AN ABSTRACT OF THE THESIS OF

William E. Nebesky for the degree of Doctor of Philosophy in Economics presented on February 4, 1994.

Title: Topics in Applied Microeconomics: Time Allocation and Natural Resource Use on Alaska's North Slope and Market Power in the U.S. Motor Carrier Industry

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Abstract approved: ______________________

Joe Kerkvliet

This paper presents two applications of empirical microeconomics based on choice theoretic optimization principles. The first topic explores the determinants of subsistence time allocation in a utility theoretic model of household production. The second topic examines firm pricing behavior in a deregulated, but concentrated industry setting.

The first part of this applied microeconomic analysis estimates the subsistence time versus wage labor time allocations of Alaska's North Slope inhabitants using ordered probit based on a household production model. The explanatory variables measure labor supply, demographic, and cultural influences.

The major findings are as follows. First parameter estimates differ statistically and substantially between Inupiat versus non-Inupiat residents, implying that optimal natural resource management decisions may vary with the ethnicity of the resource owners. Second, marital status, age, gender, and participation in generalized gift giving and receiving are important determinants of subsistence time allocations. Third, time spent in wage labor appears to be exogenous to the subsistence time allocation decision, indicating that the time allocation process is recursive. Fourth, we find an inverse

relationship between wage labor time and subsistence participation. This means that reductions in wage employment opportunities lead to increased subsistence activity. For the North Slope, this implies that Prudhoe oil depletion will result in an increase in the use of subsistence natural resources.

The second part of this study turns from the individual behavior to firm behavior. During the 1980's, researchers have noted a trend towards increased concentration in the general freight, less-than-truckload (LTL) portion of the U.S. motor carrier industry. The purpose of this study is to employ new empirical industrial organization (NEIO) techniques to determine whether the more concentrated post-1980, LTL motor carrier industry is exerting anti-competitive monopoly pricing behavior.

The NEIO approach is used to formulate the relationship between market price and marginal cost in what is referred to as the representative firm's 'supply relation.' The firm's supply relation is estimated jointly with the cost function and the factor share equations under the assumption that cross equation disturbance terms are correlated (SUR). An instrumental variables procedure is used to test and control for correlation between output (on the right hand side) and the disturbance terms in the cost and supply equations.

The results indicate that the trend toward increased industry concentration does not imply anti-competitive performance in the sense of rising price-cost margins.

Topics in Applied Microeconomics:
Time Allocation and Natural Resource Use on Alaska's North Slope
and
Market Power in the U.S. Motor Carrier Industry

by

William E. Nebesky

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Completed February 4, 1994

Commencement June 1994

APPROVED:

Redacted for Privacy

Professor of Economics in charge of major

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Date thesis is presented February 4, 1994

Typed by William E. Nebesky

ACKNOWLEDGEMENT:

I would like to express my gratitude to the North Slope Borough for its generous contribution of the data used for the study, to the members of my thesis committee for the support, wisdom, and enthusiasm they readily supplied, and to the generous financial support of the Oregon State University Graduate Faculty of Economics. This research is dedicated to the memory of Professor D. Barton DeLoach.

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I. INTRODUCTION

This research addresses topics in applied microeconomic analysis. Two applications are considered. The analysis in part II focuses on the consumer's constrained utility optimization problem. The usual utility theoretic framework is extended along the lines presented in Becker (1965) to include time as well as income as a constraint on the individual's home production, leisure, and labor market decisions. The theoretical model recognizes that households function as units of consumption <u>and</u> production. This home production framework is used to develop an empirical model that explains Alaska North Slope subsistence participation and relates the individual's subsistence time allocation decision to his/her labor market participation, as well as other economic, demographic, and cultural variables. This research contributes to a topic of interest in northern economic development: the nature of the mixed wage/subsistence economy.

Part III focuses on the firm's unconstrained profit maximization problem. The analysis draws from the New Empirical Industrial Organization theory (Bresnahan, 1986) and Strategic Group theory (Caves and Porter, 1977) to present a model of firm pricing behavior in the U.S. motor carrier industry. This industry was transformed by regulation reform in 1980, but characterized by an alarming rise in post deregulation revenue concentration. This research provides a greater understanding of the extent to which trucking firms exert anticompetitive pricing behavior in a largely unregulated industry environment.

The topics covered in this paper share in common several themes central to empirical microeconomics. The analyses in parts II and III link theoretical models of agent optimization to empirical models that explain the behavior of the agents in question; subsistence home production in one case, trucking firm pricing behavior in the other. Both analyses consider the interaction among agents; household members in one case; rival firms in the other.

The topics covered in parts II and III are linked further by the quantitative methods used for estimation. Both approaches apply maximum likelihood estimators on a cross section of observations for the 1988 time period. In addition, both approaches use multi-stage estimation techniques to control and test for non-stochasic explanatory variables.

Part IV contains a summary and conclusion. A comprehensive bibliography is contained in part V.

II. TIME ALLOCATION AND NATURAL RESOURCE USE ON ALASKA'S NORTH SLOPE

II.1 Introduction

In spite of rapid growth in the industrial sectors of the world's economies, the traditional subsistence use of natural resources by indigenous people is still critical to many major natural resource issues. Subsistence agriculture may produce tropical deforestation (Braga, 1992); Alaska Natives have sued Exxon for oil spill damages to marine subsistence resources; and the International Whaling Commission (1982) exempted subsistence harvesting from its ban on hunting the endangered Bowhead whale. As these examples illustrate, wise resource management often requires an understanding of peoples' decision to use renewable resources for subsistence.

Moreover, resource managers often face a nexus between subsistence resource use and Native peoples' entitlements to natural resources. Subsistence-based Native claims have been established for salmon and steelhead in Canadian and Northwest rivers (Randolph, 1992; and Pinkerton, 1989), Arctic Bowhead whales, and game and fish in Alaska (Morehouse, 1984; and Brown and Burch, 1992), the Canadian Arctic (Post and Colin, 1991), and many western states. Similar claims are being pressed currently and it is increasingly important for managers to understand differences in resource use patterns between Native and non-Native users.

Yet, with the notable exceptions of Dean (1963) and Stabler (1990), little economic research addresses subsistence behavior nor potential differences between Native and non-Native people. This study starts to fill this gap by explaining subsistence behavior using micro data and a model that is theoretically grounded in the household production framework. Our data include the subsistence time allocations made by Alaska's North Slope inhabitants, both Inupiat and non-Inupiat people. Subsistence activities include working on or supporting a whaling crew; hunting seal, walrus, waterfowl, moose, or caribou; trapping; picking berries; sewing skins; and building sleds or boats (Nebesky, 1989).

We derive and estimate ordered probit equations for time devoted to subsistence activities relative to time spent in wage labor. We partially explain these time allocations using variables measuring labor supply decisions as well as demographic and cultural influences.

The next section describes the wage/subsistence North Slope lifestyle. Section II.3 looks at the allocation of time to subsistence activities as a household production problem. The empirical model and the data is presented in Section II.4. Sections II.5 and II.6 give statistical results conclusions.

II.2 Subsistence on the North Slope

Alaska's North Slope Borough lies north of the Brooks Range, and contains 94,887 square miles, including the Prudhoe Bay oil field and most of the Arctic National Wildlife Refuge. It is home to 4,100 Inupiat Eskimos, residing primarily in eight villages with 200 to 3,000 people. Villages occupy traditional sites chosen for proximity to marine mammal populations and caribou migration routes.

The North Slope economy is a mix of subsistence harvesting and wage employment.[1] With Prudhoe Bay oil development, total North Slope employment increased from 1,900 to over 10,000 from 1970 to 1986 (Bureau of Economic Analysis, 1987). The Prudhoe Bay oil complex workforce peaked at 7000 in the early 1980's, but is now less than 4,000. Beyond direct employment, the Prudhoe complex provides a property tax base that supports Borough public spending. Since 1984, falling oil prices and production have led the region's economic contraction and now the primary outside economic stimuli are government and Arctic Slope Regional Corporation (ASRC) spending.[2]

Except for subsistence food, most goods are imported and local commerce is mostly confined to village stores. Barrow holds half of the region's 5,700 residents and 60 percent of its jobs and is the region's transportation hub and governmental headquarters.

Over half of North Slope households engage in subsistence and the same proportion of households obtain at least half of total meat and fish from subsistence harvests (Kruse, 1992). Harvests range from 201 to 521 pounds per capita of marine and terrestrial mammals, fish, birds, and other resources (Braund et al., 1988). Bowhead whale and caribou account for two-thirds of the total. Nearly all is consumed in the home or given away.[3] By comparison, per capita meat consumption in Western states averages 222 pounds (Wolfe and Walker, 1987).

Subsistence harvesting is a year-round process.[4] Spring whaling in May and June is preceded by weeks of sealskin boat mending, trail building, and hazardous snow machine travel to the edge of the icepack to establish whaling camps. In late June, successful whaling crews host the Nalukataq celebration. This event provides an occasion for harvest redistribution within the community and marks the transition from Spring to Summer harvesting. With the breakup of shorefast ice, bearded seal hunting begins. Summer harvests also include coastal and inland fish, waterfowl, and caribou.

Whaling resumes in September along with intensive caribou hunting. Fishing and caribou hunting continue into October, shifting to inland camps accessed by snow machine. By late fall lessening daylight and unstable weather restrict travel and by November most inland camps are disbanded. Caribou hunting continues locally into December. Seal, caribou, and furs are pursued from January to March. In early March, preparations begin again for Spring whaling.

II.3 Theoretical Model of Household Production

Subsistence harvesting combines labor with operating inputs (gasoline, ammunition) and capital (skiff, motor, tent, firearms, and tools) to harvest, prepare, and distribute subsistence products. Viewing subsistence as production highlights the trade-offs in the use of time and wage income. Household members allocate time between subsistence activities, wage labor, and leisure. Also, subsistence harvesting often uses inputs requiring substantial cash outlays. For example, it costs over $10,000 ($1982) per season to outfit a whaling crew (International Whaling Commission, 1982). The required cash is often obtained from wage labor and income must be allocated between subsistence inputs and competing purchases.

Although increasing access to the wage labor market may increase some economic opportunities, previous authors offer competing views on the implications of wage opportunities for subsistence lifestyles. The use of cash for subsistence capital implies that, contrary to previous cultural norms, success in subsistence is tied to job market success (Van Stone, 1960; Wolfe, 1979; and Chance, 1987). This led Dryzek and Young (1985) to argue that subsistence capital intensification weakens traditional lifestyles and village cohesion. Further, wage/subsistence complementarity, if it holds, implies that cyclic economic downturns will be magnified by corresponding reductions in subsistence harvests. For the North Slope, Prudhoe oil production will fall to half of 1989 levels by 2000 (Berman, et al., 1990). Under complementarity, the adverse economic effects of oil depletion will be magnified.

Alternatively, Wolfe (1979) and Wolfe, et al. (1984) argue that the potentially destabilizing effects of wages are offset by sharing rules among village households. The traditional pooling of resources and harvests is adapted to market relationships, mitigates the larger inequities, and continues to play a central role in the village. Kruse (1992) supports this view, finding that a decade of expanding wage participation has seen increasing Inupiat subsistence activities. He argues that the continuing importance of subsistence activities lies partially in the associated process benefits or satisfaction beyond that obtained directly in consumption.

Some process benefits, if they occur, are related to the role of subsistence harvests in cultural cohesion and community wealth redistributions. The Inupiat's communal pattern of sharing food harvests, especially whales, supports the traditional social, political, and economic structure (Sahlins, 1972; Brown and Burch, 1992; International Whaling Commission, 1982). On the North Slope, an average 14.6 percent of all meat and fish consumed is received as gifts from other households. Similarly, households gave away an average 17 percent of their harvests. These percentages are five to seven times larger for Inupiats than for non-Inupiats (Nebesky, 1989).

In this paper, subsistence harvests are treated as an intermediate activity in the home production model (HPM). In HPM, households members are both producers and consumers, maximizing utility by combining "capital goods, raw materials and labor to clean, feed, procreate and otherwise produce useful commodities" (Becker, 1965). Besides incorporating time into the household's resource constraint, HPM can account for process benefits and wage adjustments.

In HPM commodities replace goods as a utility function arguments. Commodities are the outputs of home production functions that combine time, market goods, and, for this paper, subsistence resources. The model predicts time allocations between leisure, work, and home production depending on time's scarcity, possible direct utility from intermediate activities, the stock of human capital, and possibly exogenous wage labor supply.

To motivate the empirical model, consider an example of a the household member choosing between two intermediate commodities: food gathered using subsistence methods, $Z_{S,}$ and food gathered from grocery markets, Z_M, both used to produce meals at home, Z_H. Both intermediate activities, Z_S and Z_M, use time and goods inputs, X_i and T_i, in the production activities

$$Z_j = Z_j(X_j,\ T_j), \qquad j = S,M \ . \tag{1}$$

Home meals production is given by

$$Z_H = Z_H(Z_S(\cdot), Z_M(\cdot), X_H, T_H) \ . \tag{2}$$

For example, X_H may include cooking fuel, X_M store-bought groceries, T_M shopping time, X_S ammunition. T_S may include whaling camp preparation as well as whale butchering and distributing.

The household member's utility function is

$$U = U[Z_H(\cdot), Z_S(\cdot), Z_M(\cdot), Z_N(\cdot), Z_L(\cdot)], \tag{3}$$

where $Z_N(\cdot)$ and $Z_L(\cdot)$ are wage labor and leisure and are of the same form as (1). Z_N may give positive, negative, or zero utility and require market inputs, X_N, such as child care. If wage labor does not involve market inputs, then the work and wage labor are likely to be the same ($Z_N=T_N$).

In HPM, a time and income resource constraint replaces the standard budget constraint. The constraint form depends on whether or not wage labor is endogenous. If this is so, subsistence production may be increased by reducing wage labor. The household is constrained by total time

$$\sum_{\theta} T_i = T, \tag{4}$$

and an income-expenditure equality

$$\sum_{\theta} P_i X_i = wT_N + V, \tag{5}$$

where $\theta=\{i|i=H,S,M,N,L\}$, V is non-labor income, and w is the fixed wage rate (see Gronau, 1986).

The utility maximizing household member solves

$$\underset{Z_i}{MAX}\ L = U[Z_H(\cdot), Z_S(\cdot), Z_M(\cdot), Z_N(\cdot), Z_L(\cdot)] + \lambda(wT_N + V - \sum_{\theta} P_i X_i) + \mu(T - \sum_{\theta} T_i), \tag{6}$$

Kuhn-Tucker first order conditions for a maximum include

$$u_i + u_H(\partial Z_H/\partial Z_i) - \lambda\pi_i \le 0 \tag{7a}$$

$$[u_i + u_H(\partial Z_H/\partial Z_i) - \lambda\pi_i]\ Z_i = 0 \quad for\ i = \theta, \tag{7b}$$

where $u_i=\partial U/\partial Z_i$, $i\epsilon\theta$. The shadow price of commodity i, $\pi_i = P_i x_i + \omega t_i$, is a function of the inverses of the marginal products of goods X_i

($x_i=\partial X_i/\partial Z_i$) and time T_i ($t_i=\partial T_i/\partial Z_i$). The ratio of the marginal utility of time and income, $\omega=\mu/\lambda$, measures time scarcity.[5]

The equilibrium wage labor time allocation satisfies

$$\frac{1}{\lambda}\frac{u_N}{t_N} + w - P_N\frac{x_N}{t_N} \leq \omega \tag{8a}$$

$$\left[\frac{1}{\lambda}\frac{u_N}{t_N} + w - P_N\frac{x_N}{t_N} \leq \omega\right] Z_N = 0. \tag{8b}$$

If wage labor does not generate utility or disutility ($\partial U/\partial T_N=0$) and market inputs associated with work are absent ($x_N=0$), then the shadow price of time is equal to the wage rate.

Figure II.1 follows Stabler (1990) and illustrates the optimal time allocation problem. Home cooked meals, our representative consumption good, is measured on the vertical axis and time is measured on the horizontal axis. The curve Y_sUVT is the home production possibilities frontier using only subsistence inputs. Because home production involves fixed costs for subsistence inputs, k, the point Y_s dominates all points along Y_sU. VY_mWH is home production using a combination of subsistence and wage labor. The frontier Y_sUVY_mWH is $Z_H(\cdot)$.

The optimal time allocation occurs at the tangency between an iso-utility curve and Z_H. Figure 1 depicts four classes of equilibrium, including: (1) all leisure (point Y_s), (2) subsistence participation with no wage labor (points on UV), (3) zero subsistence, wage labor NL, and leisure ON (point Y_m), and (4) time allocated to subsistence, wage labor, and leisure (points on WH). The interior optimum, E_0, depicts an equilibrium in which the individual works full time (NL), allocates SN to subsistence, and enjoys OS leisure.

Consider now the influence of experience, age, and other cultural factors on Z_H. Regular exposure to subsistence activities shapes the individual's hunting skills and access to community resources. So, a senior, more experienced Inupiat whale hunter is likely to be more skilled than the younger, less experienced hunter and face a Z_H of Y_s-kT′ if he doesn't work for wages, and Y_m-kH′, if he does. Labor market opportunities remain unchanged. His increased productivity is likely to result in an increase in the time allocated to subsistence and a decrease in wage labor. The new equilibrium, E_1, depicts a common case in the North Slope, where leisure time is OS′, subsistence time is S′L, and the senior whale hunter does not work for wages.

Stabler (1990) uses this framework to explain decreases in subsistence participation in response to an increase in the wage rate or a decreases in the probability of full time employment. One could extend Stabler's (1990) model to show that when employment policies provide for work schedule flexibility (eg., subsistence leave) the individual may achieve higher utility by switching from full time employment and some subsistence participation to a combination of part time employment and greater subsistence participation. Complete work schedule flexibility implies that labor force participation is endogenous.

We extend this framework to further examine the effect of fixed subsistence inputs, k. Consider the initial tangency at E_0 on curve Y_mWH in Figure II.2. The individual works NL, allocates SN to subsistence and OS to leisure. Exiting the wage labor force or total job loss has two effects. First, the time available for subsistence and leisure increases. This results in a shift from tangency E_0 to E_1 on curve Y_s-kUT assuming k and Z_H remain unchanged.

However, a likely second effect of sharply declining wage labor income is reduced expenditures on fixed subsistence inputs and lower marginal productivity for subsistence time. This effect is depicted by the flattened slope of Y_s-k′U′T′, compared to Y_s-kUT, where $k' < k$. The tangency E_2 implies less time allocated to subsistence than when the individual worked ($S'L < SN$). This outcome illustrates the cash-dependent nature of modern subsistence technology and complimentary between wage labor and subsistence participation (Van Stone, 1960).

Figure II.1

The Optimal Time Allocation Problem

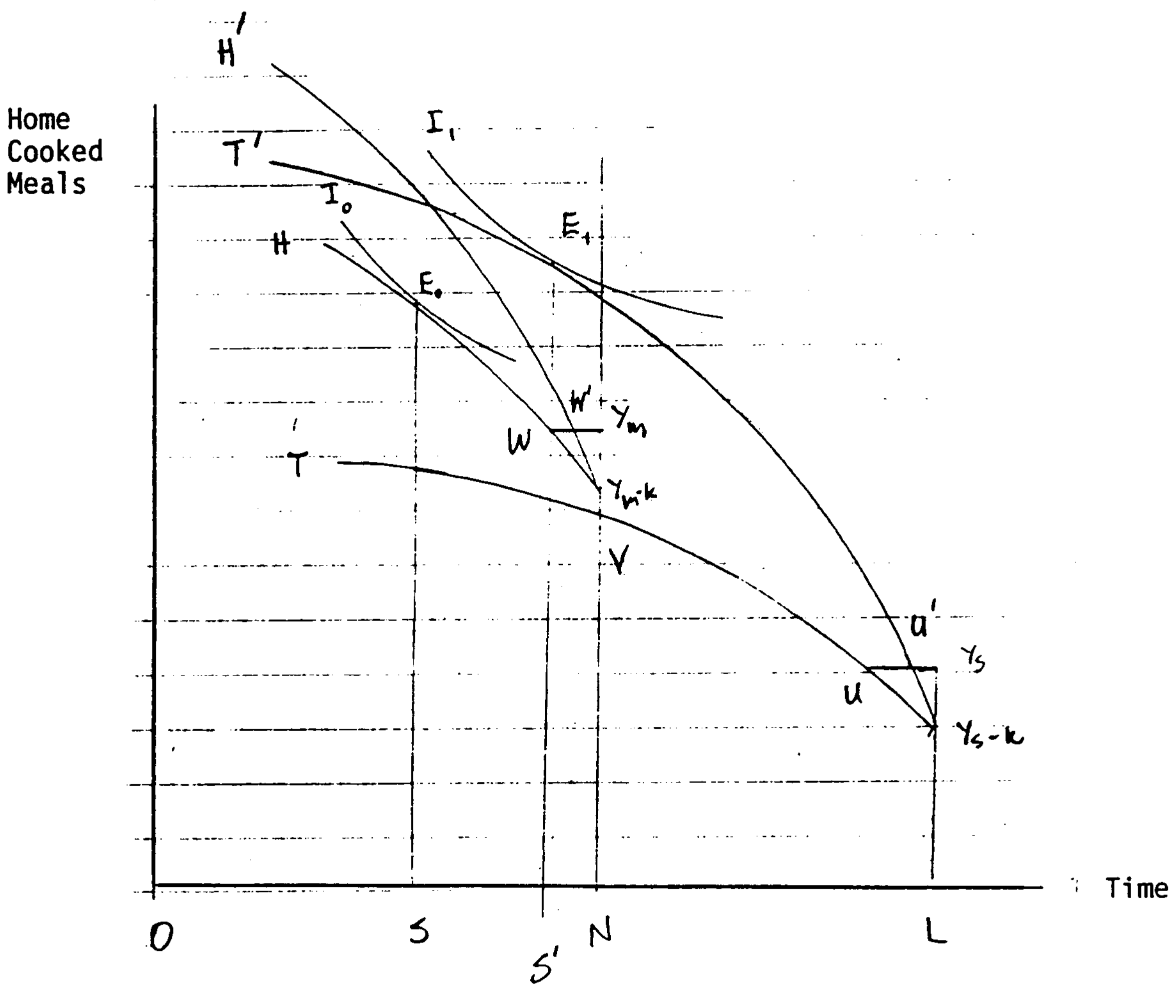
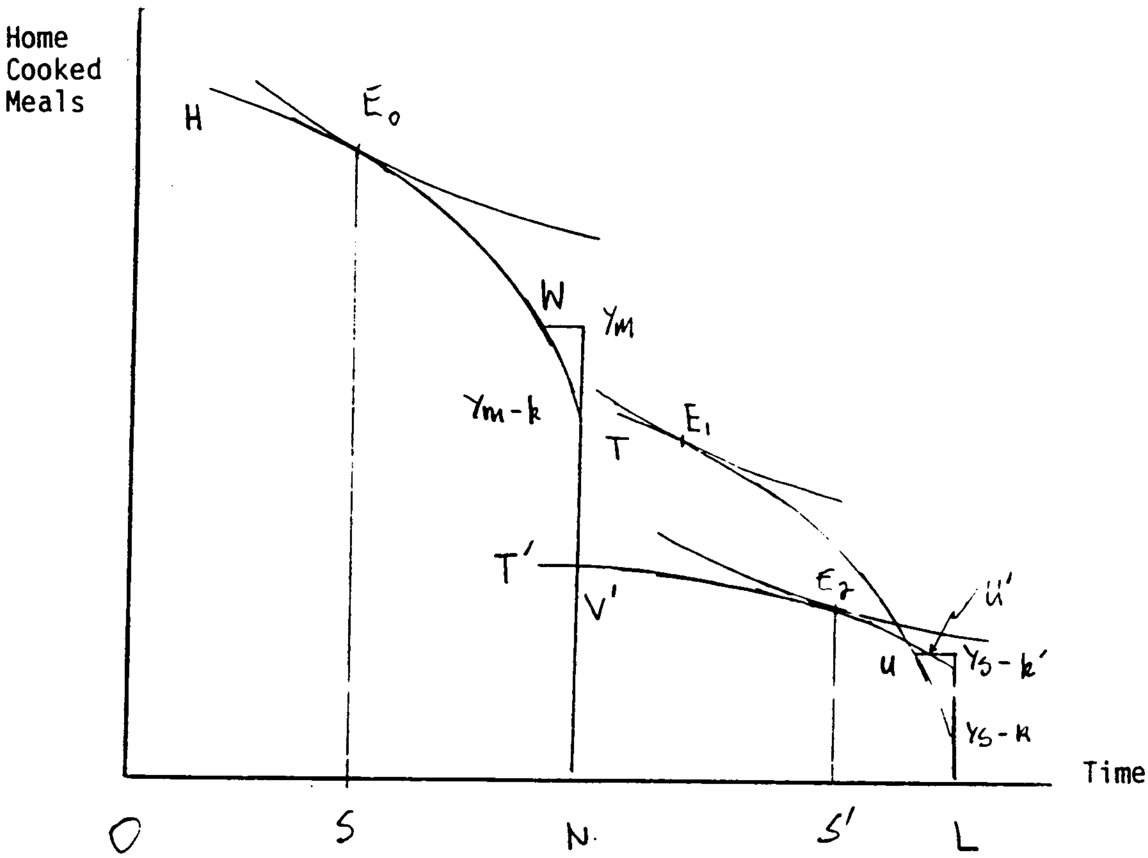


Figure II.2

The Effect of Fixed Subsistence Inputs



II.4 Empirical Model and Data

The above discussion considers continuous time allocations between subsistence, wage labor, and leisure. However, the available data contain only information on discrete subsistence time allocations relative to wage labor. The dependent variable that we seek to explain, TIME, is obtained from the question:[6]

> *"During [the last] twelve-month period, did you spend MORE TIME, about the SAME TIME, or LESS TIME engaged in subsistence activities, than you did at your job?"*

In addition to MORE, SAME, and LESS, a respondent is placed in a NONE category if responses to other questions indicate zero subsistence time allocation. A non-working respondent with any subsistence activity is assigned to MORE. The dependent variable, TIME, is a ranking of subsistence intensity relative to wage labor participation using the following ordered values: TIME≡0 (NONE), TIME≡1 (LESS), TIME≡2 (SAME), and TIME≡3 (MORE). TIME responses, sorted by ethnicity, are summarized in Table II.1. The data are from a 1988 survey of 1,688 Inupiat and 731 non-Inupiat adult residents of the eight North Slope villages (Nebesky, 1989).[7]

As a measure of the relative intensity of subsistence activity, TIME has several advantages. First, this relative measure focuses attention on a policy issue central to northern economic development: wage labor versus subsistence (Van Stone, 1960; Wolfe, 1979; Hobart, 1982; Stabler, 1990; and Kruse, 1992). Second, the question is easy to administer and is less intrusive than other measures of subsistence participation that require detailed time logs or recollection and it may

TABLE II.1

Dependent Variable (TIME) Responses by Household Ethnicity (Proportion of sample in parentheses)					
TIME			ETHNICITY		
Definition	Category	Discrete Value	Non-Inupiat	Inupiat	Total
No subsistence time.	NONE[a]	0	550 (.75)	602 (.36)	1152 (47.6)
Less subsistence time than wage labor time	LESS	1	163 (.22)	631 (.37)	794 (32.8)
Equal subsistence and wage labor time	SAME	2	8 (.01)	206 (.12)	214 (8.8)
More subsistence time than wage labor time	MORE[b]	3	10 (.01)	249 (.15)	259 (10.7)
		Total	731 (30.2)	1688 (69.8)	2419 (100)

[a] Allocates no time to subsistence
[b] Unemployed respondents that participated in subsistence harvesting are assigned to this category.

be more accurate. Finally, TIME provides a natural bridge between heterogeneous subsistence and wage activities. A 91 percent response rate shows that respondents easily used time spent in wage labor as a reference point from which to measure subsistence activity.

The discrete observations on TIME do not provide sufficient information to estimate a HPM of the type depicted in Figures 1 and 2. However, these data can be placed in a latent utility framework. To illustrate, consider again the North Slope villager facing choices among differing levels of subsistence hunting (Z_s) to produce home cooked meals (Z_H). For simplicity, assume $Z_N = T_N = \bar{T}_N$, that is, wage labor time is fixed.

The model is built around the underlying relationship

$$y^* = U[Z_H, Z_S, Z_M, \bar{T}_N, Z_L]_{T_S/\bar{T}_N > 1} - U[Z_F, Z_S, Z_M, \bar{T}_N, Z_L]_{T_S/\bar{T}_N = 0} = \beta' W + \varepsilon, \tag{9}$$

where y^* is the unobserved difference in utility obtained from differing subsistence versus grocery shopping strategies. In particular, the left hand bracketed term in (9) is utility when time allocated to subsistence exceeds wage labor time. The right hand bracketed term in (9) is utility when subsistence participation is zero. The unobserved utility differences, y^*, map into levels of subsistence participation relative to wage labor according to the following observed categories

TIME ≡ 0	if $y^* \leq 0$	NONE
TIME ≡ 1	if $0 < y^* \leq \mu_1$	LESS than job
TIME ≡ 2	if $\mu_1 < y^* \leq \mu_2$	SAME as job
TIME ≡ 3	if $\mu_2 \leq y^*$	MORE than job,

where the unknown latent utility threshold parameters μ_1 and μ_2 are estimated along with β under the assumption, $0 < \mu_1 < \mu_2$, assuring that all probabilities for the ordered choices are positive (Greene, 1990).

We can estimate the probability of the four ordered choices. Assuming that $\varepsilon \sim$ iid $N(0,1)$, the probabilities of the four ordered time categories are

$$
\begin{aligned}
P[TIME=0] &= \Phi(- \beta'W) \\
P[TIME=1] &= \Phi(\mu_1 - \beta'W) - \Phi(- \beta'W) \\
P[TIME=2] &= \Phi(\mu_2 - \beta'W) - \Phi(\mu_1 - \beta'W) \\
P[TIME=3] &= 1 - \Phi(\mu_2 - \beta'W),
\end{aligned}
\tag{10}
$$

where Φ is the normal cumulative distribution function. Parameter estimates are obtained by solving

$$
\begin{aligned}
\underset{b,\mu_1,\mu_2}{MAX} \log l = \log[&Y_0*\Phi(-b'W) + Y_1*\left(\Phi(\mu_1-b'W) - \Phi(-b'W)\right) \\
&+ Y_2*\left(\Phi(\mu_2-b'W) - \Phi(\mu_1-b'W)\right) + Y_3*\left(1-\Phi(\mu_2-b'W)\right)],
\end{aligned}
\tag{11}
$$

where $Y_i \equiv 1$ if TIME=i and zero otherwise, i=0,1,2,3.

Three categories of variables are used to explain TIME: labor supply, demographic, and cultural. In Table II.2, all the independent variables are cross tabulated with TIME. Descriptive statistics are shown in Table II.3 by ethnicity. The reader is reminded that the dependent variable, TIME, is not absolute. It measures subsistence participation relative to wage labor supply. The labor supply variables are number of months the respondent was employed in the past year (MWORK), the number of employed months for all other household members (HHWORK), and a set of binary occupational variables.

MWORK measures of the respondent's wage labor supply and, since time is allocated between wage labor, subsistence participation, and leisure, MWORK is likely to influence subsistence.[8] The correct econometric model of subsistence time allocation relative to wage labor depends on the nature of this influence. A simultaneous equations approach is appropriate if subsistence participation and MWORK are jointly determined. Conversely, a recursive approach is suggested if

TABLE II.2

Means and Standard Deviations of Independent Variables by Amount of Time Allocated to Subsistence[a]

	NONE	LESS	SAME	MORE	Total
HHS	3.96 (2.14)	4.36 (2.17)	4.86 (2.16)	4.76 (2.19)	4.26 (2.18)
MWORK	7.47 (4.95)	8.97 (3.86)	7.37 (4.48)	2.69 (4.15)	7.44 (4.83)
HHWORK	11.61 (10.25)	10.38 (8.97)	10.39 (9.13)	10.64 (9.38)	10.99 (10.59)
GET (%)	11.99 (21.34)	15.46 (20.76)	19.50 (23.47)	19.46 (24.16)	14.59 (21.84)
GIVE (%)	8.59 (17.08)	23.92 (23.50)	26.90 (21.79)	28.49 (25.45)	17.37 (22.43)
LOCAL (%)	50.79 (30.75)	55.56 (28.62)	65.68 (26.32)	66.66 (23.64)	53.37 (29.54)
AGE	36.33 (14.33)	35.80 (11.72)	35.35 (12.18)	41.79 (17.15)	36.66 (13.80)
SCH	12.17 (3.53)	11.97 (3.04)	10.87 (2.81)	9.34 (3.99)	11.68 (3.48)
HHY[b] ($1000)	60.8 (43.7)	59.5 (40.5)	44.3 (34.5)	37.1 (28.0)	56.4 (41.2)
ETHNIC (%Inupiat)	52.3 (50.0)	79.5 (40.4)	96.3 (19.0)	96.1 (19.3)	69.8 (45.9)
MAR (% Married)	47.4 (50.0)	55.4 (49.7)	50.0 (50.1)	52.1 (50.1)	51.3 (50.0)
GENDER (% Male)	42.4 (49.3)	64.0 (48.0)	65.4 (47.7)	57.9 (49.5)	53.2 (49.9)
BARROW (% Residing)	69.5 (46.1)	53.0 (49.9)	46.7 (50.0)	42.1 (49.5)	59.2 (49.2)
WJOB (%)	56.9 (49.6)	54.0 (49.9)	42.1 (49.5)	19.7 (39.8)	50.6 (50.0)
NOJOB (%)	23.8 (42.6)	6.7 (25.0)	14.0 (34.8)	55.2 (49.8)	20.7 (40.5)
BJOB (%)	19.4 (39.5)	39.3 (48.9)	43.9 (49.8)	25.1 (43.4)	28.7 (45.2)
N	1,152	794	214	259	2419

[a] Standard deviations in parentheses.
[b] Equals household income; not included in estimated model.

TABLE II.3

Means and Standard Deviations of Independent Variables by Ethnicity[a]			
VARIABLE	Non Inupiat	Inupiat	Total
HHS	3.12 (1.72)	4.75 (2.17)	4.26 (2.18)
MWORK	10.05 (3.55)	6.31 (4.87)	7.44 (4.83)
HHWORK	12.25 (10.42)	10.45 (9.28)	10.99 (10.59)
GET (%)	3.34 (11.02)	19.47 (23.51)	14.59 (21.84)
GIVE (%)	3.84 (12.64)	23.23 (23.20)	17.37 (22.43)
LOCAL (%)	33.96 (26.24)	64.65 (25.84)	55.37 (29.54)
AGE	37.08 (11.40)	36.47 (14.72)	36.66 (13.80)
SCH	14.32 (2.33)	10.54 (3.27)	11.68 (3.48)
HHY[b] ($1000)	$82.9 (45.2)	$44.9 (33.4)	$56.7 (41.2)
MAR (% Married)	57.5 (49.3)	48.5 (50.0)	51.3 (50.0)
GENDER (% Male)	53.1 (49.9)	53.2 (49.9)	53.2 (49.9)
BARROW (% Residing)	87.0 (33.7)	47.1 (49.9)	59.2 (49.2)
WJOB (%)	73.2 (44.3)	40.9 (49.2)	50.6 (50.0)
NOJOB (%)	8.3 (27.7)	26.0 (43.9)	20.7 (40.5)
BJOB (%)	18.5 (38.8)	33.1 (47.1)	28.7 (45.2)
N	731	1688	2419

[a] Standard deviations in parentheses.
[b] Equals household income; not included in estimated model.

MWORK is determined first and then the remaining time is allocated between subsistence and leisure.[9] An empirical test for the exogeneity of MWORK and its implications are considered in the next section.

As shown in Table II.3, on average MWORK is lower and more variable for Inupiats (6.31 months) than for non-Inupiats (10.05 months). In Table II.2, MWORK declines sharply with subsistence activity for respondents in SAME and MORE. Respondents with modest subsistence participation (LESS) averaged more time allocated to labor supply (8.97 months) than those in NONE (7.47 months). This reflects a higher concentration of labor force intensive non-Inupiats in LESS. Also, it indicates that some respondents, including the disabled, the aged, and students, are active in neither the wage nor subsistence markets.

We include all other household members' wage labor, HHWORK, to control for the possible influence of collective household decisions on the individual's subsistence time choice, but the sign of its effect is ambiguous. Other household members' wage labor may support the respondent's subsistence effort, but may also induce the individual to intensify labor market participation ((Brown and Burch, 1992; Kruse, 1992). Table II.2 suggests that HHWORK varies little with TIME, while Table II.3 shows that the average level of HHWORK is higher for non-Inupiats (12.25) than Inupiat respondents (10.45).

Three binary variables measure the respondent's occupation. WJOB and BJOB are white and blue collar jobs from U.S. Census classifications. Those not in the labor force or unemployed are classified as NOJOB. Occupation and ethnicity are strongly related. Inupiats are more likely to be in BJOB (.33) or NOJOB (.26) than non-

Inupiats, who are mostly in WJOB (.73) and rarely NOJOB (.08). We choose BJOB as the reference and we expect a relatively higher (lower) level of subsistence activity for NOJOB (WJOB) because of the effect of lower (higher) wage rates on the opportunity cost of subsistence time.

The demographic variables are age, gender, marital status, education, household size and geographic location. Since wage labor markets developed only recently on the North Slope, AGE may proxy human subsistence capital and identification with the traditional cultural (Kruse, 1992). We expect age to be directly related to subsistence activity.

GENDER≡1 for male respondents and zero for female. Male dominance in subsistence harvesting activity would imply a positive association with TIME. However, the data used in this study are based on a broad definition of subsistence, encompassing food processing, sewing, gathering, and camp preparation. Since many of these functions are carried out by women, the expected sign for GENDER is ambiguous.

MAR≡1 if the respondent is married and zero otherwise. Subsistence requires household members to coordinate a set of specialized activities such as butchering, storage, distribution, equipment repair, radio communications, camp preparation. Following Kruse (1992), MAR is interpreted as a measure of household cohesion and is expected to have a positive impact on TIME.

The number of years of formal education (SCH) may affect subsistence in two ways. First, an increase in schooling may result in (or result from) a disaffection with the traditional lifestyle and imply a decrease in subsistence. Second, an increase in SCH may indirectly measure the influence of higher wage offers. This could have the negative effect of increasing the opportunity cost of subsistence activity or the positive effect of encouraging the purchase of variable and capital subsistence inputs. Kruse (1992) finds that between 1977 and 1988 subsistence activities among Inupiat men increased across all levels of SCH, but he does not speculate on the cause. In contrast with Kruse, Stabler (1990) finds that subsistence participation is inversely related to educational attainment among English-speaking Native males, age 15-44, in Canada's Northwest Territories (NWT). These differences may be due in part to fundamental differences in economic conditions faced by Alaska North Slope and Canadian NWT Native populations.

Household size (HHS), the number of household members, is a proxy for the household's structure and averages 4.3 persons. Twenty-six percent of Inupiat and 17 percent of non-Inupiat households are extended families with as many as 14 persons. The larger households tend to include extended kin members whose presence is likely to facilitate cooperation in subsistence activities, increase the demand for subsistence products, and indicate a greater attachment to traditional lifestyles. We expect a positive relationship between HHS and TIME.

Usher (1981) and Kruse (1992) argue that residents of larger villages will have stronger attachments to the market economy. Barrow is the largest of the eight North Slope villages. We include a dummy variable BRW=1 if the respondent resides in Barrow and zero otherwise.

Cultural variables include ethnicity, local propensity to spend, and two variables that capture broader sharing relationships that are important to community cohesion and to the preservation of Inupiat culture (Wolfe et al., 1984 and Kruse, 1992). The variables GIVE and GET characterize the extent to which a household is oriented toward the extended family and community. GIVE is obtained from the question:

> *"Over the past year, what percent of all the meat and fish that you and members of your household harvested did you give away?"*

GET is obtained from the question:

> *"Over the past year, what percent of all the meat and fish that you and members of your household consumed came from other households (who may or may not be relatives)?"*

In both cases the respondent was asked to indicate a percentage between zero and 100. The motivation for these sharing variables stems from the debate over the resilience of generalized reciprocity in the modern mixed village economy and its importance as a form of economic security and as a determinant of subsistence participation (Wolfe 1979, Hobart 1982, Dryzek and Young, 1985). As shown in Tables II.2 and II.3, GIVE and GET both exhibit a strong positive relationship with TIME and ethnicity.

The variable LOCAL is the fraction of household income spent in the village. This is an indicator of attachment to and involvement in local affairs, including commerce. We expect a positive sign for this variable.

We allow for differences in the subsistence activity of Inupiats and non-Inupiats in two ways. First, we include a binary variable ETHNIC=1 if the respondent's household head or spouse of household head is Inupiat. The expected sign is positive reflecting what Stigler and Becker (1977) would describe as cultural effects on the opportunity cost of subsistence hunting.

Second, we allow the effect of each explanatory variable to vary with ethnicity by including interaction terms between ETHNIC and all other variables. In the discussion below, we refer to the estimates corresponding to this set of variables as indigenous interaction terms and adopt the notation of attaching a suffix D to the explanatory variable name (e.g. MAR for married non-Inupiat and MARD for married Inupiat).

II.5 Results

In this section, we conduct two independent model specification tests using (11). Conditional on the accepted specification, we report and interpret the results as well as the estimated marginal effects of the explanatory variables.

We first conduct a likelihood ratio test of the restriction that all the indigenous interaction terms are zero. Under the null, ethnicity has no structural impact and the probability of subsistence activity for Inupiat versus non-Inupiat respondents differs only in the intercept. We reject the null with a prob-value≈0, since the test statistic is χ^2=51.3 and the critical $\chi^2_{.05,13}$=22.36. This result is important because it provides evidence that the indigenous Inupiat people use and value natural resources in a manner different from non-Inupiats. This implies that optimal management policies will vary with the ethnicity of the resource owner and that resource valuations estimated with surveys of non-Natives are not likely to be valid for resources with Native entitlements.

Second, we conduct and independent test for the exogeneity MWORK using Grogger's (1990) method. Fitted values for MWORK are obtained from a 13-choice (0 through 12 months) ordered probit model. For instruments we use HHS, LOCAL, AGE, ETHNIC, SCH, GENDER, MAR, BRW, and a binary variable for private versus public sector employment.

The test statistic is χ^2=1.401, compared to the critical $\chi^2_{.05,1}$=3.84 and we fail to reject the null hypothesis of exogenous MWORK. In addition to its econometric expediency, this result implies that optimal the time allocation for home produced subsistence commodities is not determined jointly with wage labor time allocation. The home production time allocation process may be recursive, beginning with the labor force participation decision.

Institutional factors may account for this result. First, modern subsistence practices require cash outlays, which in turn require earnings. In addition to coordination among extended household and community members, subsistence requires some amount of labor force participation. Once employed, the individual is subject to labor market rigidities that, to some extent, locks them into the wage-consumption cycle.

Second, the personnel policies of many North Slope employers often allow for unpaid subsistence leave. This arrangement is compatible with the subsistence lifestyle and it creates an additional incentive for labor market participation. The North Slope labor force participation decision may be fixed, as the data suggest, but at lower average levels compatible with subsistence time allocation requirements. This explanation is consistent with lower average MWORK for Inupiat residents than for non-Inupiat residents (Table II.3). These findings suggest that the subsistence leave policies facilitate intermediate home production.

Estimation results for the accepted model are summarized in Tables II.4-7. Except for the intercept and the shifter, ETHNIC, the parameter estimates in Table II.4 are presented in pairs consisting of the original variable and its indigenous interaction counterpart. As shown in Table II.4, several variables have statistically significant coefficients, including at least one from each category: labor supply, demographic, and cultural. In addition, likelihood ratio test results indicate that the accepted model exhibits far greater explanatory power than a naive model that contains only an intercept term (the test statistic 708.58 exceeds the critical value, $\chi^2_{.05,29}$=42.6).

Table II.5 indicated goodness of fit by comparing predicted probabilities for TIME with observed frequencies. Overall, the model correctly predicts TIME for 82 percent of Inupiats and 97 percent of non-Inupiats. However, the model tends to overstate Inupiat probabilities for NONE and LESS and understate for SAME and MORE. The reverse occurs for non-Inupiats.

The interpretation of ordered probit coefficients is complicated since a coefficient's algebraic sign determines the sign of the marginal effect only for the first and last ordered categories (Greene, 1990). For the continuous variables in W the marginal effects are

$$\begin{aligned}
\frac{\partial P[TIME=0]}{\partial W} &= -\phi(b'W)b \\
\frac{\partial P[TIME=1]}{\partial W} &= (\phi(-b'W) - \phi(\mu_1-b'W))b \\
\frac{\partial P[TIME=2]}{\partial W} &= (\phi(\mu_1-b'W) - \phi(\mu_2-b'W))b \\
\frac{\partial P[TIME=3]}{\partial W} &= \phi(\mu_2 - b'W)b,
\end{aligned} \tag{12}$$

where ϕ is the normal probability density function. For β>0 (<0), an increase in W shifts the density function rightward and unambiguously decreases (increases) the P[TIME=0] and increases (decreases) the P[TIME=3]. However, the direction of change in the middle two categories is ambiguous and depends on the densities. For all cells, the magnitudes of the marginal effects depend on the point of evaluation of W. Table II.6 gives the estimated marginal effects on the

TABLE II.4

Estimated Model Parameters			
Variable	**Estimate**	**T-ratio**	**Variable Mean**
Constant	-0.648983	-1.24657	---
Labor Supply			
MWORK	0.014659	0.62796	10.053
MWORKD	-0.046802	-1.90089**	6.311
HHWORK	-0.021767	-2.94766*	12.248
HHWORKD	0.021803	2.68242*	10.452
WJOB	0.000201	0.00135	0.732
WJOBD	-0.075563	-0.45464	0.409
NOJOB	-0.216942	-0.64757	0.083
NOJOBD	0.087307	0.25137	0.260
Demographic			
HHS	0.015221	0.39234	3.120
HHSD	-0.008361	-0.20121	4.749
AGE	-0.005996	-1.15202	37.079
AGED	0.012976	2.23772*	36.474
SCH	-0.010252	-0.38944	14.317
SCHD	0.019916	0.69426	10.543
GENDER	0.343482	2.94433*	0.531
GENDERD	0.093334	0.70045	0.532
MAR	0.355329	2.97557*	0.577
MARD	-0.196123	-1.46113	0.485
BRW	-0.149301	-0.99181	0.870
BRWD	0.095207	0.59161	0.471

TABLE II. 4 (Continued)

Estimated Model Parameters			
Variable	**Estimate**	**T-ratio**	**Variable Mean**
Cultural			
ETHNIC	0.453284	0.79937	0.698
GIVE	0.025577	7.40066*	3.837
GIVED	-0.015008	-4.11269*	23.232
GET	0.008643	2.04095*	3.343
GETD	-0.009057	-2.05992*	19.467
LOCAL	-0.002746	-1.24848	33.959
LOCALD	0.002244	0.91167	64.648
Latent Parameters			
$\mu 1$	1.10649	64.9825	
$\mu 2$	1.55041	31.1115	

Log of Likelihood Function: -2482.52
Likelihood Ratio Index: .1249
Likelihood Ratio Test (DF=29) 708.58

Note: * = .05 Significance ** = .10 Significance

TABLE II.5

Estimated Probabilities and Observed Frequencies for TIME				
Subsistence TIME Allocation Decision	Inupiat		Non-Inupiat	
	Estimated Frequency	Observed Frequency	Estimated Frequency	Observed Frequency
NONE	.426	.357	.747	.752
LESS than Job	.395	.374	.215	.223
SAME as Job	.093	.122	.025	.011
MORE than Job	.087	.148	.013	.014

probabilities of each TIME category, evaluated at the Inupiat and non-Inupiat sample means.

Importantly, the marginal effects are of opposite signs for Inupiats versus non-Inupiats in the case of MWORK, AGE, and SCH. An increase in MWORK increases Prob[TIME=0] for Inupiats and somewhat uniformly decreases the probability of higher categories of TIME. The reverse holds for non-Inupiats. Also, the larger (absolute) marginal effects for Inupiats compared to non-Inupiats indicates that Inupiat subsistence participation relative to wage labor is more strongly influenced by time spent in wage labor. This result is consistent with Stabler's (1990) observations for English-speaking Native males in Canada's NWT.

AGE produces a significant upward effect on positive Inupiat subsistence participation, and the marginal effects grow with TIME. The opposite holds for non-Inupiats. As a proxy for human capital, AGE lowers subsistence opportunity costs and perhaps strengthens preferences for subsistence products among older Inupiats; these experiences are not shared by non-Inupiats. Though not statistically significant, SCH reduces the P[TIME=0] for Inupiats and increases the probability of positive subsistence participation. Diametric results are obtained for non-Inupiats. The lack of statistical significance for Inupiats may result from the assimilative effect of more education countered by the effect of increasing wages on the ability to purchase subsistence capital.

An increase in HHWORK lowers subsistence time allocation probabilities among non-Inupiats. However, the difference between

TABLE II.6

Marginal Effects for Continuous Explanatory Variables								
Inupiat								
Subsistence Choice	**MWORK**	**HHWORK**	**GET**	**GIVE**	**HHS**	**AGE**	**SCH**	**YLOCAL**
P[TIME=0]	0.0126	0.0000	0.0002	-0.0041	-0.0027	-0.0027	-0.0038	0.0002
P[TIME=1]	-0.0042	0.0000	-0.0001	0.0014	0.0009	0.0009	0.0013	-0.0001
P[TIME=2]	-0.0035	0.0000	0.0000	0.0011	0.0007	0.0008	0.0010	-0.0001
P[TIME=3]	-0.0049	0.0000	-0.0001	0.0016	0.0011	0.0011	0.0015	-0.0001
Non-Inupiat								
Subsistence Choice	**MWORK**	**HHWORK**	**GET**	**GIVE**	**HHS**	**AGE**	**SCH**	**YLOCAL**
P[TIME=0]	-0.0047	0.0070	-0.0028	-0.0082	-0.0049	0.0019	0.0033	0.0009
P[TIME=1]	0.0035	-0.0052	0.0020	0.0061	0.0036	-0.0014	-0.0024	-0.0007
P[TIME=2]	0.0007	-0.0011	0.0004	0.0013	0.0007	-0.0003	-0.0005	-0.0001
P[TIME=3]	0.0005	-0.0007	0.0003	0.0009	0.0005	-0.0002	-0.0004	-0.0001

Inupiat and non-Inupiat effects is statistically significant, and HHWORK does not affect Inupiat subsistence participation at the margin. We offer two interpretations of this result. First, HHWORK may generate two opposing effects: (a) Increased wage labor among other household members increases earnings available for fixed subsistence inputs. Increases in these inputs raise the productivity of subsistence time. (b) Increased wage labor among other household members increases the burden of household chores falling on individual household members and tends to lower subsistence activity. The latter effect may dominate for non-Inupiats. For Inupiats (a) and (b) may be offsetting. Second, the impact of wage labor for other household members is less for Inupiats because they draw on a more extended family network, beyond those in the household to aid in subsistence harvests.

Statistically significant parameter estimates are obtained for GIVE and GET, as well as for the differences by ethnicity, GIVED and GETD. A marginal increase in GIVE increases the probability of allocating some time to subsistence relative to wage labor for both ethnic groups. A rise in GET tends to reduce subsistence probabilities for Inupiat residents, although the effect is quite small. A reverse pattern occurs for non-Inupiats.

Five of the six (absolute) marginal effects for GIVE and GET are larger for non-Inupiat respondents. The Inupiat pattern of generalized reciprocity, as opposed to the non-Inupiat pattern of balanced reciprocity, may explain why Inupiat subsistence participation relative to wage labor appears to be less responsive to the gifts and giving of subsistence commodities. Alternatively, the <u>levels</u> of Inupiat participation in GIVE and GET are nearly six times greater than for non-

Inupiats. The impact of a marginal change in exogenous subsistence sharing may diminish with higher levels of sharing.

The estimated effects of the binary explanatory variables are in Table II.7. These effects are the computed using the difference between β'W with the variable equal to unity or zero, holding the continuous variables at the Inupiat and non-Inupiat means. The effect of ETHNIC shows that Inupiats allocate time to all positive (zero) levels of subsistence with greater (smaller) probability than non-Inupiat. Residency in Barrow (BRW) tends to lower the subsistence time probabilities for both Inupiat and non-Inupiat residents. With exception of TIME=3, this effect is smaller for Inupiat respondents than for non-Inupiats. The result supports Usher's (1981) hypothesis, suggesting that urban location increases Native attachment to the market economy, although the coefficient is not statistically significant.

The impact of MAR is to increase all three positive subsistence time allocation probabilities for both Inupiat and non-Inupiat residents. This result supports Kruse's (1992) hypothesis regarding marriage as an indicator of household cohesion, which enhances subsistence productivity.

The GENDER parameter estimate is positive and significant although its corresponding ethnic difference is negative and insignificant. subsistence activity and labor force participation under an extreme condition of voluntary or involuntary joblessness. Recall that a marginal change in MWORK increases the Inupiat's probability of not engaging in subsistence and lowers subsistence TIME probabilities by 1.3 percent for Inupiat respondents that do participate in subsistence.

TABLE II.7

Marginal Effects for Binary Explanatory Variables					
Explanatory Variable	Value	Probabilities			
		P(TIME=0)	P(TIME=1)	P(TIME=2)	P(TIME=3)
ETHNIC	0	0.7473	0.2144	0.0249	0.0134
	1	0.4255	0.3952	0.0927	0.0866
Change:		-0.3218	0.1808	0.0678	0.0732
BRW	Inupiat				
	0	0.4286	0.3942	0.0919	0.0853
	1	0.4498	0.3867	0.0863	0.0772
Change:		0.0212	-0.0075	-0.0056	-0.0081
	Non-Inupiat				
	0	0.7538	0.2097	0.0239	0.0126
	1	0.7983	0.1756	0.0176	0.0085
Change:		0.0445	-0.0341	-0.0063	-0.0041
MAR	Inupiat				
	0	0.4836	0.3730	0.0777	0.0657
	1	0.4207	0.3970	0.0938	0.0885
Change:		-0.0629	0.0240	0.0161	0.0228
	Non-Inupiat				
	0	0.8465	0.1368	0.0116	0.0051
	1	0.7473	0.2145	0.0248	0.0134
Change:		-0.0992	0.0777	0.0132	0.0083
GENDER	Inupiat				
	0	0.5393	0.3466	0.0645	0.0496
	1	0.3813	0.4081	0.1047	0.1059
Change:		-0.1580	0.0615	0.0402	0.0563
	Non-Inupiat				
	0	0.8410	0.1414	0.1222	0.0054
	1	0.7686	0.1986	0.0127	0.0111
Change:		-0.0724	0.0572	0.0095	0.0057

TABLE II.7 (Continued)

Marginal Effects for Binary Explanatory Variables					
Explanatory Variable	Value	Probabilities			
		P(TIME=0)	P(TIME=1)	P(TIME=2)	P(TIME=3)
WJOB		**Inupiat**			
	0	0.4254	0.3953	0.0927	0.0866
	1	0.4550	0.3848	0.0849	0.0753
Change:		0.0575	-0.0105	-0.0078	-0.0113
		Non-Inupiat			
	0	0.7927	0.1801	0.0182	0.0090
	1	0.7929	0.1799	0.0182	0.0090
Change:		0.0002	-0.0002	0.0000	0.0000
NOJOB		**Inupiat**			
	0	0.4427	0.3895	0.0880	0.0798
	1	0.4944	0.3681	0.0752	0.0623
Change:		0.0517	-0.0214	-0.0128	-0.0175
		Non-Inupiat			
	0	0.7875	0.1841	0.0190	0.0094
	1	0.8450	0.1381	0.0118	0.0051
Change:		0.0575	-0.0460	-0.0072	-0.0043

Males are more likely to allocate positive time to subsistence, a result supporting the view of male dominance in the subsistence process. The (absolute) marginal effect of GENDER also is more pronounced for Inupiat respondents.

Finally, the marginal impact of NOJOB is to decrease the probabilities of the three positive time allocation choices for both Inupiat and non-Inupiat residents and increase the probability of allocating zero time to subsistence. This result conflicts with the marginal effect of MWORK and is evidence of complementarity between This gives the same direction of effect as that predicted from becoming unemployed or leaving the labor force when NOJOB ≡ 1 (a 5 percent probability decline).

Resolution of this apparent conflict may rest in distinguishing the differing effects of time and income scarcity on subsistence participation. A marginal change in MWORK, taken in the context of 6-to-10 month average annual levels of labor supply, will increase time scarcity and discourage home production of time intensive subsistence commodities. A discrete change to NOJOB status represents a larger order impact that may sharply reduce wage income. As show in Figure 2, the individual's ability to maintain and procure subsistence inputs and, therefore, to participate in subsistence diminishes.

A decline in MWORK will lower time scarcity and raise subsistence hunting effort. However, at some point, extended underemployment or complete job loss may produce income-scarcity effects that overwhelm those associated with time-scarcity.

II.6 Conclusion

Four conclusions emerge from this research. First, Alaska's North Slope Inupiat appear to use natural resources in different manner from non-Inupiats. Since underlying differences in resource valuation are likely to influence observed behavioral differences, policies related to management of Alaska public lands should take these differences into account.

Second, the results confirm hypotheses from previous research and indicate that both tradition and economic incentives influence the allocation of time to subsistence relative to wage labor. We confirm Kruse's (1992) predictions on the impact of marriage, age, and gender on subsistence time allocations and find strong support for the importance of a system of generalized reciprocity, as measured by GIVE and GET, on the relative time allocation decisions of North Slope residents, especially Inupiats. However, we do not find significant effects for education, Barrow residency, or occupation for either Inupiat or non-Inupiats. The absence of significance for education (SCH) contrasts with Stabler (1990) and Kruse (1992), and may occur because our model explicitly controls for factors such as demography and labor force participation, in addition to household composition and traditional practices, which education is sometimes thought to proxy. The failure to find a significant effect of the labor force participation by other household members on Inupiat subsistence suggests that Inupiats draw on extended community resources beyond those available in the non-Inupiat household.

Third, our results indicate that wage labor is an exogenous determinant of subsistence time allocation and may indicate the time allocation process is recursive. North Slope residents first decide on labor supply and, second, on subsistence participation. This finding does not diminish the importance of subsistence production as a part of household income, but does indicate that Inupiat residents have adapted to North Slope labor market conditions.

Fourth, estimation results indicate an inverse relationship between the probability of subsistence and wage labor time among Inupiat residents. This means that factors that tend to reduce employment, such as a general economic downturn would, at least initially, lead to increased subsistence activity. It follows that the value of subsistence resources increase as labor market opportunities contract.

Looking ahead, the imminent depletion of Prudhoe Bay oil reserves implies economic contraction along with more pressure to open up other Arctic lands to energy development. Our results suggest that these lands gain value as subsistence resources as the pressure for their energy development grows.

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II.8 Endnotes

1. Important sources of non-labor income not explicitly considered here include state and federal transfer payments and Native corporation dividends (Chance, 1987 and Huskey, 1992).

2. ASRC is one of thirteen Native Corporations created in the 1971 Alaska Native Claims Settlement Act.

3. Alaska law prohibits the sale of most subsistence products (State of Alaska, 1978). Since 1972, the Federal Marine Mammal Protection Act prohibits commercial hunting of most marine mammal species including seal, walrus, and Bowhead whale. Observed differences in subsistence hunting patterns of North Slope Inupiat and non-Inupiat people are expected to reflect this constraint.

4. This discussion based on Braund, et al. (1989).

5. Pollak and Wachter (1975) show that if the household technology displays constant returns to scale and no jointness in production, then commodity demand is a function of implicit commodity prices (π_i). Alternatively, if home production time generates direct utility (jointness) then commodity demand depends on preferences, as well. In this study, we do not estimate commodity demands. Following Becker (1965) we allow for direct utility from intermediate activities and assume that time can be uniquely allocated among activities.

6. Before answering this question, respondents completed a series of questions about their subsistence and wage labor activities. The respondents include the employed and unemployed, as well as students, disabled, aged, and others not in the labor force.

7. The North Slope Borough sponsored the survey. Details on survey design and methodology are available from the authors on request.

8. The wage rate is not included as an explanatory variable. However, the empirical model estimated includes variables measuring education, demographic, and occupation attributes that proxy the respondent's wages. This procedure is consistent with the human resources literature explaining wage patterns. See for example, Tremblay (1990).

9. Household income (HHY) was excluded as an explanatory variable from the model because a) it is highly collinear with MWORK, b) it was not statistically significant when included, and c) the reported results are robust with respect to its omission.

III. MARKET POWER IN THE U.S. MOTOR CARRIER INDUSTRY

III.1 Introduction

During the 1980's, researchers have noted a trend towards increased concentration in the general freight, less-than-truckload (LTL) portion of the U.S. motor carrier industry (Enis and Morash, 1987; Kling, 1990; Rakowski, 1988 and 1990). These researchers have questioned the appropriateness of deregulation, suggesting that large firms may take over the industry in the future if there is no government intervention. Another set of studies suggest that the LTL motor carrier industry exhibits competitive behavior of the form that motivated regulation reform in 1980 (Ying, 1990; Ying and Keeler, 1991; Kerkvliet and McMullen, 1993).

The important issue is not whether the industry is simply becoming more concentrated, but whether the increasingly concentrated industry is exerting monopoly power and acting in an anti-competitive manner. The contribution of this research is the application of new industrial organization empirical techniques to determine the extent of trucking industry anti-competitive performance in the post-1980 deregulated environment.

The LTL segment of the U.S. motor carrier industry primarily consists of non-specialized carriers that haul mostly intercity freight in shipments of less than 10,000 pounds using a network of hub and spoke terminals.[10] By comparison, truck load (TL) carriers serve relatively specialized commodity shippers. Where as the TL segment of the industry is generally accepted to be competitive, the evidence is less clear with respect to the LTL segment (McMullen, 1987 and Winston, et al., 1990.) As shown in Table III.1, while the number of ICC certified motor carriers increased dramatically over the past decade, the number of Class I & II, Instruction 27 carriers, representing the LTL segment, declined by more than 60 percent (Xu, et al., 1993). Three-, four-, and eight-firm concentration ratios have increased steadily since 1976.

TABLE III.1

U.S. Motor Carrier Industry Size and Concentration 1976 - 1989

Year	Number of ICC Certified Motor Carriers	Number of ICC Class I & II Carriers	Annual Average Tonmiles LTL Carriers (Millions)	Concentration Ratios (Percent)		
				3-Firm	4-Firm	8-Firm
1976	16,742	614		.14	.17	.24
1977	16,606		111.3			
1978	16,874					
1980	18,045	498		.18	.21	.32
1984	30,481	326				
1987	38,338	273	271.8			
1988	39,609					
1989		237		.35	.40	.52

Source: McMullen and Stanley, 1988.
Xu, et al., 1993.
Interstate Commerce Commission, 1945-1988.

Motor carrier research has focussed on estimations of cost functions to obtain information on returns to scale. Almost all studies have found evidence of constant technological returns to scale for both industry segments (McMullen, 1987; McMullen and Stanley, 1988; Grimm, Corsi, and Jarrell, 1988; Daughety and Nelson, 1987). However, other work (Corsi and Stowers, 1991; McMullen and Tanaka, 1993) indicates that there may be networking economies or what Keeler (1989) calls "economies of integration" that give cost advantages to larger firms. These "economies of integration", however, are difficult to capture using standard econometric cost function estimation techniques.

The focus on cost structure looks at only a necessary, but not a sufficient, condition for the exercise of monopoly power. Even if large firms do have cost advantages over small and the industry becomes increasingly concentrated, the industry could be behaving in an efficient manner as long as cost savings are passed along to consumers in the form of lower prices. The real problem, from an economic efficiency perspective, occurs when large firms exert market power and price above marginal cost.

Recent advances in the theory of duality and advances in econometric methods using flexible functional forms and non-linear estimation techniques have resulted in sophisticated empirical methods for the study of industry pricing behavior. This new line of research is referred to by Bresnahan (1989) as the "new empirical industrial organization" (NEIO) framework. The purpose of this study is to employ NEIO techniques to determine whether the increases in concentration observed in the post-1980 U.S. motor carrier industry have resulted in non-competitive industry pricing behavior.

The chapter is organized as follows. Following this introduction, section III.2 introduces the NEIO model used as the theoretical basis for this study. Section III.3 provides an explanation of the empirical methodology and describes the data set used for the motor carrier industry. Results are presented and discussed in section III.4, followed by a summary of major conclusions in the final section.

III.2 NEIO Model of Pricing Behavior

The NEIO framework relies on formal profit maximizing theory to build structural econometric models designed for direct estimation of the degree of market power exerted by the firm or industry. Market power is defined as the gap between equilibrium price and marginal cost (MC). The NEIO approach produces direct estimates of MC which, under the assumption of profit maximizing equilibrium, provides a benchmark for comparison with observed price data. A large price-cost margin (PCM) implies a high degree of market power exerted by the firm or industry under examination.

To explore the relationship between market price and marginal cost, the NEIO approach begins with the structure of industry demand and cost. The objective is to formulate and empirically estimate what is referred to as the representative firm's supply relation.[11] In general, the firm's cost function, its demand curve, and its pricing behavior (conduct) represent the unknowns to be estimated. Endogenous observable variables include the firm's output price (P) and quantity (q_i). Exogenous observable variables include input supply prices (**w**), firm attributes (**a**), and appropriate demand and supply shift variables ($\mathbf{z}_d$, and $\mathbf{z}_s$).[12]

Demand is usually expressed in price-dependent (inverse) form as

$$P = P(q_i + Q_j,\ z_d,\ \Gamma_d)\,, \tag{13}$$

where $\mathbf{\Gamma}_d$ is a vector of unknown demand parameters. When output is homogeneous, $Q=q_i+Q_j$, where $Q_j=\Sigma q_j$ for $j \neq i$. The equation for firm long run minimum total cost is

$$C_i = C(q_i, w, a, \Gamma_c,), \tag{14}$$

where **a** is a vector of firm attributes that control for the effects of heterogeneous commodities, and Γ_c is a vector of unknown cost parameters.

The firm's problem is to maximize profit:

$$\max_{q_i} \pi = [P(\cdot)\, q_i - C_i(\cdot)]\ . \tag{15}$$

The firm's first order condition for profit maximization becomes:

$$P + \frac{dP}{dQ}\frac{\partial Q}{\partial q_i} q_i - MC_i = 0 \qquad for \quad i = 1, \ldots, n, \tag{16}$$

where MC_i is firm i's marginal cost. The above expression may be manipulated to give the supply relation formulation frequently encountered in the literature:

$$P = MC_i - \theta_i \frac{dP}{dQ} q_i, \tag{17}$$

where θ_i is $\partial Q/\partial q_i$, the firm's conjectural variation and dP/dQ is the slope of the market demand curve. Further simplification of (17) yields:

$$P = MC_i + \lambda_i q_i \tag{18}$$

where $\lambda_i = -\theta_i dP/dQ$. The form of λ_i indicates that monopoly power can arise either through rival behavior (θ_i) or product differentiation (dP/dQ).

Econometric estimation of λ_i is used to determine the presence or absence of market power.[13] If λ_i is equal to zero, then the firm operates in a perfectly competitive market. If λ_i is greater than zero, then the firm exerts some degree of monopoly power. Note, λ_i is bounded from below by zero, since MC_i cannot be greater than price in the long run. The strength of the NEIO approach is that pricing behavior is not imposed a priori; the data determine this behavior.

III.3 Empirical Methodology

Under the assumption that demand and cost are properly specified, and that (13) and (14) contain independent and identically distributed (iid) random disturbance terms ε_d and ε_c, respectively, the supply relation (18) may be estimated using standard econometric techniques. The exact structure of the supply relation will depend on the form of the cost function. For example, if the firm exhibits constant returns to scale, q_i is separable from other arguments in the cost function and the marginal cost (MC_i) will not depend on output.

The general translog second order approximation of (14) is used in this study and offers advantages over alternative formulations of motor carrier long run cost. First, the translog cost is a flexible functional form that enables explicit testing of the technology structure (e.g., homogeneity and returns to scale) and the application of duality theory to provide for possible efficiency gains in estimation. Second, the translog cost function provides a convenient framework to interact firm attributes (a) with other cost function arguments. Third, the general translog cost function is consistent with a long run equilibrium for the firm. This specification is appropriate because LTL motor carriers regularly rent trucking services. Their rolling stock is variable, even in the short run.

The translog form of (14) is:

$$\begin{aligned}\log C(q_i, w, a, \Gamma_c, \epsilon_c) = {} & \alpha_0 + \gamma_q(\log q_i) + \sum_j \alpha_j(\log w_j) \\ & + \sum_m \beta_m(\log a_m) \\ & + \frac{1}{2}\gamma_{qq}(\log q_i)^2 \\ & + \frac{1}{2}\sum_j \sum_k \alpha_{jk}(\log w_j)(\log w_k) \\ & + \frac{1}{2}\sum_m \sum_n \beta_{mn}(\log a_m)(\log a_n) \\ & + \sum_j \beta_{qj}(\log q_i)(\log w_j) \\ & + \sum_j \sum_m B_{jm}(\log w_j)(\log a_m) \\ & + \sum_m D_{qm}(\log q)(\log a_m) \\ & + \varepsilon_c. \end{aligned} \tag{19}$$

where each variable is normalized by its geometric mean and ε_c is an additive disturbance term. The indices j and k pertain to input prices, q_i to output of the ith firm, and m and n to attributes. Symmetry in cross-price derivatives and linear homogeneity in input prices imply:

$$\begin{gathered} \alpha_{jk} = \alpha_{kj} \quad \textit{and} \quad \beta_{mn} = \beta_{nm} \\ \sum_j \alpha_j = 1 \\ \sum_j \alpha_{jk} = \sum_k \alpha_{jk} = \sum_j \sum_k \alpha_{jk} = 0 \\ \sum_j \beta_{qj} = 0 \\ \sum_m D_{qm} = 0. \end{gathered} \tag{20}$$

Logarithmic differentiation of (19) with respect to an input price produces an expression for a conditional factor cost share equation:

$$\frac{\partial \log C}{\partial \log w_j} = \frac{X_j \cdot w_j}{C} = S_j(q, w, a, \Gamma_S), \quad \forall\, j = 1, \ldots, J \tag{21}$$

where, by Shepard's lemma, X_j is the conditional factor demand for input j. The share equations (21) are estimated jointly with the cost function to increase efficiency.[14]

Firm output, q, is measured as total annual tonmiles by Interstate Commerce Commission (ICC) Instruction 27 common carriers in 1988 (TM88). This output measure is equal to the product of total tons hauled and total distance traveled. Four firm output attributes are included to control for the multidimensional aspects of tonmiles as a measure of output: average length of haul (ALH), average load (AL), average shipment size (AS), and insurance expenditures per tonmile (INS).

ALH is found by dividing total tonmiles by total tons hauled. Firms with longer average lengths of haul are expected to have lower per unit costs as fixed costs associated with terminal expenses are spread over more units of output. AL is found by dividing total tonmiles by total vehicle miles traveled. Firms with higher average loads (measured in tons) will have lower per unit costs. AS (measured in tons) is computed by dividing total tonmiles by the total number of shipments hauled. Average shipment size controls for the consolidation and handling expenses associated with dealing with LTL traffic; firms handling larger shipments do not have to deal with as many transactions, thus they are expected to have lower costs. Finally, higher valued commodities are expected to cost firms more because they often require more costly service quality (i.e., careful handling and faster service). These attribute measures are consistent with applications found throughout the motor carrier literature (Friedlaender and Spady, 1981; McMullen and Stanley, 1988; McMullen and Tanaka, 1993; Kerkvliet and McMullen, 1993; Grimm, Corsi, and Jarrell, 1989)

The factors of production include fuel, labor, purchased transportation, and capital. Definitions of input prices are summarized in Appendix A and are consistent with those used in previous studies (McMullen and Stanley, 1988). Descriptions of all variables used in the cost function estimation are summarized in Table III.2.

Specification of the firm's supply relation follows from logarithmic differentiation of translog cost with respect to firm output:

$$\frac{\partial \log C}{\partial \log q_i} = \frac{MC_i}{AC_i} = \gamma_q + \gamma_{qq}(\log q_i) + \sum_j B_{qj}(\log w_j) + \sum_m D_{qm}(\log a_m) \,. \tag{22}$$

Solving (22) for MC gives:

$$MC_i = AC_i \cdot \left[\gamma_q + \gamma_{qq}(\log q) + \sum_j B_{qj}(\log w_j) + \sum_m D_{qm}(\log a_m)\right], \tag{23}$$

where AC_i is firm average cost. This result is substituted directly into (18) to yield the corresponding translog supply relation specification for estimation:

$$P = \langle MC_i \rangle + \lambda_i q_i + \varepsilon_s, \tag{18'}$$

where ε_s is a random disturbance and $\langle MC_i \rangle$ refers to the expression for MC_i in (23).[15]

TABLE III.2

Variable Definitions and Summary Measures (Based on 184 Observations)

Variable Definition	Variable Name	Mean	Standard Deviation	Minimum	Maximum
COST FUNCTION VARIABLES					
Ton Miles in 1988 (TM Units)	TM88	335,124.255	1,173,250.590	955.000	9,429,041.000
Total Revenue/Total Cost (%)	TRTC	1.039	0.691	0.761	10.324
Average cost ($/TM)	AC	0.470	0.393	0.041	2.429
Price (TR/TM) ($)	P	0.471	0.395	0.040	2.400
Average Load	AL	9.415	4.807	0.950	25.000
Average Length of Haul	ALH	326.596	296.662	22.390	1,546.040
Average Shipment Size	AS	3.549	6.001	0.051	35.983
Insurance Cost/Ton Mile ($/TM)	INS	0.016	0.017	0.001	0.140
Price of Fuel ($/Mile)	PF	0.680	0.249	0.000	1.751
Price of Capital ($/Ton Mile)	PK	1.406	1.448	0.311	9.363
Price of Labor ($/Employee/Year)	PL	35.529	9.394	11.002	56.694
Price of Rented Capital ($/Ton Mile)	PR	1.127	0.472	0.004	3.476
Fuel Cost Share (%)	MF	0.043	0.026	0.000	0.142
Capital Cost Share (%)	MK	0.301	0.087	0.099	0.667
Labor Cost Share (%)	ML	0.521	0.152	0.038	0.814
Rented Capital Cost Share (%)	MRK	0.135	0.162	0.000	0.782
DEMAND (INSTRUMENTS)					
Ton Miles in 1987 (TM Units)	TM87	304,986.940	1,091,547.548	1,021.000	8,628,463.000
Binary Variable (=1 National Firm)	GROUP	0.065	0.248	0.000	1.000
Output of Rival Firms within a Strategic Group	RIVAL	5,220,309.770	3,434,067.910	79,121.000	17,360,206.000

Full information maximum likelihood (FIML) is used to estimate the supply relation (18′) jointly with the cost function (19), restrictions (20), and the factor share equations (21) under the assumption that cross equation disturbance terms are correlated. Since P and q (the firm subscript is ignored here) are assumed to be jointly determined, it is likely that q (which is present in (18′)), may not be independent of the disturbance terms ε_c and ε_s. Under these circumstances, single stage estimation would produce biased and inconsistent estimators for the elements of Γ_c and Γ_s.[16] This study interprets firm output as a stochastic regressor.

Note that (18) does not require explicit incorporation of the slope of the demand curve. However, demand side factors are implicit in λ_i and possibly MC_i, as well (unless constant returns to scale prevail). If firm output is correlated with ε_c (i.e., q_i endogenous), then two-stage methods are required to obtain consistent parameter estimates. The demand side could be estimated in a simultaneous equations framework or an instrumental variable could be calculated for firm output.

We take the latter approach in this study for two reasons. First, it is difficult to model firm specific demand in the absence of data on shipper market characteristics specific to individual trucking firms and markets. Firm data are available only in a national cross-section. Furthermore, our unpublished empirical experiments with alternative direct and inverse trucking demand specifications suggest that the relationship between trucking rates and output quantities is weak. Second, a consistent estimator of reduced form parameters needed to predict q_i using the instrumental variable approach only requires identification of relevant instruments that are correlated with q and contemporaneously uncorrelated with ε_c and ε_s.

The estimation procedure begins with first stage estimation of

$$q_{IV} = q[TM87, GROUP, RIVAL] , \tag{24}$$

where TM87 measures firm output in the previous year and the variables, GROUP and RIVAL measure strategic group effects and are designed to capture demand-side influences on firm output.[17]

The first stage coefficients obtained in (24) are used to calculate the instrumental variable q_{IV} (see Appendix B). Second stage parameter estimates ($\boldsymbol{\Gamma}_{IV}$) are obtained by substituting predicted values q_{IV} from the first stage estimation of (24) for actual firm output q in equations (18′) through (21) and then proceeding with FIML.

Strategic group theory suggests that firms in the same industry fall into clusters that exhibit distinct long run patterns in competitive behavior (Caves and Porter, 1977 and Tremblay, 1993). Authorities on the trucking industry suggest that LTL motor carriers may be divided into national and regional firms. The national firms (Roadway Express, Inc., Consolidated Freightways, and Yellow Freight System, Inc.) operate along transcontinental routes and rely on regional carriers to disseminate their cargo. Differences in strategic variables between national and regional firms in the LTL motor carrier industry are summarized in Table III.3.

Each of the strategic variables listed in Table III.3 differs significantly between the national and regional groups as evidenced by their high t-statistics. The national firms are larger as measured by output, they specialize more in LTL traffic and smaller shipment sizes, travel longer distances and carry greater average loads than regional carriers.

Strategic group theory hypothesizes that firms compete with rival firms inside their strategic group. Thus, national trucking firms are not in direct competition with the regional carriers, since they operate in different markets. RIVAL measures tonmiles of output for rival firms within firm i's strategic group and is based on Tremblay (1985). For national firms, RIVAL is defined as the total output of the other national firms. For regional firms, RIVAL is defined as the total output produced by other regional firms operating in firm i's own state and in states contiguous to firm i's home state.

Strategic group theory indicates further that, since firms in different strategic groups behave differently, the structure of their demand and cost functions may differ as well. Accordingly, the supply relation (18′) and cost function (19) are modified to admit strategic group effects. In the supply relation, λ is assumed to vary across national (λ_N) and regional firms (λ_R). Large national firms have exhibited the greatest gains in terms of revenue and market share since deregulation. If their increase in size has been due to the exercise of market power, then λ_N should be significantly greater than zero. This methodology allows for the possibility of market power for national firms, but not for regional, for instance.

Finally, we explore whether national and regional carriers differ because of their marketing strategy or whether there is a real difference in their entire cost structure. If they have different cost (and thus production) structures, then pooling national and regional data for the estimation of the cost function would bias the estimates of

TABLE III.3

Strategic Differences Between National and Regional Strategic Groups in the U.S. Motor Carrier Industry					
Variable	Strategic Group	Mean	Standard Error	Sample Size	t-Stat
Output	R N	195932.00 8733057.00	441891.07 914277.54	181 3	-16.14
RIVAL	R N	5035691.57 16358900.00	3142944.67 908781.21	181 3	-19.72
LTL	R N	0.464 0.780	0.279 0.028	181 3	-10.85
ALH	R N	311.03 1265.44	272.78 109.50	181 3	-14.38
AL	R N	9.32 15.44	4.78 0.72	181 3	-11.21
AS	R N	3.60 0.52	6.04 0.01	181 3	6.87
INS	R N	0.016 0.005	0.017 0.001	181 3	8.43
P	R N	0.476 0.208	.040 .014	181 3	8.77

Note: R=Regional Group
N=National Group

marginal cost that are crucial to the derivation of the supply relation (18′). To admit differences in cost structure between the regional and national firms, (19) is estimated allowing for different intercepts between the two groups.

III.4 Results

Several models involving different strategic group effects were considered to explore whether national and regional carriers differ because of their pricing behavior or whether there is a real difference in their entire cost structure, or both. If national and regional carriers have different cost structures, then pooling national and regional data for the estimation of the cost function would bias the estimates of marginal cost that are crucial to the derivation of the supply relation (18′). To admit differences in cost structure between the regional and national firms, (19) is estimated allowing for different intercepts between the two groups. This equation is designated (19′).

To allow for strategic differences in pricing behavior, the market power parameter λ in (18′) is allowed to vary for national and regional firms. This gives

$$P = \langle MC_i \rangle + \lambda_R q_i GROUP_R + \lambda_N q_i GROUP_N + \varepsilon_s , \qquad (18'')$$

where the binary variable $GROUP_N$ ($GROUP_R$) is equal to one for national (regional) firms and zero otherwise.

The full model allowing for strategic group effects in both the cost structure and pricing behavior consisting of (18″), (19′), (20), and (21) is estimated using FIML.[18] Also, several variations of the full model are considered. At one extreme, strategic effects in the firm's cost structure and pricing behavior are restricted to be the same across national and regional groups. This restricted model is estimated using (18′), (19), (20), and (21); in effect, national and regional firm data is pooled. Also, two intermediate versions are estimated in which the full model is partially restricted. For intermediate version #1 the cost function intercept is allowed to vary for national and regional firms while pricing behavior is restricted to be the same. The nature of the restriction is reversed for intermediate version #2. In this case, only pricing behavior is permitted to differ across national and regional firms. Estimation results are summarized in Table III.3. Detailed estimation results for each model are reported in Appendix C. Estimation results reported for all models are obtained by substituting the predicted values q_{IV} from the first stage procedure using (24) for actual firm output (q). The Hausmann specification test results reported in Table III.4 favor implementation of the instrumental variable estimator.[19] [20]

Likelihood ratio test results reported in Table III.4 indicate that the full model is not favored over the restricted and intermediate versions. These results imply that neither the structure of cost nor the nature of pricing behavior differ for national and regional firms. Tests for equality of coefficients indicate that cost function intercept terms $GROUP_R$ and $GROUP_N$ in the full model are not statistically different at the .01 significance level.[21]

Estimation results indicate that the output elasticity of cost (coefficient on the log(q) term) is not significantly different from unity for all model versions.[22] Furthermore, the parameter estimates for log(q) are not statistically different across all model versions.[23] These results concerning firm technology suggest that networking economies (Keeler, 1989) size economies (Kling, 1990), strategic

Table III.4

Coefficient Estimates for U.S. Motor Carrier Industry in 1988				
	Model of Strategic Group Effect			
Independent Variables	Restricted: No SG Effect	Version #1	Version #2	Full: SG Effect in Cost & Supply
Cost Function				
Constant	11.500 (32.6829)		11.515 (32.6446)	
$GROUP_N$		12.012 (4.8946)		12.112 (1.5352)
$GROUP_R$		11.509 (32.4246)		11.500 (31.2769)
log(q)	1.252 (7.6794)	1.238 (7.1797)	1.261 (7.9133)	1.228 (6.6173)
Supply Relation				
λ	2.249E-08 (0.1575)	1.004E-08 (0.0615)		
λ_N			2.195E-08 (1.4717)	7.698E-09 (0.0106)
λ_R			-9.947E-09 (-0.0858)	2.930E-09 (0.1429)
Log of Likelihood Function	716.147	717.327	716.421	717.398
Likelihood Ratio Test	2.502	0.142	1.954	-
Hausmann Test	33.513	46.235	48.650	64.788
Observations	184	184	184	184

marketing (Enis and Morash, 1987), or other factors account for cost differences between the national and regional firms.

Estimates of the market power parameters (λ, λ_N, and λ_R) are positive in all but one case, but not statistically different from zero for all model specifications. Even when ignoring the absence of statistical significance, the magnitude of the market power parameters imply a modest market power effect on price. For example, the price cost margin [(P-MC)/MC] for the average firm in the restricted model is 1.93 percent. These results provide evidence that, despite observed increases in industry concentration, there is an absence of market power in the U.S. motor carrier industry following deregulation.

The absence of strong evidence of market power in the national segment of the trucking industry despite the presence of only three large firms suggests that these markets may be contestable. If a large national firm try monopoly pricing in a particular corridor, a regional firm could easily enter that network segment and compete away the excess profit.

The results for regional firms suggest an absence of factors that give rise to local monopoly conditions. For example, entry barriers imposed by differing intrastate regulations do not favor the incumbent regional carrier.

III.5 Conclusion

There are four major conclusions from this study. First, the results from estimation of the supply relation indicate the prevalence of competitive pricing behavior amongst general freight motor carriers nearly a decade after the Motor Carrier Act of 1980. Thus, the observed trend toward increased industry concentration does not imply anti-competitive performance in the sense of rising price-cost margins. The substantial reduction in LTL carriers following regulation reform in 1980 may reflect superior efficiency of surviving firms (Stigler, 1958).

Second, evidence from this study suggests that differences among regional and national carriers are due to marketing strategies rather than to differences in production technology or pricing behavior. Furthermore, it appears that an industry structure consisting of three large national firms and a fringe of regional carriers can be competitive. Regional carriers may be perceived as potential entrants to national markets, curbing the exercise of market power in national markets. The theory of contestable markets (Baumol, Panzar, and Willig, 1988) presents an alternative to Stigler's (1958) survivor test for reconciling the prevalence of competitive behavior in the face of rising concentration.

Third, the results here show that the NEIO approach is a satisfactory research method even in the absence of exerted market power. Past studies (eg., Applebaum, 1982, Porter, 1983, and Suslow, 1986) have focused on industries where market power is generally acknowledged to exist.

Finally, empirical tests consistently indicate that output is endogenous, as predicted in a model of profit maximization in a deregulated setting. Evidence of endogenous output does not necessarily imply that firms exert monopoly power. It suggests only that firms choose output. A key objective of this study is to focus on the extent that firm output decisions influence market price. An instrumental variable procedure is used to control for correlation between the regressor, output, and the disturbance terms in the cost function and supply relation. The results are consistent with past studies in finding no compelling evidence of scale economies even after correcting for endogeneity.

The conclusion that the U.S. motor carrier industry is competitive is supported here both by findings of constant technological returns to scale and by evidence showing the absence of market power in the industry. Accordingly, there is no valid economic argument for reimposition of regulatory policy in the U.S. motor carrier industry.

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III.7 Endnotes

10. The ICC broadly classifies general commodity carriers into (1) those that derived at least 75 percent of their revenues over the past three years from intercity shipments (Instruction 27 firms) and (2) commodity carriers not covered by Instruction 27 that commonly handle specialized shipments in excess of 10,000 pounds (Instruction 28 firms). See American Trucking Associations, (1988 and 1989).

11. Supply "relation" instead of supply function follows from the same reasoning that a price-searching monopolist does not have a supply curve: a one-to-one correspondence between price and firm quantity does not exist.

12. Bold letters indicate vectors.

13. The subscript i indicates that λ_i may vary across firms by factors representing potential sources of market power. See, for example Porter (1983) and Tremblay and Tremblay (1993).

14. One share equation in (21) is dropped to avoid perfect multicollinearity, since the shares sum to one. The choice is arbitrary since full information maximum likelihood is used for estimation.

15. An alternative formulation of the supply relation is sometimes used (Porter, 1983 and Ying and Keeler, 1991). Rearrange (16) to give

$$P + P[\frac{dP}{dQ}\cdot\frac{Q}{P}]\,[\frac{\partial Q}{q_i}\cdot\frac{q_i}{Q}] = MC_i. \tag{16.1}$$

This may be rewritten as

$$P\left[1 + \frac{\theta_i s_i}{\eta}\right] = MC_i, \tag{16.2}$$

where η is the market price elasticity of demand and s_i is firm i's share of industry output. Moving the bracketed term in (16.2) to the right-hand-side gives

$$P = m_i \cdot MC_i + \varepsilon_{sm}, \qquad where \qquad m_i = \left[\frac{1}{1+\frac{\theta_i s_i}{\eta}}\right]. \tag{16.3}$$

Here the parameter m is bounded from below by 1, with m=1 consistent with perfectly competitive pricing behavior and m>1 with exerted market power. One further adjustment is introduced by multiplying through (16.3) by $1/AC_i$. This gives

$$\frac{TR_i}{TC_i} = m_i\left(\frac{MC_i}{AC_i}\right) + \varepsilon_{sm}. \tag{16.4}$$

Estimation results using this formulation (not reported) are comparable to those using the additive formulation given in (18′). That is, the coefficient for m is not statistically different than unity for a wide variety of econometric specifications.

16. For example, Kling (1990) fails to consider endogeneity of q in his econometric specification of a supply relation using a sample of the 23 largest LTL firms in 1987. Consequently, his estimates of economies of size and price-cost margins may contain specification bias.

17. TM87 is not contemporaneously correlated with ε_c provided ε_c is not autocorrelated.

18. The cost function (7) with restrictions (8) and share equations (9) were estimated initially using FIML in order to obtain start values for the full system. Parameter estimates (not reported) are consistent with those from previous studies.

19. A Hausmann specification test was used to test the null hypothesis that q is independent of the disturbance terms in the cost function and supply relation (ie., $\mathbf{\Gamma}_{FIML}$ for the entire system is consistent and efficient) against the alternative hypothesis that q is stochastic (ie., $\mathbf{\Gamma}_{IV}$ is consistent). Under the null hypothesis, the test statistic, $(\mathbf{\Gamma}_{IV} - \mathbf{\Gamma}_{FIML})'[\mathbf{\Omega}_{IV} - \mathbf{\Omega}_{FIML}]^{-1}(\mathbf{\Gamma}_{IV} - \mathbf{\Gamma}_{FIML})$, is distributed $\chi^2_{(k)}$, where $\mathbf{\Gamma}_i$ is a k-element vector of coefficients corresponding to terms in (18″), (19′), (20), and (21) that contain q. $\mathbf{\Omega}_i$ is the corresponding k-dimensional partition of the variance-covariance matrix for respective IV and FIML estimators. For the full model, the test statistic, 64.788 exceeds the critical value 24.72 for a χ^2 variate with .01 significance and k=11 degrees of freedom, supporting the hypothesis that output is stochastic. Comparable results are obtained for the restricted and intermediate models.

20. A Goldfeld-Quandt test is used to test the null hypothesis that the disturbance terms in the cost equation and supply relation are homoskedastic. The middle 24 observations are removed from the sample leaving 73 observations each for the low output and the high output segments of the industry. The null hypothesis cannot be rejected at the .05 significance level for both equations. The values of the test statistics are 0.1550 (cost) and 0.0222 (supply). The critical value for an F(73,73;.05)=1.50.

21. The t-test for equality of $GROUP_i$ (i=N,R) coefficients for intermediate version #1 is 1.967. The null hypothesis (equality) is rejected at the 0.1 and 0.05, but not the 0.01 significance levels. The t-test for $GROUP_i$ (i=N,R) coefficient equality in the full model (t=1.1621) favors the null at the 0.1, 0.05, and 0.01 significance levels.

22. The null hypothesis that the coefficient 1.228 in the full model is equal to unity is not rejected at the .05 significant level.

23. The t-test for equality of coefficients on log(q) is 0.708 for the full and restricted models; 0.283 for the full and intermediate #1 models; 0.975 for the full and intermediate #2 models.

IV. CONCLUSION

Chief among all the conclusions that emerge from this work is that, while economic analysis can not explain the many dimensions of human behavior, it does provide an enormously useful framework for evaluating (i) certain forms of behavior that may not commonly be viewed as economic (subsistence hunting) or (ii) economic behavior that does not clearly fall within the parameters of a particular structure or school of thought (motor carrier pricing).

The results from the analysis of North Slope subsistence participation in part II indicate that both economic and cultural factors determine the subsistence time allocation decision. Subsistence is linked importantly to economics in two ways. First, a marginal increase in wage labor participation (i.e., a shift from under-employment to full-employment) reduces subsistence participation. Second, complete job loss also reduces subsistence participation. The first case may reflect time scarcity effects while the second case is likely to transmit the effect of income scarcity. The latter result provides evidence that subsistence practices are somewhat cash dependent.

The strong statistical significance of explanatory variables measuring gift giving and receiving suggest that traditional sharing practices still play an important role in the modern mixed wage/subsistence economy. This implies that an individual's level of utility can be importantly linked to their perception of community wellbeing.

The results from part III suggest that in spite of a recent trend toward increased revenue concentration and differences in the structure of cost between national and regional carriers, the industry pricing behavior is competitive. To the extent that market power is exerted, it is likely to occur among regional carriers that may benefit from some form of specialized trucking service or local monopoly conditions.

The applied microeconomic analysis contained in parts II and III draws from two research techniques: First, theoretic concepts and quantitative techniques used in other research applications may be appropriate for use in a new set of problems. The dependent variable TIME in part II is a case in point. It attempts to operationalize Becker's (1965) theoretical notions of time allocation. The analysis in part III combines NEIO and Strategic Group theories in a model of firm pricing behavior.

Second, in order to understand and correctly model the process generating the data it is important to incorporate salient features of the institutional setting relevant to the hypothesis under investigation. Inclusion of the cultural variables GIVE and GET and the variable HHWORK to measure the interaction among household members provide examples from part II. The application of switching regression techniques in part III addresses the dichotomous, national/regional structure of the U.S. motor carrier industry.

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APPENDICES

APPENDIX A

All data for the computation of cost and factor prices are from the 1988 Motor Carrier Annual Report. Total cost (C) is calculated to include a 12 percent return to capital

$$C = TOE + 0.12*(NOPE + WC), \qquad \text{(A1)}$$

where TOE is total operating expense, NOPE is net operating property and equipment, and WC is net current assets, or working capital. A real value for net operating property and equipment is obtained by deflating the 1988 dollar values using a ten year average of the producer's durable equipment implicit price deflator for trucks.

The price of labor (PL) is the firm's total employee compensation divided by the total number of employees. The price of rented capital (PR) is total expenditures on purchased transportation divided by the total number of rented vehicle miles. The price of capital (PK) is computed by dividing residual expenses (obtained by subtracting total fuel, labor, and purchased capital expenditures from total cost) by net operating property and equipment plus working capital.

Finally, the price of fuel (PF) is calculated as total fuel and oil expense divided by an estimate of the number of gallons of fuel used. We assume that trucks average 5 miles per gallon and estimate gallons by dividing total vehicle miles by 5. For those firms not reporting purchased transportation or fuel expenses, regional averages were used as proxies for their PF and PR. Firms are assigned to regions according to the state in which the firm is located. Although there are 267 Section 27 firms listed, only 174 firms all the data required for this analysis.

APPENDIX B

Equation (24) was estimated under a variety of specifications. All versions use dummy variables for each strategic group and omit the constant term. The dummy $GROUP_N$ ($GROUP_R$) is equal to one for national (regional) firms and zero otherwise. As shown in Table B.1, F-test results favor model version #3 and suggest that state economic factors (GSP and HWY), firm attributes, and ICC regional dummies are not jointly significant explanatory variables for post-deregulation trucking firm output. In addition, version #3 generated predicted values, q_{IV}, that are positive over the entire range of observations and provide reasonably closed approximations for actual output.

The statistically significant coefficient for the $GROUP_N$ intercept dummy is consistent with the substantially greater output levels produced by national firms over regional firms. The results indicate that tonmiles in the previous period (TM87) interacted with $GROUP_R$ is positive and statistically significant. The effect of an increase in previous period output for national firms ($TM87*GROUP_N$) is negative, but not significant.

The coefficient for $RIVAL*GROUP_R$ is small and not significantly different from zero. This indicates that a regional firm's level of production is not affected by a change in the output produced by rival firms in its region. However, the large, negative, and statistically significant coefficient for $RIVAL*GROUP_N$ indicates that national firm i reduces its output in response to an increase in output by competing national firms. Differences in firm response to the actions of rivals may reflect a difference in the structure of the two markets.

TABLE B.1

OLS Coefficient Estimates for Alternative Instrumental Variable Specifications for TM (Ton Miles)

	Full IV Specification	Restricted Version #1	Restricted Version #2
R-Squared	0.9933	0.9927	0.9925
Adj R-Squared	0.9925	0.9922	0.9923
F-test		0.6444	1.2796
Critical Value		$2.21=F^c_{(5,173;.05)}$	$1.67=F^c_{(15,163;.05)}$
No. Observations	184	184	184

Variable	Full IV Estimate	Full IV t-statistic	Restricted #1 Estimate	Restricted #1 t-statistic	Restricted #2 Estimate	Restricted #2 t-statistic
$GROUP_N$	0.1987E+08	5.7504***	20759700.0	6.1215***	20892400.0	6.1963***
$GROUP_R$	-48061.9	-1.0069	-23305.2	-0.6499	2319.75	0.1569
$TM87_N$	0.3785	1.6992*	0.302	1.3864	0.2927	1.3528
$TM87_R$	1.0543	42.7673***	1.066	45.7274***	1.0663	56.0937***
$RIVAL_N$	-0.8743	-7.4956***	-0.8871	-7.7044***	-0.8893	-7.7663***
$RIVAL_R$	-0.2197E-02	-0.5540	0.1336E-02	0.5281	0.1449E-02	0.5945
GSP	-128.814	-1.1172				
HWY	-.629222	-0.1571				
ALH	-33.6051	-0.7452	-30.9829	-0.7669		
AS	2522.65	1.3478	1700.5	0.9451		
AL	3871.22	1.6570*	1902.91	0.8390		
INS	-306988.0	-0.5136	-437699.0	-0.7431		
LTL	77581.4	1.8049*	41223.1	1.0168		
H2	25869.5	0.6905				
H3	49567.7	1.1725				
H4	39676.3	0.8263				
H5	19040.2	0.3565				
H6	15895.1	0.3313				
H7	66943.5	1.2197				
H8	61527.0	1.2432				
H9	-26907.8	-0.6514				

* Significant at the 0.1 level
** Significant at the 0.05 level
*** Significant at the 0.01 level

APPENDIX C

The tables in this appendix provide detailed results for estimation of the empirical models summarized in Table III.4

TABLE C.1

Coefficient Estimates for Restricted Model: No Strategic Group Effects

Parameter	Estimate	t-statistic
CONST	11.49990	32.68290***
Q	1.25188	7.67943***
Q*AL	-0.01146	-0.10901
Q*ALH	-0.04957	-0.54758
Q*AS	0.03668	0.52981
Q*INS	0.14145	1.74807*
Q*PF	-0.00240	-1.13138
Q*PK	-0.01155	-1.11219
Q*PL	0.01131	1.04602
Q*PR	0.00263	0.18328
Q*Q	-0.02530	-0.39985
AL	-0.31922	-0.83788
ALH	-0.67286	-2.31696**
ALH*ALH	-0.03750	-0.12235
ALH*AS	0.07842	0.66229
ALH*INS	-0.33382	-1.36137
ALH*PL	-0.07488	-2.93704***
AL*AL	0.20996	0.47382
AL*ALH	-0.11742	-0.44904
AL*AS	-0.12865	-0.89355
AL*INS	-0.06444	-0.22253
AL*PL	0.04969	1.41063
AS	-0.15901	-0.77306
AS*AS	0.11294	0.94491
AS*PL	-0.07662	-5.70216***
INS	0.23132	0.59584
INS*AS	0.00015	0.00104
INS*INS	-0.09087	-0.30760
PF	0.05420	9.98000***
PF*AL	-0.01316	-1.96862**
PF*ALH	0.01438	3.06124***
PF*AS	0.01378	6.47138***
PF*INS	-0.00119	-0.25299
PF*PF	0.00819	5.01045***

Parameter	Estimate	t-statistic
PK	0.32837	11.97060***
PK*AL	0.00510	0.19134
PK*ALH	0.04401	2.12326**
PK*AS	0.02475	2.33582**
PK*INS	0.03330	1.49424
PK*PF	-0.00011	-0.04511
PK*PK	-0.00579	-0.51598
PK*PR	0.01262	1.03835
PL*INS	0.01833	0.60842
PL*PF	-0.01238	-3.41199***
PL*PK	0.45677	11.88170***
PL*PK	-0.00673	-0.52448
PL*PL	0.07551	3.35453***
PL*PR	-0.05640	-2.16142**
PR	0.16066	3.22777***
PR*AL	-0.04163	-0.85190
PR*ALH	0.01649	0.52766
PR*AS	0.03809	2.31269**
PR*INS	-0.05043	-1.25974
PR*PF	0.00430	1.29150
PR*PR	0.03948	1.02737
λ	2.2478E-08	0.15749

Log-Likelihood Ratio	716.147
Number of Observations	174

Equation	R-Square
Cost	0.865
Fuel Share	0.488
Capital Share	0.094
Labor Share	0.435
Supply Reln	0.312

* Significant at the 0.1 level
** Significant at the 0.05 level
*** Significant at the 0.01 level

TABLE C.2

Coefficient Estimates for Intermediate Model: Strategic Group Effects on Cost Intercept

Parameter	Estimate	t-statistic
GROUP$_N$	12.01200	4.89461***
GROUP$_R$	11.50910	32.42460***
Q	1.23749	7.17974***
Q*AL	-0.00587	-0.05563
Q*ALH	-0.05905	-0.66376
Q*AS	0.04047	0.59010
Q*INS	0.13434	1.68702*
Q*PF	-0.00244	-1.16073
Q*PK	-0.01166	-1.14749
Q*PL	0.01164	1.10446
Q*PR	0.00246	0.18212
Q*Q	-0.03798	-0.55614
AL	-0.30190	-0.78802
ALH	-0.68344	-2.36257**
ALH*ALH	-0.03397	-0.10754
ALH*AS	0.07580	0.62796
ALH*INS	-0.33151	-1.33665
ALH*PL	-0.07492	-2.94469***
AL*AL	0.20240	0.45990
AL*ALH	-0.11737	-0.44579
AL*AS	-0.11982	-0.80930
AL*INS	-0.05963	-0.20262
AL*PL	0.05017	1.42404
AS	-0.15669	-0.76401
AS*AS	0.10631	0.90009
AS*PL	-0.07692	-5.68933***
INS	0.22549	0.57754
INS*AS	0.00290	0.02020
INS*INS	-0.08909	-0.29593
PF	0.05407	9.85625***
PF*AL	-0.01311	-1.96589**
PF*ALH	0.01433	3.01965***
PF*AS	0.01376	6.48049***
PF*INS	-0.00127	-0.26839
PF*PF	0.00821	5.05261***

Parameter	Estimate	t-statistic
PK	0.32808	12.02100***
PK*AL	0.00513	0.19130
PK*ALH	0.04413	2.12764**
PK*AS	0.02472	2.37744**
PK*INS	0.03314	1.49018
PK*PF	-0.00007	-0.02987
PK*PK	-0.00593	-0.52731
PK*PR	0.01258	1.03969
PL*INS	0.01794	0.58933
PL*PF	-0.01241	-3.43422***
PL*PK	0.45693	11.90300***
PL*PK	-0.00658	-0.51335
PL*PL	0.07544	3.33379***
PL*PR	-0.05645	-2.14842**
PR	0.16093	3.21250***
PR*AL	-0.04219	-0.86314
PR*ALH	0.01646	0.52282
PR*AS	0.03844	2.36662**
PR*INS	-0.04982	-1.23172
PR*PF	0.00427	1.28279
PR*PR	0.03960	1.02564
λ	1.0044E-08	0.06153

Log-Likelihood Ratio	717.327
Number of Observations	184

Equation	R-Square
Cost	0.868
Fuel Share	0.488
Capital Share	0.094
Labor Share	0.435
Supply Reln	0.321

* Significant at the 0.1 level
** Significant at the 0.05 level
*** Significant at the 0.01 level

TABLE C.3

Coefficient Estimates for Intermediate Model: Strategic Group Effects in Supply Relation

Parameter	Estimate	t-statistic
CONST	11.51520	32.64460***
Q	1.26092	7.91327***
Q*AL	-0.01302	-0.12450
Q*ALH	-0.05019	-0.56204
Q*AS	0.03729	0.53466
Q*INS	0.13817	1.70664*
Q*PF	-0.00244	-1.14790
Q*PK	-0.01164	-1.12216
Q*PL	0.01153	1.07438
Q*PR	0.00256	0.17870
Q*Q	-0.02251	-0.38094
AL	-0.31815	-0.83910
ALH	-0.67251	-2.32943
ALH*ALH	-0.03657	-0.12007
ALH*AS	0.07689	0.65602
ALH*INS	-0.33308	-1.35907
ALH*PL	-0.07485	-2.93463**
AL*AL	0.21152	0.48038
AL*ALH	-0.11701	-0.45022
AL*AS	-0.12496	-0.87217
AL*INS	-0.06243	-0.21675
AL*PL	0.04974	1.42054
AS	-0.15870	-0.77362
AS*AS	0.11099	0.92904
AS*PL	-0.07673	-5.69787***
INS	0.22809	0.58832
INS*AS	0.00134	0.00943
INS*INS	-0.09062	-0.30713
PF	0.05410	9.87597***
PF*AL	-0.01315	-1.96915**
PF*ALH	0.01438	3.06218***
PF*AS	0.01378	6.46281***
PF*INS	-0.00120	-0.25496
PF*PF	0.00820	5.01635***

Parameter	Estimate	t-statistic
PK	0.32818	11.92130***
PK*AL	0.00508	0.19016
PK*ALH	0.04408	2.13352**
PK*AS	0.02478	2.34448**
PK*INS	0.03339	1.50053
PK*PF	-0.00010	-0.04058
PK*PK	-0.00584	-0.51937
PK*PR	0.01262	1.03923
PL*INS	0.01812	0.59947
PL*PF	-0.01239	-3.41588***
PL*PK	-0.00669	-0.52054
PL*PK	0.45707	11.83520***
PL*PL	0.07555	3.34414***
PL*PR	-0.05647	-2.15652**
PR	0.16065	3.17596***
PR*AL	-0.04167	-0.85449
PR*ALH	0.01639	0.52339
PR*AS	0.03816	2.32973**
PR*INS	-0.05031	-1.24802
PR*PF	0.00429	1.28513
PR*PR	0.03956	1.02681
λ_H	2.1954E-08	0.17017
λ_R	-9.9465E-09	-0.08577

Log-Likelihood Ratio 716.421
Number of Observations 184

Equation	R-Square
Cost	0.866
Fuel Share	0.488
Capital Share	0.094
Labor Share	0.435
Supply Reln	0.316

* Significant at the 0.10 level
** Significant at the 0.05 level
*** Significant at the 0.01 level

TABLE C.4

Coefficient Estimates for Full Model: Strategic Group Effects in Cost Intercept and Supply Relation

Parameter	Estimate	t-statistic
$GROUP_N$	12.1115	1.53519
$GROUP_R$	11.4998	31.27690***
Q	1.22776	6.61729***
Q*AL	-0.00348	-0.03307
Q*ALH	-0.06069	-0.65616
Q*AS	0.04074	0.59651
Q*INS	0.13464	1.70310*
Q*PF	-0.00243	-1.15225
Q*PK	-0.01162	-1.14884
Q*PL	0.01158	1.11429
Q*PR	0.00247	0.18775
Q*Q	-0.04269	-0.59839
AL	-0.29906	-0.77713
ALH	-0.68618	-2.28417**
ALH*ALH	-0.03375	-0.10505
ALH*AS	0.07636	0.62496
ALH*INS	-0.33154	-1.31680
ALH*PL	-0.07495	-2.95563***
AL*AL	0.19917	0.45097
AL*ALH	-0.11758	-0.44398
AL*AS	-0.12060	-0.80388
AL*INS	-0.06074	-0.20532
AL*PL	0.05024	1.42110
AS	-0.15667	-0.76233
AS*AS	0.10623	0.90423
AS*PL	-0.07692	-5.68161***
INS	0.22550	0.57182
INS*AS	0.00255	0.01772
INS*INS	-0.08948	-0.29616
PF	0.05411	9.91724***
PF*AL	-0.01312	-1.96680**
PF*ALH	0.01432	2.99960***
PF*AS	0.01376	6.47684***
PF*INS	-0.00128	-0.27026
PF*PF	0.008207	5.05267***

Parameter	Estimate	t-statistic
PK	0.32814	12.10230***
PK*AL	0.00514	0.19160
PK*ALH	0.04410	2.11786**
PK*AS	0.02469	2.37506**
PK*INS	0.03305	1.48300
PK*PF	-0.00007	-0.03025
PK*PK	-0.00593	-0.52705
PK*PR	0.01257	1.03796
PL*INS	0.01798	0.593146
PL*PF	-0.01241	-3.43550***
PL*PK	0.45676	12.0915***
PL*PK	-0.00657	-0.51301
PL*PL	0.07540	3.32921***
PL*PR	-0.05642	-2.14183**
PR	0.16100	3.29762***
PR*AL	-0.04226	-0.86630
PR*ALH	0.01652	0.52249
PR*AS	0.03847	2.35145**
PR*INS	-0.04975	-1.23903
PR*PF	0.00427	1.28469
PR*PR	0.03957	1.02326
λ_N	7.6982E-09	0.010601
λ_R	2.9299E-08	0.142869

Log-Likelihood Ratio 717.398
Number of Observations 184

Equation	R-Square
Cost	0.867
Fuel Share	0.488
Capital Share	0.094
Labor Share	0.435
Supply Relation	0.319

* Significant at the 0.1 level
** Significant at the 0.05 level
*** Significant at the 0.01 level