1a

If poor economic opportunities provided motivation to disperse to Gothic, fathers of cohort members should be disproportionately from low status and low paying occupations. Fathers' occupations for cohort members were primarily found in the 1860 US Census. Because some cohort members were brothers (7 brother pairs), a father was only used once in analysis. The occupations of the fathers of cohort members can be compared to US-wide frequencies of individuals with these occupations. Occupations such as coal miner, farm laborer, and day laborer are coded as 'laborer'. Occupations such as blacksmith, carpenter, railroad conductor, and steamboat captain and coded as 'skilled laborer'. Occupations such as merchant, gentleman, lawyer, banker, and stock speculator are coded as 'elite'.

Hypothesis 1b

If poor economic opportunities provided motivation to disperse to Gothic, the wealth per family member and value of the disperser's family farm should be lower than average. Since some cohort members were brothers (7 brother pairs), only one estimate of family wealth and farm value per family was used in analysis. Data on the wealth and value of the farm (if a farming family) for a cohort member's family in 1860 were found in US Census records. County level statistics of per capita wealth ((total personal property + real estate)/total free population)) and the value of the average farm (total value of farms/total number of farms) were gathered from the 1860 US Census (University of Virginia Historical Census Browser) for each childhood county. Relative wealth was calculated as the per capita wealth from the disperser's family in 1860 minus the per capita wealth for the county in 1860. Relative farm value was calculated as the average value of a disperser's family farm in 1860 minus the value of the average family farm for that county in 1860.

One concern is that data on cohort family wealth would be subject to censoring bias. It is possible that cohort members who are wealthier are easier to find in their childhood homes because census enumerators neglected less prominent families. Under this type of bias, cohort individuals matched for family wealth would tend to come from wealthier families, making the cohort appear relatively wealthy overall. Because this bias would reduce support for the hypothesis that cohort members are generally poorer than average, our conclusions about cohort family wealth would be conservative. Although we were unable to detect systematic censoring for family wealth, even if censoring were present it would only present a more conservative test of our hypothesis.

Family competition (Hypothesis 2)

Hypothesis 2a

If high intra-familial competition provided motivation to disperse to Gothic, cohort members should have more brothers than sisters (sex ratio > 0.5). Since some cohort members are brothers, each family was used only once in this analysis. Let B be the total number of brothers over all of the disperser's family, and S be the total number of sisters. The naïve method of calculating the sex ratio of the cohort $B/(B+S)$ will be inherently male-biased because there is already one male in each family by definition. Removing cohort

members allows for a calculation of the sex ratio of their competitors, the 'sibling sex ratio'. Let k be the number of individuals in the cohort. Patil & Rao (1978) demonstrate that the estimate $(B - k)/(B + S - k)$ removes the inherent male bias introduced by the inclusion of cohort members. We used this method to estimate sibling sex ratio for the Gothic cohort. It is unlikely that sex ratio affects the chances of an individual being censored for numbers of siblings. Therefore, it is reasonable to assume that the cohort members, matched for number of siblings, provide a random sample from within the cohort with regard to sex ratio.

Hypothesis 2b

If high intra-familial competition provided motivation to disperse to Gothic, the cohort should have larger families than the national average. The naïve estimate $(B + S)/k$ does yield the average family size for the cohort, but this average is difficult to compare to national averages. Most cohort families already had at least one son in 1860 (a few older cohort members had already left home in 1860, and a few cohort members were not born yet), which introduces a size bias. It would be ideal to compare the average family size of the Gothic cohort with the average family size of families with at least one son of similar age to our cohort, but this is not feasible. In order to make a similar comparison, the size bias can be corrected for by removing the cohort member. Let B_i and S_i be the number of brothers and sisters, respectively, in the family of the ith cohort member, and let $t_i = B_i + S_i$. Patil & Rao (1978) demonstrate how to obtain such an average family size estimate (δ) by taking $k/\Sigma(1/t_i)$. Since some cohort members are brothers, each family was used only once in this analysis. It is unlikely that family size affects the chances of an individual being censored for family size. It is a reasonable assumption that cohort families are missing at random in regards to family size and should not bias analysis.

Kennedy (1864) provided information on the total number of households, total number of individuals, and the total number individuals in single person households in the USA in 1860 (it would be ideal to have comparative data on nuclear family size, but this is not available). It would be a poor comparison to our families to include single-person households. A better comparison is to calculate the average household size in 1860 for households with at least two individuals ((total No. individuals−No. single person households)/(total No. households − No. single person households)). Thus, the recalibrated family

size (δ) for our cohort can be compared to households having greater than two or more individuals in the USA in 1860 to test the hypothesis that cohort members come from larger families than average.

The Civil War (1861–1865) would have caused large numbers of male children to die, making the number of family members in 1860 an overestimate of the number of brothers at the time of dispersal. However, this should not be a problem for estimating cohort family size relative to the typical family size. It is not likely that sons from Gothic families were disproportionately killed in the Civil War. Therefore, we predict that families with Gothic dispersers would still be larger than average when the time comes to disperse to Gothic.

Hypothesis 2c

If high intra-familial competition, such as a large number of older brothers, motivated dispersal to Gothic (Clark & Low, 1992; Voland & Dunbar, 1995), the cohort should be composed of a higher proportion of later-born sons than the general population. We used census and genealogical records to determine brother rank, birth order considering only male children, and also total number of brothers for the cohort members' completed families. Siblings who appeared in one census record as a baby and then disappeared in the next census ten years later were assumed to have died at too young an age to be in competition with the cohort member and are excluded from analysis.

A probability distribution was calculated for a theoretical cohort, formed by a stratified random sample from the cohort families as follows. Each male sibship is given an equal weight of inclusion. Within each male sibship, each brother has an equal weight of inclusion. The above steps completely specify the probabilities of inclusion for every sibship member with a given brother rank. The probability distribution of brother ranks for this theoretical cohort can be compared to the probability distribution of brother ranks for cohort members. Some cohort members are brothers (7 brother pairs). For simplicity in creating the theoretical distribution each family was only counted once in the theoretical cohort. However, the brother rank of each cohort individual was included in the graph of the actual cohort.

Farmers and family competition (Hypothesis 3)

To analyze how family pressures might have differed according to father's occupation, we also analyzed the data on sibling sex ratio, family size and

brother rank according to whether individuals came from farming or non-farming families. This allows for a comparison within the cohort showing how family pressures might have been shaped by father's occupation.

Results

Poor economic opportunity (Hypothesis 1)

Hypothesis 1a

Cohort members had fathers in a wide variety of occupations but were predominantly from farming families. Information about the father's occupation for 67 families was found. Of these fathers 52% were farmers, 15% skilled laborers, 15% laborers and 18% elites. The frequency of fathers who were farmers among the cohort is the same as the per capita number of farms in 1860 USA (No. farms/total population = 0.52). Thus, cohort members are drawn as if at random from the total US population with respect to father's occupation and do not come disproportionately from low-status jobs. These data do not provide support for the hypothesis that cohort members were disproportionately from resource poor and low-status families.

Hypothesis 1b

On average, cohort members came from families that had slightly less wealth and less valuable family farms than average, but they came from families with a wide distribution of economic resources. Information about wealth in 1860 was found for 48 families. Figure 2 shows that the majority (58%) of cohort members had less wealth than the average of their childhood county. Since relative wealth is calculated using the per capita wealth in the childhood county, which has a heavy right tail, individuals may appear to be poorer than they actually were. However, many cohort members (40%) were more than $300 below average for their childhood county. Gothic migrants came from a wide range of natal families, from extremely poor at $978 below, to quite wealthy at $74 485 above average per capita wealth for the natal county (in 1860 US dollars). Information about the value of a family farm was found for 28 families of the 35 whose head declared his occupation as a farmer. Figure 3 shows that the majority (64%) of focal family farms were poorer than the average farm in that county. Since relative farm value is

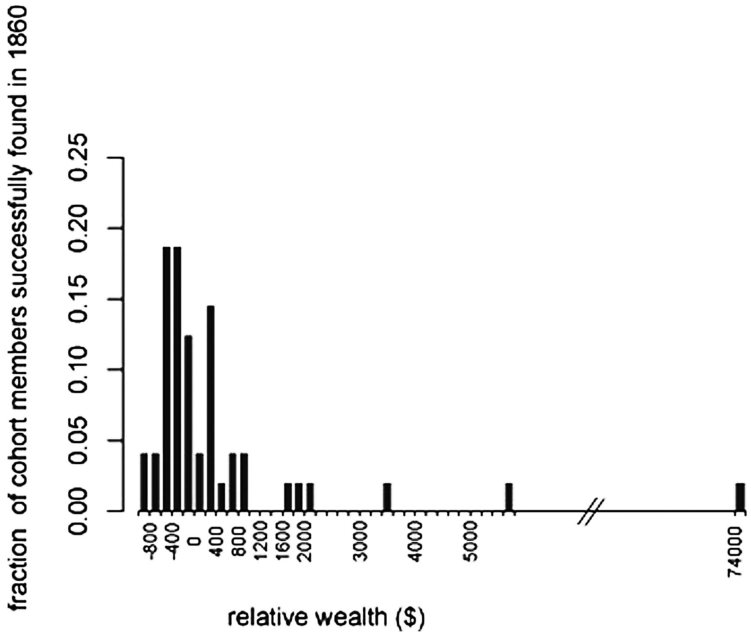

Figure 2. Distribution of the relative wealth for cohort members in 1860 ($N = 48$). Relative wealth is calculated as the per capita family wealth in 1860 minus the county wide per capita wealth for the childhood county of the cohort member. Individuals whose families were wealthier than average have positive values. Individuals whose families were poorer than average have negative values. Note that the majority (58%) of cohort members had less wealth than average, but that some cohort members do come from wealthy families. Some cohort members were brothers but each family was used only once in this analysis.

calculated using the average value of a farm in the childhood county, the distribution of which has a heavy right tail, individuals may appear to be poorer than they actually experienced. However, many cohort members (50%) were more than $1000 below average for their childhood county.

Although cohort members came from across the wealth spectrum, taken together, the data provide support for the hypothesis that they were disproportionately from resource poor childhood homes, especially among farmers.

Family competition (Hypotheses 2 and 3)

Hypotheses 2a and 3a

Cohort members experienced a slightly male-biased sibling sex ratio of 0.52. If only farming families are considered, the sibling sex ratio was not male bi-

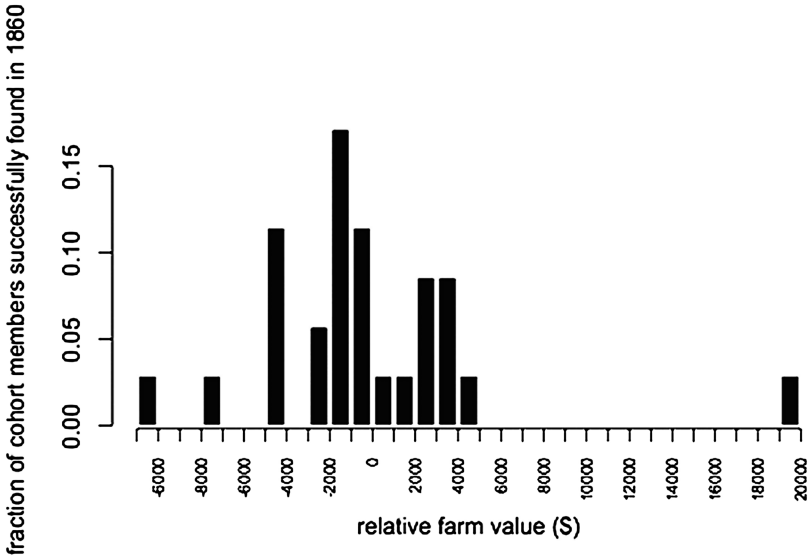

Figure 3. Distribution of the relative value of a cohort member's family farm in 1860 ($N = 28$). Relative value is calculated as the value of the family farm in 1860 minus the county-wide average value of farms in the childhood county. Individuals whose families had more valuable farms than average have positive values. Individuals whose families had poorer farms than average have negative values. Note that the majority (64%) of the cohort members had poorer farms than average, but that some cohort families have valuable farms. Some cohort members were brothers but each family was used only once in this analysis.

Table 1. Summary of the sibling sex ratios and family sizes for the whole cohort, farmers, and non-farming families.

Group	Sibling sex ratio	Family size 1860 (δ)
Cohort	0.52	6.75
Farmers only	0.48	7.00
Non-farmers only	0.57	6.45

The mean number of individuals in a family of at least 2 individuals in the US in 1860 is 5.38.

Note: we did not calculate standard errors for sex ratio or family size. This is because we are not applying Patil & Rao (1978) to recover or estimate a parameter. Patil & Rao (1978) have been invoked for their bias-correction properties for comparability to the available statistics for the US population.

ased (0.48), which left the non-farming families with a highly male-biased sibling sex ratio of 0.57. Table 1 summarizes these results. These data pro-

vide little support for the hypothesis that all cohort members experienced high levels of intra-familial competition (Hypothesis 2), but do support the hypothesis that farmers' sons experienced different incentives for migration than sons from non-farming families (Hypothesis 3).

If older brothers died in the Civil War (1861–1865), then we may have calculated sibling sex ratios as more male-biased than they actually were at the time of dispersal. While this may weaken our conclusion slightly, the sex ratio of non-farming families 0.57 is so high that, even if some brothers died, it is still likely that these cohort families were still male-biased. This potential bias does not weaken our conclusion about different incentives for migration for cohort members from farming and non-farming families.

Hypotheses 2b and 3b

The calculated δ (average family size) for the whole cohort was 6.75. This can be compared to the 1860 national average of 5.38 members in households of at least 2 individuals. The calculated δ for farmers was 7.00 compared to 6.45 for non-farmers. These data provide strong support for the hypothesis that cohort members were drawn from families with high levels of intra-familial competition (Hypothesis 2), as well for the hypothesis that farmers' sons experienced different incentives for migration compared to those from non-farming families (Hypothesis 3).

Hypotheses 2c and 3c

Figure 4 demonstrates that there is very little difference between the theoretical distribution of brother ranks (if one member was drawn at random from each family, ignoring brother rank) and the actual distribution of brother rank among cohort members. Therefore, it is likely that cohort members as a whole were not inspired to migrate to Gothic because of having many older brothers. These data do not provide support for the hypothesis that cohort members were drawn from families with high levels of intra-familial competition (Hypothesis 2).

However, there is a small difference between the theoretical distribution of brother ranks from farming families and the actual distribution of brother rank among cohort members from farming families (Figure 5). The number

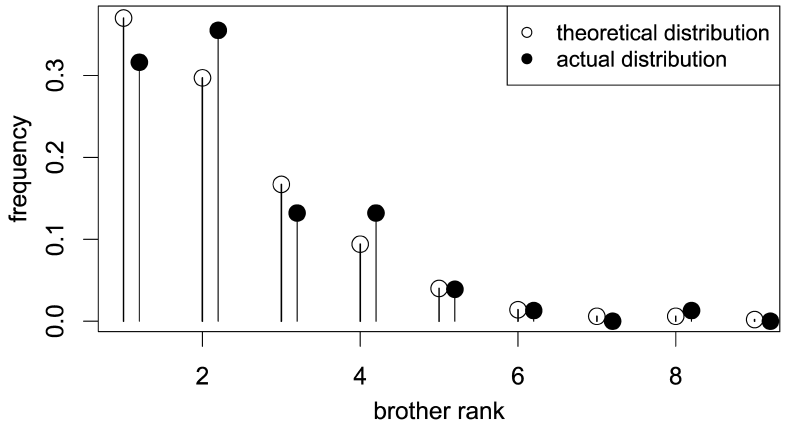

Figure 4. Theoretical distribution if one individual from each family were selected at random ignoring brother rank compared to the actual distribution of brother rank among cohort members. The theoretical distribution was calculated as follows. Each male sibship was given an equal weight of inclusion. Within each male sibship, each brother has an equal weight of inclusion. This completely specifies the probabilities of inclusion for every sibship member with a given brother rank. These calculations are based on 69 cohort members and a total of 241 brothers.

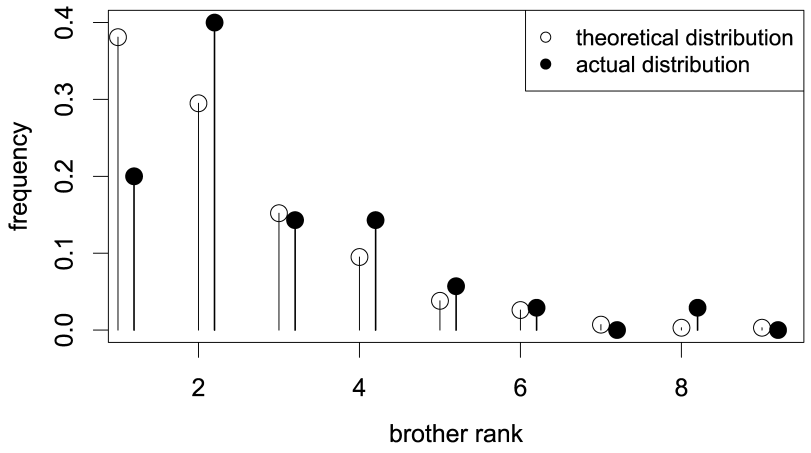

Figure 5. Theoretical distribution if one individual from each farming family were selected at random ignoring brother rank compared to the actual distribution of brother ranks among cohort members from farming families. Each male sibship was given an equal weight of inclusion. Within each male sibship, each brother has an equal weight of inclusion. This completely specifies the probabilities of inclusion for every sibship member with a given brother rank. These calculations are based on 35 farming cohort members and a total of 123 farming brothers.

of first-born sons is smaller among the cohort members than would be predicted under the null model. The fact that few first-born and many second-born sons of farmers migrated to Gothic indicates that these farmers may have practiced primogeniture. These data provide some support for the hypothesis that farmers' sons experienced different incentives to migrate than non-farmers' sons (Hypothesis 3).

Also note that the Civil War (1861–1865) would have caused large numbers of male children to die, making the number of older brothers in 1860 an overestimate of the number of brothers in cohort members had when they dispersed as young adults. If older brothers died in the Civil War, then we may be recording brother ranks that are much lower than cohort members actually experienced as young adults (e.g., a fourth-born son may actually experience life as a first born son if three older brothers died in the war). If this were true for many members of the cohort, we should have a cohort of mostly late-born sons and few first-born sons. We did not find this to be the case.

Discussion

The potential for social and economic mobility on the frontier has been hotly debated among social scientists since Turner (1920), but the actual rewards for migrating to the frontier are not yet well understood (Peterson, 1975; Guest, 2005). One productive way to investigate what drives population of the frontier is to investigate individual level incentives that motivate an individual to choose the risky strategy of long-distance dispersal. A longitudinal study of Gothic migrants provides an excellent opportunity to study the life-history factors that inspired individuals to participate in the risky long-distance dispersal to the ephemeral boomtowns of the frontier. Gothic immigrants undoubtedly experienced few prospecting and reproductive rewards during their tenure in Gothic and endured high levels of interpersonal violence and physical dangers (see historical background).

Previous research suggests that those with poor access to resources and status should be more likely to choose to shoulder the costs of short-distance dispersal (Clarke & Low, 1992; Voland & Dunbar, 1995; Strassmann & Clarke, 1998; Herscovici, 1998; Towner, 2000; Hitztaler, 2004). Our longitudinal study of unmarried US-born prospectors also supports this hypothesis for long-distance dispersers. Members of the Gothic cohort came

from poorer families (58% are below average for childhood county: Figure 2), with comparatively poor farms (64% below average for childhood county: Figure 3), and from large families with slightly more same-sex siblings (slightly-male biased sibling sex ratio of 0.52 for the whole cohort and larger families by 1.37 members on average for the whole cohort: Table 1).

Although cohort members from farming families did not have a male-biased sibling sex ratio, these cohort members did experience family competition because their families were larger than the US average (by 1.62 members: Table 1). It is unclear if these larger families meant that more family competition (more siblings) was needed to inspire farmers' sons to migrate than sons not in farming families, or if the extra family members were actually farmhands and laborers.

Contrary to expectations, there was little support from the whole cohort for the hypothesis that later-born sons were more likely to disperse than earlier born sons (Figure 4). However, if only cohort members from farming families were considered, there were fewer first-born sons than expected (Figure 5). This might indicate that among farmers, first-born sons were more likely to inherit wealth and not disperse, and that second-born sons of farmers were slightly more likely to disperse. In general, the hypotheses that poor economic opportunity and high intrafamilial competition inspire dispersal are supported. Sons of farmers who are not first-born may be particularly vulnerable to dispersal.

Previous research focused mainly on dispersal sites that were similar to natal sites, but with less competition for critical resources (Clarke & Low, 1992; Voland & Dunbar, 1995; Strassmann & Clarke, 1998; Herscovici, 1998; Towner, 2000; Hitztaler, 2004). Different incentives might be expected for long-distance dispersal. Gothic immigrants probably experienced higher levels of cost and potentially higher rewards associated with finding a bonanza mine compared to typical dispersal sites. There was also a great deal of allure and romance for 19th century Americans for participating in the manifest destiny and 'improving' wild frontier lands (Billington, 1967; Morse, 2003). Contrary to predictions based on short-distance dispersal, not all Gothic migrants came from a disadvantaged background. In fact, 18% of the cohort comes from elite families. This pattern is confirmed in the broad range of values for relative wealth (Figure 2) and relative value of family farms (Figure 3). The elite and very wealthy fathers of cohort members included a congressman, a merchant banker, a lawyer, and a university president. Perhaps the sons of the wealthy and elite families were drawn to Gothic

not only by potential prospecting rewards, but also by the social rewards of participating in a romantic adventure.

Some aspects of Gothic dispersal are similar to previously studied dispersal events. Like short distance dispersers, Gothic dispersers were typically those who lacked access to resources in their childhood homes. However, there is a heterogeneous nature in the incentives inspiring migration to the mining frontier. For instance, it is likely that those who dispersed to Gothic in brother pairs (i.e., parallel dispersal; see Schoof et al., this issue) experienced different (and likely lower) dispersal costs than lone dispersers. This might inspire individuals with brothers who also plan to disperse to leave home at higher levels of family wealth and lower levels of family competition. Unfortunately our data only provide information on seven brother pairs, which is not enough to really speak to this hypothesis. This would be an interesting avenue for further research.

Another potential area of research would be to investigate the socio-political impacts on individual dispersal decisions. For example, many soldiers were displaced during the Civil War. Having already paid the costs of long-distance dispersal, perhaps the benefits of seeking their fortune at the frontiers easily outweighed the costs. It would be intriguing to investigate if displacement during the Civil War increased the probability of long-distance dispersal. There are many opportunities for productive research in understanding dispersal focusing on the heterogeneity of dispersal incentives experienced by different socio-economic classes of dispersers in a variety of economic and ecological dispersal sites. This paper will demonstrates the utility of such an approach and we hope it will inspire others interested in dispersal to use an individual-level perspective.

Acknowledgements

Many thanks to Bruce Winterhalder, Monique Borgerhoff Mulder, Mark Grote and Richard McElreath for the time they devoted to improving this project, as well as to our guest editors Kathy Jack and Lynne Isbell, and two anonymous reviewers. Thanks also to our tireless research assistants, Mary King, Devin Snyder, Jessica Rockwell, Emily Bergmann and Colin Cannell for their devotion in the archives. This project was made possible through logistical support by the Rocky Mountain Biological Laboratory and funding from several UC Davis Anthropology Department block grants and a Grant in Aid of Research from Sigma Xi.

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