Energy Costs and Rural Alaska Out-Migration

Prepared with support from
Alaska Energy Authority

By
Matthew Berman
Institute of Social and Economic Research
University of Alaska Anchorage
3211 Providence Drive
Anchorage, Alaska 99508

March 2017

Acknowledgments

The author gratefully acknowledges technical assistance provided by Alaska Department of Labor and Workplace Development Research and Analysis Section staff. Eddie Hunsinger in particular genersouly provided help and advice that greatly improved the quality of the research.

Energy Costs and Rural Alaska Out-Migration

Summary

This report contains results of a formal statistical analysis of the association of high prices for home heating fuel with out-migration from rural Alaska communities, using data from Alaska Permanent Fund Dividend applications from 2003 to 2015. Although anecdotal reports have described hardships caused by the rising cost of fuel, this study is the first to subject the hypothesis of fuel-related out-migration to rigorous statistical testing.

This study addressed five main research questions:

1. What is the evidence that out-migration from rural Alaska communities was associated with fuel prices?
2. How sensitive are out-migration rates to fuel prices?
3. Does the effect of high prices on out-migration in communities with the chronically high fuel prices differ from the effect across all communities of high-cost years?
4. How do effects of fuel prices on out-migration differ for regional hubs and smaller villages?
5. How does the magnitude of the effect of fuel prices compare to that of other drivers of mobility, such as employment and income?

The study region was defined as the area of western and northern Alaska with neither road nor year-round water access. We divided this region into local areas consisting of the nine Census Areas/Boroughs in the region with the regional hub communities of Dillingham, Bethel, Nome, Barrow/Utqiagvik, and Kotzebue separated from smaller villages in their respective Census Areas/Boroughs.

The statistical analysis examined five binary variables representing different types of potential moves that an individual could make outside the local area of residence:

1. Leave rural Alaska (yes or no, all residents of the rural region);
2. Leave the local area (yes or no, all residents of the rural region);
3. If leave the local area, leave rural Alaska: (yes or no, residents leaving local area);
4. If leave a village, leave rural Alaska: (yes or no, residents leaving local area who started in a smaller village and not a regional hub);
5. Leave rural Alaska (yes or no, regional hub residents only)

Logistic regression equations were estimated for residents 18 years old to associate each of the five binary variables with fuel prices, controlling for age, gender, employment status and earnings, as well as several characteristics of the community of residence. Teachers, oil workers, mining workers, and pilots were excluded from the analysis. Alaska Department of Labor staff used the applicant's Social Security Number to link individual Permanent Fund Dividend (PFD) applications across successive years and to

state employment security records. Data from PFD applications included age and gender, as well as place of residence. Employment records included earnings by occupation and industry. Retail fuel price surveys conducted by the Alaska Housing Finance Corporation and the Alaska Division of Community and Regional Community Affairs provided price data for home heating fuels. Fuel prices for communities not included in the surveys were estimated from wholesale diesel fuel prices published in Power Cost Equalization program reports. Additional community level data on labor force size, employment, and earnings supplemented data from individual records. Earnings and fuel prices were adjusted to 2015 dollar values using the Anchorage Consumer Price Index.

The study found that high fuel prices were associated with more rural Alaska residents moving to urban Alaska, but the size of the effect was relatively small: less than 40 adults each year for each $1 rise in fuel prices. Observed increases in moves to urban Alaska triggered by higher fuel prices came entirely from regional hubs rather than from smaller villages. Although rural Alaska residents were more likely to move from both villages and regional hubs when fuel prices rose, higher fuel prices diverted more village movers to hubs instead of urban areas, so there was a negligible net effect from villages to urban Alaska. Other factors besides fuel prices that change over time also affect migration decisions. The study found that local labor market conditions, as well as the individual's employment status and earnings had much stronger effects on out-migration than fuel prices.

Energy Costs and Rural Alaska Out-Migration

Introduction

Rural Alaska residents have long been mobile. In addition to moving between neighboring villages, which has always occurred, about ten percent of rural Alaska Native residents typically move into urban Alaska over a given five-year period, and nearly as many return (Huskey et al., 2005). However, a number of observers noted that out-migration from rural Alaska accelerated in recent years, coinciding with the rise in oil prices in 2008 (Kizzia, 2008). Despite anecdotes and popular opinion describing hardships caused by the high cost of fuel, studies have been equivocal about the role of energy costs in village out-migration and potential depopulation (Lowe, 2009; Martin, 2009; Martin et al., 2008).

Understanding and quantifying the true role played by village energy costs in population dynamics is key to developing sound public policies related to rural Alaska fuel and electricity costs. This study addressed this issue with a statistical analysis of the effect of household energy costs -- mainly home heating fuel -- and other factors in determining rates of population moves between Alaska communities. Electric costs in rural Alaska are highly subsidized through the Power Cost Equalization (PCE) program, and the main factors determining cost of power in any case are community size and the cost of diesel fuel. Diesel fuel is also the main home heating fuel in most rural communities, and the price of gasoline is also highly correlated with home heating fuel prices.

Fuel prices are not uniformly high in all places. Coastal communities with year-round ice-free access can receive fuel deliveries by barge year-round and have much lower home heating costs. More northerly communities accessible by barge seasonally and with adequate bulk-fuel storage have lower fuel prices than small communities without water access or bulk storage. Barrow has inexpensive natural gas, and the North Slope Borough subsidizes energy prices for other villages in the borough. In addition, fuel prices have varied quite a bit over the past ten years: rising to 2008, then falling somewhat, followed by another round of escalating prices. (There has not been sufficient time since the most recent softening of oil prices to test its effect on migration, given the data available at this time.)

Research questions

The study specifically addressed several specific related research questions. First, did high fuel prices cause out-migration from rural Alaska communities? What is the evidence that hardship associated with rural energy costs has actually driven people out? Second, if there is an effect of fuel prices on migration decisions, how large was the effect? How sensitive are out-migration rates to fuel prices? Third, is the effect of relatively high fuel prices in some communities different from the effect of high-cost years? The third question asks whether there is a persistent pattern of out-migration from communities with the highest fuel prices.

In addition to these three basic questions, the study addressed two questions aiming to increase understanding of the role that fuel prices play in the overall pattern of mobility in rural Alaska. A fourth question is whether and how effects of fuel prices on out-migration differ for regional hubs and smaller villages. Previous research demonstrated that most moves from rural Alaska follow a "stepping stones" pattern (Howe et al., 2013). Most moves of village residents are to the larger nearby regional hubs. Most in-migrants from rural Alaska to Anchorage, on the other hand, come from the regional hubs. Regional hub residents also frequently move back to villages. Finally, how does the magnitude of the effect of fuel prices compare to the magnitude of the effects of other drivers of mobility, such as employment and income?

We addressed these five research question by correlating the spatial and temporal variation in fuel prices in rural Alaska with data on mobility choices to test hypotheses about the effect of fuel prices on population change. The objective was to quantify the association between variation in fuel prices among communities and over time and inter-regional mobility, while controlling for other factors that could influence migration decisions and also vary across space and time. We estimated the effect of energy prices both in absolute terms and relative to other drivers of population mobility.

Methods

Data Sources

Data on inter-community migration came from Permanent Fund Dividend (PFD) applications. PFD applications also provided basic demographic information: age and gender of the applicant, as well as place of residence. Because of the potential role of unemployment and underemployment in decisions to move, we derived information on employment status and earnings of individuals, as well as their occupation and industry, from employment security data maintained by the Alaska Department of Labor. Community level data on employment, labor force size, and earnings were compiled from published Alaska Department of Labor sources.

We derived information on home heating fuel prices at the community level from fuel price surveys conducted regularly by the Alaska Housing Finance Corporation (AHFC) and the Alaska Division of Community and Regional Affairs (DCRA). In addition, we assembled data on prices for diesel fuel used in electricity generation from the Alaska Energy Authority PCE database, which includes a number of communities that are not included in the fuel price surveys.

Data management

We started by selecting PFD applications for all individuals at least 18 years old at the time of their application, for application years 2003 to 2015. PFD applications for the

same person were linked across successive years using the applicant's Social Security Number (SSN). For this study, we created a person-year record consisting of two consecutive years. The individual had to have filed a PFD application for two consecutive years to be included in the data set. The SSN was also used to link the PFD applicant's employment records.

Individual records with identifying information such as the SSN are confidential under state law; only authorized state employees have access to them. Alaska Department of Labor, Research and Analysis Section employees who regularly analyze these records linked the data sets PFD records to each other and to the employment security records at the individual level. Research and Analysis Section employees also linked the community level data, including the fuel price information to the confidential data set using the community of residence reported on the PFD application.

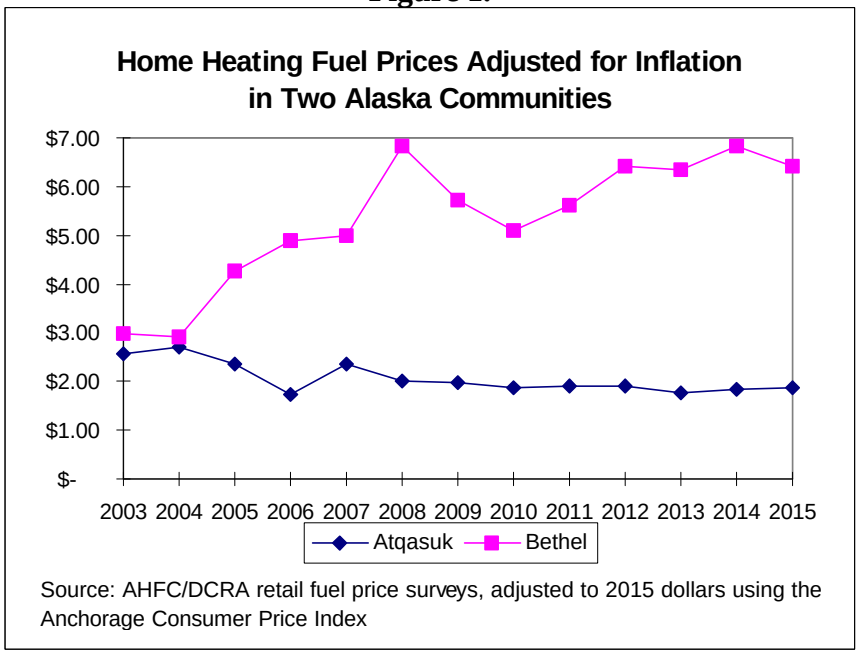
Since we wanted to test the hypothesis that high fuel prices might increase migration from rural Alaska, we limited the analysis to the rural Alaska region where fuel prices were highest, and therefore most likely to show an effect if it had occurred. For the statistical analysis, we selected the rural Alaska region as the set of nine Census Areas/Boroughs in western and northern Alaska that have neither road access nor year-round water access. These included the Bethel Census Area, Bristol Bay Borough, Dillingham Census Area, Kusilvak Census Area, Lake & Peninsula Borough, Nome Census Area, North Slope Borough, Northwest Arctic Borough, and Yukon-Koyukuk Census Area. We generated 14 "local areas" to frame the regional analysis. These consisted of the nine Census Areas/Boroughs, with the five that contain hub communities further divided into the regional hub community and the remaining set of villages. Census Areas containing hubs include the Dillingham Census Area (Dillingham), Bethel Census Area (Bethel), Nome Census Area (Nome), North Slope Borough (Barrow/Utqiagvik), and Northwest Arctic Borough (Kotzebue).

Fuel prices from the AHFC-DCRA surveys represent retail prices that correspond closely to what households actually paid for fuel. However, they only cover about 100 communities. Many communities that were not included in the AHFC-DCRA surveys did have PCE data available. We estimated a linear regression equation that predicted the retail fuel price as a function of the PCE price and community size, and used the estimated equation to predict retail prices for communities that had PCE data but not retail price survey data. For the few remaining communities that had neither PCE nor AHFC-DCRA data, we estimated the retail fuel price as the average of retail prices in communities in the same local area and year for which we had price data. The local areas for average prices were the same as mentioned above: Boroughs or Census Areas, with the five areas with regional hub communities -- Kodiak, Dillingham, Bethel, Nome, Kotzebue, and Barrow -- considered as separate local areas from the smaller communities in the same Census Area or Borough.

To eliminate the effects of price inflation, we adjusted all earnings and fuel price data to 2015 dollar values using the Anchorage Consumer Price Index. Figure 1 shows the

pattern over time of fuel prices adjusted for inflation for two rural Alaska communities. The figure illustrates how prices in Bethel rose by nearly $4.00, from $2.90 per gallon to $6.83 per gallon (in 2015 prices) between 2004 and 2008. Over the next two years, the price fell by almost $2.00 per gallon before rising again. In Atqasuk, however, the price did not rise at all, and actually fell slightly over time after adjusting for inflation. The North Slope Borough subsidizes home heating fuel in Atqasuk and other North Slope communities, insulating them from the price shocks that affected other rural communities.

Figure 1.



The combined data set spanned a 13-year study period contained about 1.4 million person-year records. The 1.4 million records were condensed to pairs by combining consecutive observations for the same individual, creating a set of nearly 700,000 individual mobility records.

Migration decisions analyzed

A person observed filing a PFD application from a community in year *t* was considered to have moved if in the PFD application in year *t*+1 listed a different community of residence. Many rural Alaskans move among neighboring villages for social and family reasons. These moves are not relevant for testing the effects on rural out-migration. Instead, the moves we are interested in represent movement to a community outside the "local area" of residence. To construct statistical tests, we created five binary variables representing different types of potential moves that an individual could make outside the local area of residence. These were defined as follows:

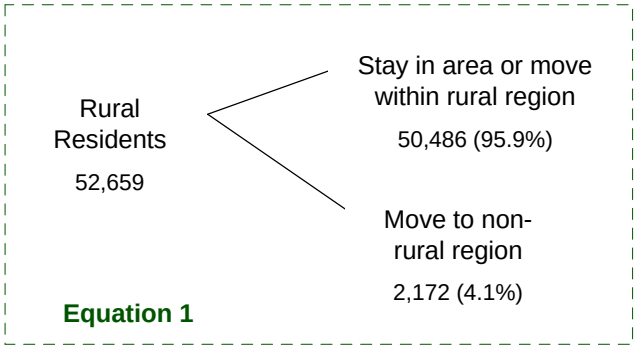
1. Leave rural Alaska: (1=leave the rural region, 0=stay in the rural region);

2. Leave the local area: (1=move to new local area, 0=stay in the same local area);
3. If leave the local area, leave rural Alaska: (1=leave rural region; 0=stay in rural region, conditional on leave the local area=1)
4. If leave a village, leave rural Alaska: (same as above except excludes regional hub residents)
5. Leave rural Alaska, regional hub residents (1=leave rural region; 0=stay in rural region, same as 1, except regional hub residents only)

The first binary variable -- equation 1: leave rural Alaska -- represents a simple direct test of the hypothesis that fuel prices were associated with out-migration, as depicted in the decision tree in Figure 2. The population for the equation includes all residents of high-cost rural region. About four percent of the 53 thousand residents left the high-cost rural region each year. This percentage reflects the gross migration flow. The average annual net out-migration was positive but much smaller: less than one percent annually.

Figure 2. Decision tree for equation 1: Did the person move to a community outside the high-cost rural region? (Direct test)

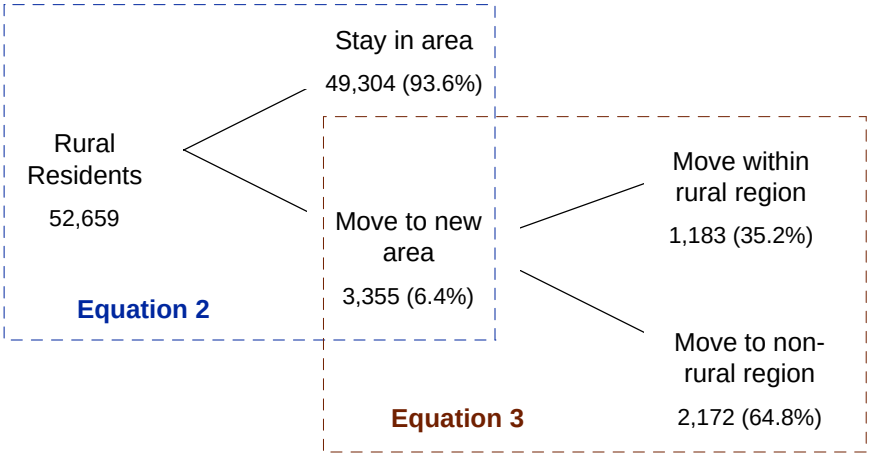
Numbers indicate average annual population at least 18 years old between 2003 and 2015.



The second, third, and fourth binary variables -- equation 2: leave the local area; equation 3: if leave the local area, leave rural Alaska; and equation 4: if leave a village, leave rural Alaska -- together represent a two-stage test of the same hypothesis (Fig. 3). The two-stage specification separates the decision to move out of a local area from the decision on where to relocate. That permits us to test whether the factors determining decisions to leave a community are the same for movement within rural Alaska, most of which is between villages and regional hubs, as for movement between rural and urban Alaska. Of the 6.4 percent of adults who moved each year from local areas in the rural high-cost region, nearly two thirds moved to urban areas, and slightly more than one-third remained in rural Alaska.

Figure 3. Decision tree for equations 2 and 3: Did the person move to a community outside the high-cost rural region? (Two-stage test)

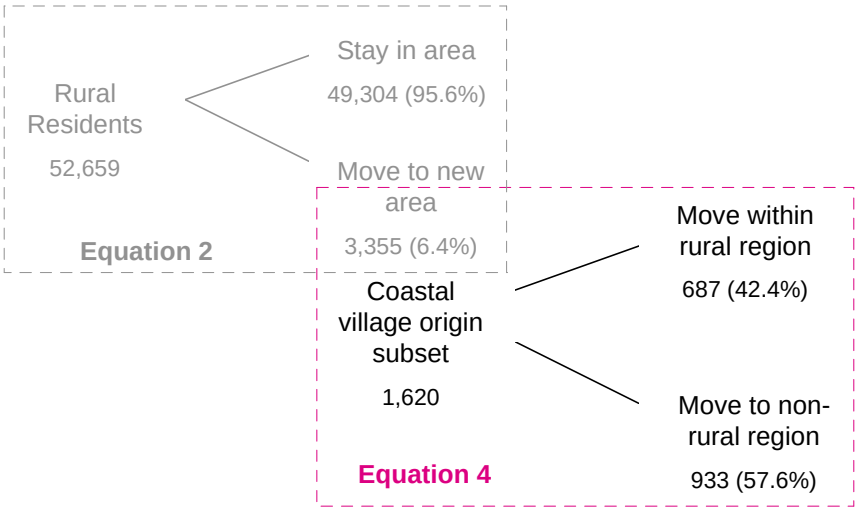
Numbers indicate average annual population at least 18 years old between 2003 and 2015.



The fourth binary variable addresses the same decision as equation 3 but considers only the subset of movers who moved from a village rather than from a regional hub (Fig. 4). Rates of migration to urban Alaska from villages are somewhat less than rates from villages, as has been noted before (Howe et al., 2013). Coastal village residents represent about two-thirds of the population of the high-cost rural region 18 years and older, but slightly less than one-half of out-migrants. The term, "coastal village residents" represents residents of the high cost region excluding the five regional hub communities and the Interior region. We exclude residents of the Interior region, the Yukon-Koyukuk Census Area when estimating equation 4 because the regional hub community effectively is Fairbanks, which lies outside the rural high-cost region.

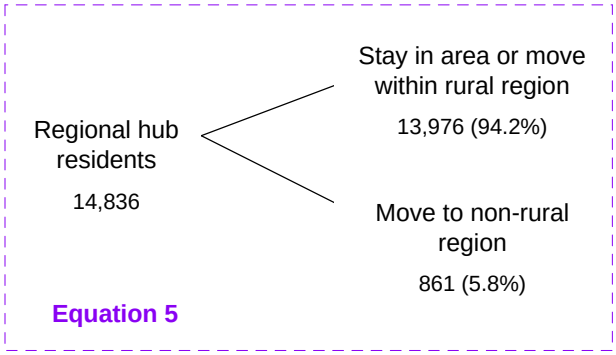
Figure 4. Decision tree for equation 4: Did a person leaving a village leave rural Alaska?

Numbers indicate average annual population at least 18 years old between 2003 and 2015.



The final binary variable, equation 5, represents the direct test of out-migration from the rural high-cost region for residents of the five regional hubs (Fig. 5). As mentioned before, out-migration rates from the rural region are somewhat higher for regional hub residents: nearly 6 percent compared to 4.1 percent for the region as a whole.

Figure 5. Decision tree for equation 5: Did regional hub residents move outside high-cost rural region?
Numbers indicate average annual population at least 18 years old between 2003 and 2015.



Statistical approach

We estimated maximum likelihood logistic regression equations for each of the five binary variables using the PLUM procedure in SPSS. Community-level explanatory variables entered into the equation included the estimated community fuel price, the size of the labor force (population 16 years and older), the ratio of employment to the labor force (employed rate), average annual earnings per employed person. Individual-level variables included age, gender, whether the person was employed (had positive earnings), and annual earnings. Separate regional binary variables were added for the Interior region (Yukon-Koyukuk Census Area), Northwest Alaska (Nome Census Area, North Slope, and Northwest Arctic Boroughs), and the Yukon-Kuskokwim Delta (Bethel and Kusilvak Census Areas), and Southwest Alaska (Dillingham Census Area, Bristol Bay and Lake and Peninsula Boroughs).

Because fuel prices were trending upward during the study period even after adjusting for inflation, we wanted to be sure that effects found for fuel prices were not merely trends. We tested two specifications to control for trend effects. One specification included intercepts (fixed effects) for each study year. With this specification, tests of the effects of fuel prices measured strictly differences across communities, ignoring changes in the overall level of prices between years, which get captured in the yearly fixed effects. For the second specification, we included a trend variable. In this case, the effects of fuel prices included both inter-community differences in each year and the overall fuel price level relative to the trend. We tested equations including the natural logarithms of fuel prices and wages as well as levels. We also tested whether individuals with higher

earnings might have reacted differently to changes in fuel prices than individuals with lower earnings by adding a variable interacting fuel prices with wages.

We suspected that workers in certain types of jobs with high mobility -- specifically teachers, seafood processing workers, oil workers, mining workers, construction workers, and pilots -- might have different responses from those of other rural Alaska residents. A preliminary statistical analysis conducted on a random 10 percent sample of the records to reduce computational burden determined that mobility patterns of teachers, oil workers, mining workers, and pilots did indeed differ significantly from mobility patterns of other residents, while mobility patterns for construction and seafood workers were not significantly different. Consequently, we excluded teachers, oil workers, mining workers, and pilots, most of whom are not long-term residents, and estimated the logistic regressions with the full data set for the remainder of the population. After excluding a small percentage of the records with missing information for age or gender, the final data set contained 631,903 records.

Results

Table 1 summarizes the results of the logistic regression equations estimated for out-migration from rural Alaska communities from the PFD application data. Appendix A contains the set of tables that includes the full set of equation results. Specifications with logarithms of earnings and prices were very similar to equations estimated with actual units. Equations specified in actual units slightly out-performed logarithmic specifications using the likelihood ratio Chi-squared test in all instances except one -- the destination choice of out-migrants from rural villages -- in which the logarithmic specification had a better fit. The village out-migration equation was also the only one in which the interaction of wages with the fuel price was significantly different from zero. We therefore report the results for equations 1, 2, 3, and 5 using actual units and excluding the interaction term, and the logarithmic equation results including the interaction of fuel price with the log of wages for equation 4.

Table 1. Summary results of logistic regression equations for out-migration from rural Alaska

(Maximum likelihood estimates)

	Equation 1	*Equation 2*	*Equation 3*	*Equation 4*	*Equation 5*
Population included	All rural residents	All rural residents	All rural residents who moved	Village residents who moved	Regional hub residents
Destination	Not rural Alaska	Anywhere	Not rural Alaska	Not rural Alaska	Not rural Alaska
Effects					
Odds ratio, fuel price across places[a]	1.004 (p=.42)	1.031 (p=.000)	0.934 (p=.000)	0.964 (p=.012) $*.988^{ln(wages)}$ (p=.035)	1.039 (p=.001)
Odds ratio, fuel price relative to trend[s]	1.017 (p=.001)	1.038 (p=.000)	0.955 (p=.000)	0.967 (p=.011) $*.988^{ln(wages)}$ (p=.036)	1.053 (p=.000)
Other significant effects[b]	age (-)	age (-)	age(+) (small)	age(-) small	age (-)
	female (+)	female (+)	female (+) (small)		female (+)
	employed (+)	employed (+)	employed (-)	employed (+)	employed (+)
	ind. earnings (+)	ind. earnings (+)	ind. earnings (+)	ind. earnings (+)	ind. earnings (+) small
	population (-)	population (-)	population (-)	population (+)	
		employed rate (-)	employed rate (+)	employed rate (-)	employed rate (-)
	ave. earnings (+)	ave. earnings (+)	ave. earnings (-)		

[a]p values in parentheses represent probability that the estimated odds ratio differs from 1.0 due to random variation.

[b]Significant effects represent coefficients different from zero with p<.05 in a two-tailed test.

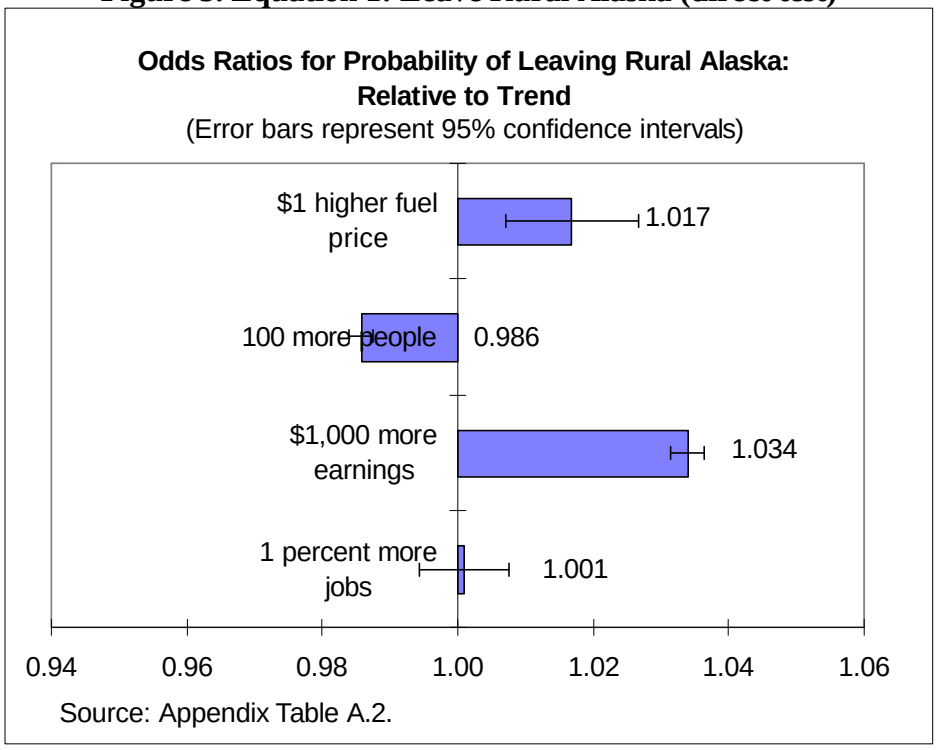
Source: Appendix Tables A.1-A-10.

Overall, the estimated equations provided evidence that higher fuel prices were associated with an increased likelihood that a person living in a rural Alaska community would move out of the community. However, the magnitudes of the effects were relatively small. The results for simplest specification, equation 1, the direct test probability of moving from any rural Alaska location to any location outside the rural Alaska region, are summarized in the second column of Table 1. Variation in fuel prices across communities had essentially no measurable effect on migration after controlling for other factors. Considering variation in fuel prices over time as well as across places -- fuel prices in each community each year relative to an overall trend -- the effect was positive and significant (p==.001).

Figure 5 compares the direction and magnitudes of odds ratios for fuel prices and other factors influencing mobility. The error bars represent 95 percent confidence intervals for

the odds ratios. The figure shows that out-migration rates are lower in larger communities, and higher in communities with higher average earnings. A $1 dollar increase in fuel prices increases the probability that a person leaves the rural region by 1.7 percent. Given the average out-migration rate shown in Figure 2 of 2,172, the 1.7 percent increase translates to about 37 adults per year. The effect of a $1 dollar increase in fuel prices is equivalent to an increase in average earnings in the community of about $500 per worker. Higher earnings in a community were associated with higher mobility. Regional hubs are much larger than villages, so the negative effect of population size will outweigh the positive effect of higher earnings for comparing villages to regional hubs. Instead, the equation suggests that out-migration rates are higher in small communities with more earnings opportunities, such as in the North Slope Borough, relative to poorer communities such as in the Nome region. Since richer communities are not losing population at a greater rate, it is likely that in-migration rates to the richer communities are higher as well.

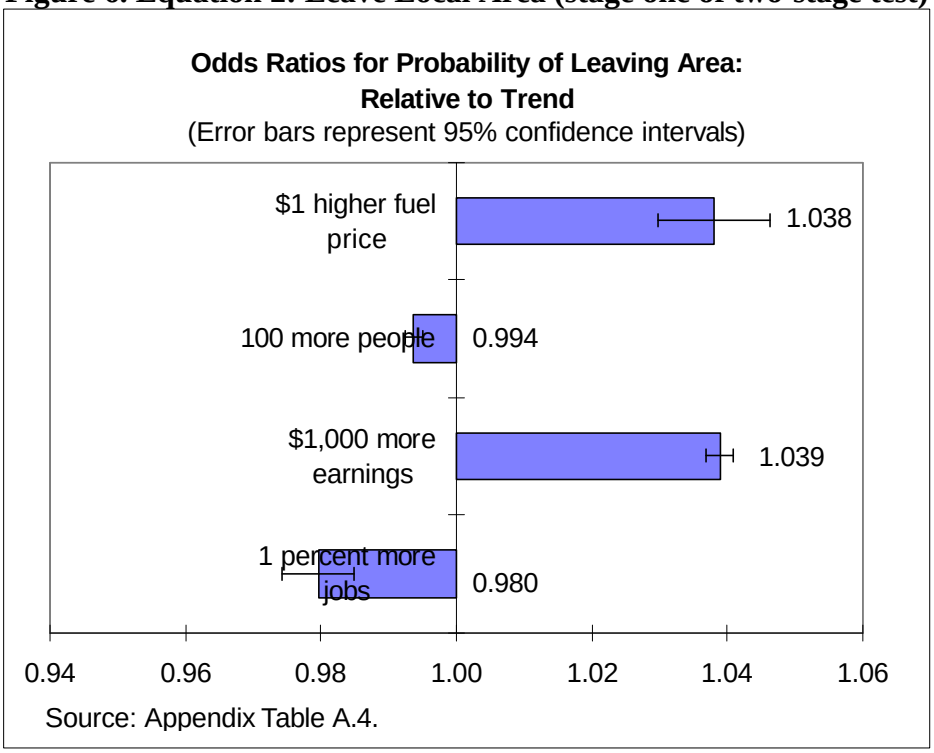
Figure 5. Equation 1: Leave Rural Alaska (direct test)



Breaking the decision two leave rural Alaska into two pieces reveals a more complex pattern of mobility and effect of fuel prices. The fuel price was significantly associated with a higher probability that a resident would leave his or her local area (column 3 of Table 1). The odds ratio was nearly 1.04, meaning that a one dollar increase in fuel prices was associated with a four percent increase in the odds of moving relative to staying. The magnitude of this effect was a little higher when considering the effects of fuel prices relative to the trend than when considering only the effects of relative fuel prices among communities. The results suggest that a $1 dollar increase in fuel prices would be associated with about 130 more adult out-migrants that year.

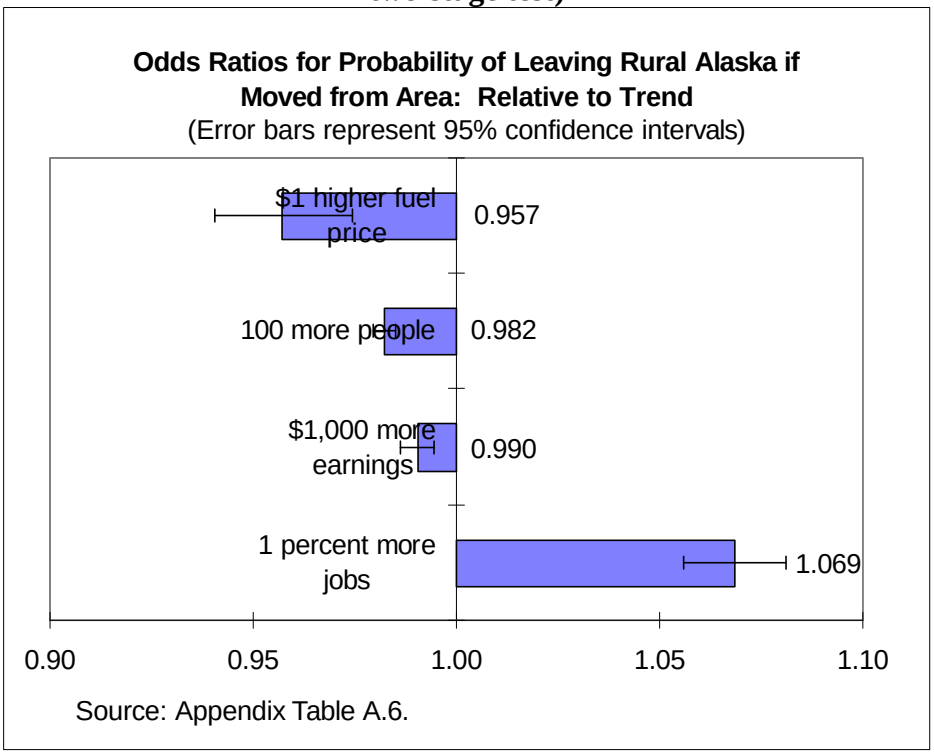
Figure 6 shows that the effect of a $1 increase in fuel prices was about the same as the effect of $1,000 more earnings. Having more jobs in a community had the opposite effect, reducing the likelihood of leaving. Taking the positive effect of earnings together with the negative effect of employment, the results suggest that people are more likely to remain in rural communities when there are more part-time jobs.

Figure 6. Equation 2: Leave Local Area (stage one of two-stage test)



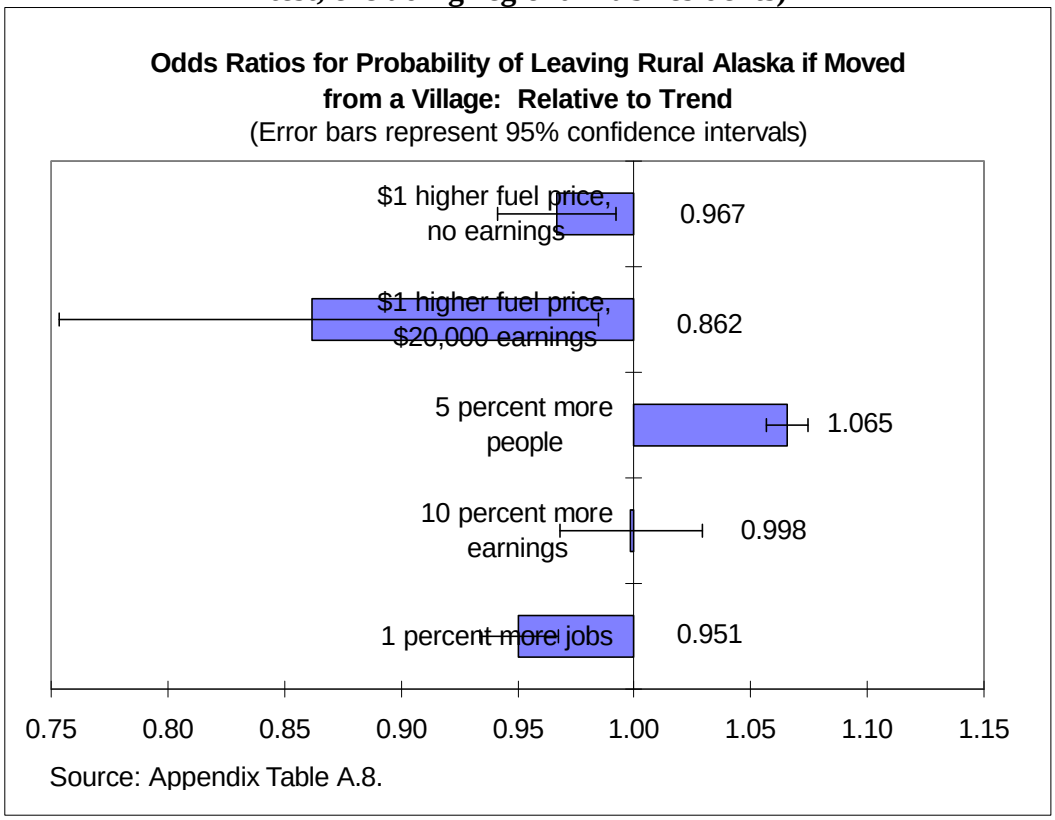
Considering now all the individuals who did decide to move from their local area (column 4), higher fuel prices were associated with a decreased likelihood that the move made was to a location outside the rural region. In this case, the odds ratio of 0.957 (Fig. 7) refers to the destination of migrants rather than the likelihood of moving, so it applies to a much smaller number of people. Although Figure 6 showed that higher earnings and fewer jobs were associated with more people leaving an area, Figure 7 shows that this same set of conditions reduced the likelihood of moving out of the rural region. Since the effects are all present in the equation that just considers relative effects across communities, the results are picking up a pattern of difference among communities more than of changes over time. The implication is that village residents moving to regional hubs dominate moves in equation 2 (Figure 6), while the higher fuel prices in equation 3 (Figure 7) reduce the likelihood that a regional hub residents move to urban Alaska.

Figure 7. If Leave the Local Area, Leave Rural Alaska: Equation 3 (stage two of two-stage test)



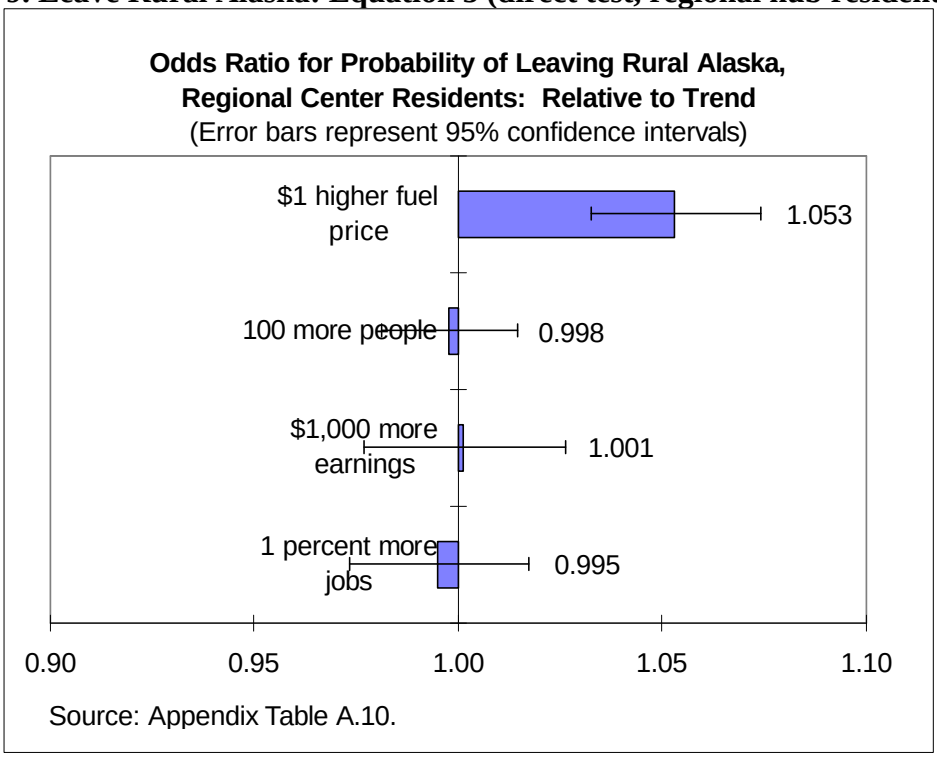
Equation 4 models a decision similar to that of equation 3, except that it is considers the destination only for movers who started in a village and not a regional hub. As in equation 3, fuel prices had a significant negative effect on the likelihood that the move would be to a destination outside the rural region of Alaska. In the case of village movers, as mentioned above, interaction terms for fuel prices and wages were significant for moves of village residents. The interaction term was negative. Since the results are similar for the equation comparing only effects of communities relative to each other as well as for the equation also considering changes over time, the results mean that a smaller percentage of residents with earnings who left communities with higher fuel prices went to urban Alaska than residents with earnings from leaving communities with lower fuel prices. . As Figure 8 illustrates, the odds ratio for fuel prices on the probability that village movers would leave rural Alaska fell from .967 (3.3 percent less likely to leave) for an individual with no earnings to .862 (13.8 percent less likely to move) for an individual with $20,000 in earnings. Most village residents who leave the local area but do not leave the rural region are moving to regional hubs. The combined results of equations 2, 3, and 4 suggest that higher fuel prices increase migration from villages to regional hubs.

Figure 8. If Leave a Village, Leave Rural Alaska: Equation 4 (stage two of two-stage test, excluding regional hub residents)



The equation for the likelihood that a regional hub resident would move outside the rural Alaska region (equation 5) showed a significant positive effect for the effect of fuel prices. The estimated odds ratio for a dollar increase in fuel prices of 1.053 shown in Figure 9 was substantially larger than the odds ratio of 1.017 estimated for rural Alaskans as a whole (Fig. 4). Applying the odds ratio to the average annual number of out-migrants from regional hubs, the results suggest that a $1 increase in fuel prices leads to 46 additional adults moving to urban Alaska. None of the other community variables besides the fuel price had a significant effect on mobility of regional hub residents.

Figure 9. Leave Rural Alaska: Equation 5 (direct test, regional hub residents only)



The estimated effects of fuel prices controlled for a number of other factors, many of which had much stronger effects on migration patterns than fuel prices. Younger adults, women, individuals who were employed, and employed individuals with higher earnings were generally more likely to move; however, age, gender, and employment status had relatively little effect on the proportion of migrants that moved to urban Alaska rather than to regional hubs. Individuals with higher earnings who left their local area were more likely to have moved to urban Alaska than to regional hubs.

Out-migration rates were higher in smaller rural communities, but migrants from larger places such as regional centers, were more likely to leave rural Alaska. Migrants from smaller villages stayed within rural Alaska, typically moving to the nearby regional hub community. Communities with higher earnings per employed person had higher migration rates, but communities with higher employment rates had fewer out-migrants.

Discussion

Taking these results as a whole, it appears that high fuel prices did alter migration patterns somewhat, but the effects are subtle and complex. We found that rural Alaska residents were more likely to move to urban areas when prices were high, but the effects were only significant when examined in certain specific ways. We found that higher fuel prices led to higher out-migration from villages and regional centers. However, higher fuel prices also reduced the likelihood that those who left smaller villages went to urban Alaska. Higher prices were associated with more people moving within rural Alaska, both moves from villages to regional hubs and from regional hubs back to villages.

Observed net increases in moves to urban Alaska triggered by higher fuel prices came entirely from regional hubs rather than from smaller villages. Indeed, the estimated total number of additional moves to urban Alaska from the five regional hubs exceeded the total estimated for the rural region as a whole, indicating a slight decline in the rate of movement directly from smaller villages to urban areas. The results suggest that at their peak in 2008, when fuel prices had risen by about $4.00 from 2004 levels (in 2015 dollars), the higher fuel price might have led 180 more adults per year to leave regional hubs for urban Alaska, offset somewhat by a few dozen fewer moves from smaller villages. Increased moves from regional hubs back to villages effectively balanced increased movement from villages to hubs.

The results tend to affirm the stepping stones hypothesis described in Howe et al. (2013). To the extent that fuel prices increased migration rates, they followed the pattern of village residents moving to regional hubs, and regional hub residents moving to urban Alaska. However, the effects for village residents especially were small overall. Local labor market conditions, as well as individual employment status and earnings had much stronger effects on out-migration than fuel prices. In particular, employed individuals and individuals with higher earnings were more mobile. For example, the odds ratio of an employed person moving out of the local area relative to an unemployed individual, as shown in Appendix Tables A.1-2 and A.9-10, was 1.3 for regional hub residents and 1.25 for all rural Alaskans, not even considering teachers, oil and mining workers, and pilots, whom we excluded from our study population because of their typically high mobility rates.

Many Alaskans also move from urban to rural Alaska each year. The percentage of urban Alaskans who are not Alaska Natives that move to the rural region is very small, though. Predicting migration from urban to rural Alaska statistically is challenging with the PFD application data available for this study, which does not have any information on race or ethnicity. This effectively prevents us from considering whether Alaska Natives living in urban Alaska were less likely to return to rural communities when village fuel prices were high there. If high fuel prices did reduce return flows of Alaska Natives to rural areas, fuel prices might have led the Alaska Native population in urban Alaska to increase even if there were no increased out-migration.

Conclusion

Our research using PFD applications found some evidence that rural Alaska residents were more likely to leave communities with high fuel prices relative to communities with lower prices and more likely to leave when fuel prices were especially high, controlling for other individual and community factors affecting mobility. However, the magnitude of the effect was relatively small. We found a modest increase in migrants from the five regional hub communities (Barrow, Kotzebue, Nome, Bethel, and Dillingham) to urban Alaska, and a smaller increase in flows of village residents to regional hubs. Because higher fuel prices diverted more village movers to hubs instead of urban areas, the net

effect from villages to urban Alaska was negligible. Fuel prices had an even stronger effect influencing village residents with earnings to move to hubs instead of urban Alaska.

Energy costs represent one of many factors affecting decisions to move. Our results suggest that high fuel prices were apparently not a salient factor in those decisions for most rural Alaska residents, although they may have had a modest incremental effect for residents of regional hub communities.

References

Kizzia, T. 2008. Leaving the village: More people from the Bush are moving to urban areas. *Anchorage Daily News*, May 14.

Lowe, M.E. 2009. *New Students in the Anchorage School District: Where are they from? Analysis of ISER 2008-2009 survey data*. Anchorage: ISER, November.

Howe, E. L., Huskey, L., Berman, M. 2013. Migration in Arctic Alaska: Empirical Evidence of the Stepping Stones Hypothesis. *Migration Studies*,; doi: 10.1093/migration/mnt017.

Huskey L., Berman, M., Hill, L. 2004. Leaving home, returning home: Migration as a labor market choice for Alaska Natives. *Annals of Regional Science*, 38(1): 75-92.

Martin, S. 2009. The effects of female out-migration on northern Alaskan villages. *Polar Geography*, 32(1-2): 61-67.

Martin, S. Killorin, M., Colt, S. 2008. *Fuel Costs, Migration, and Community Viability*. Anchorage: ISER, May.

Appendix A. Logistic Regression Equations for Out-Migration from Rural Alaska

Table A1. Logistic Regression Equations for Out-Migration from Rural Alaska, All Residents of the Rural Alaska Region

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska

Maximum likelihood estimates, with year fixed effects

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.986	.000	0.985	0.987
Employment rate	1%	1.002	.551	0.995	1.009
Earnings per worker	$1,000/year	1.033	.000	1.031	1.036
Population aged 16+	100 people	0.986	.000	0.984	0.988
Employed (y/n)	1	1.249	.000	1.209	1.291
Individual earnings	$1,000/year	1.003	.000	1.002	1.003
Fuel price	$1/gallon	1.004	.422	0.994	1.014
Female	1	1.134	.000	1.106	1.163
Year=2003	1	0.898	.001	0.845	0.955
Year=2004	1	0.950	.092	0.895	1.008
Year=2005	1	0.966	.281	0.908	1.028
Year=2006	1	0.935	.037	0.878	0.996
Year=2007	1	1.027	.417	0.963	1.094
Year=2008	1	1.072	.036	1.004	1.143
Year=2009	1	0.928	.029	0.867	0.993
Year=2010	1	0.738	.000	0.690	0.790
Year=2011	1	0.839	.000	0.784	0.897
Year=2012	1	0.902	.003	0.843	0.964
Year=2013	1	0.963	.291	0.899	1.033
YKDelta region	1	1.104	.008	1.027	1.187
Northwest region	1	0.793	.000	0.755	0.832
Interior region	1	2.987	.000	2.800	3.187
Seafood worker	1	1.038	.596	0.904	1.193
Construction worker	1	0.970	.473	0.891	1.055
Observations	631,903				
Chi-sq. (24)	7494.4		0.000		

Table A2. Logistic Regression Equations for Out-Migration from Rural Alaska, All Residents of the Rural Alaska Region

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska
Maximum likelihood estimates, with time trend

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.986	.000	0.985	0.987
Employment rate	.1%	1.001	.785	0.994	1.008
Earnings per worker	$1,000/year	1.034	.000	1.032	1.036
Population aged 16+	100 people	0.986	.000	0.984	0.987
Employed (y/n)	1	1.249	.000	1.209	1.290
Individual earnings	$1,000/quarter	1.003	.000	1.002	1.003
Fuel price	$1/gallon	1.017	.001	1.007	1.027
Female	1	1.134	.000	1.106	1.163
Trend	1 year	0.988	.000	0.983	0.992
YKDelta region	1	1.113	.004	1.035	1.197
Northwest region	1	1.246	.000	0.765	0.843
Interior region	1	3.001	.000	2.813	3.202
Seafood worker	1	1.044	.547	0.908	1.199
Construction worker	1	0.968	.444	0.889	1.053
Observations	631,903				
Chi-sq. (14)	7319.4		0.000		

Table A3. Logistic Regression Equations for Out-Migration from Local Area, All Residents of the Rural Alaska Region

Dependent Variable: 1=Leave Local Area, 0=Stay in Local Area

Maximum likelihood estimates, with year fixed effects

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.985	.000	0.984	0.985
Employment rate	1%	0.980	.000	0.974	0.985
Earnings per worker	$1,000/year	1.039	.000	1.037	1.041
Population aged 16+	100 people	0.994	.000	0.992	0.995
Employed (y/n)	1	1.376	.000	1.340	1.413
Individual earnings	$1,000/year	1.000	.994	0.999	1.001
Fuel price	$1/gallon	1.031	.000	1.022	1.040
Female	1	1.131	.000	1.108	1.154
Year=2003	1	0.929	.003	0.884	0.976
Year=2004	1	0.915	.000	0.872	0.961
Year=2005	1	0.888	.000	0.844	0.935
Year=2006	1	0.862	.000	0.819	0.908
Year=2007	1	0.885	.000	0.840	0.933
Year=2008	1	0.880	.000	0.834	0.929
Year=2009	1	0.789	.000	0.746	0.834
Year=2010	1	0.658	.000	0.623	0.696
Year=2011	1	0.695	.000	0.657	0.735
Year=2012	1	0.752	.000	0.711	0.795
Year=2013	1	0.776	.000	0.732	0.822
YKDelta region	1	1.082	.007	1.021	1.146
Northwest region	1	0.843	.000	0.811	0.878
Interior region	1	1.610	.000	1.526	1.699
Seafood worker	1	1.008	.883	0.906	1.122
Construction worker	1	0.961	.268	0.895	1.031
Observations	631,903				
Chi-sq. (24)	7533.3		0.000		

Table A4. Logistic Regression Equations for Out-Migration from Local Area, All Residents of the Rural Alaska Region

Dependent Variable: 1=Leave Local Area, 0=Stay in Local Area

Maximum likelihood estimates, with time trend

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.985	0.000	0.983	0.987
Employment rate	1%	0.091	0.004	0.018	0.472
Earnings per worker	$1,000/year	1.036	0.000	1.029	1.042
Population aged 16+	100 people	0.942	0.004	0.904	0.981
Employed (y/n)	1	1.319	0.000	1.219	1.426
Individual earnings	$1,000/quarter	1.002	0.005	1.001	1.003
Fuel price	$1/gallon	1.042	0.001	1.016	1.067
Female	1	1.099	0.003	1.033	1.169
Trend	1 year	0.969	.000	0.966	0.973
YKDelta region	1	1.086	.005	1.025	1.150
Northwest region	1	0.848	.000	0.815	0.882
Interior region	1	1.616	.000	1.531	1.705
Seafood worker	1	1.012	.829	0.909	1.126
Construction worker	1	0.960	.256	0.894	1.030
Observations	631,903				
Chi-sq. (14)	7390.6		0.000		

Table A5. Logistic Regression Equations for Out-Migration from Rural Alaska, Individuals Moving from Local Area

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska
Maximum likelihood estimates, with year fixed effects

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	1.003	.000	1.004	1.001
Employment rate	1%	1.069	.000	1.082	1.057
Earnings per worker	$1,000/year	0.990	.000	0.994	0.986
Population aged 16+	100 people	0.982	.000	0.985	0.979
Employed (y/n)	1	0.795	.000	0.840	0.753
Individual earnings	$1,000/quarter	1.009	.000	1.010	1.008
Fuel price	$1/gallon	0.938	.000	0.956	0.920
Female	1	0.957	.044	0.916	0.999
Year=2003	1	0.882	.017	0.796	0.978
Year=2004	1	1.070	.190	0.967	1.185
Year=2005	1	1.277	.000	1.147	1.422
Year=2006	1	1.281	.000	1.151	1.426
Year=2007	1	1.521	.000	1.361	1.700
Year=2008	1	1.708	.000	1.522	1.917
Year=2009	1	1.589	.000	1.410	1.789
Year=2010	1	1.414	.000	1.258	1.590
Year=2011	1	1.760	.000	1.563	1.983
Year=2012	1	1.732	.000	1.535	1.954
Year=2013	1	1.863	.000	1.646	2.108
YKDelta region	1	0.915	.138	0.813	1.029
Northwest region	1	0.775	.000	0.715	0.841
Interior region	1	15.695	.000	13.408	18.371
Seafood worker	1	1.089	.437	0.879	1.348
Construction worker	1	1.030	.718	0.877	1.209
Observations	40,257				
Chi-sq. (24)	4003.5		0.000		

Table A6. Logistic Regression Equations for Out-Migration from Rural Alaska, Individuals Moving from Local Area

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska
Maximum likelihood estimates, with time trend

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	1.003	.000	1.004	1.001
Employment rate	1%	1.069	.000	1.081	1.056
Earnings per worker	$1,000/year	0.990	.000	0.994	0.986
Population aged 16+	100 people	0.982	.000	0.985	0.979
Employed (y/n)	1	0.794	.000	0.839	0.752
Individual earnings	$1,000/quarter	1.009	.000	1.010	1.008
Fuel price	$1/gallon	0.957	.000	0.974	0.940
Female	1	0.956	.039	0.915	0.998
Trend	1 year	1.058	.000	1.067	1.049
YKDelta region	1	0.916	.143	0.815	1.030
Northwest region	1	0.782	.000	0.721	0.848
Interior region	1	15.717	.000	13.430	18.393
Seafood worker	1	1.095	.407	0.884	1.356
Construction worker	1	1.032	.699	0.879	1.212
Observations	40,257				
Chi-sq. (14)	3932.6		0.000		

Table A7. Logistic Regression Equations for Out-Migration from Rural Alaska, Village Residents Moving from Local Area

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska

Maximum likelihood estimates, with year fixed effects

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.996	.000	0.995	0.998
Employment rate	1%	0.944	.000	0.927	0.961
Earnings per worker	10% more	1.001	.930	0.971	1.033
Population aged 16+	5% more	1.065	.000	1.057	1.074
Employed (y/n)	1	1.195	.000	1.104	1.294
Individual earnings	log($1000)	1.587	.032	1.006	1.137
Fuel price	$1/gallon	0.964	.012	0.937	0.992
Fuel price*ln(earnings)	$1*ln($1,000)	0.898	.035	0.978	0.999
Female	1	1.005	.860	0.948	1.066
Year=2003	1	0.972	0.894	1.477	0.640
Year=2004	1	0.946	0.797	1.442	0.621
Year=2005	1	0.628	0.033	0.964	0.409
Year=2006	1	0.600	0.028	0.945	0.381
Year=2007	1	0.559	0.013	0.883	0.354
Year=2008	1	0.623	0.057	1.015	0.383
Year=2009	1	0.501	0.008	0.834	0.300
Year=2010	1	0.470	0.003	0.772	0.287
Year=2011	1	0.548	0.017	0.899	0.334
Year=2012	1	0.640	0.076	1.049	0.390
Year=2013	1	0.428	0.001	0.719	0.254
YKDelta region	1	0.612	0.101	1.101	0.340
Northwest region	1	1.363	0.098	1.966	0.945
Seafood worker	1				
Construction worker	1				
Observations	19,435				
Chi-sq. (24)	855.6		0.000		

Table A8. Logistic Regression Equations for Out-Migration from Rural Alaska, Village Residents Moving from Local Area

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska

Maximum likelihood estimates, with time trend

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.996	.000	0.995	0.998
Employment rate	1%	0.951	.000	0.934	0.967
Earnings per worker	10% more	0.998	.900	0.968	1.029
Population aged 16+	5% more	1.065	.000	1.057	1.074
Employed (y/n)	1	1.194	.000	1.103	1.293
Individual earnings	log($1000)	1.577	.035	1.005	1.136
Fuel price	$1/gallon	0.967	.011	0.941	0.992
Fuel price*ln(earnings)	$1*ln($1,000)	0.899	.036	0.978	0.999
Female	1	1.003	.925	0.946	1.063
Trend	1 year	0.965	.000	0.954	0.976
YKDelta region	1	0.324	.000	0.414	0.254
Northwest region	1	0.739	.000	0.871	0.626
Seafood worker	1	0.842	.169	1.076	0.659
Construction worker	1	0.830	.076	1.019	0.675
Observations	19,435				
Chi-sq. (14)	808.3		0.000		

Table A9. Logistic Regression Equations for Out-Migration from Rural Alaska, Regional Hub Residents

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska
Maximum likelihood estimates, with year fixed effects

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.986	.000	0.985	0.988
Employment rate	1%	0.565	.635	0.054	5.961
Earnings per worker	$1,000/year	0.977	.147	0.947	1.008
Population aged 16+	100 people	1.062	.549	0.873	1.292
Employed (y/n)	1	1.309	.000	1.241	1.382
Individual earnings	$1,000/quarter	1.002	.000	1.001	1.003
Fuel price	$1/gallon	1.039	.001	1.016	1.061
Female	1	1.099	.000	1.056	1.144
Year=2003	1	0.796	.000	0.717	0.882
Year=2004	1	0.863	.005	0.778	0.957
Year=2005	1	0.782	.000	0.693	0.882
Year=2006	1	0.862	.009	0.770	0.964
Year=2007	1	0.850	.007	0.755	0.956
Year=2008	1	0.834	.003	0.738	0.942
Year=2009	1	0.718	.000	0.625	0.825
Year=2010	1	0.624	.000	0.547	0.712
Year=2011	1	0.652	.000	0.564	0.754
Year=2012	1	0.749	.000	0.647	0.868
Year=2013	1	0.705	.000	0.600	0.827
YKDelta region	1	0.993	.966	0.705	1.398
Northwest region	1	1.089	.130	0.975	1.216
Seafood worker	1	0.956	.815	0.655	1.395
Construction worker	1	1.066	.454	0.901	1.262
Observations	178,036				
Chi-sq. (23)	726.9		0.000		

Table A10. Logistic Regression Equations for Out-Migration from Rural Alaska, Regional Hub Residents

Dependent Variable: 1=Leave Rural Alaska, 0=Stay in Rural Alaska
Maximum likelihood estimates, with time trend

				95% Confidence Interval	
Explanatory variable	Units	Odds ratio	Sig.	Lower Bound	Upper Bound
Age	1 year	0.986	.000	0.985	0.988
Employment rate	1%	0.995	.654	0.973	1.017
Earnings per worker	$1,000/year	1.001	.929	0.977	1.026
Population aged 16+	100 people	0.998	.789	0.981	1.014
Employed (y/n)	1	1.308	.000	1.240	1.380
Individual earnings	$1,000/quarter	1.002	.000	1.001	1.003
Fuel price	$1/gallon	1.053	.000	1.032	1.074
Female	1	1.099	.000	1.056	1.144
Trend	1 year	0.970	.000	0.958	0.981
YKDelta region	1	1.075	.639	0.794	1.456
Northwest region	1	1.052	.345	0.946	1.170
Seafood worker	1	0.958	.823	0.656	1.398
Construction worker	1	1.069	.438	0.903	1.265
Observations	178,036				
Chi-sq. (13)	669.8		0.000		