2008

Three papers on the behavior modeling of the shrimp fishermen in the Gulf of Mexico

Tao Ran
Louisiana State University and Agricultural and Mechanical College, tran1@lsu.edu

THREE PAPERS ON THE BEHAVIOR MODELING OF THE SHRIMP FISHERMEN IN THE GULF OF MEXICO

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Agricultural Economics and Agribusiness

by
Tao Ran
B.A., Nanjing Agricultural University, 1998
M.S., Iowa State University, 2004
December, 2008

ACKNOWLEDGMENTS

I am indebted to my major professor Walter R. Keithly, who has been tremendously helpful in my dissertation research and writing. Dr. Keithly also shows extreme patience in my exploring some areas that are new to me. To this student who has endless questions, he is always there trying to help and giving the greatest support in any way he can.

Many thanks also go to the rest of my committee. Dr. Kazmierczak has given many constructive suggestions on conducting the research. Dr. Hill has directed me in building the model and estimation. Dr. Caffey gives many practical suggestions on the policy applications. Dr. Salassi is very supportive in all the aspects. Dr. Crumbley asks very interesting questions which encourage me to explore broader and deeper.

A lot of help has been given by Dr. Escobar from Statistics Department. Dr. Zapata generously lends me handy books on econometric analysis. Thank Ms. Huizhen Niu for making all the maps using GIS, which helps me to illustrate the problem clearly. I also appreciate the computer support staffs of this department for providing timely help on computer issues. In addition, thank the department head, Dr. Cramer, who is always encouraging the students with a positive attitude by saying "Fantastic!", "Keep on going!"

To all the fellow students, thank you for the help in studying, research and even practical things in living. Special thanks are to my officemates in room 215 for bearing with me during the past year. Cristian, thanks for giving me the priority to use the fastest computer. Liliane, thanks for all the encouraging words. Tyler, thanks for all your help in so many practical aspects.

My biggest thanks are to my family members. I appreciate your tremendous patience and deep love. Last but not least, to the Believers at LSU and the church in Baton Rouge, thank you for making my four years here a sweat experience full of meaning.

TABLE OF CONTENTS

ABSTRACT

The overall goal of this research is to empirically analyze shrimp fishermen behavior to help improve the management of the Gulf of Mexico shrimp fleet. Given that optimal management requires consideration of more than the net benefits derived from shrimp harvesting, this research also seeks to provide an empirical framework that would allow future investigators to measure benefits lost through bycatch-related management actions. This paper expands on previous fishing behavior literature by focusing on two of the most important short-run decisions confronting Gulf of Mexico shrimp fishermen (where to fish and how long to fish). A better understanding of these factors can provide useful information to policy makers in designing and implementing more effective policies.

This study uses panel data for up to 15 years, which is a combination of the Coast Guard Vessel Operating Unit File and the Shrimp Landing File from National Marine Fisheries Service. In the location choice analyses, the U.S. Gulf of Mexico is divided into three areas: FL, LAM, and TX. For each area a conditional logit and mixed logit based on Random Utility Model are run to analyze the influence of fishermen's past choice decision on current choice (state dependence), and the fishermen's difference in preferences (preference heterogeneity). The results show that past experience does affect current decision, but the influence dies out fast. In addition, fishers are different in their preference in many aspects. Also, it seems that fishermen's risk attitudes can change over the years. Their tolerance towards congestion exhibits changes over time too. As for their trip length decision, it seems that diesel price is negatively related to the length of days fished, so is the price difference between large and medium sized shrimp. Further, there seems to be a pattern that the trip length is increasing over the years.

The incorporation of unobserved heterogeneity into the location choice and duration models corrects the potential biasedness in estimates and improves the goodness-of-fit considerably, aside from provides intuitive economic interpretations.

CHAPTER 1. INTRODUCTION

1.1 General Background

The Gulf of Mexico seafood industry is not only important to the local and regional economies of the Gulf states (i.e., Florida through Texas), but it also accounts for more than a third of all landings (by weight) in the lower United States (i.e., excluding Alaska). The majority of this catch consists of Gulf Menhaden (*Brevoortia patronus*), a primary source of commercial fishmeal. At the same time, however, the shrimp fleet has consistently harvested in excess of 200 million pounds of shrimp (heads-on) annually during the ten-year period ending in 2004. What makes the Gulf shrimp fishery particularly important is that it accounts for more than 50 percent of the total dockside revenues generated by all Gulf fisheries as well as a significant portion of value-added processing activities. In addition to the harvesting, wholesaling, processing and distribution activities, the shrimp industry supports thousands input supply and retailing jobs throughout the Gulf of Mexico.

While the largest Gulf of Mexico commercial fishery by value, the economic viability of the shrimp industry has, in recent years, deteriorated. This deterioration reflects both a declining output price and increasing input costs. With a rapid increase in cultured shrimp production and subsequent import of much of the product, the Southeast U.S. dockside price (deflated) fell by 40% between 2000 and 2003.[1] Coinciding with the decline in dockside price, the diesel price, which represents the primary variable cost incurred by the Gulf of Mexico shrimp fleet, began a relatively constant upward trend in the late 1990's. Caught in the middle of a "cost-price squeeze," the industry has changed significantly since 2000. These changes include both a

[1] See Keithy and Poudel (in press) for a more detailed discussion of the impact of increasing world shrimp production and export of this product to the U.S. market on the Southeast U.S. dockside price.

reduction in vessels as well as fishing practices among those participants remaining in the fishery.

In general terms, the Gulf of Mexico shrimp fishery is comprised of both an inshore/near shore component and an offshore component. The inshore/near shore component consists of several thousand "smaller" boats and vessels, i.e., generally less than 60 feet in length.[2] The mobility of these craft is limited and, as such, trips tend to be of short duration (often a single day). The fishermen tend to be part-time in nature with the amount of effort exerted by this fleet being tied to the availability of shrimp in inshore/near shore waters and regulations that specify harvesting seasons.[3] Management of shrimp during their early life stages (i.e., when they are in the inshore/near shore waters) is the responsibility of the respective Gulf states.[4]

The offshore component of the Gulf of Mexico shrimp fishery is comprised of larger vessels (generally in excess of 60 feet). These vessels generally make several trips per year and an individual trip can last several weeks. Mobility of the vessels in this component of the fleet allows them to follow the migration patterns of the shrimp (i.e., from the near shore to offshore waters) as well as moving broadly from one area of the Gulf to another if economic conditions warrant such a movement . The management of the offshore component of the Gulf shrimp fishery is under the purview of the Gulf of Mexico Fishery Management Council, one of eight regional councils established under the Magnuson-Stevens Fishery Conservation and

[2] A vessel is characterized as a commercial fishing craft in excess of five net tons. These craft are registered with the Coast Guard. Smaller craft are registered with the respective states.
[3] Without going into detail, the abundance of shrimp in inshore/near shore waters is very seasonal and is tied to the lifecycle of the species. As shrimp grow, they tend to emigrate from the estuaries to the inshore/nearhsore waters at which point they become vulnerable to inshore/near shore fleet effort. As the shrimp continue to age, they move to offshore waters at which point they become susceptible to offshore effort (see Garcia and Le Reste, 1981).
[4] One is referred to the Final Environmental Impact Statement to the Gulf of Mexico Shrimp Federal Management Plan and the various amendments to the Plan for additional information on the inshore/nearhsore shrimp fishery.

Management Act.[5] Unlike most of the fisheries managed by the Gulf of Mexico Fishery Management Council, the offshore shrimp fishery has, until recently, been open access in nature.

Given its historically open-access property rights structure, the offshore shrimp harvesting sector has, until recently, been considered overcapitalized from an economic perspective, and this overcapitalization has resulted in a suboptimal generation of rents and high external costs. [6] These high external costs include incidental by-catch of endangered sea turtle species and important commercial and recreational fish species. There is also concern that trawling may be detrimental to habitat which, in the long run, may further impact the long-run carrying capacity associated with many of the Gulf fisheries.

Various management measures have been considered or implemented in an effort to reduce the externalities associated with shrimp trawling activities, with most of them focusing on seasonal/area closures and/or mandatory harvesting devices that are designed to limit the interaction of shrimp trawls and other species (e.g., turtle excluder devices and by-catch excluder devices). But, although the shrimp fishery is arguably the most important commercial fishery in the Gulf of Mexico, the economic structure underlying the dynamics of the harvesting fleet is poorly understood. This lack of information makes it not only difficult to adequately analyze the impacts of past management measures but also presents obstacles in formulating future policy initiatives that may seek to address not only the direct activities of the shrimp fleet, but also their effect on other fisheries and habitat.

---

[5] More detailed discussion of the Act as well as activities of the Council can be found at www.gulfcouncil.org.

[6] A vessel moratorium was implemented under Amendment 13 to the Gulf of Mexico Shrimp Fishery Management Plan in 2006. While this action curtails new entry into the fishery, it does not address effort by individual vessels. Also, some of the Gulf states have implemented programs that limit effort in state/inshore waters. Texas, for example, has instituted a limited-entry program in conjunction with a vessel buyback program as a means of reducing effort. While the success of this program has been touted by Texas Parks and Wildlife, failure to account for other factors (e.g., output price) that may have contributed to any reduction in effort suggests that the “true” effect of the limited-effort/buyback program remains unresolved.

Previous studies have tended to use bioeconomic simulations of proposed management measures to examine the implications of regulations, but simulations generally do not take into account the behavioral reactions of shrimp fishermen to policy implementation, either in isolation or with simultaneously changing market prices and shrimp abundance.[7, 8] Partly as a result, proposed regulations often do not achieve their anticipated policy goals once implemented, and there appears to be considerable potential for improving management decisions given new insights into the behavioral patterns of shrimp fishermen (Ward and Keithly 2000).

Improvements to the management process can potentially arise from additional information on how fishing practices change in response to changes in relative shrimp prices, management actions, and/or biological abundance. One of the more important factors that should be incorporated into such models is the response of fishermen to changes in economic incentives. For instance, fishermen are likely to adjust their fishing effort in response to the policy or economic effects on their expected revenue or its variability. Because current regulations cannot completely circumscribe the behavior of fishermen, useful management models should account for these responses and incorporate them when determining the feasible set of management options. Given that the response of fishermen is linked to their vessel's characteristics, their past experiences, and their financial situation, it is important to examine how the biological, physical, and economic environment influences their short- and long-run decision behavior. This study

[7] Bioeconomic modeling, which accounts for the majority of the fisheries economics literature, employs hypothetical relationships between major system components and solves for the optimal production level based on these relationships. While these models can characterize the nature of the optimal solutions, they generally have limited practical value because of (a) the lack of information required by the model to accurately examine testable hypotheses and (b) the maintained assumption that fishing effort is under strict control of the regulator.

[8] Given that shrimp is generally considered an annual crop, changes in abundance can be significant from one year to the next, with these changes independent of the amount of fishing effort.

focuses on the decision behavior of the shrimp fishermen in the Gulf of Mexico in terms of site selection and trip duration.

1.2 Study Objectives

The overall goal of this research is to empirically analyze fleet and fishermen behavior in order to help improve the management of the Gulf of Mexico shrimp fleet. Given that optimal management requires consideration of more than the net benefits derived from shrimp harvesting, this research also seeks to provide an empirical framework that will allow future investigators to measure benefits lost through bycatch-related management actions. To accomplish this goal, the following objectives are proposed:

1. Location choice is one of the most important short-run decisions made for each fishing trip, and the potential ramifications of overlooking the spatial behavior of fishermen can include unexpected and perverse outcomes from management policies. As such, the first objective of this study is to examine and quantify those economic, biological, and regulatory factors that influence location choice by Gulf of Mexico shrimp fishermen.
2. Any management action that limits or prohibits fishing in "preferred" areas will result in a loss of welfare to the fleet. Based on the outcome associated with Objective 1, therefore, a second objective of this research is to quantify welfare losses that would be forthcoming from a hypothetical area closure during a portion of the shrimping season.
3. Trip duration represents an additional short run decision made by economic agents in the Gulf of Mexico shrimp fishery. The trip duration consists of two components: travel time (which also includes search time) and fishing time. The third objective of

this study is to examine and analyze the various economic, biological, and regulatory factors that influence trip duration.

1.3 Contributions of This Study

Previous literature covers fishermen's fishing behavior or trip decision in various aspects such as gear change (Eggert and Tveteras 2004), location choice (Mistiaen and Strand 2000), trip length (Smith 1999, Hernandez and Dresdner 2006) and entry or exit (Bockstael and Opaluch 1983, Ward and Sutinen, Smith 2004). This paper expands on previous fishing behavior literature by focusing on two of the most important short-run decisions confronting Gulf of Mexico shrimp fishermen (where to fish and how long to fish). A better understanding of these factors can provide useful information to policy makers in designing and implementing more effective policies. Also, even though there are some notable differences between the Gulf of Mexico shrimp fishery and other fisheries in the Gulf as well as throughout the United States, the models developed for this study can be used to assist in the model-building process that would allow one to examine short-run behavior of fishermen in other fisheries.

From the modeling perspective, this study is one of a select few in commercial fishery which examine those factors that influence the short-run decision making process of fishermen. Major factors included in the respective analyses are seasonality, shrimp abundance and prices, price differentials between different shrimp sizes, shrimper's risk attitudes, tolerance towards crowding, and inertia to change. Two of the chapters, which focus on location choice modeling, examine and consider the differences between conditional logit, the basic model for choice decision, and mixed logit, which allows for a more flexible error term assumption and accounts for the random effect in using a repeated choice dataset. Another chapter is devoted to examining the amount of time engaged in fishing activities on a given trip as well as the duration of a trip.

The analysis is one of only a few that employed survival analysis to model the trip duration decision by individual fisherman in commercial fishery studies.

Since the available data are panel data in nature, the problem of neglecting unobserved heterogeneity in the nonlinear models should not be ignored. This study addresses this problem in the specific aspect of distinguishing true state dependence and unobserved heterogeneity in both the logit model and the duration model. The results from the misspecified model and the improved one are compared and contrasted to give empirical evidence of the importance of incorporating unobserved heterogeneity in the model using panel data.

While the Gulf of Mexico Fishery Management Council has recently taken action to curtail fleet expansion, no actions have been taken to limit the effort among individual vessels. Should economic performance of the harvesting sector improve, one can expect increased effort among individual vessels. Increased effort can be the result of either an increased number of trips or an increase in length of an "average" trip. The survival analysis considered in this study examines the role of economic factors in determining trip length and fishing time and results can be used to help "tailor" policy intended to curtail expansion of effort at the vessel level.

1.4 Outline of This Study

This work accomplishes the objectives through a "journal-article-style" dissertation. Chapter 2 discusses the short-run location choice decision model using a conditional logit model with IIA assumption. Chapter 3 relaxes the IIA assumption and uses a mixed logit model to accommodate the heterogeneous change in fishermen's preference. Chapter 4 uses a duration model to analyze the trip length decision of the shrimp fishermen. Finally, conclusions and considerations for additional research are presented in Chapter 5.

CHAPTER 2. LOCATION CHOICE BEHAVIOR OF THE U.S. GULF OF MEXICO SHRIMP FISHERMEN --- CONDITIONAL LOGIT APPROACH

2.1 Introduction

Fishermen's location choice is one of the most important short-run decisions made for each trip. The potential ramifications of overlooking fishermen's spatial behavior are demonstrated in the studies of various fishing practices and management tools. Recent studies have looked not just at the role of management policy in shaping the spatial expression of fishermen behavior, but also at how explicitly spatial policies interact with fishermen behavior to reach or not reach policy goals. For example, Smith and Wilen (2002, 2003) show that the effect of a spatial policy (such as a marine reserve) is often overestimated when biological modeling includes only a simplistic representation of fishermen behavior. Furthermore, the authors demonstrate that the incorporation of spatial behavior has strong effects on the predicted management outcomes even in cases where the policy analyzed is not spatial in nature.

As evidenced by the previous studies and literature, there is an increasing recognition among marine ecologists, biologists, economists and fishery managers that conventional measures to protect fish stocks, such as season lengths and gear restrictions, generally do not accomplish the desired management goal and that new management approaches are warranted. It is also becoming clear that new policies need to be spatially explicit, reflecting the patchiness of real systems, the heterogeneity of productivity and other life-cycle factors over space, and the kinds and character of mechanisms that link various elements of metapopulations (Walters, 1998, 2000). The purpose of this section is to develop, based on simple discrete choice theory, an analysis of shrimpers' spatial behavior and to provide an *ex post* empirical economic analysis of this behavior. A basic random utility, conditional logit model is used to capture the influence of the factors in shrimp fishermen's location choice behavior. The simplicity of the model provides a basic idea of the modeling process, based on which a more complicated model can be developed. Also, the development and empirical testing of this model can be used to assess and forecast spatial management for more effective management of the Gulf of Mexico shrimp fishery.

2.2 Literature Review

Bockstael and Opaluch (1983) were perhaps the first economists to examine the potential role of behavioral modeling in the management of fisheries. In particular, they point out that regulations can have unexpected and/or adverse effects if detailed and accurate predictions of firm responses to policies are not considered. Based on random utility theory, Bockstael and Opaluch's simple logit choice model incorporates two key factors: economic or noneconomic inertia that prevents fishermen from transferring immediately to a fishery with expected returns higher than the fishery that they are currently in; and uncertainty in returns, a feature they captured by using the expected means and variances of returns. They find that fishermen's response to increasing expected returns is positive while their response to increasing variation in returns is negative, thus leading to an overall sluggish response to changes in expected profit. These results are contradictory to the prevailing belief at the time that fishermen were risk seekers, and suggest that fishing effort can be redistributed among fisheries by policies that directly or indirectly affect the expected returns or variation in the returns.

In a similar manner, Eales and Wilen (1986) ask whether fishermen behave as rational economic decision makers (i.e., maximizers of expected profits) when they select a fishing location. The authors incorporate into their location choice model the potential influence of recent information about fishing success in various regions within the Northern California pink shrimp fishery, with expected catch and distance being the main variables hypothesized to drive location choice. The results of their modeling not only support the idea that fishing location choice is an economically motivated process, but also that a good predictor of current fishing activity and location is the activity and location exhibited in the previous time period. In essence, fishermen tend to exhibit repeated behavior in the choice of fishing location.

Another important paper in the study of fishing location choice is that by Holland and Sutinen (2000). The authors examine reasons for participation in a given fishery and the fishing location choice, focusing on the New England trawl fishery. Through ethnographic interviews and the explicit use of spatial components in a random utility, nested-logit empirical model, the authors are able to conclude that both historical and more recent information are important in location and fishery choice, especially information based on personal experience. While the method employed by the authors in combining various pieces of economic and sociological data is somewhat unique, their use of simple dummy variables to proxy experience and their implicit assumption that fishermen have a uniform attitude towards uncertainty leaves room for improvement. This is especially true given that their results indicate that fishermen are uniformly risk seekers, a conclusion that might not hold for each specific fisherman.

One approach to improving the realism of the expectations process in location choice studies is attempted by Dupont (1993) in analyzing the salmon fishery of British Columbia. Instead of using simple past experience, expected profits and their variations are calculated using prices that are themselves predicted using an ARIMA model. The author compares two different model specifications; one using expected seasonal profit and its variability as explanatory variables, and the other using expected wealth and its variability as explanatory variables. The results of the study indicate that location choice decisions are positively related to expected profits, but that expected wealth plays a more important role in explaining location choice behavior. In addition, if only expected profits are considered, fishermen as a whole are found to be risk-neutral in behavior. If pre-season wealth is included in the model, however, fishermen as a whole appear to be risk seekers, suggesting that fishermen are more willing to run risks if their initial wealth level is high.

2.3 Econometric Model

In this chapter, a conditional logit model[9] based on random utility theory is used to analyze location choice by the Gulf of Mexico offshore shrimpers. In reality, expected utility is not directly observable. It can be modeled through the indirect utility function, which is usually a linear combination of observable explanatory variables and is treated as the systematic or non-random component of expected utility. Here the implied assumption is that the alternative chosen is the one which generates the highest expected utility (Holland and Sutinen 2000).

The discrete choice formulation with respect to spatial decision-making is consistent with the basic random utility model (RUM) in McFadden (1974 and 1981), assuming that the fishermen make location choices among several discrete alternatives (fishing areas). RUM is a frequently used method in economics to model discrete choices made by individuals. Two parts comprise the typical RUM: one is a systematic component of utility, the other is a random component of utility. The former is observable and non-random to all individual agents in the data set, while the latter is unobservable and varies across individuals and/or alternatives. The model captures the empirical phenomenon observed by analysts that individuals having the same observable characteristics often make different choices.

The basic idea of the model is illustrated in the following equation from Wilen et al. (2002), with EU being expected utility

$$EU_{ijt} = E\overline{U} + \varepsilon_{ijt} = g(X_{it}, Z_{i1t}, Z_{i2t}, \cdots, Z_{iMt}; \theta) + \varepsilon_{ijt} \qquad eq.\ 2.1$$

[9] The term conditional logit sometimes is interchangeably used as multinomial logit. Rigorously speaking, conditional logit model contains alternative and individual specific explanatory variables; whereas multinomial logit model includes only individual specific explanatory variables.

where X_{it} includes individual-specific and time-specific characteristics that are constant across choices, Z_{ijt} includes alternative-specific characteristics such as travel costs and expected resource abundance that may also be individual- and time-specific, θ is a parameter vector, and ε_{ijt} is a random component that is unobservable to the analyst. This random utility model posits that given M possible fishing locations and the possibility of not fishing, fisher i in period t will choose location k if the expected utility of choice k is higher than that of the other M - 1 location choices as well as the choice of not to fish in period t. For instance: Pr [i chooses 1 at t] = pr [$EU_{i1t} > EU_{i2t}$, $EU_{i1t} > EU_{i3t}$, … , $EU_{i1t} > EU_{iMt}$, $EU_{i1t} > EU_{inot}$]. The error is assumed as independent and identically distributed log Weibull, and the probability function of the ith individual chooses jth alternative at time t is

$$P_{ijt} = \frac{\exp[E\overline{U}(\theta, X_{it}, Z_{ijt})]}{\sum_{j=1}^{J} \exp[E\overline{U}(\theta, X_{it}, Z_{ijt})]} \qquad eq.\ 2.2$$

From this the log-likelihood function can be written as

$$L = \sum_{i=1}^{I} \sum_{j=0}^{J} d_{ij} \ln p(y_i = j) \qquad eq.\ 2.3$$

where

$$d_{ij} = \begin{cases} 1, & individual\ i\ chooses\ alternative\ j \\ 0, & otherwise \end{cases}$$

One of the implicit restrictions made by conditional logit model is the Independence of Irrelavant Alternatives (IIA). This means that the ratio of the probabilities for any two alternatives does not depend on a third alternative, namely, the ratio of any two alternatives is necessarily the same regardless of what other alternatives are in the choice set or what kind of characteristics of the other alternatives are. This restriction essentially follows from the iid (independent and identically-distributed) assumption of the error term, which may not be valid in a wide variety of economic situations. Other specifications of the model (e.g., the nested logit and multinomial probit) have been proposed as a means of relaxing this restriction.

In this chapter, a conditional logit is considered for each of the three large areas within the Gulf of Mexico study area: Florida (FL), Louisiana/Alabama/Mississippi (LAM), and Texas (TX) based on the assumption that IIA holds within each of the three areas.[10] The IIA assumption is tested in the next chapter when a mixed logit analysis is conducted. Also, not fishing is not included in the choice set, as it may involve fishermen's labor leisure trade-off decision, which is not the focus of this study.

2.4 Data Description

The data used in the location choice model is a combination of the Coast Guard Vessel Operating Unit File (VOUF) and the Shrimp Landings File (SLF).[11] Information in the VOUF, which is collected on an annual basis, includes vessel and gear characteristics (e.g., vessel length, vessel age, type and number of gear employed). As discussed in more detail in a subsequent section, data in the VOUF are used in both the location choice model and to standardize effort by grid; a prerequisite to estimating the final location choice models.

The SLF includes detailed information on individual shrimp trips including geographical information covering the spatial distribution of landings, effort, and other critical variables for management. The geographical information has three major components – a harvesting location defined on a statistical grid of longitude and latitude, a harvesting depth based on the fathom zone where harvesting is reported, and a record that identifies the port where the harvest was

[10] The alternative to this model would be a nested logit. Due to the wide coverage of the study area, however, a conditional logit model for each area is considered (e.g., a Texas shrimper may never consider a Florida area).
[11] The Shrimp Landings File is maintained by the National Marine Fishery Service (Galveston Laboratory). It includes detailed information on individual shrimp fishing trips and the data have been collected since the 1960's.

landed. The statistical grids are roughly defined as 1^{o} longitudinal or latitudinal areas that project from shore out to 50 fathoms, with 21 of these grids occurring in the U.S. Gulf of Mexico territorial waters. The fathom zones are defined as intervals of water depth in 5 fathom increments from the U.S. shoreline out to 50 fathoms. Given the bathometry of the continental shelf in the Gulf of Mexico, the overlap of these two measures generates a maximum of 210 statistical subareas to which harvesting activity, and thus landings, are assigned during data collection (Figure 2.1).[12]

Two periods of time (1995-1999 and 2000-2004) have been chosen to capture fishermen's location choice behavior. These two time periods are selected based on the changing economic viability of the fishing fleet. Specifically, the first five year period can be characterized as one of relative financial fleet stability. The second period can be characterized as one of rapidly deteriorating economic conditions associated with a rapidly declining dockside price and increasing input costs (particularly fuel costs).[13] Only large vessels (vessel length >= 60) who appeared at least once each of five years are considered in the analysis since their movement is more relevant and their choice decisions are more consistent.

After observing the frequency of the vessels who visited different areas from their homeports, it is observed that most trips that departed from Florida ports had as their harvesting destinations subareas 1-8 (which are offshore the Florida peninsula and panhandle), while most of the vessels home ported in Texas had as their harvesting destination statistical subareas 14-21. Vessels home ported in Alabama, Louisiana, and Mississippi mainly harvested in statistical subarea 10-18. Given this relationship between the home port and the harvesting area, the overall

[12] The statistical grid and fathom zone information that is recorded when a fishing vessel interview is not conducted is "assigned" by the port agent based on information obtained from the dealer or knowledge of the fleet's activity.
[13] In each period of analysis, five years of data are used to ensure a sufficient number of observations.

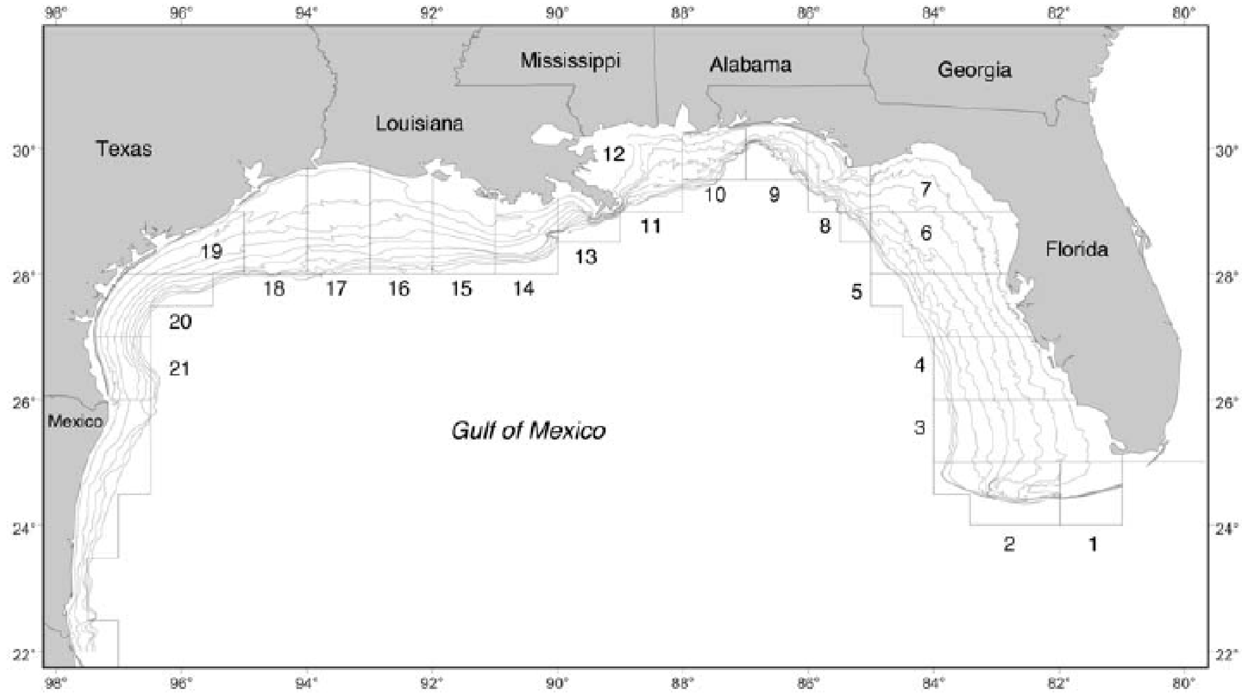

Figure 2.1 Relationship of 1° longitude/latitude statistical grids with fathom zones in the U.S. Gulf of Mexico (from Nance, Keithly, et al. 2006)

SLF dataset is divided into three geographical subsets, one each for Florida (FL), Texas (TX), and the aggregation of Louisiana, Alabama and Mississippi (LAM). This separation of the overall data in three geographically distinct datasets is important for the location choice modeling, as the computational burden would generally preclude the use of the entire SLF dataset. As might be expected, not all of the 210 potential statistical subareas received an adequate number of harvesting visits to be used in any spatial analysis, as some of the subareas are either not traditional fishing locations or have not yielded many recordable harvests. In order to ensure that any given spatial location had enough observations to analyze, the subareas are aggregated into newly defined grids.[14] This process resulted in six aggregated grids for the FL

[14] These grids are aggregations of the statistical grid/fathom zone information contained in the SLF. Given that the aggregation is designed with the twin goals of gaining enough observations per location and keeping the geographic expanse of each grid at a minimum, trips to some infrequently visited subareas that lay at the outer spatial edges of harvesting activity are deleted from the data (approximately 5-7 percent of all trips). In general, aggregation decisions are based on two factors: (a) ensuring a sufficient number of observations per location for statistical

data (Table 2.1), 18 aggregated grids for the LAM data (Table 2.2), and 16 aggregated grids for the TX data (Table 2.3). The geographical figures are available in Appendix A.

Table 2.1 Grids Assignment in FL Area

Grid	Fathom	Subarea
F1	5-15	1,2,3
F2	5-10	4,5,6
F3	0-10	7,8
F4	15-25	1,2,3
F5	10-15	4,5,6
F6	10-15	7,8

Table 2.2 Grids Assignment in LAM Area

Grid	Fathom	Subarea
M1	0-5	10,11
M2	0-5	12,13
M3	0-5	14,15
M4	0-5	16
M5	0-5	17,18
M6	5-10	10,11
M7	5-10	12,13
M8	5-10	14,15
M9	5-10	16
M10	5-10	17,18
M11	10-15	10,11
M12	10-15	12,13
M13	10-15	14,15
M14	10-15	16,17,18
M15	15-25	10,11
M16	15-25	12,13
M17	15-30	14,15
M18	15-20	16,17,18

Table 2.3 Grids Assignment in TX Area

Grid	Fathom	Subarea
T1	0-10	18
T2	0-10	19

analysis and (b) use in the management process. As such, attempts are made to aggregate in a manner that would be most useful for management purposes subject to the constraint of a sufficient number of observations.

Table 2.3 , continued

T3	0-10	20
T4	0-10	21
T5	5-20	14,15,16
T6	5-20	17
T7	10-20	18
T8	10-20	19
T9	10-20	20
T10	10-20	21
T11	20-35	14,15,16
T12	20-35	17
T13	20-35	18
T14	20-35	19
T15	20-35	20
T16	20-35	21

Among the three areas, Florida has the fewest trips and the greatest concentration of trips to a single grid location, with 412 FL home ported vessels making 14,043 trips in the 1995-1999 period and 336 FL vessels making 10,132 trips in the 2000-2004 period.[15] For TX data, 971 vessels made 41,757 trips in 1995-1999, with 964 vessels making 32,433 trips in 2000-2004. Lastly, 689 LAM home ported vessels made 33,664 trips in years 1995-1999 and 722 LAM vessels made 32,076 trips in years 2000-2004.[16] Approximately 10 percent of the total trips from TX and LAM visited more than one of the newly defined grids on a single harvesting trip. In

[15] A brief description of the rationale of the choice of time periods are: data before 1995 appears to suffer from systematic consolidation of vessel information such that effort calculations may not be representative of the important parts of the commercial fleet. Data from 2005-2007 represents a fleet severely impacted by hurricanes Katrina and Rita and the adjustments that were made, and are still being made, in the industry. Given that this study is focused on fundamental harvesting behavior and not behavior during transitional periods following exogenous shocks, the chosen time period is deemed appropriate to best represent the long-run economic behavior of the harvesting fleet.

[16] Note that these reported trip numbers are slightly lower than the potential number of trips that could have been used as reported in Table 2.4 with the difference being trips for which various information needed for the location analysis (in particular, vessel length) could not be obtained.

these cases, the dominant location (e.g., the one that has the most catch) was assigned as the fishing location.[17]

For each of the vessels and defined grids, a measure of vessel mobility is estimated using the spatial coefficient of variation for each vessel in each of the sample periods. This is

Table 2.4 Percent Trips Used in Analysis and the Total Number of Trips Potentially Used

	1995 – 1999		2000 - 2004	
Geographic Area	Percent	Trips	Percent	Trips
FL (Florida)	96.6	14,135	92.4	10,174
LAM (Louisiana, Alabama and Mississippi)	93.8	36,109	91.2	37,735
TX (Texas)	96.3	50,395	91.7	38,968

accomplished by computing the mean grid number, the standard deviation of the grid number, and the coefficient of variation of the grid number (or the ratio of the standard deviation to the mean) for each vessel, thereby generating an approximate measure of the varying degrees of mobility between grids for the vessels, with higher coefficients of variation implying higher degrees of mobility. Vessels operating in FL and TX tend to be less mobile in the period 2000-2004 compared to the earlier time period, perhaps due to increases in search costs or other factors (Table 2.5 and Appendix B). For example, while less than 50% of the TX fleet falls in the 0-1 CV range during the 1995-99 period, the proportion increases to almost two-thirds (63.9%) during the most recent five-year period. LAM-based vessels, however, are more mobile (at least by this measure) in 2000-2004 compared to the earlier time period, although it is difficult to

[17] If there was information pertaining to the timing of these visits (i.e., which of the newly defined grids was visited initially, secondly, etc.), then an alternative model could have been proposed which would have accounted for multiple site visits. Since this information does not exist, this modeling effort was not pursued.

imagine why they might be different than vessels in the TX area.[18] One possible explanation is related to deviations in the way data was collected for Louisiana and Alabama during 2002-2004, a time period when fathom zone information was not recorded.

Table 2.5 Measured Coefficients of Variation (CV) Of Fishing Grid Choice

	Percent of Vessels in the Mobility Range					
	1995-1999			2000-2004		
Mobility CV Range	FL	LAM	TX	FL	LAM	TX
0-1	71.1	27.7	49.4	79.7	18.0	63.9
1-2	27.5	35.3	35.4	18.6	9.6	26.1
2-3	1.4	20.8	12.8	1.7	14.0	8.1
3-4	---	11.4	1.6	---	19.7	1.6
4-5	---	2.8	0.6	---	19.0	0.2
5-6	---	0.6	0.2	---	11.8	0.1
6-7	---	0.3	---	---	4.5	---
7-8	---	0.6	---	---	2.4	---
8-9	---	0.0	---	---	0.2	---
9-10	---	0.3	---	---	0.1	---
10-11	---	0.1	---	---	---	---
11-12	---	0.0	---	---	---	---
12-13	---	0.0	---	---	---	---
13-14	---	0.1	---	---	---	---

In order to maintain data consistency over time and space, NMFS developed a method to estimate this lost fathom information from known depth data, biological, and seasonal

[18] It makes more sense that LAM vessels would be more mobile than FL vessels given the smaller size of the FL fleet and its fishing grounds.

characteristics of the harvests (Nance, Keithly, et al. 2006). This calculated information is currently part of the shrimp landings data files used for this study and may have introduced error into the LAM mobility calculations for this latter time period.

2.5 Variable Description

The dependent variable for the estimated models is grid choice, where separate models are estimated for each of the three state-based areas being investigated (FL, LAM, and TX) Furthermore, as noted, the analysis focuses on the period 1995-2004 which is divided into two time periods (1995-1999 and 2000-2004). The explanatory variables selected are: vessel length (vel), expected revenue (wer), the coefficient of variation of expected revenue (vcof), distance adjusted by Gulf of Mexico diesel price index as proxy for cost (distance), loyalty (loy), crowding externality (crwd), and the squared term of crowding externality (crwd2), seasons, and TX closure (txcl). Of these, vessel length, expected revenue, variation of expected revenue, distance, crowding externality, and crowding externality squared are continuous variables. Summary statistics associated with the continuous variables are provided in Appendix C. The remaining variables (season and txcl) are discrete and/or dummy in nature. The variables included in the location choice models are briefly discussed below.

<u>Vessel Length (vel):</u> While vessel length is self-explanatory, within the context of a location choice model it serves as a proxy for the vessel's mobility given that larger vessels are observed in the data to fish in more locations that are further apart (but not necessarily on a given trip).

<u>Expected Revenue (wer):</u> Although the calculation of expected revenue (wer) would seem to be straightforward, there are a number of different ways it can be derived depending on the availability and quality of data. Smith (2005) simply uses an individual vessel's past revenue as expected revenue, whereas Holland and Sutinen (2000) use overall past fleet revenue as

expected revenue for a location. In this study, it is assumed that shrimp fishermen share information about past catch experience at different locations, either because they have formal financial ties among vessels that provide incentives for information sharing or because of family and social arrangements. As a result, the weighted average fleet revenue during the previous 10 days is used as the proxy for the expected revenue of a particular vessel-trip to a given grid location.[19] In order to calculate the average fleet revenue, days fished for each trip needs to be standardized to account for the way technological inputs varied among vessels. In addition, information on days fished is only available for a small subset of the shrimp landings data (the interview data), and for most of the observations it needs to be estimated. A number of methods were attempted to estimate days fished for the non-interview data, with a simple linear regression ultimately chosen as the best method due to its simplicity and overall smallest estimation error. The linear regressions used the interview data to regress days fished against a set of variables that are recorded for both interview and non-interview data, including shrimp price, catch per trip, vessel length, subareas, depth, landing year, landing month, gear, and species (Appendix D). Once estimated for the interview data, the relationship is then used to predict the days fished for each trip observation in the non-interview data. After this, catch-effort linear regression is estimated to obtain parameter estimates of the relative role days fished per trip, vessel length, and foot rope length (as indicators of effort) played in determining catch. These estimates are

---

[19] The 10-day 'window' period used for estimating expected revenues is based on two factors. First, the use of this time frame generally generated a number of observations in each aggregated area sufficient to provide a 'reasonable' estimate of expected revenues (e.g., if a much shorter period is considered, the number of observations, in certain areas, is extremely low which would preclude developing reliable estimates). Second, the information content associated with trips ending more than 10 days prior to a vessel leaving port is believed to be heavily discounted. Some initial attempts were made to develop a distributed lag function wherein more recent fleet landings were assigned a higher weight, but gaps in the data precluded use of such a technique (e.g., there may have been some fleet landings during the past 2, 5, 8, 9, and 10 days but no reported landings during the previous day, days 3 and 4, and days 6 and 7). Lastly, despite this level of temporal aggregation, there were still some (though relatively few) observations for which there were no trips during the previous 10 days. In these cases, the minimum value among the other areas included in the specific analysis during the same 10-day period was used as a proxy.

then used to calculate the relative fishing power index on which the days fished per trip is standardized.[20]

Another unfortunate aspect about this data set is that only landing date information is available instead of departure date for the non-interview data. To solve this, days fished are used to estimated days at sea, from which the departure date can be estimated. Finally the average expected revenue is obtained as the ratio of the sum of the fleet revenue over the sum of the standardized days fished during the past ten days before departure. This ratio is then weighted by the vessel's portion of the fleet revenue each year so that different vessels departed on the same day and went to the same grid would have different expected revenue.

Coefficient of Variation of Expected Revenue (vcof): Variation of the expected revenue as a measurement of uncertainty in the expected revenue is calculated based on the assumption that fishermen share information among themselves. To estimate *vcof*, the standardized per trip revenues over the past ten days are first calculated. Then, the variation is the variance of per trip revenue with respect to the average revenue in the past ten days. The calculation of the per trip variance involves the variance of trip revenue within a single fishing day, the weighted variance of daily revenue during the past ten days, and the weighted cross product of per trip revenue variance within a day and of the daily revenue variance over the past ten days. The coefficient of variance is then obtained by dividing the variation by the expected revenue. If the estimated

[20] Although similar to the procedures used by Griffin, Shah and Nance (1997) and Griffin (2006), the model used to estimate days fished in the current study has some noteworthy differences. Specifically, based on the interview data, we first estimated days fished for each trip by individual species (four in total and included in the analysis using dummy variables) and by aggregated sites. We then aggregated across individual trips to determine the estimated days fished. The aggregated estimated days fished for each trip in the interview data was then used to estimate days fished for each trip in the non-interviewed data set. While this approach is considered to be preferable, given the model objectives, to that of Griffin, Shah and Nance (1997), it is obvious that the parameter results for either approach are likely to be biased and inconsistent as a result of simultaneity not considered in the model formulation. Specifically, while days fished is a function of catch per trip, the latter is also likely to be a function of the former. Given that the model is being used strictly for prediction purposes, however, OLS estimates should predict as well as, if not better than, any instrumental variable (e.g., 2SLS) or GMM technique (Pindyck and Rubinfeld, 1998). As such, we did not attempt to estimate days fished using an instrumental variable technique.

parameter associated with *vcof* is positive and significant, the fishermen are considered to be risk-loving. Conversely, if the estimated parameter associated with *vcof* is negative, fishermen are considered to be risk averse.

Distance (distance): The distance traveled to a fishing location is used in this study as a proxy for the cost of the trip given that cost data is generally not available for this fishery and any attempt to directly estimate it would be complicated and require numerous simplifying assumptions. Distance from a landing (departure) port is determined using a GIS (geographic information system) routine that calculated the straight-line distance from a vessel's departure port to the centroid of each fishing location grid. This distance measure is then weighted by the monthly diesel price index for the Gulf of Mexico region in order to account for the market-based price effects on the costs incurred by harvesters on any given trip.

Loyalty (loy): It is generally assumed that an individual's current choice behavior is to some extent influenced by their past decisions and should be taken into account when modeling location choice. A positive effect of loyalty may be an indication of habit persistence, as discussed in Holland and Sutinen (2000), inertia related to exploration of other locations, or familiarity combined with risk aversion. A negative effect, on the other hand, might be the result of variety seeking due to the risk-loving nature of the individual or a result of unobservable frustration associated with previously chosen locations (Bhat et al. 2002). In the marketing and labor economics literature, state dependence is described as a phenomenon where "individuals who have experienced an event in the past are more likely to experience the event in the future than are individuals who have not experienced the event" (Heckman 1981). Using this definition, Heckman defines two basic kinds of state dependence. The first kind of state dependence, termed true state dependence or structural state dependence, represents a situation where there is a genuine behavioral effect such that the experience of an event changes the individuals' preferences and/or constraints relevant to future choices. The second kind of state dependence, termed spurious state dependence, is caused by improper control of some unmeasured variables that happen to be correlated over time, thus making previous experience erroneously appear to be a determinant of future experience (where, in fact, the underlying reason is that past experiences are serving as a proxy for the temporally persistent unobservables). If this unobservable heterogeneity is not properly controlled for in the modeling, the estimate of the true state dependence may be biased. While a number of studies in the marketing literature have examined the different sources of state dependence (Seetharaman 2004, Keane 1997), in general they have found that true state dependence and unobserved heterogeneity capture most of the observed temporal dynamics in choice behavior. The measurement of true state dependence is part of this conditional logit modeling (the mixed logit modeling presented in Chapter 3 will discuss the measurement of unobserved heterogeneity).

In deciding how to incorporate measures of habit persistence, or true state dependence, into a choice model, a number of methods might be used. A simple approach would be to use dummy variables that indicate whether or not a vessel visited a fishing location in some set of previous time periods, but this assumes that the relevant time period is known and that the importance of information gained at the location is the same whether the last visit was recent or at some time in the more distant past. A better assumption would be that previous years' experiences have an influence on current decision making, but that the degree of influence decays as time passes. Using this assumption, a loyalty variable (loy) can be estimated in a way that measures true state dependence and can be incorporated into the location choice model without introducing a large number of estimable parameters. Guadagni and Little (1983) proposed a method that remains popular in the literature, one where true state dependence is an exponentially weighted average of the past decision history of the individual. Specifically, the measure has the following structure:

$$LOY_j^i(t) = \lambda LOY_j^i(t-1) + (1-\lambda)y_j^i(t-1) \qquad \textit{eq. 2.4}$$

where $LOY_j^i(t)$ is loyalty of individual i to alternative j on choice occasion t, $y_j^i(t)$ is a dummy variable indicating whether individual i chose alternative j on choice occasion t or not, and λ is a smoothing parameter which takes the value between zero and one.

The expression (*equation 2.4*) is a linear combination of the previous periods' loyalty and the previous period's choice decision. If the equation is solved backwards, it is the sum of the initial period's loyalty and a geometrically decaying sum of all previous decisions associated with a given alternative. Several methods were proposed in previous studies to estimate the smoothing parameter λ, and the one used here is by Fader, Lattin, and Little (1992). Given that loyalty is nonlinearly dependent on the single parameter λ, and λ cannot be estimated directly as an ordinary logit coefficient, a Taylor series is used to expand the loyalty variable at a starting value λ_0. If the derivatives of loyalty with respect to λ are bounded in an interval containing both λ_0 and the maximum likelihood estimate value of λ, then the second and higher order terms in the Taylor expansion will approach zero as λ_0 approaches its maximum likelihood estimate value. Therefore, only loyalty and the first derivative of it are included in the conditional logit model to estimate λ iteratively. The model estimation is then divided into two steps – first, estimate λ using LOY and its first derivative, then, secondly, use the optimal value of λ to calculate LOY and include LOY in the full model to estimate all of the remaining parameters. For this study, the initial value of LOY is taken as the same for all the alternatives, being one divided by the total number of alternatives. Thus, for the FL model, the initial LOY is 1/6 for each alternative, while it is defined as 1/18 and 1/16 for each alternative in the LAM and TX models, respectively. All

10 years of the data (1995-2004) are used to estimate λ for each area, and the process yielded results that are consistent with similar estimates that have been published in the marketing literature (values close to 0.75).[21]

Crowding Externality (crwd): As might be expected, a particular fishing location tends to be popular when shrimp are abundant at the site. When too many vessels go to the same area, however, the location might become less desirable, however, because of the crowded, competitive conditions for harvesting regardless of the continuing abundance of shrimp stock. As a result, the crowding externality manifests itself in reluctance by fishermen to visit the location. For the purposes of this study, the crowding externality (crwd) is proxied by days fished per unit area of a location. Conceptually, if there is a large amount of fishing effort at a particular location in the previous ten days, it likely means that shrimp abundance is relatively high in that location. When the days fished is divided by the actual size of the location grid (in acres), it yields a measure of how intense the fishing is on a per unit area basis, which itself is an indicator of the "traffic level" during the past ten days. Given a constant number of days fished in the previous ten days, a larger grid (defined in terms of acres) will generate a smaller ratio and a smaller measure of the fishing traffic, or, a smaller measure of the crowding externality. In addition, the squared term of the crowding externality measure (crwd2) is included in the model because it has been hypothesized in the literature that the crowding effect will not generate changed behavior until some threshold is reached. Numerically, this suggests that a crowding indicator at the beginning should have a positive effect on the expected utility of choosing the grids, since a higher the ratio is presumably generated by a greater abundance of shrimp at that location.[22] After the indicator reaches certain level, however, the expected utility associated with

---

[21] The values are 0.786 for FL, 0.795 for LAM and 0.83 for TX.

[22] Recall, however, that expected revenue is a variable included in the model. Hence, it might be preferable to consider the positive effect as benefits forthcoming from social arrangements (e.g., knowledge that other vessels are

choosing the grid declines due to the competition for harvesting space. When the negative effects of the crowding externality outweighs the attractiveness of an area due to shrimp abundance, then fishermen would choose to harvest in other areas. Therefore, the crowding indicator is hypothesized to have a positive sign, with its squared term taking on a negative sign.

Season: In terms of season, a dummy variable approach is used to define specific monthly periods during the year that appear to correspond well with overall catch fluctuations in the shrimp industry in each of the three state-based areas examined in this study.[23] In the FL models, two seasons are defined: season 1 (November-June) and season2 (July-October). In the LAM models, three seasons are defined: season1 (December-April), season2 (May-June), and season3 (July-November). Like the LAM models, three seasons are defined for the TX models: season1 (January-May), season2 (June-September), and season3 (October-December).

Texas Closure (txcl): The Texas Closure, a seasonal management event that precludes harvesting in all but the inshore waters off of the Texas coast, is modeled using a dummy variable approach. In general, the Texas Closure occurs from mid-May to mid-July each year, with some variation in the specific regulatory dates. [24] Given the assumption that Florida-based vessels do not participate in the TX or LAM shrimp fisheries, the estimated FL models do not include a Texas Closure variable.

2.6 Results and Interpretation

The results for conditional logit estimation of the location choice for the periods 1995-1999 and 2000-2004 for the three study areas are presented briefly in the tables below and in

---

in the area which allows for the sharing of information on a 'real time basis'. This explanation may be particularly appropriate given the relatively large size associated with the aggregated areas. Specifically, while the captain may determine the general area prior to departure from port (i.e., the aggregated area), information to be used in selecting a specific fishing location within the aggregated area can be facilitated via social arrangements with others fishing in that area.

[23] To a large extent, the respective seasons were based on 1995-2004 plots of monthly production in each of the three areas.

[24] The specific time and area information about TX closure is presented in Appendix E.

detail in Appendix F. A likelihood ratio test, proposed by Malhotra (1987), is conducted to test for homogeneity of parameter estimates of the two periods for each area (Appendix G). The hypothesis that the parameters for the first five-year period (1995-1999) and those for the second five-year period (2000-2004) are the same for all the three areas is rejected. Therefore, dividing the dataset at year 2000 is appealing from both a statistical and empirical context.[25]

Table 2.6 Parameter Estimates---FL Area

1995-1999			2000-2004	
Parameter	*Estimate*	*Pr > |t|*	*Estimate*	*Pr > |t|*
Grid 1	1.2678	0.2341	-1.0595	0.4202
Grid 2	7.0714	<.0001	5.9933	0.0003
Grid 3	4.9853	<.0001	0.2057	0.8592
Grid 4	5.0865	<.0001	1.8229	0.1752
Grid 5	3.0351	0.0046	0.3439	0.7981
Loyalty	3.0573	<.0001	2.6487	<.0001
Season 1grid 1	0.8575	<.0001	0.1354	0.4733
Season 1grid 2	1.0694	<.0001	0.2928	0.163
Season 1grid 3	0.4561	0.0015	-0.0046	0.978
Season 1grid 4	0.9444	<.0001	0.1579	0.4078
Season 1grid 5	1.0473	<.0001	0.5576	0.0024
Vessel length grid 1	-0.0239	0.1293	0.018	0.349
Vessel length grid 2	-0.1205	<.0001	-0.1069	<.0001
Vessel length grid 3	-0.0841	<.0001	-0.00823	0.6284
Vessel length grid 4	-0.083	<.0001	-0.0248	0.2066
Vessel length grid 5	-0.0584	0.0002	-0.0204	0.2984
Expected revenue	-0.0259	0.2506	0.1107	<.0001
Variance of ER	0.1489	0.1509	0.0146	0.6463
Distance	-0.00652	<.0001	-0.00776	<.0001
Crowdedness	0.1795	<.0001	0.1054	<.0001
Crowdedness squared	-0.00559	<.0001	-0.00228	<.0001

Table 2.7 Parameter Estimates---LAM Area

1995-1999			2000-2004	
Parameter	*Estimate*	*Pr > |t|*	*Estimate*	*Pr > |t|*
Grid 1	7.4164	<.0001	5.0636	<.0001
Grid 2	4.1119	<.0001	4.1757	<.0001

[25] The underlining assumption is that the technology does not change over the years during the ten year period.

Table 2.7, continued

Grid 3	4.2216	<.0001	2.4449	<.0001
Grid 4	4.8615	<.0001	3.1985	<.0001
Grid 5	5.1136	<.0001	1.244	0.0198
Grid 6	3.3551	<.0001	2.6867	<.0001
Grid 7	0.9585	0.1847	-1.0253	0.0978
Grid 8	1.8289	0.0052	-1.1248	0.0753
Grid 9	3.3737	<.0001	-1.5243	0.2487
Grid 10	4.2358	<.0001	-6.4872	<.0001
Grid 11	-0.2819	0.6935	-2.3206	0.0002
Grid 12	0.7975	0.4032	-4.4753	<.0001
Grid 13	1.0883	0.1521	-3.5587	0.0003
Grid 14	1.5863	0.0648	-2.004	0.2115
Grid 15	0.8888	0.2426	0.2805	0.5904
Grid 16	-0.359	0.6826	-0.3613	0.5014
Grid 17	0.7197	0.3444	-0.2033	0.6742
Loyalty	4.0161	<.0001	3.9959	<.0001
Season 1 grid 1	0.034	0.8543	-0.401	0.0024
Season 1 grid 2	0.4127	0.003	0.5805	<.0001
Season 1 grid 3	-0.097	0.4439	0.1673	0.0907
Season 1 grid 4	-0.3513	0.0025	-0.5737	<.0001
Season 1 grid 5	-1.0482	<.0001	-0.3216	0.0207
Season 1 grid 6	0.3827	0.0149	-0.3897	0.0113
Season 1 grid 7	0.7459	<.0001	0.5435	0.0001
Season 1 grid 8	-0.2683	0.047	0.0153	0.9098
Season 1 grid 9	-0.6578	<.0001	0.9128	0.0005
Season 1 grid 10	-0.8116	<.0001	-1.1362	0.0011
Season 1 grid 11	0.0547	0.7266	-0.1006	0.4951
Season 1 grid 12	0.7678	<.0001	0.1569	0.4044
Season 1 grid 13	-0.0177	0.904	0.1001	0.5899
Season 1 grid 14	-1.3663	<.0001	-1.472	0.0027
Season 1 grid 15	0.5581	0.001	0.449	0.0016
Season 1 grid 16	0.3424	0.0395	0.8807	<.0001
Season 1 grid 17	-0.3059	0.0299	0.218	0.0605
Season 2 grid 1	3.4138	<.0001	0.382	0.0179
Season 2 grid 2	3.9501	<.0001	0.3189	0.0171
Season 2 grid 3	3.0122	<.0001	-0.8033	<.0001

Table 2.7, continued

Season 2 grid 4	0.5974	0.002	-1.2662	<.0001
Season 2 grid 5	1.1546	<.0001	-0.5782	0.0007
Season 2 grid 6	3.173	<.0001	0.1553	0.4364
Season 2 grid 7	3.2421	<.0001	0.2829	0.225
Season 2 grid 8	1.8704	<.0001	-0.5798	0.0037
Season 2 grid 9	1.6879	<.0001	-0.8286	0.0605
Season 2 grid 10	-0.5828	0.0165	-1.807	<.0001
Season 2 grid 11	3.0404	<.0001	0.5598	0.0049
Season 2 grid 12	2.7259	<.0001	-0.2988	0.3791
Season 2 grid 13	1.4319	<.0001	0.0475	0.8646
Season 2 grid 14	0.8714	0.0001	-1.1661	0.0414
Season 2 grid 15	2.5857	<.0001	0.6163	0.0014
Season 2 grid 16	2.3768	<.0001	-0.0361	0.838
Season 2 grid 17	0.8337	0.002	0.8016	<.0001
TX closure grid 1	0.9856	<.0001	0.3105	0.0512
TX closure grid 2	-0.1333	0.4634	-0.6415	<.0001
TX closure grid 3	0.5094	0.0045	-0.0308	0.7942
TX closure grid 4	-0.1963	0.2808	-0.6339	<.0001
TX closure grid 5	-0.0755	0.7327	0.0901	0.6124
TX closure grid 6	0.6632	0.0006	0.087	0.6613
TX closure grid 7	0.3902	0.052	-0.7619	0.0014
TX closure grid 8	0.5539	0.0032	-0.2432	0.2306
TX closure grid 9	-0.6513	0.0011	0.1045	0.8089
TX closure grid 10	0.5734	0.0126	2.1766	<.0001
TX closure grid 11	0.2668	0.1815	-0.0727	0.7127
TX closure grid 12	0.5112	0.067	-0.0534	0.8703
TX closure grid 13	-0.0146	0.9504	0.1217	0.6615
TX closure grid 14	-0.0626	0.7705	0.8385	0.1206
TX closure grid 15	-0.1702	0.486	-0.0892	0.645
TX closure grid 16	0.0173	0.9487	0.1005	0.576
TX closure grid 17	-0.6635	0.0124	-0.7708	<.0001
Vessel length grid 1	-0.1571	<.0001	-0.0915	<.0001
Vessel length grid 2	-0.0959	<.0001	-0.0722	<.0001
Vessel length grid 3	-0.0827	<.0001	-0.0365	<.0001
Vessel length grid 4	-0.0832	<.0001	-0.0499	<.0001
Vessel length grid 5	-0.0621	<.0001	-0.0204	0.006
Vessel length grid 6	-0.0899	<.0001	-0.0625	<.0001
Vessel length grid 7	-0.0601	<.0001	-0.0166	0.0411

Table 2.7, continued

Vessel length grid 8	-0.0416	<.0001	0.000584	0.9444
Vessel length grid 9	-0.0603	<.0001	-0.0193	0.2644
Vessel length grid 10	-0.0551	<.0001	0.0636	<.0001
Vessel length grid 11	-0.0392	<.0001	0.000734	0.9286
Vessel length grid 12	-0.0657	<.0001	0.0214	0.0484
Vessel length grid 13	-0.0322	0.0019	0.0221	0.082
Vessel length grid 14	-0.0208	0.0753	0.001054	0.9608
Vessel length grid 15	-0.0579	<.0001	-0.0328	<.0001
Vessel length grid 16	-0.0381	0.0015	-0.0292	<.0001
Vessel length grid 17	-0.0185	0.0729	-0.00514	0.4201
Expected revenue	0.0387	<.0001	0.0474	<.0001
Variation of ER	-0.0346	0.3415	-0.0273	0.0007
Distance	-0.0167	<.0001	-0.00952	<.0001
Crowdedness	0.0407	<.0001	0.00295	<.0001
Crowdedness squared	-0.0003	<.0001	-9.90E-07	<.0001

Table 2.8 Parameter Estimates---TX Area

1995-1999			2000-2004	
Parameter	Estimate	Pr > |t|	Estimate	Pr > |t|
Grid 1	-1.3439	0.0295	-3.0357	<.0001
Grid 2	-3.3457	<.0001	-7.8153	<.0001
Grid 3	-0.8736	0.423	0.3302	0.8557
Grid 4	1.0064	0.3754	1.0085	0.5718
Grid 5	2.3341	<.0001	-0.9822	0.0681
Grid 6	0.4201	0.4566	-1.1895	0.0216
Grid 7	-1.2887	0.0362	-1.998	0.0006
Grid 8	-1.4874	0.0024	-2.7172	<.0001
Grid 9	0.0598	0.9038	1.8518	0.0006
Grid 10	-0.0499	0.9133	0.8342	0.0722
Grid 11	6.2117	<.0001	5.5267	<.0001
Grid 12	-0.2276	0.727	3.2592	<.0001
Grid 13	0.1	0.9007	3.8992	<.0001
Grid 14	-0.0396	0.9363	-0.8046	0.0857
Grid 15	-0.2329	0.6058	1.3709	0.0034
Loyalty	3.8019	<.0001	3.9157	<.0001

Table 2.8, continued

Season 1 grid 1	0.0638	0.588	0.2563	0.0482
Season 1 grid 2	-0.1262	0.2132	1.9951	<.0001
Season 1 grid 3	1.2379	<.0001	2.6431	<.0001
Season 1 grid 4	1.152	<.0001	0.3826	0.1542
Season 1 grid 5	0.9703	<.0001	2.238	<.0001
Season 1 grid 6	0.1766	0.1418	0.5356	<.0001
Season 1 grid 7	-0.6573	<.0001	-0.5576	0.0015
Season 1 grid 8	0.2261	0.0045	0.1099	0.2372
Season 1 grid 9	-0.0265	0.7364	-0.0266	0.7903
Season 1 grid 10	0.006405	0.9172	0.3764	<.0001
Season 1 grid 11	0.9182	<.0001	0.9586	<.0001
Season 1 grid 12	-0.00415	0.9711	-0.00753	0.9462
Season 1 grid 13	-0.288	0.0214	-0.4054	0.0009
Season 1 grid 14	-0.1005	0.1436	-0.875	<.0001
Season 1 grid 15	-0.1137	0.0597	-0.0357	0.6447
Season 2 grid 1	-0.9584	<.0001	-0.8471	<.0001
Season 2 grid 2	-1.1975	<.0001	-0.7267	0.0066
Season 2 grid 3	1.4234	<.0001	1.3325	0.0011
Season 2 grid 4	1.1528	<.0001	0.3004	0.1969
Season 2 grid 5	-0.267	0.0442	0.7493	<.0001
Season 2 grid 6	-0.6823	<.0001	-1.1435	<.0001
Season 2 grid 7	0.2789	0.0046	0.0954	0.4356
Season 2 grid 8	0.2349	0.0013	-0.3886	<.0001
Season 2 grid 9	1.0341	<.0001	0.2849	0.0003
Season 2 grid 10	1.0738	<.0001	0.9038	<.0001
Season 2 grid 11	-1.4595	<.0001	-2.2423	<.0001
Season 2 grid 12	-1.4465	<.0001	-1.8299	<.0001
Season 2 grid 13	-1.1561	<.0001	-1.0858	<.0001
Season 2 grid 14	-0.3422	<.0001	-0.5617	<.0001
Season 2 grid 15	-0.2729	<.0001	-0.213	0.0019
TX closure grid 1	-3.0439	<.0001	0.0734	0.715
TX closure grid 2	-4.1329	<.0001	-0.3815	0.3148
TX closure grid 3	-4.7741	<.0001	-2.6735	0.0006
TX closure grid 4	-6.5559	<.0001	-1.6992	<.0001
TX closure grid 5	1.31	<.0001	2.063	<.0001

Table 2.8, continued

TX closure grid 6	0.3826	0.0138	1.3042	<.0001
TX closure grid 7	-3.4039	<.0001	-0.0423	0.8344
TX closure grid 8	-3.7302	<.0001	-0.3782	0.0439
TX closure grid 9	-4.0642	<.0001	-2.193	<.0001
TX closure grid 10	-4.6309	<.0001	-2.7679	<.0001
TX closure grid 11	-0.4181	0.0403	1.0795	<.0001
TX closure grid 12	-3.8079	<.0001	-2.312	<.0001
TX closure grid 13	-4.1329	<.0001	-1.9697	<.0001
TX closure grid 14	-4.9538	<.0001	-2.8279	<.0001
TX closure grid 15	-5.3215	<.0001	-3.5877	<.0001
Vessel length grid 1	0.0579	<.0001	0.0689	<.0001
Vessel length grid 2	0.079	<.0001	0.1005	<.0001
Vessel length grid 3	-0.00486	0.7631	-0.0532	0.0487
Vessel length grid 4	-0.0434	0.0114	-0.0555	0.036
Vessel length grid 5	0.0303	0.0003	0.0518	<.0001
Vessel length grid 6	0.041	<.0001	0.0538	<.0001
Vessel length grid 7	0.0512	<.0001	0.0475	<.0001
Vessel length grid 8	0.0475	<.0001	0.0658	<.0001
Vessel length grid 9	0.0069	0.3462	-0.0209	0.0081
Vessel length grid 10	-0.009	0.2031	-0.0233	0.0006
Vessel length grid 11	-0.013	0.1361	-0.0177	0.0287
Vessel length grid 12	0.0485	<.0001	-0.00798	0.3611
Vessel length grid 13	0.0296	0.0113	-0.0273	0.0061
Vessel length grid 14	0.0322	<.0001	0.0381	<.0001
Vessel length grid 15	0.0226	0.0007	-0.00739	0.2792
Expected revenue	0.0159	<.0001	0.008374	0.1741
Variation of ER	-0.0312	0.1634	-0.0228	0.0049
Distance	-0.0127	<.0001	-0.0094	<.0001
Crowdedness	0.0267	<.0001	-0.00011	0.7512
Crowdedness squared	-0.0001	<.0001	2.70E-06	0.0002

For the first five-year period, location choice by FL fishermen depends to a large extent on past experience (loyalty) rather than on the expected revenues or the variation in the expected revenues, both of which are statistically insignificant. Somewhat in contrast, the FL results for the second period indicate that the fishermen are placing more emphasis on the expected revenues when choosing a fishing location, with the coefficient for expected revenues being positive and significant. Habits still dominate as a determining factor in fishing location, however, and the variation in the expected revenues is still statistically insignificant. As expected, the coefficient on weighted distance, a proxy for cost, is negative and statistically significant in both time periods.

In terms of seasonality, grid 6 is least preferred in season 1 compared to season 2 during 1995-1999, but there is little seasonal difference in choosing sites in season 1 or season 2 during the second five year period (with the exception that grid 5 is the most preferred in season 1). As for mobility, increasing vessel size increases the odds of going to grid 6 or grid 1 rather than other FL grids in the first five year period, but for the second period the probability of visiting a grid given increasing vessel size is fairly evenly distributed with the exception of grid 2. Overall, the parameter estimates for FL suggest that fishermen are more revenue driven, more willing to harvest in different areas as vessel size increased, and less influenced by seasonal factors in choosing a fishing location during the period 2000-2004.

In the LAM models, results again indicate that past experience (loyalty) has a strongly positive and statistically significant influence on location choice in both time periods, suggesting that old habits are playing an important role in site selection. At the same time, however, LAM location choice is driven by expected revenues (both time periods) and variation in expected revenues (second time period) to a greater extent than in FL. Coupled with the statistically significant and negative weighted distance parameters for both time periods, these results suggest a greater degree of profit motivation in the LAM fleet. In terms of seasonality during 1995-1999, season 2 (May to June) is linked to a lower probability of visiting grids 10 and 18 compared to location choice in season 3 (July to October). This same relationship between season 2 and 3 holds as well for grids 5, 10, 14, and 18 in the second five year period. Interactions between vessel size and grid choice are also found in the LAM data, as increasing vessel size is related to a preference for grid 18 over other grids in the period 1995-1999. Given the bathometry of grid 18, this implies that vessels would prefer, given size, to harvest in deeper waters off of Louisiana in the first period of analysis. In the period 2000-2004, however, increasing vessel length is related to a preference for grids 10, 12 and 14 over grid 18 – all areas that are shallower than grid 18. This suggests that, even as vessels got larger, they are being forced to try alternative fishing locations that they may not have attempted to harvest in during 1995-1999. Another point of interest is that the variation of expected revenues is negative and significant for LAM in the period 2000-2004, a stark contrast to its insignificance in 1995-1999.[26] This points out that the LAM shrimp harvesters, although revenue (and perhaps profit) driven in the first period of the data, paid little attention to the uncertainties in their harvesting activities and are, as a result, risk neutral. Anecdotally, if information become available that a given location is yielding large harvests, they are likely to try fishing in the area even if the persistence of the phenomenon is ephemeral. In the second period, however, the harvesters display caution in choosing sites based solely on expected revenues, and are much more interested in assuring that those harvesting opportunities persist over time before they would shift effort to the new location.[27]

[26] Under basic neoclassical expected utility theory, harvesters should not be observed to change their response to risk from one period to the next. Given that their rank preferences for various outcomes are theoretically based on an endogenous utility structure, harvesters should be observed as risk averse, risk neutral, or risk seeking across the entire range of decision outcomes they face. This approach to risk analysis in empirical work, however, often does not always match well with observed behavior, particularly in dynamic settings. Originating with the research of Kahneman and Tversky (1979), the more advanced risk concept of Prospect Theory assumes that economic agents subjectively frame expected utility based on exogenous factors such as wealth, reference points, status quo, etc. While the models used in this study do not incorporate a direct measure of wealth, they do indirectly measure income through the revenue variable at each location. Prospect Theory suggests that individuals would become more risk averse as revenues declined and/or became more variable, an outcome that was observed in a number of our empirical models (as discussed through the results section). This approach to interpreting empirical measures of behavior towards risk will be used in the rest of the study.

[27] From a prospect theory perspective, this finding is not unexpected given changing conditions in the industry. Specifically, much of the empirical literature suggests that as income falls, individuals will often be observed to behave as if they had changed their degree of risk aversion to become more risk averse. While industry profitability

Results for the TX area are similar to those found in LAM. In general, past experience is the dominating influence on location choice in both time periods. While both expected revenues and their variation play a minor role in determining location choice in TX for 1995-1999, only the variation in expected revenues is statistically significant for 2000-2004. The seasonal effects for TX are mixed. In both time periods, the regulatory closure of Texas waters (roughly from mid-May to mid-July) drove the harvesting effort that stayed active into grids 5, 6, 11 and 12 (off of Louisiana). Increasing vessel length is statistically related to the movement of vessels into the south Texas grids 4, 10 and 16 during the first time period, but not during the second time period, suggesting that vessel mobility is limited in the second period compared to the first. As with the LAM harvesters, the decrease in mobility for TX harvesters may have been driven by increased focus on the risks inherent in fishing new locations, a supposition that is supported by the increased importance of variations in expected revenue on the location decision. In fact, expected revenue itself is not statistically significant in the second period, suggesting that TX harvesters behave as if they are very risk averse in their location choices and are relying primarily on past experience.

Additional results to consider are the signs of the crowdedness parameter and its square term. The estimated linear term for crowdedness is positive and the estimated squared term is negative for all areas in both time periods (except for TX in 2000-2004). This indicates that, *ceteris paribus,* the utility function for harvesters is concave with respect to the crowdedness indicator, meaning that the expected utility of shrimp fishermen increases at first with an increase in per area effort, but decreases after certain level of congestion is reached. This threshold of crowdedness, however, is different for different areas and different time periods. For

for the two periods is not known, it is readily acknowledged that industry profitability during this decade (beginning around 2001) is low by historical standards.

example, the threshold for FL area in year 1995-1999 is calculated to be 16.03, while that for the same area in year 2000-2004 is 22.91, suggesting an increasing tolerance for congestion. In LAM, the threshold is 67.83 for the first five years and 1489.9 for the second five years, while in TX the threshold is133.5 for the first five years and not statistically significant in the second five-year period.[28] Appendix H illustrates the above in figures.

The semi-elasticities of the continuous variables are calculated at the average value of the continuous variable for different seasons (Appendix I). For all the areas in both periods, the percentage change in probability given a one percent change in the variables is generally very small for the vast majority of season/grid combinations. There are, however, some notable exceptions. In FL during the 1995-1999 period, the semi-elasticity for loyalty is 0.25, for distance is -0.39, and for crowding is 0.27 for grid 1 in both season 1 and 2. In addition, the semi-elasticities for distance (-0.35 and -0.34) and crowding (0.22 and 0.22) are substantial with respect to grid 4 in both seasons. The semi-elasticities for loyalty are not particularly large for FL in the period 2000-2004, but those for the variation in expected revenues and distance are, at least for grids 1 and 4 in both time periods. Similar isolated cases of substantial semi-elasticities can be found for specific grids and seasons in LAM and TX.

Note that about 55% of the vessels appeared at least once each year during the whole ten year period of 1995-2004. The same models for the three areas are then run using this subsample for each of the periods. The results based on the subsample are very similar to those presented in the tables above, which indicate that the change in parameter estimates over the two periods are not due to difference in samples.

[28] The lack of statistical significance for the most recent five-year period may reflect the overall reduction in effort and, hence, failure to reach a 'threshold' point. Given this to be the case, one would not expect concavity (i.e., a positive linear term and a negative quadratic term). Alternatively, with an increased level of risk aversion, fishermen may become more tolerant to heavy traffic in the area. This being the case, they would not choose an alternative site even with a high degree of crowdedness. Finally, some combination of these two factors may explain the lack of concavity during the second five-year period.

2.7 Discussion

This section uses a conditional logit discrete choice model to analyze the various factors that influence shrimp fishermen's short-run location choice in the Gulf of Mexico. For each of the three areas (FL, LAM, and TX), two periods of five years each are chosen to see the change in their behavior. Through the perspective of the estimated conditional logit discrete choice model, the past experiences of shrimp harvesters at specific harvesting locations has an overwhelming and highly significant impact on the probability associated with their current period site choices. This result, which holds across all study areas (FL, LAM, TX) and time periods (1995-1999 and 2000-2004), is consistent with the results in other location choice studies such as Holland (2000). In essence, the behavioral inertia associated with changing fishing sites, perhaps due to lack of information or risk-aversion, makes shrimp harvesters reluctant to changing their fishing location from one trip to the next. Expected revenues, however, also play a role in the fishing location decision, even though they have much smaller and have less uniform impact when compared to experience. So, although harvesters in FL do not appear to consider expected revenue in their 1995-1999 choices, they behave more rationally (in an economic sense) in years 2000-2004. This may have been due to the declining overall profit opportunities in the industry during this latter time period, and thus the need to be more careful in assuring that individual trips do not cost more than the expected revenues that they would generate. Harvester behavior toward risk in the form of variations in expected revenues, however, fluctuates over time and space. For both LAM and TX, fishermen behave as if they are risk-neutral in the period 1995-1999, only to begin behaving as if they are risk-averse in the period 2000-2004. As with the greater emphasis on expected revenues, this concern for variations in expected revenues in the latter period could have been due to the economic pressure placed on harvesters from the changing and unfavorable economic conditions in the industry.

Another point highlighted by the model results is that harvesters appear to have a higher tolerance towards congestion at a fishing location in the period 2000-2004 when compared to the earlier time period, with the threshold of crowding being substantially higher in the second period for all but the TX area (where insignificant parameter estimates prevent its calculation). Perhaps one explanation for this observation is related to the decreasing number of vessels in the industry. Given that the crowding variable is defined as the number of days fished per unit of area in a given grid, then crowding can increase by either having more vessels fishing the same amount of time in an area or by having fewer vessels fishing, but for longer periods of time. It may be that having fewer vessels fishing longer in a given area is not as easily perceived as congestion, and thus not avoided, as each individual vessel comprises a larger percentage of the crowding measure. Of course, the alternative explanation is that, given the economic pressures on the industry in the period 2000-2004, shrimp harvesters are more willing to tolerate congestion and crowding in their pursuit of economic viable catches.

Although these general results from the conditional logit are appealing in that they seem to confirm to various anecdotal evidence and the conclusions of previous studies on fishermen behavior, it must be remembered that the model structure assumes that each harvester assigns the same value to each attribute of a location grid. Given that this IIA assumption is strict and is not likely be valid in empirical studies, the potential for misinterpreting the actual behavioral objectives of the fleet warrants a deeper investigation that relaxes the IIA assumption and allows for heterogeneity in harvester preferences. This relaxed model, the mixed logit, is the focus of the next chapter of the study.

CHAPTER 3. A MIXED LOGIT APPROACH ON LOCATION CHOICE BEHAVIOR

3.1 Introduction

The conditional logit approach to estimating a random utility model is both straightforward and relatively easy to implement, especially using modern software. The approach, however, has some well known conceptual flaws, and its application to the location choice problem is no exception. First and foremost among these problems is that the conditional logit model implicitly assumes an independence of irrelevant alternatives (IIA) in the structure of the error term. This assumption requires that if a change in the attributes of an alternative choice (for instance, if the expected revenue in location M changes) leads to a change in the probability of choosing that alternative, then every other alternatives should change proportionally as well, thus ensuring that the probability ratio of choosing another alternative with respect to the original alternative holds constant. In many cases this assumption is too restrictive, and it is difficult to imagine a set of real-world economic decisions in which it might apply. Secondly, which is sort of following the first disadvantage, the parameter estimates generated by a conditional logit approach are assumed to be equal across all agents, implying that all decision makers will make the same alternative choice if they experience the same values for all of the explanatory variables (assuming the random component of the utility is the same among them). In this latter case, the model structure does not allow for preference differences among agents, even though experience makes it clear that identical preferences across economic agents is the exception, not the rule.

As an example of the implications of this limitation, Holland and Sutinen (2000) conclude that all fishermen are risk-seekers due to the positive sign of the variation of the expected revenue in their estimated model, whereas the conditional logit estimates from earlier in this study suggests that shrimp harvesters generally behave as if they are risk-averse or, at best, risk neutral, depending on the geographic area and time period examined. It is quite likely, however, that a more sophisticated structure for the error term of the model might have indicated that there is a wide variation in the risk attitudes of fishermen and shrimp harvesters, an outcome that could have important implications for policy development and implementation. The same kind of preference variability among economic agents may well exist for loyalty and crowdedness/congestion on the fishing grounds, leading to different kinds of decisions being made by different harvester sub-populations. Thus, an ideal model structure would accommodate these potential differences in preferences.

A third problem with a conditional logit estimation, at least in cases where there are repeated observations over time for the decision makers as is true in this study, is that the model structure assumes that all unobservable information on a decision maker is independent over time, a requirement that can hardly be expected to be true for real economic agents. Part of this potential correlation among choice occasions was incorporated in the earlier conditional logit through the use of the loyalty variable, which was an attempt to get a measure of true state dependence. Nevertheless, Heckman (1981), Keane (1997), and other studies have noted that if unobserved heterogeneity is present in the true model, ignoring it by estimating only the true state dependence will overstate the influence of past experience on current choice behavior.

Various attempts have been made to improve on the conditional logit model in cases where the IIA assumption is unlikely to be maintained. One approach is the development of the nested logit model, where the decision process is conceptualized as occurring in steps that can be considered independent from one another. While the nested logit does improve on the conditional logit by allowing the estimation to account for various forms of dependence among the nesting decision levels, it still leans heavily on the IIA assumption when considering choices within a decision level. Another alternative to the conditional logit is the mixed/random parameter logit model, which has a more flexible functional form and imposes less restriction on the behavior of the individual decision maker with respect to the information on choices and the preference response.

3.2 Mixed Logit---Theory Review

Mixed logit is a flexible function form which allows for non IIA error pattern, correlation among observations, and preference variation among the fishermen. As demonstrated by McFadden and Train (2000), any random utility model can be approximated by a mixed logit model with appropriate choice of variables and mixing function. As suggested by Revelt and Train (1998), furthermore, when repeated choices are made by the individuals, as is the case in this study, mixed logit model allows for efficient estimation of the parameters.

As noted in the previous chapter, the probability function for conditional logit can be expressed as

$$P_{ijt} = \frac{\exp[E\overline{U}(\theta, X_{it}, Z_{ijt})]}{\sum_{j=1}^{J} \exp[E\overline{U}(\theta, X_{it}, Z_{ijt})]} \qquad eq. 3.1$$

If the parameter vector θ is not assumed fixed, the conditional probability can be obtained by integrating over the density of θ. The integration is called mixed logit probability, which has the form

$$L_{ijt} = \int P_{ijt}(\theta) f(\theta) d\theta \qquad eq. 3.2$$

where P_{ijt} is the conditional logit probability and $f(\theta)$ is the density function of θ. This is actually a weighted average of the conditional logit formula evaluated at different values of θ since, unlike in the conditional logit, θ is not fixed. The weights are given by the density function, or the mixing distribution, which can be discrete or continuous.

In practice, the density $f(\theta)$ is usually characterized by some set of parameters which are themselves estimated.[29] From the estimation on the parameters that describe the population distribution of θ, we indirectly obtain information about θ. If we define the parameter vector that describes the density of θ as β^*, the probability function takes the form:

$$L_{ijt} = \int P_{ijt}(\theta) f(\theta \mid \beta^*) d\theta \qquad eq. 3.3$$

While essentially equivalent, the mixed logit model can be considered from the perspective of either random coefficients or error components with differences being the result of interpretation. From a random coefficients perspective, the mixed logit model interpretation is one of explaining difference in preferences among individuals. Recall that conditional logit assumes that preferences among individuals towards the attributes of the alternatives are homogeneous. In mixed logit, this restriction is relaxed by allowing for preference heterogeneity among individual fishermen. Using the same formula of expected utility as previously provided and assuming a linear utility function and that the preference by an individual fisherman does not change over modeling time, we have:

$$EU_{ijt} = E\overline{U} + \varepsilon_{ijt} = \theta_i' Y_{ijt} + \varepsilon_{ijt} \qquad eq. 3.4$$

where Y_{ijt} represents a vector of explanatory variables and θ_i is a vector of parameters of the variables for fisherman i (representing the fisherman's preference), and ε_{ijt} is again iid extreme value. The parameter value changes over fishermen in the population with density $f(\theta)$.

[29] Even though θ is of interest in the probability function, it cannot be directly estimated because it is not fixed. Instead, the parameters of the probability function are estimated, as (for example) the mean and variance in the case of a normal distribution. Thus, the conditional logit can be considered as a special case of the mixed logit where the probability function is degenerate at fixed parameters – for instance, at zero variance in the case of a normal distribution.

This density is a function of parameters β^* that represent, for instance, the mean and covariance of the θ's in the population. If θ_i was observable to the researcher, the probability for each individual fisherman would be conditional on θ_i and would have the functional form

$$\widetilde{P}_{ijt} = \frac{\exp[E\overline{U}(\theta_i, Y_{ijt})]}{\sum_{j=1}^{J} \exp[E\overline{U}(\theta_i, Y_{ijt})]} \qquad eq. 3.5$$

In reality, however, there is no way for the researcher to observe θ_i, so the probability takes the functional form

$$L_{ijt} = \int P_{ijt}(\theta) f(\theta \mid \beta^*) d\theta \qquad eq. 3.6$$

A couple of distributions can be specified to estimate the parameters of θ. The normal distribution is the distribution most frequently considered in applied analysis since, in many cases, it is a good approximation of the population distribution. Alternatively, if some coefficients, such as price, are known to have a positive or negative sign for every individual included in the analysis, a log normal distribution can be used. As a final example, if the coefficients have bounds in certain scenario, a uniform or triangular distribution can be used.

In contrast to the random coefficients perspective, the error components perspective of the mixed logit model is useful for understanding how the model accommodates the correlations across alternatives and/or choice occasions without assuming IIA or imposing restricted substitution patterns (Train, 2003, P143). Suppose the utility function is specified as

$$U_{ij} = \alpha' X_{ij} + \eta_{ij} \qquad eq. 3.7$$

where $\eta_{ij} = \mu_i' Z_{ij} + \varepsilon_{ij}$, X_{ij} and Z_{ij} are vectors of observed variables related to alternative j, α is a vector of fixed parameters, μ is a vector of random terms with zero mean, ε_{ij} is iid extreme value independent of Z_{ij}. The stochastic portion of the utility is defined by η_{ij}, and Z_{ij} are the error components along with ε_{ij}. As long as Z_{ij} are different from zero, utility is correlated over alternatives: $COV(\eta_{ij}, \eta_{ik}) = E[(\mu_i' Z_{ij} + \varepsilon_{ij})(\mu_i' Z_{ik} + \varepsilon_{ik})] = Z_{ik}' W Z_{ij}$, and W is the covariance of μ_i. Even when the error components are independent, or when W is a diagonal matrix, the correlation will sometimes still exist due to the non-zero value of Z_{ij}. A special case of conditional logit specification (i.e., where the IIA assumption is met) is exhibited when Z_{ij} are zero.

Different choices of variables entering the error components lead to various correlation patterns. An example of nested logit, where the alternatives within a nest are more correlated than alternatives in different nests, is provided by Train (2003, P143). For M non-overlapping nests, a dummy variable with values being equal to one for alternatives within each nest and zero for alternatives outside that nest is defined. Then,

$$\mu_i' Z_{ij} = \sum_{m=1}^{M} \mu_{im} d_{jm}, \qquad eq.3.8$$

where $d_{jm} = 1$ if alternative j is in nest m and zero otherwise. Suppose further that μ_{im} is iid normal with mean zero and variance σ_m. Then, the random term μ_{im} enters the utility of each alternative in nest m and causes the alternatives within the nest to be correlated. However, it does not enter the utility of alternatives outside of nest m. Thus, there is no correlation between alternatives from different nests. To see this more clearly, consider equation 3.9, where the covariance of two alternatives within a nest m is given by

$$COV(\eta_{ij}, \eta_{ik}) = E[(\mu_m + \varepsilon_{ij})(\mu_m + \varepsilon_{ik})] = \sigma_m, \qquad eq.\ 3.9$$

while the variance for the alternatives is given by

$$VAR(\eta_{ij}) = E(\mu_m + \varepsilon_{ij})^2 = \sigma_m + \pi^2/6 \qquad eq.\ 3.10.$$

Thus, $CORR\ (\eta_{ij}, \eta_{ik}) = \dfrac{\sigma_m}{\sigma_m + \pi^2/6}$ for alternatives within nest and zero for those between the nests.

Herriges and Phaneuf (2002) give a detailed illustration of the patterns of correlation induced by different specifications of the error term. A more general cross alternative correlation can be created by specifying

$$\eta_{ijt} = \psi_{it} + \sum_{k=1}^{J} \tau_{it}^{jk} + \varepsilon_{ijt} \qquad eq.3.11,$$

where the τ_{it}^{jk}'s capture the pair-wise similarities of sites, with

$$VAR(\eta_{ijt}) = \sigma^2 + \sigma_\psi{}^2 + \sum_{k=1}^{J} \sigma_{\tau(j,k)}^2 \quad (k \neq j), \qquad eq.3.12$$

and

$$COV(\eta_{ijt}, \eta_{ikt}) = \sigma_\psi{}^2 + \sigma_{\tau(j,k)}^2 \qquad eq.\ 3.13$$

(suppose $VAR(\varepsilon_{ijt}) = \sigma^2$ and $\tau_{it}^{jk} \sim N(0,\ \sigma_{\tau(j,k)}^2\ (k \neq j))$, $\psi_{it} \sim N(0,\ \sigma_\psi{}^2)$). Imposing different restrictions on $\sigma_{\tau(j,k)}^2$ will induce different correlation across alternatives. For example, a general error structure of nested logit indicates that the within nest covariance $\sigma_\psi{}^2 + \sigma_{\tau(j,k)}^2$ is always larger than the covariance of alternatives that are not in the same nest, which is $\sigma_\psi{}^2$. Naturally, then, the correlation is higher within nests. To introduce the cross choice occasion correlation into the model, Herriges and Phaneuf add individual specific error components that are constant over time into the stochastic error. In general terms, equation 3.11 can be modified to add the individual error components as follows

$$\eta_{ijt} = \psi_{it} + \sum_{k=1}^{J} \tau_{it}^{jk} + \gamma_{ij} + \varepsilon_{ijt}, \qquad eq.3.14$$

where $\gamma_{ij} \sim N(0, \sigma^2_{\gamma(j)})$, for instance, can be seen as the unobserved portion of an individual's alternative utility that does not vary over time, or individual specific random effects. For example, it can be assumed that given fishermen tend to visit certain areas because of unobserved knowledge they have about the site (fish abundance at certain spot). This can be captured in the model by allowing for a random dummy variable shared across choice occasions for that alternative. In this case $COV(\eta_{ijt}, \eta_{ikt}) = \sigma^2_{\psi} + \sigma^2_{\gamma(j)}$.

Of course, the simplest case is to assume that the unobserved portion of the individual is the same across alternative and time, which is the assumption made by Train (1998, 1999). Train also mentioned in his 1999 paper that the sequencing effects over time can be incorporated into the model by allowing θ_i to evolve over time, such as an AR(1) sequence or Markov process. Hensher and Greene (2001) elaborates on this issue and points out the fact that if the heterogeneity in preferences is ignored by treating the error variance constant, then the variation will be shown in the intercept and slope parameters across choice set. Such an analysis would lead to the artifact /nonexistence of order effects (due to the order of the choice occasions made by the individuals) in the data. As long as unobserved heterogeneity is explicitly modeled, the correlation is automatically accommodated. The correlation is recognized as due to the sharing of unobservable heterogeneity between choice occasions made by the same individual, which is not distinguished from the long time experience know as state dependence. In short, random preference induces correlation between alternatives and choice occasions.

Based on the discussion in Heckman (1981), even the simplistic case of ignoring $\theta_{it} = \theta_i$ (i.e., by assuming $\theta_i = \theta$) will cause spurious state dependence problem as well as inconsistency. A similar example to Heckman (1981) is given here in the context of this study to illustrate this problem. Assume the individuals have different intercepts in the true model as defined by $\Phi(i)$

and the structural state dependence or loyalty variable is captured by a simple summation of $\sum_{s=1}^{t-1} y_j^i (t-s-1)$, where y is a dummy variable indicating whether individual I chose alternative j on choice occasion t or not, then the true model is

$$EU_{ijt} = \alpha x + \phi(i) + \delta loy + \varepsilon_{ijt} \qquad eq.\ 3.15$$

where X is the matrix of other control variables, ε_{ijt} is i.i.d. Treating the individuals as having the same intercept $\overline{\phi(i)}$ will result in

$$EU_{ijt} = \alpha x + \overline{\phi(i)} + \delta loy + \varepsilon_{ijt} + \phi(i) - \overline{\phi(i)} \qquad eq.\ 3.16$$

The error term is composed of the last three terms in equation 3.16. The structure of the error term results in two problems. First, the choice occasion by same individuals are correlated due to the correlation in the error. Second, while less obvious, loy is correlated with the composite disturbance, results in an upward biased estimation of δ, (since loy is the summation of past choice). Of course in this simple case the bias could be avoided by permitting each individual to have their own intercept.

Due to the IIA restriction in conditional logit, a change in the attributes of one alternative will change the probabilities of all the other alternatives proportionately. Explicitly, in the conditional logit model, the first derivative of alternative k's probability with respect to alternative j's attribute r, x_j^r is equal to

$$\frac{\partial P_k}{\partial x_j^r} = -b^r * P_k * P_j \qquad (k \neq j) \qquad eq.\ 3.17,$$

where b^r is the coefficient of x^r. As such, the percent change in the probability for any alternative k that results from a change in the rth attribute of alternative j, j ≠ i, is

$$\frac{\partial \ln P_k}{\partial x_j^r} = -b^r * P_j \qquad eq.\ 3.18\ ,$$

which does not depend on alternative k. In other words, a change in attributes of alternative j brings about the same percent change in the probabilities for all other alternatives. If certain sites are closed for some portion of the year, for instance, this will cause the fishermen to switch to other sites. The conditional logit model indicates that the percentage change in probability of visiting the non-closed sites due to the closure of some site is the same among the sites to which they switched. In reality, however, it is highly possible that the probability change in visiting the sites that are closer to the closed area is higher than those that are farther. Mixed logit does not impose the IIA assumption and thus allows for more realistic substitution patterns. Unlike the case in conditional logit, where the probability ratio of alternative k to alternative j does not depend on other alternatives, in mixed logit the probability ratio depends on all the data, including attributes of alternatives other than j and k. Therefore, the percent change in the probability of alternative k given a change in alternative j's attribute r is

$$\frac{\partial \ln L_k}{\partial x_j^r} = -\frac{1}{L_K}\int b^r P_j(\theta) P_K(\theta) f(\theta) d\theta \qquad eq.\ 3.19$$

which is essentially the ratio of two integrals and the substitution pattern depends on the specification of the variables and the mixing distribution. For instance, the percent change in probability relies on the correlation of $P_j(\theta)$ and $P_k(\theta)$ over different values of θ.

Again, the error components specification and random coefficient specification are equivalent. An error component expression of utility,

$$U_{ij} = \alpha' X_{ij} + \mu_i' Z_{ij} + \varepsilon_{ij}, \qquad eq.\ 3.20$$

can be viewed as a random parameters model with fixed parameters for variables *X* and random parameters for *Z*. If *X* and *Z* overlap, the parameters of the overlapping variables can be considered to vary randomly with mean β and the same distribution as μ around their mean. Conversely, the utility function specified in the random parameter scenario is

$$U_{ij} = \theta' Y_{ij} + \varepsilon_{ij}, \qquad \textit{eq. 3.21}$$

where θ is random. The parameters θ can be decomposed into a form represented by the characteristic parameters of the distribution of *f(θ),* for instance, mean β and deviation μ in the case of normal distribution:

$$U_{ij} = \beta' X_{ij} + \mu' X_{ij} + \varepsilon_{ij}. \qquad \textit{eq. 3.22}$$

by defining $X_{ij} = Z_i$ in equation 3.20.

Due to the integrals in the probability function, the Log likelihood function for mixed logit model cannot be solved explicitly. Simulation methods for estimation are discussed in Train (2002). Basically, for the probability function of individual i and alternative k,

$$L_{ik} = \int P_{ik}(\theta) f(\theta \mid \beta^*) d\theta$$

where

$$P_{ik}(\theta) = \frac{\exp(\theta' x_{ik})}{\sum_{j=1}^{J} \exp(\theta' x_{ij})}$$

is approximated through simulation for any given value of β^*. The steps are: (1) draw a value of θ from $f(\theta|\beta^*)$ and label it θ^1; (2) calculate the logit formula $P_{ik}(\theta^1)$; (3) repeat steps 1 and 2 many times, and average the results. The simulated probability is thereby:

$$SP_{ik}(\theta) = \frac{1}{R}\sum_r P_{ik}(\theta^r) \qquad eq.\ 3.23$$

where R is the total number of draws. Steps (1) to (3) are then conducted for each of the sampled individuals using a different set of draws for each. According to Train (2002), *SP* is an unbiased estimator for *P* by construction. It is continuous and twice differentiable in the parameters θ and the data, which facilitates the numerical search for the maximum of the likelihood function. The simulated likelihood function is constructed with the simulated probabilities, $SLL(\beta^*) = \sum_n \ln SP_{ik}(\theta)$, which is not unbiased for log likelihood even though SP is unbiased for P. A detailed discussion about all the simulation methods can be found in Train (2002).

3.3 Mixed Logit --- Applications

Mixed logit models are commonly used in Marketing, Labor Economics, transportation analysis and recreation demand analysis, although a few applications have used commercial fisheries as subject matter. Bockstael and Opaluch (1983) allow for heterogeneity in the degree of risk aversion by letting the differences be based on initial wealth level even while they impose homogeneous risk preferences. Mistiaen and Strand (2000) point out that ideally the expected utility should be a function of both initial wealth and random returns and their analysis tests a conceptual short-run model of fishermen who are maximizing the expected utility via discrete location choice. Because initial wealth is not known, the heterogeneity of risk preferences is incorporated into the random-parameter specification in the logit model. The authors conclude that most fishermen in the East Coast and Gulf longline fleet are risk-averse, with about five percent of the trips exhibiting risk-seeking behavior. Eggert and Tveteras (2004) analyze gear choice, allowing for heterogeneity in production technology and risk preferences, all in the context of temporary area closures. Their results indicate that a conditional logit model that ignored the substantial heterogeneity in the fleet would produce misleading results, as 70 percent of the fishermen exhibited risk-averse behavior and they had a strong tendency to use the same gear as in a previous trip. The applicability of their results is somewhat questionable, however, given that only 47 vessels are in their sample and their use of a lagged dependent variable as the measure of inertia is econometrically suspicious. Dupont (1993) does not use mixed logit, but she breaks the sample into four different groups according to their vessel types and runs the same model with wealth level included. The results show that different groups have different risk attitudes and it is concluded that heterogeneity in risk preferences does exist among fishermen.

Breffle and Morey (2000) investigate several different parametric methods to incorporate heterogeneity in the context of a repeated discrete choice model. The authors use three different approaches to the estimation problem. The first method involves interacting the socioeconomic variables with the alternative specific variables. This allows a wider range of estimated impacts on different types of people and allowed the researchers to determine which groups are most affected by policy changes. The second method uses a random parameter logit model with interaction. Only the constant terms for two different groups are specified to have the random parameters, which is similar to a nested model where IIA is relaxed across the two groups but not within either group. The results from this method indicate that randomization has a significant impact on economic values. The third method specifies the heterogeneity in the stochastic part of the expected utility function, either at individual-specific scales, group-specific scales or a random scale parameter in the error term. This relaxes the assumption that the individuals have an identical error distribution. Overall, the authors show that if preferences vary across individuals and are incorrectly restricted as homogeneous, the mean consumer surplus estimates for changes in characteristics, such as catch rates at recreational fishing sites, will be biased. They point out that randomizing parameters improves model fit and significantly affects consumer surplus estimates. However, since it addresses heterogeneity across the population without having to confront the sources, the model "provides more flexibility but also little interpretability in terms of distributional impacts associated with heterogeneity."

Smith (2005), in his study of the sea urchin fishery in California, distinguishes between state dependence and preference heterogeneity in location choice behavior. The author notes that the exclusion of state dependence may exaggerate the significance of the random preference parameters which are the indicators of preference heterogeneity.[30] This phenomenon is fundamentally different from preference heterogeneity, which can be captured by the unobservable variations that are correlated over time and by the variation in tastes for attributes of different locations. A mixed logit model with a linear indirect utility function is used to analyze taste heterogeneity, while state dependence is modeled as a linear combination of previous period's state dependence level and a geometrically decaying summary of all previous decisions associated with that location. The three explanatory variables entering into the model are expected revenue, distance and the indicator of state dependence. The results indicate that exclusion of preference heterogeneity from the model does not significantly alter results but exclusion of state dependence can have significant ramifications. Even though the data set contained about 1000 harvesters' daily decisions over the years from 1988 to 1997, Smith only used 50 randomly sampled divers in the model due to the computational burden involved in the simulations. In addition, harvest risk preferences are not discussed.

Building on this previous work and employing the data as constructed for the conditional logit model, a mixed logit model is estimated for the Gulf of Mexico shrimp fishery. In addition to analyzing the results of this estimation, comparisons are made between the results of the

[30] State dependence is the notion that "individual experience of locations shape their information sets in a manner that gives rise to heterogeneous expectations about the future value for choosing that location."

mixed and conditional logit models, with an example welfare analysis used to illustrate the impact of the different models on the interpretation of policy outcomes.

3.4 Results and Interpretation

The results for mixed logit estimation of the location choice behavior for the two time periods (i.e., 1995-1999 and 2000-2004) and three regions (i.e., FL, TX, and LAM) are presented in the tables 3.1 through 3.3 in brief and in detail in Appendix J. A comparison of the log likelihood values of conditional logit model and mixed logit model for the FL area suggests little difference. However, for both LAM and TX areas, the log likelihood values are higher for the mixed logit models than those associated with the conditional logit models. In fact, a likelihood ratio test of the conditional logit model as a nested model in the mixed logit model rejected the hypothesis that the reduced models and the full models are equivalent (i.e., no significant differences at 5% significance level) for all four LAM and TX comparisons.[31]

Table 3.1 Parameter Estimates---FL Area

1995-1999			2000-2004	
Parameter	*Estimate*	*Pr > |t|*	*Estimate*	*Pr > |t|*
Grid 1	-2.3566	0.0194	-2.714	0.054
Grid 2	3.6501	0.0023	4.3893	0.0117
Grid 3	1.836	0.2232	-0.1809	0.9112
Grid 4	1.2484	0.2589	0.3052	0.8327
Grid 5	-0.6872	0.4654	-1.1864	0.3914
Loyalty (mean)	3.0818	<.0001	2.7703	<.0001
Loyalty (s.d.)	0.0702	0.9676	-0.0983	0.9301
Season 1grid 1	0.8761	<.0001	0.202	0.2955
Season 1grid 2	1.088	<.0001	0.2442	0.2769
Season 1grid 3	0.4561	0.0164	0.0749	0.7925
Season 1grid 4	0.9643	<.0001	0.2069	0.297

[31] Hausman test for IIA assumption used in conditional logit is also conducted for part of the data. Even though for some area the hypothesis that IIA assumption holds was not rejected, mixed logit is still preferred due to its better fit.

Table 3.1, continued

Season 1grid 5	1.0737	<.0001	0.6564	0.0005
Vessel length grid 1	0.0295	0.0475	0.0424	0.0395
Vessel length grid 2	-0.0702	<.0001	-0.0832	0.0013
Vessel length grid 3	-0.0375	0.0952	-0.00272	0.9096
Vessel length grid 4	-0.0264	0.1065	-0.00196	0.9261
Vessel length grid 5	-0.00376	0.7861	0.001035	0.9593
Expected revenue (mean)	-0.0277	0.2283	0.1119	<.0001
Expected revenue (s.d.)	2.43E-05	1	-0.0378	0.7018
Variance of ER (mean)	0.1495	0.1507	0.006248	0.8613
Variance of ER (s.d.)	0.0249	0.9964	0.000193	0.9999
Distance (mean)	-0.00667	<.0001	-0.00856	<.0001
Distance (s.d.)	0.001295	0.0629	-0.00204[32]	0.0003
Crowdedness (mean)	0.1799	<.0001	0.1424	<.0001
Crowdedness (s.d.)	0.004807	0.9695	0.0985	<.0001
Crowdedness squared (mean)	-0.0056	<.0001	-0.00424	<.0001
Crowdedness squared (s.d.)	-0.00047	0.8675	0.001747	0.0021

Table 3.2 Parameter Estimates---LAM Area

1995-1999			2000-2004	
Parameter	*Estimate*	*Pr > |t|*	*Estimate*	*Pr > |t|*
Grid 1	7.8718	<.0001	5.3702	<.0001
Grid 2	5.0108	<.0001	4.4039	<.0001
Grid 3	4.644	<.0001	2.475	<.0001
Grid 4	5.5032	<.0001	3.3195	<.0001
Grid 5	5.682	<.0001	1.1592	0.037
Grid 6	3.8433	<.0001	2.9119	<.0001
Grid 7	1.3345	0.0871	-1.228	0.0551
Grid 8	2.1933	0.0015	-1.1371	0.0799
Grid 9	3.9083	<.0001	-1.5152	0.2538
Grid 10	4.7362	<.0001	-7.0138	<.0001
Grid 11	0.2803	0.7214	-2.1745	0.0011

[32] The standard error of a random parameter should be always positive, but sometimes in the output of the procedure in SAS or other software it has negative sign. This is because t is the variance of the random parameter that was estimated in the simulated likelihood. Then the square root of the estimated variance was taken to get the standard deviation, which might be given a negative sign by the computer.

Table 3.2, continued

Grid 12	1.5128	0.1302	-4.7716	<.0001
Grid 13	1.405	0.0748	-3.567	0.0003
Grid 14	1.6564	0.0574	-2.2016	0.1718
Grid 15	1.4366	0.0897	0.5993	0.2922
Grid 16	-0.00203	0.9983	-1.0803	0.0727
Grid 17	0.9508	0.23	-0.2719	0.5819
Loyalty (mean)	4.3339	<.0001	4.2566	<.0001
Loyalty (s.d.)	1.2605	<.0001	-1.0585	<.0001
Season 1 grid 1	0.0455	0.8222	-0.5042	0.0004
Season 1 grid 2	0.4257	0.0055	0.55	<.0001
Season 1 grid 3	-0.1313	0.3339	0.1017	0.3299
Season 1 grid 4	-0.3449	0.0058	-0.5938	<.0001
Season 1 grid 5	-1.018	<.0001	-0.4006	0.0057
Season 1 grid 6	0.3728	0.0331	-0.5327	0.0011
Season 1 grid 7	0.757	<.0001	0.5185	0.0005
Season 1 grid 8	-0.3139	0.028	-0.1109	0.4271
Season 1 grid 9	-0.6223	<.0001	0.7951	0.0025
Season 1 grid 10	-0.8053	<.0001	-1.0731	0.0023
Season 1 grid 11	0.0186	0.9153	-0.2087	0.184
Season 1 grid 12	0.7676	0.0001	0.1433	0.4585
Season 1 grid 13	-0.0615	0.6888	0.006731	0.9717
Season 1 grid 14	-1.2587	<.0001	-1.5347	0.0018
Season 1 grid 15	0.4837	0.0108	0.3093	0.0457
Season 1 grid 16	0.3459	0.0536	0.665	<.0001
Season 1 grid 17	-0.3463	0.0191	0.2027	0.0902
Season 2 grid 1	3.3996	<.0001	0.2241	0.2038
Season 2 grid 2	4.0256	<.0001	0.1244	0.3918
Season 2 grid 3	3.0516	<.0001	-1.0008	<.0001
Season 2 grid 4	0.5116	0.0109	-1.4871	<.0001
Season 2 grid 5	1.0465	<.0001	-0.7138	<.0001
Season 2 grid 6	3.1132	<.0001	-0.00534	0.9798
Season 2 grid 7	3.2608	<.0001	0.1327	0.5815
Season 2 grid 8	1.8422	<.0001	-0.7834	0.0001
Season 2 grid 9	1.5912	<.0001	-0.9377	0.034
Season 2 grid 10	-0.7565	0.0022	-1.7104	<.0001

Table 3.2, continued

Season 2 grid 11	2.9684	<.0001	0.4019	0.0583
Season 2 grid 12	2.6979	<.0001	-0.408	0.2365
Season 2 grid 13	1.4207	<.0001	-0.00419	0.9881
Season 2 grid 14	0.8206	0.0003	-1.1654	0.043
Season 2 grid 15	2.3192	<.0001	0.3835	0.0652
Season 2 grid 16	2.3683	<.0001	-0.2736	0.2373
Season 2 grid 17	0.7222	0.0101	0.6736	<.0001
TX closure grid 1	1.1027	<.0001	0.472	0.0071
TX closure grid 2	0.007465	0.9699	-0.5613	<.0001
TX closure grid 3	0.6181	0.0011	0.004423	0.9715
TX closure grid 4	-0.2869	0.1352	-0.6351	<.0001
TX closure grid 5	-0.011	0.9609	0.1623	0.3849
TX closure grid 6	0.7822	0.0004	0.2187	0.3001
TX closure grid 7	0.5324	0.0149	-0.6422	0.0094
TX closure grid 8	0.5643	0.0041	-0.1725	0.4045
TX closure grid 9	-0.7438	0.0003	0.0814	0.8508
TX closure grid 10	0.6541	0.0048	2.168	<.0001
TX closure grid 11	0.3958	0.0799	0.0728	0.7313
TX closure grid 12	0.6764	0.0205	0.0581	0.8614
TX closure grid 13	-0.0414	0.8637	0.0998	0.7227
TX closure grid 14	-0.0411	0.8493	0.8512	0.1179
TX closure grid 15	0.0255	0.9253	0.1067	0.613
TX closure grid 16	0.0573	0.8416	0.349	0.1323
TX closure grid 17	-0.6488	0.0195	-0.7061	<.0001
Vessel length grid 1	-0.1666	<.0001	-0.095	<.0001
Vessel length grid 2	-0.1117	<.0001	-0.0747	<.0001
Vessel length grid 3	-0.0907	<.0001	-0.0349	<.0001
Vessel length grid 4	-0.0943	<.0001	-0.052	<.0001
Vessel length grid 5	-0.0702	<.0001	-0.0183	0.0181
Vessel length grid 6	-0.0986	<.0001	-0.0638	<.0001
Vessel length grid 7	-0.0672	<.0001	-0.0132	0.1176
Vessel length grid 8	-0.0465	<.0001	0.003699	0.6679
Vessel length grid 9	-0.0691	<.0001	-0.0178	0.3061
Vessel length grid 10	-0.0622	<.0001	0.0692	<.0001
Vessel length grid 11	-0.0487	<.0001	-3.8E-05	0.9965

Table 3.2, continued

Vessel length grid 12	-0.0771	<.0001	0.0262	0.0184
Vessel length grid 13	-0.0356	0.0009	0.0251	0.0521
Vessel length grid 14	-0.0216	0.0694	0.005407	0.8019
Vessel length grid 15	-0.0665	<.0001	-0.0353	<.0001
Vessel length grid 16	-0.0445	0.0004	-0.0177	0.0258
Vessel length grid 17	-0.0208	0.0534	-0.00263	0.6872
Expected revenue (mean)	0.0423	<.0001	0.0563	<.0001
Expected revenue (s.d.)	-0.001	0.9936	0.00214	0.9946
Variation of ER (mean)	-0.037	0.3152	-0.03	0.0004
Variation of ER (s.d.)	0.002	0.9983	-0.00092	0.9969
Distance (mean)	-0.020	<.0001	-0.0118	<.0001
Distance (s.d.)	0.007	<.0001	-0.00498	<.0001
Crowdedness (mean)	0.048	<.0001	0.004748	<.0001
Crowdedness (s.d.)	0.006	0.2976	0.000031	0.9471
Crowdedness squared (mean)	-0.0004	<.0001	-3.44E-06	<.0001
Crowdedness squared (s.d.)	-0.0002	<.0001	1.45E-06	<.0001

Table 3.3 Parameter Estimates---TX Area

1995-1999			2000-2004	
Parameter	*Estimate*	*Pr > |t|*	*Estimate*	*Pr > |t|*
Grid 1	-1.7359	0.0416	-2.7258	0.0006
Grid 2	-3.395	<.0001	-8.458	<.0001
Grid 3	-0.1928	0.8646	0.37	0.841
Grid 4	1.4602	0.2051	1.3401	0.4528
Grid 5	-1.1132	0.232	-3.198	0.0001
Grid 6	-0.064	0.938	-0.2523	0.7447
Grid 7	-1.0424	0.2014	-1.1725	0.1375
Grid 8	-0.0863	0.8955	-2.4538	0.0002
Grid 9	1.5177	0.0076	2.2451	0.0002
Grid 10	0.6824	0.1532	1.1168	0.0182
Grid 11	3.1717	0.0023	4.4658	<.0001
Grid 12	-0.4755	0.5764	3.8639	<.0001
Grid 13	0.7993	0.3831	4.6304	<.0001
Grid 14	1.2606	0.049	-0.2466	0.699

Table 3.3, continued

Grid 15	1.0948	0.0378	1.6445	0.0014
Loyalty (mean)	3.7651	<.0001	3.8415	<.0001
Loyalty (s.d.)	0.003252	0.9968	0.0485	0.9584
Season 1 grid 1	0.0854	0.624	0.6248	0.0009
Season 1 grid 2	0.0317	0.8082	2.3327	<.0001
Season 1 grid 3	1.2454	<.0001	2.6448	<.0001
Season 1 grid 4	1.1457	<.0001	0.3613	0.1791
Season 1 grid 5	1.8087	<.0001	3.3734	<.0001
Season 1 grid 6	0.2477	0.1826	1.0167	<.0001
Season 1 grid 7	-0.4964	0.0051	-0.1804	0.3948
Season 1 grid 8	0.3001	0.0064	0.2987	0.0176
Season 1 grid 9	-0.00521	0.9532	0.031	0.7747
Season 1 grid 10	0.0336	0.5936	0.4117	<.0001
Season 1 grid 11	1.7982	<.0001	2.1547	<.0001
Season 1 grid 12	0.2792	0.0607	0.5459	0.0003
Season 1 grid 13	-0.1177	0.4164	-0.0726	0.6213
Season 1 grid 14	-0.0643	0.4771	-0.7611	<.0001
Season 1 grid 15	-0.1145	0.1086	-0.00545	0.9492
Season 2 grid 1	-1.5639	<.0001	-1.254	<.0001
Season 2 grid 2	-1.7196	<.0001	-1.0585	0.0001
Season 2 grid 3	1.135	<.0001	1.1502	0.0052
Season 2 grid 4	1.1457	<.0001	0.2328	0.3207
Season 2 grid 5	-0.4034	0.0381	0.4539	0.0253
Season 2 grid 6	-1.1186	<.0001	-1.6147	<.0001
Season 2 grid 7	-0.2598	0.0402	-0.3425	0.0245
Season 2 grid 8	-0.1614	0.0923	-0.7003	<.0001
Season 2 grid 9	0.8375	<.0001	0.1158	0.1784
Season 2 grid 10	1.1827	<.0001	0.9234	<.0001
Season 2 grid 11	-1.8422	<.0001	-2.6104	<.0001
Season 2 grid 12	-1.8792	<.0001	-2.2717	<.0001
Season 2 grid 13	-1.6794	<.0001	-1.4297	<.0001
Season 2 grid 14	-0.8644	<.0001	-0.8457	<.0001
Season 2 grid 15	-0.5203	<.0001	-0.3726	<.0001
TX closure grid 1	-3.9738	<.0001	-0.486	0.0219
TX closure grid 2	-6.157	<.0001	-1.2545	0.001

Table 3.3, continued

TX closure grid 3	-9.2584	<.0001	-4.0878	<.0001
TX closure grid 4	-12.883	<.0001	-3.3988	<.0001
TX closure grid 5	3.5839	<.0001	2.723	<.0001
TX closure grid 6	0.5367	0.001	1.2145	<.0001
TX closure grid 7	-4.3519	<.0001	-0.4769	0.0221
TX closure grid 8	-6.3332	<.0001	-0.9293	<.0001
TX closure grid 9	-8.4649	<.0001	-3.5083	<.0001
TX closure grid 10	-10.288	<.0001	-4.3993	<.0001
TX closure grid 11	2.1732	<.0001	1.9597	<.0001
TX closure grid 12	-4.937	<.0001	-2.7841	<.0001
TX closure grid 13	-6.827	<.0001	-2.7085	<.0001
TX closure grid 14	-9.3216	<.0001	-4.126	<.0001
TX closure grid 15	-11.011	<.0001	-5.1315	<.0001
Vessel length grid 1	0.073	<.0001	0.0774	<.0001
Vessel length grid 2	0.0891	<.0001	0.1228	<.0001
Vessel length grid 3	0.00049	0.9765	-0.0392	0.1525
Vessel length grid 4	-0.0548	0.0017	-0.0637	0.0161
Vessel length grid 5	0.0735	<.0001	0.0905	<.0001
Vessel length grid 6	0.0613	<.0001	0.0579	<.0001
Vessel length grid 7	0.0637	<.0001	0.0546	<.0001
Vessel length grid 8	0.0434	<.0001	0.0791	<.0001
Vessel length grid 9	0.0002	0.9854	-0.013	0.1375
Vessel length grid 10	-0.023	0.0011	-0.0307	<.0001
Vessel length grid 11	0.0231	0.1177	0.003234	0.8061
Vessel length grid 12	0.0691	<.0001	0.003829	0.7407
Vessel length grid 13	0.0393	0.0032	-0.0162	0.175
Vessel length grid 14	0.032	0.0007	0.0498	<.0001
Vessel length grid 15	0.0188	0.0163	0.003322	0.6572
Expected revenue (mean)	0.0187	<.0001	0.0185	0.0053
Expected revenue (s.d.)	-0.009	0.4203	-0.0039	0.9707
Variation of ER (mean)	-0.0432	0.0795	-0.06	<.0001
Variation of ER (s.d.)	0.00350	0.9932	0.1286	<.0001
Distance (mean)	-0.0222	<.0001	-0.0162	<.0001
Distance (s.d.)	0.0118	<.0001	0.009207	<.0001
Crowdedness (mean)	0.035	<.0001	0.001298	0.0011

Table 3.3, continued

Crowdedness (s.d.)	-0.0152	<.0001	9.05E-05	0.9718
Crowdedness squared (mean)	-0.0002	<.0001	4.06E-07	0.6228
Crowdedness squared (s.d.)	0.0001	0.0004	-1.28E-07	0.9768

For the Florida (FL) model, the signs associated with the individual parameters are generally as expected.[33] Many of the estimates associated with the standard deviations of the random parameter, however, are not significant, particularly during the period 1995-1999. Overall, there is very little difference between the conditional logit and mixed logit estimated parameters for FL, suggesting that FL shrimp harvesters are either relatively uniform in their preference structures and/or are primarily influenced by past experience/habit in choosing their fishing locations.

For the LAM model, differences in the signs or magnitude of the non-random parameters between the mixed logit and conditional logit models tended to be minor. For the random parameters with a normal distribution, the means estimated in the mixed logit model have the same signs as those in the conditional logit model. In terms of the mixed logit itself, the standard deviation of the parameter for loyalty is significant in the LAM models for both time periods. Given that the coefficient means are approximately 4 while the standard deviations are approximately 1 would indicate, however, that only a small part of the distribution would be expected to take on a negative value. In terms of seeking a variety of fishing locations, the results indicate that LAM harvesters are very conservative when it comes to exploring alternative locations (Appendix K). The standard deviations of both the expected revenue and its variation are not significant for LAM harvesters, as evidenced in Appendix J. This would suggest that the LAM fishermen are profit driven and risk-neutral towards revenue uncertainty during years

[33] As with the conditional logit model, expected revenue during the initial five-year period was negative (though statistically insignificant).

1995-1999, while during 2000-2004 they remain profit driven but behaved uniformly risk-averse towards revenue uncertainty. The standard deviation for the linear term of crowdedness is not significant in either time period, but the standard deviation for the squared term is significant. This suggests that, in general, fishermen have a threshold for congestion on the fishing grounds and that the threshold is different for each individual fisherman. For the period 1995-1999 in LAM, the threshold has a mean of 52.81 and standard deviation of 26.29, but it ranges by vessel from zero to 104. For the period 2000-2004, the threshold has mean of 691 and standard deviation of 284.6, suggesting that a large majority of the thresholds are well above zero. Appendix L shows the probability density functions of the threshold for each time period. The distribution of the threshold is asymptotically normal, and the standard deviation is calculated using the delta method. The reason why a small portion of the population exhibits a zero (or lower) threshold might be because those trips are taken immediately after the Texas closure expired (around mid-July). Thus, even though there are no trips over the ten days before the closure is lifted (and thus the congestion indicator would have taken on a zero value), the fishermen are still expecting that a large number of vessels are going to the reopened area and thus they anticipated congestion. This explanation is relevant to grids 5, 10, 14, and 18, parts of which are in Texas waters and thus are included in the Texas closure for modeling purposes.

As with the FL and LAM models, the signs of non-random parameters associated with the TX models are approximately the same as those estimated with conditional logit, even though the mixed logit model experienced a significant improvement in log likelihood value. The standard deviation of the parameter for loyalty is not significant for TX in either time period, indicating that TX harvesters behave uniformly alternative seeking inertia, with little interest in seeking alternative fishing sites due to the uncertainties that might be involved. For years 1995-1999, the standard deviations of the expected revenue and its variation are not significant, suggesting that TX harvesters are profit driven and risk-averse towards revenue uncertainty during this time period. In addition, results suggest that their behavior towards risk does not vary substantially across harvesters. During the period 2000-2004, however, behavior toward expected revenue uncertainty apparently changed, with some harvesters exhibiting risk-averse behavior, some exhibiting risk-neutral behavior and some even exhibiting risk-seeking behavior; even as they all still sought to maximize profits. The mean of the variation of expected revenue is -0.06, with standard deviation of 0.13, suggesting that about 40% of the population behaved like risk-seekers during the years 2000-2004 (illustrated in the Figure below). As for crowdedness, parameter estimates associated with the mean and standard deviation of congestion were all statistically significant in the first period. The threshold of "crowdedness" in the years 1995-1999 has a mean of 97.22 and standard deviation 67.29, implying that around 10 percent of the population has a threshold of at least zero. Again, this negative outlook regarding congestion may have occurred at the time when the Texas closure reopened. Because the majority of the grids in TX study area are encompassed by the closure (the exceptions being grids 5, 6, 11, and 12 in Louisiana waters), the initial days after reopening of offshore waters may have been avoided even though the possibility existed for good harvests. The years 2000-2004 had an insignificant square term of crowdedness and variation, thus implying no threshold during this period of time. This result might be because fewer vessels were in the industry, in general, during that time period and about 10,000 fewer trips were taken during the period 2000-2004 compared to the previous five-year period, perhaps alleviating any potential for troublesome congestion.

One thing to note in these results is that, overall, the estimates for the means of the random parameters are larger in magnitude in the mixed logit model than in the conditional logit

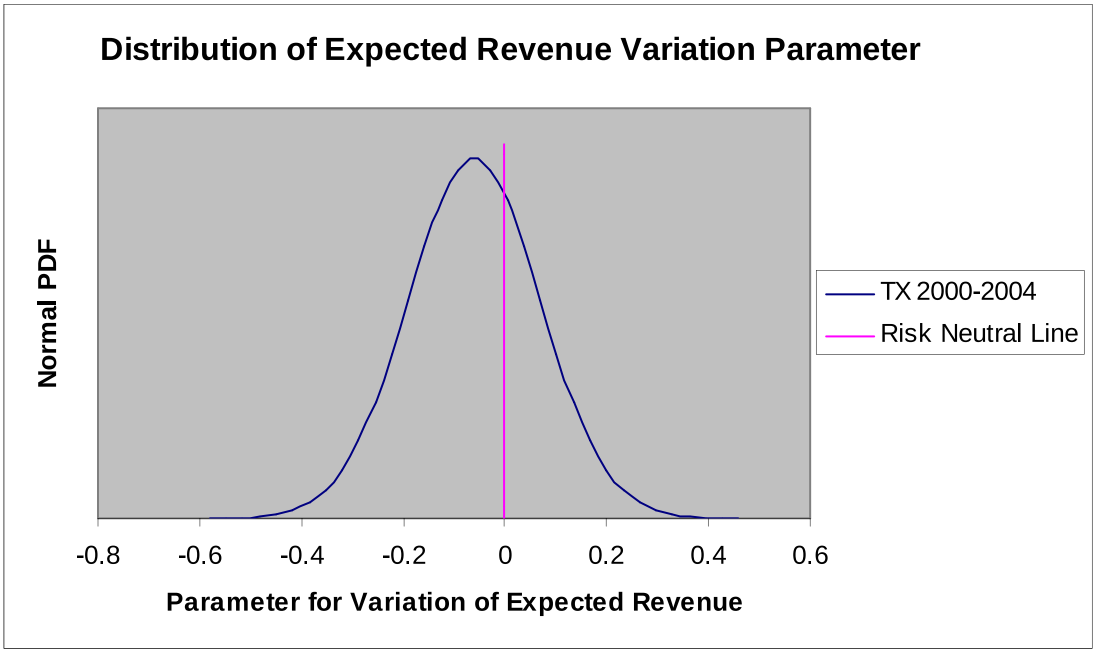

Figure 3.1 Distribution of variation of expected revenue parameter

model. This result is consistent with theory and the empirical results of other studies using mixed logit models (Train 1999, Smith 2005). As explained by Train (1999), "The scale of utility is determined by the normalization of the iid error term ε. In a standard logit, all stochastic terms are absorbed (as well as possible, given that they are not, in reality, all iid) into this error term. The variance of this error term is larger in the standard logit model than in a mixed logit since, in the mixed logit, some of the variance in the stochastic portion of utility is captured in (some deterministic term such as) η rather than ε. Utility is scaled so that ε has the variance of an extreme value. Since the variance before scaling is larger in the standard logit than the mixed logit, utility (and hence the parameters) are scaled down in the standard logit relative to the mixed logit." Expressed somewhat differently, since mixed logit draws some of the stochastic part of the error into the deterministic part, the error term is smaller in magnitude compared to conditional logit. When the parameters are normalized by the error term, mixed logit is using smaller "weights," so the parameter estimates are larger than in the conditional logit.

Smith (2005) mentions that potentially spurious preference heterogeneity might occur when state dependence is not modeled. This is tested in the current analysis by deleting the variable loyalty from the models and observing the significance of the random parameters. The results presented in Appendix M show that there is little spurious preference heterogeneity when the state dependence variable is ignored. Therefore, Smiths's conclusion does not hold in the case of the Gulf shrimp fishery, though the likelihood value significantly decreases without state dependence variable in the model. This would imply that the state dependence variable representing old habit or past experience of the fishermen has a significant amount of explanatory power in the model.

3.5 A Policy Application[34]

For purposes of examining the ability of the developed models to provide a measure of welfare loss from the closure of a given area, we consider extending the Texas closure into Federal waters off Louisiana (during the same time period). Since only Federal waters would be closed off Louisiana, the relevant area for consideration would be seaward of five fathoms and the closure was assumed to encompass subareas 13 to 17 for Louisiana (and, of course, the existing Texas closure area). Ten grids in the LAM area are influenced by this policy hypothesis (7, 8 9, 10, 12, 13, 14, 16, 17, 18). For the TX area, without the simultaneous closure, portions of grids 5, 6, 11, and 12 are open during the TX closure. If the simultaneous closure measure was taken, however, all these grids would be closed. The question of interest is the magnitude of the welfare loss under this assumed simultaneous closure. This estimate of welfare loss can be

[34] While the discrete choice model used a diesel price index that included state and federal excise taxes, these taxes were removed prior to estimating welfare losses associated with the hypothetical extension of the Texas Closure. In addition, recall that the location model included only a subsample of the population of trips (i.e., those vessels fishing continuously during the five-year period being considered). To generate an approximation of welfare losses for the entire fleet, the welfare losses from the subsample of trips was extrapolated to the population of trips based on the ratio of the population of trips to the sample of trips for any given year (and region).

regarded as the cost of this assumed policy instrument which can then be compared to other policy instruments for analyzing benefits and costs of alternative management measures.

The theoretical derivation of compensating and equivalent variation in the RUM is presented by Small and Rosen (1981) and Hanemann (1999). The basic intuition is that the "marginal willingness-to pay for a quality change is given by the marginal utility of quality, converted to monetary units via the marginal utility of income." The formula is widely applied in empirical studies such as Parsons and Kealy (1992) for nested logit models, Breffle and Morey (2000) for mixed logit models and Train (1998) for conditional and mixed logit models. Following Parsons and Kealy and Train, the welfare change can be measured as

$$\frac{1}{\beta_y}\cdot \ln\{\frac{\sum_j \exp(x_{ijt}\beta')}{\sum_j \exp(\tilde{x}_{ijt}\beta')}\} = \{\ln(\sum_j \exp(x_{ijt}\beta')) - \ln(\sum_j \exp(\tilde{x}_{ijt}\beta'))\}/\beta_y \qquad eq.\,3.24$$

where x is the vector of original attributes, and $\tilde{x}$ is the vector of the new attributes, the attributes are of individual i for alternative j on choice occasion t. β_y is the cost coefficient indicating the marginal utility of income.

To calculate the welfare change associated with the hypothetical extension of the Texas closure (to Federal waters off Louisiana), the procedure to be used is as follows. First, the hypothetically closed grids are excluded in the second summation and for all other grids (i.e., those that are to remain open) x is constrained to equal $\tilde{x}$. Second, the coefficient for weighted distance divided by the diesel price at the base month (i.e., converting the diesel price index into a dollar amount) is determined. However, this provides an estimate on the cost coefficient based on the assumption that it takes one gallon of diesel per kilometer traveled.[35] This assumption may be somewhat unrealistic. Because no published studies that provide an estimate of fuel usage per unit of distance for the Gulf shrimp fishery could be found in the literature, other sources (sales of shrimp vessels that mention fuel usage per hour and knots traveled per hour; telephone calls with selected shrimp industry members and others) were utilized to estimate fuel consumption per unit of distance traveled.[36] Provided information varied widely, but generally fell in the range of 1.5 gallons per nautical mile to 3.0 gallons per nautical mile. These figures are used to derive a final cost coefficient. Given this range, both a lower-bound and upper-bound estimate of welfare losses are calculated.

Table N.1 and Table N.2 in Appendix N list the estimated welfare change, under the two scenarios (i.e., an assumed estimate of fuel usage equal to 1.5 gallons per nautical mile and 3.0 gallons of fuel usage per nautical mile) based on the conditional logit model for each year (Table N.1 presents welfare change estimates for LAM-based vessels while Table N.2 presents welfare change estimates for TX-based vessels). As indicated, welfare losses for LAM-based vessels in the second time period (particularly after 2001) are generally significantly higher than those estimates in the first time period. This is to be expected given increased fuel costs. While total yearly welfare losses appear to be relatively low (consistently less than $200 thousand per year during the first five-year period and generally less than $400 thousand during the second five-year period), two important factors need to be considered. First, closure of the Federal waters off Louisiana may well not force fishermen to stop shrimping. Specifically, they have a large number of other choice locations, including the Louisiana state waters and/or areas in Mississippi

[35] Note that the coefficient is based on traveling while steaming rather than trawling. The distance variable as previously considered in the report reflects travel to the fishing ground rather than trawling activities. Trawling, of course, consumes more fuel per hour than does steaming.

[36] Of course, the actual fuel usage would depend on both individual vessel characteristics (e.g., vessel size, single versus twin screw, whether the generator is being run, etc.) and weather conditions (e.g., fuel consumption is likely to increase by a third or more under 'rough' seas).

or Alabama. The second factor to consider is that the fleet used in the model development consisted only of those vessels that fished continuously during the five-year period and, hence, the total number of trips that will be impacted would be higher than the number reported in the Table N.1.

Given this to be the case, it is also useful to consider the loss per trip. Among the LAM-based vessels that historically fished in the hypothetically closed area, losses during the initial five-year period consistently falls in the range of about $37-$154 per trip (much of the difference reflecting whether the lower-bound estimate or the upper-bound estimate is considered). [37] With increasing fuel costs during the second time period (and possibly other factors such as increased "crowding" in near shore waters), losses per trip during the second five-year period is about $93-$246. Based on these estimates, one could easily determine for any given year the total number of trips that would be directly impacted due to the hypothetical closure (i.e., among those vessels that fished continuously during the five-year period and those that fished only intermittently or in only one year) and estimate the total direct welfare loss.[38]

For TX-based vessels, the welfare loss associated with an extension of the Texas closure to Louisiana Federal waters, based on the conditional logit analysis, is substantially larger (Table N.2). During the first five-year period, total estimated welfare losses ranges from about $230 thousand to almost one-million dollars (depending upon year and whether the lower-or-upper bound estimate is considered) and remains at roughly that level during the second five-year period. Among affected vessels, welfare losses range from about $350 to $580 per trip (based on upper-bound estimates). Hence, estimated per trip welfare losses among the TX-based vessels is

[37] Recall that this is equivalent to the amount of income that would be required for them to willingly forgo a trip to the area being examined during the period of time when the Texas closure is in force.
[38] There is, in theory, also a welfare loss associated with vessels that would not be 'closed out' from the assumed extension of the Texas closure (i.e, those LAM-based vessels who did not fish in the proposed area) due to change in welfare associated with a reduced choice set but this analysis suggests that it is effectively zero in this particular case.

an order of magnitude greater than that for LAM-based vessels. The explanation for this is two-fold. First, TX-based vessels tend to be larger and make longer trips and, hence, per trip losses would be magnified. Second, and likely of greater relevance, closure of Federal waters off Louisiana essentially closes out fishing options for the TX-based vessels. In other words, the ability to switch locations among these vessels become exceedingly limited and, hence, some compensation in welfare losses via switching to an alternative location are minor.

Table O.1 and Table O.2 in Appendix O list the estimated welfare changes associated with the extension of the Texas closure based on the mixed logit model results. As indicated, the welfare losses for LAM-based vessels within the context of the mixed logit results (Table O.1) are approximately one-third lower than those estimated based on the conditional logit results (Table N.1). For the TX-based vessels, conditional logit results can be twice as large as those for mixed logit. This suggests that the conditional logit models have the potential to overestimate the welfare effects using the method proposed by Small and Rosen.

3.6 Conclusions

While this chapter uses the same data as is used in Chapter 2, a more flexible and general model (i.e., the mixed logit model) is employed. By specifying some parameters of the continuous variables as random and normally distributed, mixed logit incorporates the heterogeneity of the preferences of fishermen.

In general, the mixed logit results presented in this chapter are comparable with the conditional logit results presented in Chapter 2. The mixed logit results suggest, however, that even though their levels are heterogeneous, fishermen in all three areas are reluctant to seek alternative sites once they have become accustomed to a given one. In addition, the threshold for “crowdedness” tends to vary among fishermen.

Despite the uncertain nature associated with commercial fishing, few studies have examined the effects of risk on the decision-making behavior of the fishermen. An early study by Bocksteal and Opaluch (1983), while considering risk, base their conclusions on the wealth level of the fishermen (which is generally unavailable). Anderson (1982) considers a single location fishing decision under uncertainty by fishers who are profit maximizers. Adding to the previous literature body, Holland and Sutinen (2000) develop a model that incorporates the variation in revenue that is expected on a given fishing trip and conclude that the fishermen in their study are risk-loving. The same risk-loving conclusion is made by Dupont (1993) for the salmon fishermen when the model uses wealth level as an explanatory variable. Dupont (1993) also breaks the sample into four different groups according to their vessel types and run the same model with wealth level included. The results show that different groups have different risk attitudes and it is concluded that heterogeneity in risk preferences does exist among fishermen. Nevertheless, studies on heterogeneous risk preferences among fishermen are even fewer. Based on a quadratic functional form, Mistiaen and Strand (2000) use a random parameter analysis to accommodate the heterogeneity of risk preferences in their model and conclude that a small proportion of the fishermen are risk-lovers. Eggert and Tveteras (2004) are interested in the risk preferences heterogeneity in gear choices. Using a mixed logit model, analysis by Eggert and Tveteras is able to accommodate the risk in expected revenue by specifying the coefficient of variation for the expected revenues as random and normally distributed to reflect the heterogeneity of risk attitude.

Using mixed logit, this study examines risk preferences among Gulf of Mexico shrimp fishermen. Results suggest that most fishermen in the LAM region exhibit uniform risk attitudes. Texas shrimp fishermen, however, appear to exhibit heterogeneous risk preferences in the second period of analysis (2000-2004), with about 40% of them being risk-loving, although they were uniformly risk averse in the first period (1995-1999).

A simple welfare analysis of a hypothetical policy of simultaneous TX and LAM area closure is discussed to compare the results from conditional logit model and those from the mixed logit model. Using conditional logit, the annual welfare loss for LAM area can be as high as $440 thousand, and $965 thousand for the TX area. If mixed logit model is used and the welfare loss is measured at the mean of the random parameters, estimated losses among LAM fishermen approximate $278 thousand and $702 thousand for the Texas fleet. A comparison of welfare loss estimates associated with the conditional logit analsyis with those estimated under mixed logit suggests that conditional logit estimates may exaggerate the magnitude of estimated welfare gain or loss.

CHAPTER 4. SURVIVAL ANALYSIS ON TRIP LENGTH DECISION OF THE SHRIMP FISHERMEN

4.1 Introduction

In addition to location choice, a major short-run decision that a shrimp fisherman must make on a continuous basis is that of trip length. Assuming quasi profit maximization, the objective of fishers is to generate a level of trip returns above the variable trip costs prior to terminating the trip. Therefore, the trip length is expected to be significantly influenced by both trip catch and the output price. Other factors that can be expected to influence trip length decisions include costs, weather conditions, vessel characteristics, distance from port to the preferred fishing location, fishing regulations, and fishers' preferences. Over a more extended period (e.g., a season or a year), fishers would need to determine the number of trips to make. Given that: (a) the amount of time that is allowed or suitable for fishing in a season or year is limited, and (b) fishermen's preferences towards labor-leisure tradeoff do not change (implying that the layover days are not influenced by the preferences), the combination of trip length and number of trips represents a decision to be made by fishers. This indicates that if an enacted regulation or a change in market conditions affects the number of trips, the trip length will change accordingly (given fixed layover days preferences).[39] Assuming quasi-profit maximization, the optimal combination should be one that maximizes the seasonal profit.

Some descriptive statistics associated with the number of trips made each year from 1990-2004 for interview and whole fleet data are presented in Appendix P (Figure 4.1 below illustrates it graphically), while information with respect to average trip length for the interview data and average number of trips for the fleet is presented in Appendix Q (Figure 4.2 and Figure 4.3 provide graphical illustrations). From the information provided in the tables, one may

[39] Conversely, a regulation or change in market conditions that impact the length of a trip may also impact the number of trips.

observe that, over time, trip length tends to increase while the number of trips decline. This might be an indication that it takes longer for fishers to generate a certain level of expected returns per trip, on average, compared to past experiences. Given a fixed amount of fishing time during the year, this would translate into a reduction in number of trips.[40]

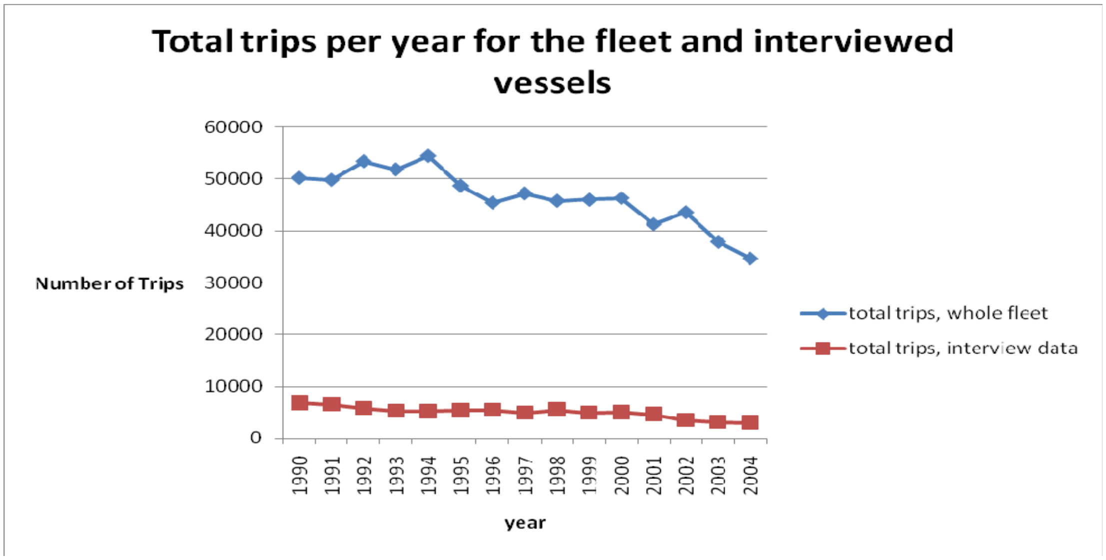

Figure 4.1 Yearly trips for the whole data and interview data

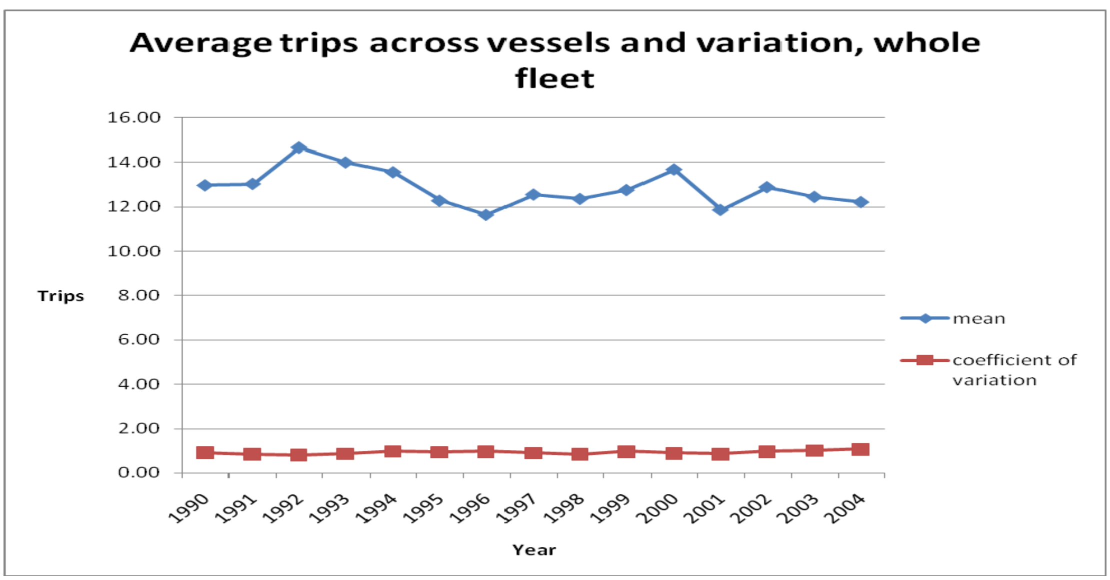

Figure 4.2 Average trips and variation for the whole fleet

[40] To some extent, the decline in total number of trips reflects a reduction in number of vessels in the fleet.

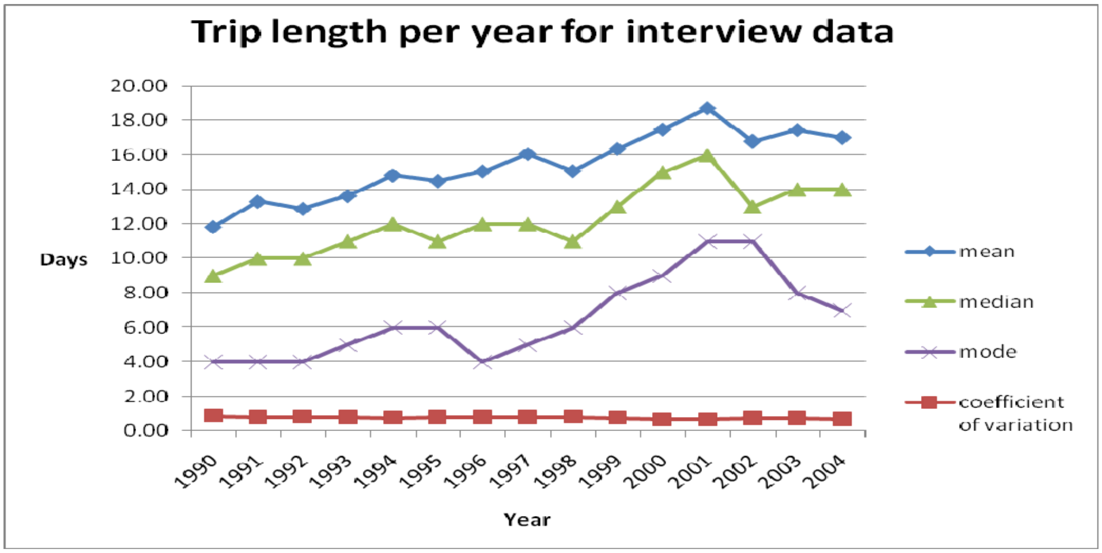

Figure 4.3 Trip length statistics for each year (interview data)

While this discussion provides *prima facie* evidence of a relationship between trip length and the annual number of trips, further study is required to verify such a relationship. This section considers the first issue in the apparent relationship. Specifically, this section focuses on the trip length decision of the shrimp fishermen and factors that influence it. Doing so will provide evidence as to whether regulation and/or changes in input or output prices influence trip length decisions. These results can then be employed in an analysis of number of trips, which is not the focus of this study.

From a policy standpoint, tools used in the management of the Gulf of Mexico offshore shrimp fishery (i.e., Federal waters) have historically emphasized by-catch reduction (particularly juvenile red snapper and turtles) and enhancing the market value of the harvested product (i.e., the Texas closure).[41] These factors are likely to have influenced trip length and, hence, indirectly the number of trips. More recently, a permitting system, which requires the

[41] The Texas Closure was enacted as a means of increasing the value of the shrimp harvest (via a larger average size of shrimp). Though this goal was undoubtedly achieved, the issue as to whether the increased revenues translated into a long-term increase in profits is more speculative.

requisite permit for shrimping in federal waters, was enacted (Amendment 11 to the Gulf of Mexico Shrimp Management Plan) with an effective date of December 5, 2002. A moratorium on those permits was put in place via Amendment 13 to the Gulf of Mexico Shrimp Management Plan. As noted by the NOAA FISHERIES SERVICE, Southeast Regional Office (Shrimp 13 Frequently Asked Questions[42] "[t]he moratorium will begin an economic recovery of the fishery." [43] Specifically, "[w]ith a cap on the number of vessels catching shrimp, the catch for each vessel should improve." [44] Assuming Amendment 13 achieves its goal (i.e., to begin the economic recovery of the shrimp fishery), one might anticipate that behavior among participants in the fishery will be influenced. One behavioral change is likely that of trip length (and, hence, indirectly the number of trips). As such, a better understanding of the economic and regulatory determinants of trip length can assist managers in the development of more effective management tools that consider changes in trip length that are likely to be forthcoming from any proposed management action. Contributing to this understanding serves as the purpose of this Chapter.

To contribute to a more complete understanding of those factors influencing trip length, survival analysis is utilized. Survival analysis (or the duration model) has been used in social sciences to analyze a multitude of issues, including, but not limited to the duration of strikes, length of unemployment, and time until business failure. The use of survival analysis to analyze trip length, while relatively new, does include recent tourism management and transportation science studies. The emphasis of the duration model is on the duration of events (the length of

---

[42] This document can be accessed at http://sero.nmfs.noaa.gov/sf/shrimp/shrimp13faqs.htm

[43] As discussed in Chapter 1, the economic viability of the shrimp harvesting sector has been eroding in recent years. This erosion, at least in part, reflects increasing imports and a concomitant decline in the real dockside price (See Keithly and Poudel, forthcoming, for additional discussion).

[44] This comment is based on the premise, of course, that the moratorium is a binding constraint. In the current economic environment, this assumption can certainly be questioned. The moratorium, which will be in force for ten years, unless subsequently changed by the Council, is a prerequisite to any limited entry program.

trip in this case) as well as the likelihood that the event will end at the next point in time given that it has lasted until a certain period. The survival function is the probability of observing a survival time greater than or equal to some stated value, while the hazard function is the rate at which the spell (i.e., the event) will be completed at duration t, given that it has lasted until t (Kiefer, 1988). The advantage of survival analysis over other models is that it deals with the time duration variable that has to be positive (either treated as discrete or continuous), and the linear regression model might not be suitable for this kind of dependent variable.[45] In addition, some covariates might be time-varying and the time-varying nature of covariates can be accommodated within the context of survival analysis.[46] Also, the change in trip ending decision over time can be included into the model. Compared to discrete choice model, the time factor is introduced without any concern about the inconsistency problem as with a lag dependence variable included in the discrete choice model. On the other hand, in terms of interpretation and prediction, the duration model might not be as straightforward as other models. Nevertheless, this study provides an alternative method to analyzing fishing trip length using panel data.

4.2 Literature Review

Hernández and Dresdner (2006) use a hazard function to analyze the impact of such regulatory regimes as temporal closures and individual quota systems on trip length. The model is applied to the pelagic industrial fleet in central-Southern Chile (between October 1997 and November 2002) which operates on four different species. The authors argue that the duration nature of the trip makes the use of the duration model appealing for at least two reasons. First, there is no left or right censoring of the data because the observations used are completed trips. In addition, since the trip length is usually too short to be affected by the change in its

[45] Specifically, both travel time and fishing time are truncated from below (i.e., must be positive). Predictions only in the positive domain are not guaranteed with a linear model specification (e.g., Ordinary Least Squares).
[46] It is also noteworthy that the duration model can be utilized in those instances where data are censored (i.e., incomplete observations).

determinants, one does not have to worry about the time-varying covariates problem mentioned in most survival analysis. Assuming a Weibull specification, a proportional hazard functional form is used and, due to its efficiency advantage over least squares, Maximum Likelihood is used to conduct the estimation. The covariates in their model include output and factor prices, fish availability indicators, technical characteristics of the vessels, amount of effort used per trip, the regulation regime indicators, and the interaction terms. The data show no sign of heterogeneity or autocorrelation. The duration dependence parameter is positive and significant, indicating that the probability of ending a trip increases with the trip length. This finding is intuitively appealing given the technical constraint of the vessel. The non-regulatory explanatory variables are significant with expected signs, but the quantitative effects are generally small. However, the regulatory regimes do have significant and important effects, as measured by elasticities. A temporal closure is found to increase the trip length while the individual quota is found to reduce trip length, which is consistent with the theoretical model presented by the authors. The authors conclude that an individual quota system is a preferable regime vis-à-vis temporal closures in terms of efficiency. The analysis also shows that trip length is more sensitive to price and biomass changes under the individual quota system than under other regulatory regimes, while the vessel dimension is not found to affect trip duration under this regime. The implication of these findings is that vessel owners are better able to plan their trips under an individual quota system. Further, after the introduction of the system, modern vessels are found to have a higher probability of remaining in operation. Finally, it is concluded that, since vessels can always recover unearned incomes during the closure time by increasing their activity once the area is re-opened, the temporal closure regime is relatively inefficient in terms of controlling fishing effort.

Smith (2004) analyzes fleet composition and attrition in the California red sea urchin fishery that is under limited entry regulation. In addition to exploring the dynamics of heterogeneity in catch and revenue, he uses a duration model to study individual fisherman attrition by incorporating both individual characteristics and time-varying covariates. In contrast to Bockstael and Opaluch (1983) or Ward and Sutinen (1994) who uses discrete choice to model disaggregated exit behavior, Smith (2004) uses duration analysis. Such an analysis permits Smith (2004) to forecast the overall size and fishing power of a fleet at future dates by integrating over individual survival functions. As noted by Smith (2004), survival analysis has two econometric advantages over the discrete choice model in the scenario considered by the author. First, the allowance of continuous length of participation distinguishes exit behaviors that took place after different lengths of time. Further, exit inertia can be included into the model with a parametric assumption on the hazard function. In this manner, the possible inconsistency problem in using lagged dependent variables in discrete choice modeling can be avoided. Survival time is defined in this situation as the length of time that an individual remains active in the industry. The factors that influence the time between entry and exit include abundance of urchin, the individual's skill, weather conditions, the physical stress of diving time, and regulations (such as size limits and season closures). To help address the management questions of "what drives the rate of attrition, how many harvesters will remain in the future, and what types of individuals are likely to remain active in the fishery," an Accelerated Failure model with Weibull specification is constructed.[47] Under the important assumption that the duration of being active in the fishery does not influence the regressors, or strict exogeneity of the explanatory variables, the author considers two separate subsamples: the full sample of all participants and those who fished at least one full

[47] As noted by the author, one of the reasons for using the Weibull specification is that it incorporates "a tenure effect" of exiting behavior or the instantaneous probability of exiting the fishery changes over time.

year during the year of 1988-1997. Those who are excluded in the second subsample are participants that are active only once or a few times (probably being recreational divers switching to a urchin dive). Out of the six models listed by the author, four models have results indicating a decreasing hazard rate, which implies switching inertia or exit resistance. In addition, the probability of exiting decreases with increasing average revenue per season and with an increasing number of ports visited. This shows that attrition is lower for more successful divers and/or more mobile divers. Also, tightened size limits and season restrictions are found to hasten the individual's choice to exit. The author does not discuss in detail why the parametric model is preferred. Furthermore, since most individual characteristics in the model are unobservable for which proxies are used, the author has not checked for unobserved heterogeneity.

The probability that a trip ends after a certain period of time for sport anglers under the Daily Bag Limit (DBL) constraint and the extent to which the probability is influenced by angling success was examined by Smith (1999). A maximum likelihood model was used on samples of anglers who targeted either Chinook salmon or coho salmon in the Strait of Georgia from 1984 to 1993. The probability of ending a trip after a certain number of hours with a certain catch depends on the probability that certain fish are caught after this period of time and on the probability that the trip will end at this point on the condition that it has lasted until a moment before this point of time. The latter part of the probability is just a duration model. The author uses a Weibull distribution since it "is well suited to model the probability of a boat-trip ending as a function of time." Further, the Weibull specification is modified such that the probability of a trip ending at a point in time is dependent on the cumulative amount of time spent fishing and total catch. Based on a GLM model, he also tests whether the number of anglers or the number of angling lines for each boat influence angling success and thus anglers' willingness to either extend or shorten the length of the trip. The results show that for either species, the number of angling lines significantly influence the trip duration, with each additional line increasing the trip length by 30-45 minutes (the number of anglers does not significantly influence trip length). In terms of their reaction towards angling success, furthermore, anglers can be categorized into two types. The first type tends to shorten the trip length if they successfully caught the desired number of fish (i.e., satiation sets in). The second category includes those who are motivated to catch more if they succeed in catching the fish they want. The author suggests that the model can be used to judge the effectiveness of DBL by including a sensitivity analysis of the model parameters to the hypothetical change in DBL.

4.3 Econometric Model

Life duration models, which are extensively used in biometrics and were first introduced to economics in the literature of job search and strike, can be used to estimate the probability of ending a trip at a certain point of time given the trip has lasted till the moment before that point. The probability distribution of duration is specified by the cumulative distribution function $F(t) = Pr\ (T \leq t)$, or the probability that the duration variable T is less than some value t, and the density function is $f(t) = d\,F(t)/d\,t$. The survival function defined by $S(t) = Pr\ (T > t) = 1 - F(t)$ is the probability that duration equals or exceeds t. The hazard function, or the rate of failure at $t+\Delta$, given survival up to t, is defined as:

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{Pr\left[t \leq T < T + \Delta t \mid T \geq t\right]}{\Delta t} = \frac{f(t)}{S(t)}, \qquad eq.4.1$$

and the cumulative hazard function is:

$$\Lambda(t) = \int_0^t \lambda(u)du = -\ln S(t) \qquad eq.\ 4.2$$

The hazard function provides a notion of duration dependence, with positive duration dependence implying the hazard rate increases with time and vice versa.

Nonparametric estimation of survival functions is useful for descriptive purposes. One does not have to incorporate an explanatory variable to have a general knowledge of the shape of the raw hazard or survival functions (hazard and survival functions are considered since they are more interpretable than the density function). The Kaplan-Meier estimator of the survivor function discussed in detail in Cameron and Trivedi (2005) and Kiefer (1988) is commonly used as a decreasing step function with a jump at each discrete failure time. Plots of the integrated hazard are typically smoother and therefore easier to interpret than plots of the hazard directly. The Nelson-Aalen estimator of the cumulative hazard function is commonly used.

If the duration distribution under consideration is correctly specified, the parametric method can be used to ensure a consistent estimation. The most common distributions used in economic literature are Exponential, Weibull, Gamma, Generalized Weibull, Gompertz, Log-normal, and Log-logistic. The Exponential is simple and has a memoryless hazard rate that does not vary with t, but it is generally too restrictive with just one parameter. The Weibull is widely used because, with two parameters, it gives more flexibility than the Exponential. In practice, the cumulative hazard function of the Weibull is more precisely estimated than the hazard function itself. Also, the logarithms of the cumulative hazard function is linear in $ln(t)$, so a plot of $ln\Lambda(t)$ against $ln(t)$ is helpful. The Generalized Weibull introduces an additional shape parameter in the Weibull and allows for more flexibility. The Log-normal and Log-logistic have an inverted bathtub hazard function that first increases with t and then decreases with t. This property makes them theoretically more attractive than the Exponential, Weibull, and Gompertz for duration data.[48]

For two-parameter distributions, explanatory variables are usually incorporated into the model by using $exp(\mathbf{x}'\beta)$ to ensure the non-negativity of the hazard function, where $\boldsymbol{x}$ is the vector of explanatory variables and β is the vector of parameters. Theoretically, if the density function is correctly specified, both Least-Squares Estimation (LSE) and Maximum Likelihood Estimation (MLE) can be used, with the former being less efficient. If the density is incorrectly specified, however, even MLE is inconsistent. Therefore, the main issues in parametric modeling are the dependent on correct model specification for consistent parametric estimates and the wide range of parametric models that are available. Most models can be classified as either a Proportional Hazard (PH) model or an Accelerated Failure Time (AFT) model, with the Weibull model being in both classes.

The PH model is widely used in the economics literature. The conditional hazard rate of it can be factored as

$$\lambda(t \mid x) = \lambda_0(t, \alpha)\phi(x, \beta) \qquad eq.4.3$$

where $\lambda_0(t, \alpha)$ is the baseline hazard and is a function of t alone, with α being the parameter of the duration distribution, and $\phi(x, \beta)$ is a function of $\boldsymbol{x}$ alone. A common functional form for $\phi(x, \beta)$ is $exp(x, \beta)$. The PH model makes it easier to estimate the parameters β consistently without specification of the functional form of the baseline hazard. The interpretation of the coefficients is also simple, with a positive β implying an increase in the hazard rate as a component of $\boldsymbol{x}$ increases, or the changes in the explanatory variables have the effect of a

[48] The Gompertz is generally considered for mortality data and biostatistics analysis.

multiplicative change in the hazard function, since given $\phi(x,\beta) = \exp(x,\beta)$ in the Weibull model, for instance,

$$\partial\lambda(t)/\partial\mathbf{x} = \beta\cdot exp(\mathbf{x}'\beta)\alpha t_{\alpha-1} = \lambda(t)\beta \qquad eq.4.4$$

The PH model allows flexible transformations of the duration variable to achieve linearity in regressors, but it restricts the distribution of the additive error. The AFT model, on the other hand, restricts the transformation of duration but allows fairly general error distributions. In the AFT model, the effect of explanatory variables is, in essence, to rescale time directly. Defining the baseline survival function as $S_0(t)$, we have for AFT model:

$$S(t,\mathbf{x},\boldsymbol{\beta}) = S_0[t\phi(\mathbf{x},\boldsymbol{\beta})] \qquad eq.4.5$$

To solve the inconsistency problem related to the fully parametric model when any part of the model is misspecified, a semiparametric method that requires less than complete distributional specification is commonly used due to its success in the empirical studies. Take the PH model as an example. A semiparametric specification allows the functional form for $\phi(x,\beta)$ fully specified and the functional form for $\lambda_0(t)$ unspecified. Usually, a partial likelihood with the baseline hazard dropped out is used to estimate the parameters that are of interest. The resulting estimator is not efficient, but is consistent. Also, according to Cameron and Trivedi (2005), a comparison of the partial likelihood estimator with the MLE for parametric PH model such as Weibull shows small efficiency loss, if at all.

One problem in economic data and in most econometric specifications is ignoring the unobserved heterogeneity in modeling. According to Cameron and Trivedi (2005), at least two consequences need to be considered if we ignore the unobserved heterogeneity in the hazard modeling. First, the neglect of unobserved heterogeneity may lead to serious bias such as an estimated hazard rate that is falling faster or rising more slowly than the actual hazard rate, or an underestimation of the slope of the hazard function. Another issue is that given heterogeneity, the proportional impact of a change in an explanatory variable is smaller and depends on time. Thus, the estimates from the model ignoring heterogeneity may be misleading even if the unobserved heterogeneity term is uncorrelated with the explanatory variables.

Usually, a graph of the estimated integrated hazard against $\hat{\varepsilon}$, the estimated generalized residual of the model is plotted and it is expected that without misspecification the plot should yield an approximately linear positive relationship with 45 degree slope. More formally, one can regress $-\ln S(\hat{\varepsilon})$ on $\hat{\varepsilon}$ and test whether the intercept is zero and the slope is one, which works for any parametric model. Cameron and Trivedi (2005) also consider a score test of the unobserved heterogeneity based on the exponential null model. Due to the claim that tests of state dependence in the presence of incorrectly neglected heterogeneity are biased, and the reverse is also true, a joint test of zero unobserved heterogeneity and no duration dependence is proper. It is also suggested, based on Han and Hausman (1990) and Meyer (1990), that estimates show little sensitivity to alternative functional forms for the heterogeneity term when the baseline hazard is not parameterized. Hence, a PH model with no specification of the hazard function is appropriate to combine with the heterogeneity assumption.

4.4 Variable Description

As in the previous chapters, data used in the survival analysis reflect a combination of the Coast Guard Vessel Operating Unit File (VOUF) and the Shrimp Landings File (SLF) for the 1990-2004 period.[49] For the entire fleet, there are 695,503 trips taken by 9,512 vessels over the

[49] Unlike the previous sections in this report, the survival analysis extends from 1990 through 2004. In part, the time-period extension reflected an attempt to alleviate multicollinearity issues that were evident using a shorter period of time. As discussed later in this section, increasing the time period of analysis only partially addressed the

fifteen years. In general, the trips taken and vessels participating in shrimping decrease over the period of analysis. Simple statistics associated with the fleet trips are provided in Appendix Q. Due to the fact that the departure date of a trip is only available in the interview data, which is required to calculate the trip length, only the interview data is used in the survival analysis which, on average, comprises about 10% of the data available on the entire fleet.

The percent of total trips sampled each year, as indicated, has remained relatively constant, approximating 10%. The portion from each state by year, however, varies and is not balanced. A detailed discussion about some concerns on the sampling can be found in Griffin (2006). Comparisons of the entire fleet and the interview data in terms of the number of trips and the average trips per year across vessels are in Figure 4.1and Figure 4.2, respectively.

The interview data included 74,668 trips for the 15 years, but due to the missing values or errors that could not be easily corrected, approximately 10,000 trips are deleted from the analysis.[50] In appendix Q the trip length statistics for interview data are presented. From the information in the Table, one can observe that the mean and median of the trips length across trips per year are increasing (as graphically demonstrated in Figure 4.3. Note that the coefficient of variation is plotted in the figures. Graphical analysis suggests that variation in the means is relatively small).

The trip duration can be decomposed into three time elements: travel time, searching time, and fishing time. Some factors likely affect all three elements while others may influence only one or two of the elements. In order to better understand how the fishermen decide on the trip length, the trip duration is split into two components for analysis: days spent fishing and

---

multicollinearity issue. As such, a restricted model (i.e., omitting some variables) was estimated in lieu of an unrestricted model.

[50] For example, a trip with an departure date of, say, June 12, 1995 and a return date of June 14, 1996 reflects a data entry error which could (and was) easily be fixed.

days spent traveling and searching.[51] The interview data provides information on days fished for each site and each species. From the raw dataset, days fished for each trip is calculated by summing over size, site, and species. Appendix R lists the simple statistics of days fished per year (graphically illustrated in Figure 4.4.a below). A comparison of average days fished and average trip length for each year is presented in Figure 4.4.b. As indicated, average trip length appears to be increasing over time as does the average number of days fished, but the increase in days fished is relatively small vis-à-vis trip length. From this, one can conclude that much of the increase in average trip duration is due to the increase in time spent traveling and searching.

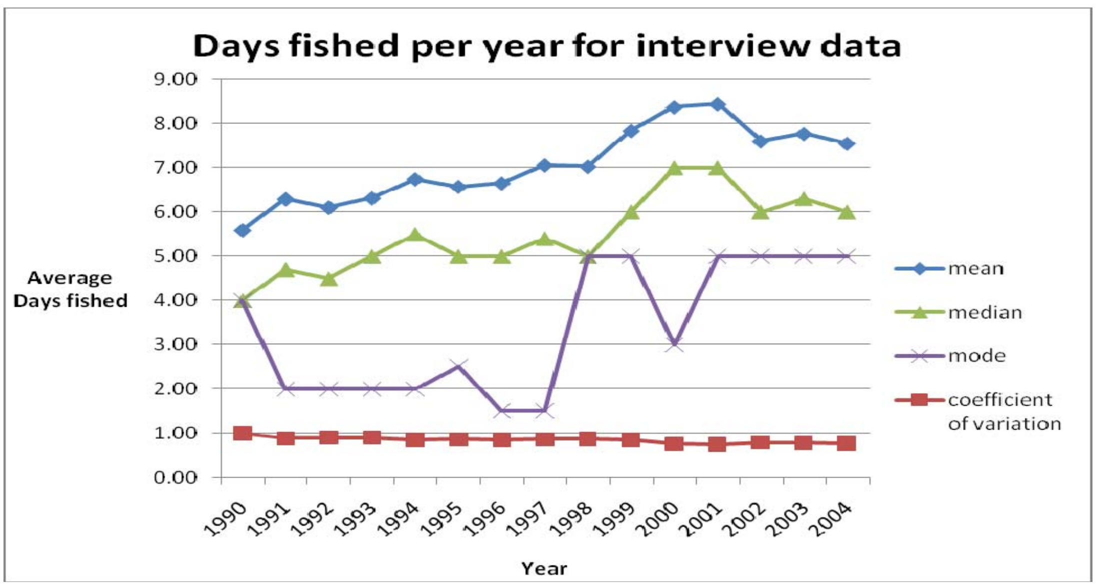

Figure 4.4.a Days fished statistics for each year

One of the factors that determine trip length is distance. One would expect that travel time (and likely search time) is positively correlated with distance. The influence on days fished associated with distance is also expected to be positive, *ceteris paribus*. This reflects the fact that incurred costs increase in relation to distance and, assuming quasi profit maximization, one would assume that fishermen attempt to recoup these additional

[51] Lack of information on travel time versus search time necessitated combining the two in the analysis. The "travel time" in this analysis is in fact travel time plus searching time.

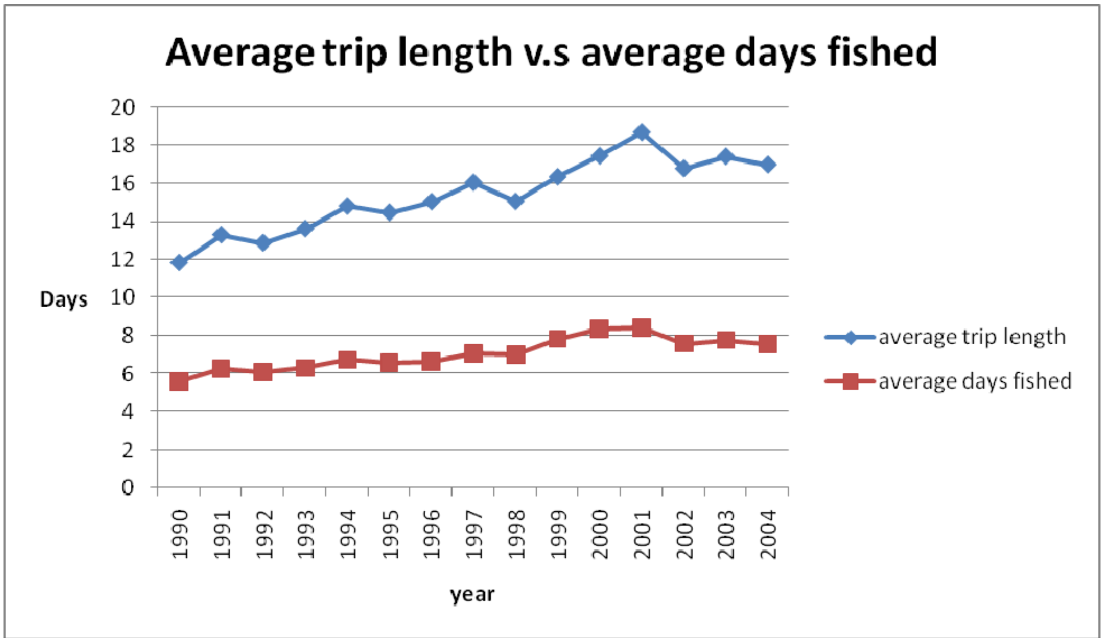

Figure 4.4.b Days fished vs. trip length

costs[52]. Distance in this part of the analysis is calculated by GIS software measuring the distance from homeport to the center of the small grid defined by fathom zone and subarea in the raw data. About ten percent trips visited more than one site and distance to the farthest site is chosen as the value of distance for the particular trip. In the model considered for analysis, a dummy variable for multi-sites is included to capture the effect of multiple sites visits. The hypothesis is that visiting more than one site tends to extend the trip length. About two percent of the trips visited areas deeper than 50 fathoms, and they are treated as visiting 50 fathoms. Since larger vessels are capable of traveling longer distances, vessel length is hypothesized to be positively related to trip length.[53] Trip duration, *a priori*, is also thought to be correlated with shrimp abundance which, undoubtedly, varies by area. As such, a measure of shrimp abundance based on fishery dependent data is included in the survival analysis model. To obtain a measure of

[52] Strictly speaking, travel time is simply equal to distance weighted by a time unit, so travel time represents distance multiplied by some constant (assuming homogeneity among vessels which is not likely to hold.

[53] Vessels that did not have length data were excluded from the analysis. In some instances, furthermore, vessels were observed to change length (generally by one or two feet). For these vessels, length used in the analysis was maintained at its initial level.

shrimp abundance for analysis, four large areas (i.e., aggregated over a number of subareas) are first defined. Then, by analyzing the monthly shrimp abundance, by size, for the different fathom zones for each of the four areas, further refinement (i.e., subdivision) is made within each area.[54] Based on each grid, the monthly shrimp abundance expressed in pounds, is estimated for the fleet (i.e., total catch by the fleet in that area over the past month). Then the total catch is standardized by dividing it by standardized days fished for the whole fleet over the past month for each area. The standardized total pounds are in turn divided by the area of each grid (given in acres) to obtain an estimate of shrimp abundance per unit area for each of the grids.

Due to the price differential associated with shrimp of different sizes, the decision of trip length might also be influenced by respective abundance of different sizes of shrimp. Three categories of shrimp size are considered in this analysis: large, medium and small. The definition of the sizes is given in Table 4.1. The shrimp abundances for each grid by sizes are also calculated in addition to the general abundance. For purposes of analysis, relative abundances of the different size classes are defined as the log ratio of the different classes (i.e., large vs. medium and small vs. medium). [55]

The monthly dockside shrimp price (deflated), which is equal to the weighted average of the different size categories (as opposed to the created classes), is also included in the analysis. The variability in shrimp price across areas is assumed to be small and, hence, the average price is considered to be the same for all fishermen at a given point in time (i.e., month). In addition to the average dockside price, the differentials (deflated) between large and medium shrimp and small and medium shrimp are also included as covariates in the two models (i.e., the travel time model and the days fished model). These two variables are included in an attempt to determine

---

[54] A detailed definition of areas used to calculate shrimp abundance is provided in Appendix S

[55] A log ratio was used with respect to relative abundance of the different classes because of observed skewednesss in the untransformed ratio.

Table 4.1 Definitions of Shrimp Sizes

Size	By counts	By size
Large	< 25	1-3
Medium	25-67	4-7
Small	>67	8

how changes in relative prices influence shrimper behavior in terms of both travel time and fishing time. As the information in Figure 4.5 would suggest, the price spread between the "large" and "medium" shrimp has narrowed substantially in recent years. While less obvious, there has also been a narrowing of the price differential between the "medium" and "small" shrimp.

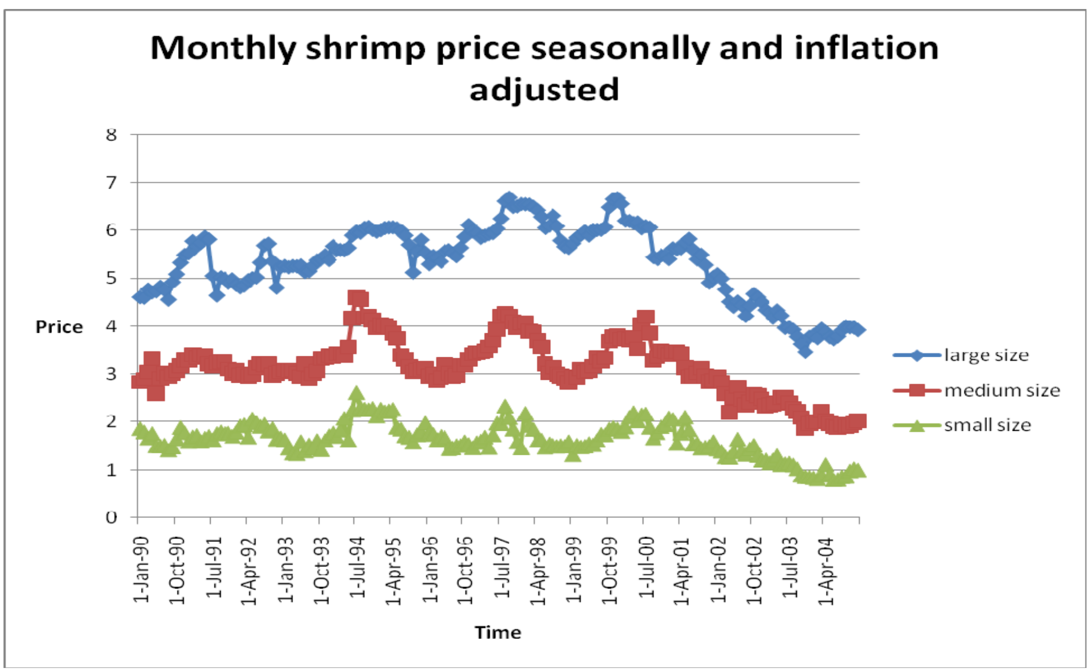

Figure 4.5 Monthly shrimp price against time

The diesel price represents the primary variable input- cost expected to determine travel and fishing time and thus the length of trip.[56] It is well known that fuel use associated with trawling activities (per unit of time) is significantly higher than that in running to the fishing ground. Therefore, one might anticipate that fishermen might be more concerned about the diesel price when considering days fished than when considering traveling time. To account for changes in diesel price over the time period of analysis, a diesel price index (adjusted for inflation) is included in the analysis (Figure 4.6). Management tools, such as the TX closure and the requirement of bycatch reduction devices (BRD), may also influence trip length (via either travel time or fishing time, or both). Appropriate discrete variables were included in the analysis in an attempt to "capture" the influence of these factors.[57]

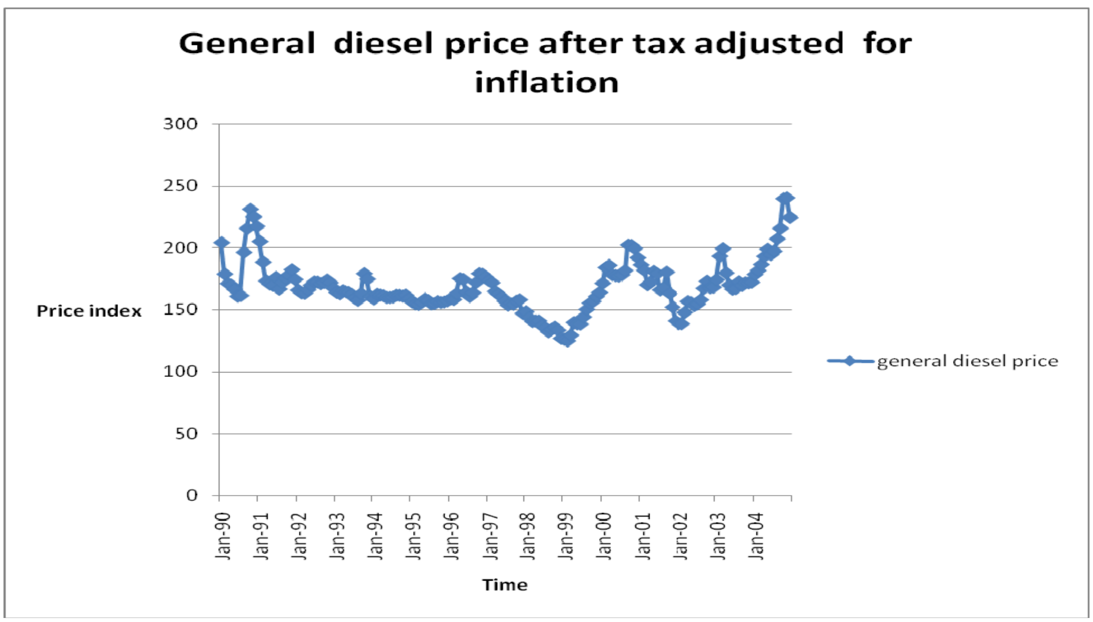

Figure 4.6 Diesel price index over the years

[56] While it may be argued that payments to the crew represent and additional input component, the share system will to some extent minimize its relevance in determining trip length. Furthermore, to the extent that fuel costs are deducted from crew share prior to payments, the same factors that determine the length of trip to the owner/operator of a vessel will also influence crew input in the decision-making process.

[57] While regulations only require BRDs on vessels fishing in federal waters after May1998 (Florida and Texas subsequently mandated the use of BRDs in state waters), the discrete variable (equal to 1) was imposed on all trips after that period (regardless of where fishing occurred). The rationale for doing so was that the mandatory use of a BRD may influence the decision whether to fish in state or federal waters.

4.5 Results and Interpretation

Recall that the trip length is composed of searching time, travel time and fishing time. Since days fished information is available from the original data, two models are run with days fished and travel time being the respective dependent variables to better capture each covariate's effect on the trip length.[58] With the exception of the variable distance, days fished and travel time share the same explanatory variables. Since travel time, as noted, would be perfectly linear related to distance (if the fleet were homogeneous), it is not included in the travel time equation. Since increased costs are incurred as travel time increases, however, distance is expected to influence days fished based on quasi-profit maximization criteria.

The explanatory variables for both models are: vessel length, the inflation adjusted diesel price index, the average shrimp dockside price, two shrimp dockside price differentials (large vs. medium and small vs. medium), a shrimp abundance index by area, two abundance differentials by area (large vs. medium and small vs. medium), a multiple site indicator, a TX closure categorical variable, and a BRD categorical variable. Also, since the samples are not taken evenly for each year and each state, year and state dummy variables are also included in the model.[59] Summary statistics by state and year are presented in Appendix T and Appendix U, respectively (note that the summary statistics are based on the final dataset where 420 observations are deleted because days fished is equal to or larger than trip duration which is assumed to be the result of data entry errors).

In order to gain a general appreciation of the two durations (days fished and travel time) a nonparametric Kaplan-Meier estimator is first run for each model by state and year without covariates. The results are in Appendix V. As indicated, none of the observations are censored,

[58] Travel time, as noted, incorporates search time. It is calculated by subtracting days fished from trip duration.
[59] An initial specification of the model also included monthly dummy variables. They were deleted in the final version of the model due to multicollinearity problems.

an outcome that facilitates estimation and interpretation. From the graphs, one can note that stratification by year does not appear to be of concern but that stratification by state is more relevant. Given this to be the case, a semi-parametric Cox Proportional Hazard model is estimated due to its flexibility in baseline hazard function and its popularity. The q-q plots on the distribution of durations are analyzed to see which distribution has a better fit in terms of running parametric models. It turns out that the Weibull fits both days fished and travel time better. Also, the advantage of using the Weibull is that it belongs to both the proportional hazard and accelerated failure time families. The results of parametric models assuming Weibull distribution and semi-parametric models are in Appendix W and Appendix X, respectively. The robust error is chosen to correct for heterogeneity after stratifying the variable state. Comparing the two results suggests that the estimates in the parametric models are similar to those in the semi-parametric models.[60] However, after checking for goodness-of-fit in both SAS and STATA, both models indicate a poor fit. Specifically, even after incorporating additional variabales, the model appears to be misspecified.[61] After checking for potential unobserved heterogeneity (and possibly the random effects), the parametric model with unobserved heterogeneity incorporated has the best fit, and it is this specification upon which results (Table 4.2) and interpretations are based. The Gamma distribution is chosen for the heterogeneous error due to the popular combination of Weibull-Gamma in duration modeling with unobserved heterogeneity and also as a result of its ease in computation of the combination.

Table 4.2 Parametric Estimation Results---with Gamma Distributed Heterogeneity

	Travel time		Days fished	
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
year91	-0.162***	0.851***	-0.0358	0.965
	(0.0288)	(0.0245)	(0.0254)	(0.0245)

[60] Both the parametric and semi-parametric models are using robust error and stratify on states.
[61] While the robust error may correct the test for zero covariates, it would not correct for the misspecificataion of the model.

Table 4.2, continued

year92	-0.251***	0.778***	-0.101***	0.904***
	(0.0303)	(0.0236)	(0.0266)	(0.0240)
year93	-0.256***	0.774***	-0.0615**	0.940**
	(0.0327)	(0.0253)	(0.0288)	(0.0271)
year94	-0.288***	0.750***	0.153***	1.166***
	(0.0362)	(0.0272)	(0.0320)	(0.0373)
year95	-0.270***	0.764***	0.0664**	1.069**
	(0.0360)	(0.0275)	(0.0318)	(0.0340)
year96	-0.398***	0.672***	-0.0175	0.983
	(0.0327)	(0.0220)	(0.0287)	(0.0282)
year97	-0.487***	0.614***	0.0695**	1.072**
	(0.0388)	(0.0238)	(0.0341)	(0.0366)
year98	-0.645***	0.525***	0.200***	1.222***
	(0.0571)	(0.0299)	(0.0496)	(0.0606)
year99	-0.782***	0.457***	0.221***	1.247***
	(0.0656)	(0.0300)	(0.0570)	(0.0710)
year2000	-0.808***	0.446***	0.00421	1.004
	(0.0675)	(0.0301)	(0.0577)	(0.0579)
year2001	-1.016***	0.362***	-0.00473	0.995
	(0.0637)	(0.0231)	(0.0541)	(0.0539)
year2002	-0.798***	0.450***	0.0338	1.034
	(0.0628)	(0.0283)	(0.0534)	(0.0552)
year2003	-0.963***	0.382***	-0.0491	0.952
	(0.0623)	(0.0238)	(0.0527)	(0.0502)
year2004	-0.951***	0.386***	-0.221***	0.801***
	(0.0623)	(0.0241)	(0.0527)	(0.0423)
FL	-0.534***	0.586***	0.156***	1.169***
	(0.0274)	(0.0161)	(0.0237)	(0.0277)
LA	0.749***	2.114***	-0.460***	0.631***
	(0.0325)	(0.0686)	(0.0302)	(0.0191)
MS	-0.673***	0.510***	-0.225***	0.799***
	(0.0799)	(0.0408)	(0.0711)	(0.0568)
TX	-0.247***	0.781***	-0.125***	0.882***
	(0.0217)	(0.0169)	(0.0188)	(0.0166)
vessel length	-0.0514***	0.950***	-0.0509***	0.950***
	(0.0010)	(0.0009)	(0.0009)	(0.0008)
diesel price index	0.0546	1.056	0.662***	1.938***
	(0.0820)	(0.0866)	(0.0725)	(0.1410)
shrimp price	-0.0846***	0.919***	-0.215***	0.807***
	(0.0216)	(0.0198)	(0.0190)	(0.0154)

Table 4.2, continued

price difference	-0.0116	0.988	0.151***	1.163***
(large V.S medium)	(0.0185)	(0.0183)	(0.0163)	(0.0189)
price difference	0.0505**	1.052**	0.0203	1.021
(small V.S medium)	(0.0220)	(0.0231)	(0.0193)	(0.0197)
ln(abundance)	0.0411***	1.042***	-0.0336***	0.967***
	(0.0038)	(0.0040)	(0.0033)	(0.0032)
ln(abundance)	-0.163***	0.850***	-0.0157***	0.984***
(large V.S medium)	(0.0065)	(0.0056)	(0.0057)	(0.0056)
ln(abundance)	0.0695***	1.072***	0.0791***	1.082***
(small V.S medium)	(0.0046)	(0.0050)	(0.0040)	(0.0043)
TX closure	-0.605***	0.546***	-0.191***	0.826***
	(0.0210)	(0.0114)	(0.0179)	(0.0148)
BRD	0.524***	1.689***	-0.283***	0.753***
	(0.0511)	(0.0862)	(0.0437)	(0.0329)
multiple site	-0.918***	0.399***	-0.409***	0.664***
	(0.0182)	(0.0073)	(0.0153)	(0.0102)
ln(distance)			-0.708***	0.492***
			(0.0085)	(0.0042)
constant	1.057***	2.877***	3.705***	40.66***
	(0.1420)	(0.4070)	(0.1350)	(5.4880)
Weibull shape		1.765***		1.583***
		(0.0103)		(0.0084)
Gamma parameter (θ)		0.403***		0.192***
		(0.0108)		(0.0083)
Log Likelihood	-76070		-77605.6	
Observations	64038		64038	

*** p<0.01, ** p<0.05, * p<0.1

Standard errors in parentheses

Note:

Likelihood-ratio test of theta=0: chibar2(1) = 2586.03 Prob>=chibar2 = .000

Likelihood-ratio test of theta=0: chibar2(1) = 783.95 Prob>=chibar2 = .000

Most often, the hazard ratio is used in interpretation instead of the coefficient of a variable. While the former is just taking the exponential of the latter, it is easier to understand. Technically, when the coefficient of a categorical variable x is, say, b, then, a unit increase in x will increase the hazard by *exp(b)* ─ 1 percent. For instance, the coefficient of BRD in travel time model is 0.524. This implies that once a BRD is installed on a vessel, it increases the hazard of ending a trip by 69% in relation to a vessel without BRD. The interpretation for continuous variables is similar. The hazard function is defined as the instantaneous rate of failure which has unit 1/t. It is the limiting probability that the failure event occurs in a given interval, conditional upon the subject having survived to the beginning of that interval, divided by the width of the interval (Cleves et al., 2004).

For the days fished model, adding an additional foot to the vessel length is found to decrease the hazard of ending the trip by 5%, implying that large vessels tend to fish longer. Similar results are found for the travel time model, indicating that larger vessels will also spend more time on traveling and searching. The model results also indicate that an increasing shrimp price will induce fishermen to fish longer and will also result in a higher travel/search time. As one would expect, the relationship between visiting multiple sites and fishing time (as well as travel time) is positive, implying that total trip length increases as the number of sites visited increases. Regulations are also found to statistically influence fishing time and/or travel time. The Texas Closure is found to result in an increase in both travel time and fishing time. This finding is expected given that the closure "forces" a segment of the fleet to physically travel a longer distance; hence explaining the increase in travel time. Given the higher costs incurred in travelling a greater distance, these additional costs need to be recouped via increased fishing time. The installation of a BRD is found to increase fishing time, likely the result of shrimp loss associated with its use.

A higher shrimp abundance per unit area is found to induce fishermen to fish longer, everything else being equal. Higher abundances likely translate into higher catch per unit effort for the individual vessel and, as such, would encourage additional fishing (i.e., days fished) to maximize quasi profits. An increase in the shrimp abundance, however, is found to result in a decrease in travel and searching time. Such a finding is not unexpected. Specifically, given the migration nature of shrimp, abundance will tend to decrease in relation to distance from shore. Hence, higher abundances are, to a large extent, inversely related to distance. The trip length is also found to increase in relation to the ratio of large medium shrimp. Given that size of shrimp tends to be related to depth, this finding is expected. Similarly, an increase in the ratio of medium shrimp to small shrimp is found to increase trip length.

With respect to the output price, the analysis indicates a negative relationship between fishing time and the differential (deflated) between large and medium shrimp. Hence, as the price differential between large and medium shrimp increases, the time engaged in fishing declines. As previously noted, the price differential between large and medium shrimp has narrowed during the period of analysis. The narrowing of this differential may help to explain the observed increase in the average days fished per trip. Results also suggest, however, that a change in the price differential between large and medium shrimp will have no effect on travel time. However an increase in the price differential between medium and small shrimp is found to result in an increase in the travel time and in fishing time. While the reason for this finding is not obvious, one plausible explanation may be that the change in the price differential between medium and small shrimp is not as significant as that observed between the large and medium shrimp. As such, so there will not be too much effect on fishing time which is directly related to revenue.

The input factor of particular relevance with respect to its cost is, as mentioned, diesel. Results from the survival analysis indicate that the change in diesel price does not affect travel time. On the other hand, an increasing fuel price is found to result in a reduction in time spent fishing, *ceteris paribus*.[62] Considerably more fuel is consumed per unit of time fishing than in

[62] In interpreting the estimated relationship between the price of diesel and fishing time, it is important to recognize that distance travelled has already been taken into account. If it were excluded, the relationship would possibly be different.

traveling or searching. With relatively low fuel prices, it may be advantageous for the individual fisherman (in terms of maximizing profits) to trawl to and from a preferred location even if the catch per unit effort is relatively low. As the price of diesel increases, however, the expected benefits from trawling to and from a preferred location decrease. If this is the situation, shrimp fishermen will tend to shorten the amount of time actually engaged in fishing.[63]

One observation of interest is that when the models are run on only year and state dummy variables, controlling for heterogeneity, there is an obvious decline in hazard ratio of ending the trip over the years. That is, both the days fished and the travel time tend to increase over the years. When the explanatory variables on vessel characteristics, trip characteristics, policy tools and market indicators are added, the change in time spent fishing is, to a large extent, accounted for by the change in those variables. As we can see by comparing Table 4.2 above with Appendix Y, the declining hazard ratio pattern over the years does not appear in the full model for days fished. The increase in days fished over the years is, at least in part, likely the result of the net effect of increasing diesel price and the decreasing price margin between large and medium shrimp. Also, travel time appears to have increased during the period of analysis suggesting a possible increase in distance traveled. Recouping the increased travel costs would translate into an increase in fishing time. However, the pattern of declining hazard ratio over the years still exists after adding the covariates into the travel time model. This might indicate that there remain some unobserved factors such as vessel characteristics and/or fishermen's skills that affect travel time but are not included into the model.

[63] While this explanation appears plausible, these findings are somewhat contradictory to those in the location choice modeling exercise (Chapters 2 and 3).

4.6 Some Comments on Unobserved Heterogeneity

As mentioned in the previous section of this chapter, ignoring unobserved heterogeneity might result in misleading results even when the unobserved heterogeneity is not correlated with the explanatory variables. This can be seen by comparing the parametric model with and without heterogeneity specified (Table 4.2 and Appendix Z). Note that the magnitude of the estimators in the models with heterogeneity specified is, in general, larger than those without, especially for the Weibull shape parameter. This is consistent with theory since, as noted, one of the consequences of neglected heterogeneity in the PH model is underestimation of the hazard rate. The log likelihood is also higher in the former, particularly for the travel time model. A likelihood ratio test for heterogeneity is given for the travel time and days fished models respectively, and both are rejected (as presented in the footnote of Table 4.2). This can also be seen from the p-value of the Gamma parameter estimator. The distribution of the heterogeneity term can be inverse Gaussian too, but after trying it and comparing it to the Gamma distribution, the latter yields a better fit. The parameter specification of the heterogeneity distribution is due to the ease in computation and, as mentioned in Cameron and Trivedi (2005), if the baseline hazard is corrected specified, “the parametric specification of unobserved heterogeneity is relatively innocuous.” The reason is that the specification of the baseline hazard function affects the first moment of the density function, while the specification of the heterogeneity influences the second moment, with the non-correlated relationship between the error term and covariates assumed. Therefore, the loss would be in efficiency of the estimator, even if the heterogeneity distribution is not correctly specified. In this analysis, the Weibull specification of the baseline hazard function is checked in both SAS and STATA, giving the assurance that it is properly specified. An alternative is semi-parametric model with stratification of state variable, but the model does not provide a good fit.

There are two kinds of frailty (or unobserved heterogeneity in biostatistics term) that can be easily incorporated into the model using STATA. One is unshared frailty, while the other is shared frailty. The latter reflects the random effect in the survival model. Both are considered in this analysis and the unshared one provides the better fit. The goodness-of-fit graphs for the different models, which can be compared, are in Appendix AA.

4.7 Conclusions

This chapter uses a duration model to analyze the trip length dynamics of the Gulf of Mexico shrimp fleet over a 15-year period. The trip length is decomposed into days fished and travel (including searching) time, so two models are considered with differences in model specification limited to the inclusion of travel distance in the days fished model. The results show that a fishing trip tends to increase in relation to vessel length and the number of sites visited. While the trip length is found to be positively related to the average shrimp price, changes in the price differentials between different shrimp sizes have mixed results. The change in abundance of large shrimp relative to medium or small are positively related to increased trip length. The Texas Closure is also found to increase trip length, likely the result of forcing fishermen (mainly from TX) to travel farther. Diesel price is significantly negatively related to days fished due to the high consumption of fuel in trawling, however, no significant relation is found between diesel price and travel time.

The Weibull-Gamma mixture model is selected for the analysis, which is just a special case of a mixed PH model. The semi-parametric model is also run for comparison purposes, which would have little loss of efficiency if the model was correctly specified. However, since the unobserved heterogeneity in the error cannot be identified from the baseline hazard function for the semi-parametric model, a parametric model with Gamma distribution of the unobserved heterogeneity is chosen due to its popularity and its computational convenience which has a closed form.

In a duration model, the state dependence is just duration dependence (in this case is indicated by the shape parameter of Weibull since a shape parameter bigger than one means increasing hazard). This analysis again shows the importance of incorporating observed heterogeneity when state dependence is in the model, as stated in Chapter 3. Unobserved heterogeneity should be considered in the model to avoid biased estimation of the duration dependence term and underestimation of other parameters.

CHAPTER 5. CONCLUSIONS

5.1 Summary and Conclusions

With a dockside value approaching or exceeding $250 million in recent years, what makes the Gulf shrimp fishery particularly important is that it accounts for more than 50 percent of the total dockside economic value generated by all Gulf fisheries. In addition to the harvesting, wholesaling, processing and distribution activities, the shrimp industry supports thousands of input supply and retailing jobs throughout the Gulf region. Although the shrimp fishery is arguably the most important in the Gulf of Mexico, the economic structure underlying the dynamics of the harvesting fleet is poorly understood. This lack of information has made it difficult to adequately analyze the impacts of past management measures. Given the historically open-access property rights structure in federal waters, the deeper, offshore water shrimp harvesting sector has been severely overcapitalized, leading to suboptimal generation of rents and high external costs, including incidental bycatch of endangered sea turtle species and important commercial and recreational fish species. The ‘less than complete’ understanding of the economic structure underlying the dynamics of the fleet, furthermore, presents obstacles to the future formulation of policy initiatives aimed at correcting the market failures associated with historically open access nature of the federal-water fleet and/or the externalities associated with the interaction of shrimp gear with other species (i.e., bycatch) or habitat.

The overall goal of this research was to empirically analyze fleet and fishermen behavior in order to help improve the management of the Gulf of Mexico shrimp fleet. Given that optimal management requires consideration of more than the net benefits derived from shrimp harvesting, this research also sought to provide an empirical framework that would allow future investigators to measure benefits lost through bycatch-related management actions.

Two aspects of shrimp fishermen's behavior are analyzed in detail in this study. One aspect is on the choice of fishing location. The other aspect is on the length of the fishing trip. Both are important short-run decisions to make for the profit maximizing shrimp fishermen. It is hypothesized that their choices of ending the trip and of where to fish are influenced by the market conditions for output price and input costs, their social/economic characteristics, the relevant government regulations, and the particular characteristics of the location or the trip.

Location choice is one of the most important short-run decisions made for each fishing trip, and the potential ramifications of overlooking the spatial behavior of fishermen can include unexpected and perverse outcomes from management policies. As the expanding body literature clearly demonstrates, there is an increasing recognition among marine ecologists, biologists, economists and fishery managers that conventional measures to protect fish stocks, such as season lengths and gear restrictions, generally do not accomplish the desired management goal. Concomitantly, it is becoming clear that new policies need to be spatially explicit, reflecting the patchiness of real systems, the heterogeneity of the fishing fleet, and response of a heterogeneous fishing fleet to future formulation of policy initiatives aimed at correcting the market failures.

The spatial behavior of shrimp fishermen is analyzed using discrete choice theory with the goal of developing an understanding of how to assess and forecast spatial management policies for the Gulf of Mexico shrimp fishery. For purposes of analysis, the Gulf shrimp fleet is portioned into three components: those vessels taking trips from Florida ports, those vessels taking trips from ports in any of the three central Gulf states (i.e., Alabama, Mississippi, and Louisiana), and those vessels taking trips from Texas ports. The 1995-1999 and 2000-2004 periods are also considered separately.

For analytical purposes, both a conditional logit model and a mixed logit model are considered. From the perspective of the conditional logit choice model, the past experiences of shrimp harvesters at specific harvesting locations have an overwhelming impact on the probability of them again choosing that location for harvesting. While past experiences are important, expected revenues also play a role in choosing a fishing location and the role (in some cases) appears to be increasing. At the same time, harvester behavior towards the risk associated with expected revenues varies over time, with their decisions suggesting an increasing level of risk aversion in recent years. As with the greater emphasis on expected revenues, this concern for variations in expected revenues in the latter period could have been due to the economic pressure placed on harvesters from the changing and unfavorable economic conditions in the industry. Similarly, conditional logit results indicate that shrimp harvesters appear to have developed a higher level of tolerance for congestion in recent time periods, either due to increasing economic pressure on individual vessels or because there are physically fewer vessels fishing, but that the vessels present are spending more time on the fishing grounds. Mixed logit results, in general, are in agreement to those of conditional logit.

To examine the use of the developed models in providing information that could be used by policy makers, we analyze the impacts of a hypothetical extension of the Texas Closure to include the federal waters off Louisiana. Depending upon the model considered (i.e., the conditional logit or mixed logit model), the time frame of analysis (i.e., 1995-1999 or 2000-2004), and cost structure (i.e., fuel consumed by the 'average' vessel per nautical mile traveled), results suggest welfare losses to the industry ranging from about $400 thousand to $1.4 million. While much of the difference between the lower and upper bound estimates reflect assumptions related to the variable cost structure (i.e., fuel consumption), substantial differences are also noted depending upon whether the conditional logit results or mixed logit results are used to analyze welfare losses (without exception welfare losses associated with the conditional logit results exceed those of the mixed model). Regardless of which model is considered, however, results point to the fact that welfare losses by the Texas fleet would be an order of magnitude larger than those which would be realized by the Alabama/Mississippi/Louisiana fleet. The higher expected losses by the Texas fleet likely reflect the fact that closure of federal waters off Louisiana during the period of the Texas closure would significantly constrain the location-choice set of options that would be available to this fleet and the significantly longer distance that would need to be taken by vessels that would wish to continue to fish during the closure. This is particularly relevant given that fishing in much of Louisiana's near shore waters (which would remain open during the hypothetical extension of the Texas closure to federal waters off Louisiana) would probably not be conducive to many of the larger Texas-based trawlers.

Survival analysis is used to examine trip duration. The duration of a trip is comprised of two components: (a) travel time which, due to data limitations includes search time, and (b) fishing time (i.e., days fished). Given the database framework, travel time is defined as trip length less days fished. Because neither days fished nor departure date is recorded for non-interview data, the survival analysis is limited to the interview data. The survival analysis shows a strong linkage between trip duration and economic and regulatory factors. Of particular interest in the current economic environment of rising fuel costs, the survival analysis indicate that an increasing diesel price is related to a decrease in fishing time, *ceteris paribus*. However, the change in diesel price does not have any effect on the travel time. It is hypothesized that because an increasing diesel price makes trawling less profitable (at a given output price and stock abundance), increased searching replaces trawling until higher abundances are found. Results also indicate that fishing time is influenced by the absolute shrimp price and shrimp abundance. Finally, regulatory restrictions, including the mandatory use of bycatch excluder devices and the Texas closure, are found to be related to increase in the amount of fishing time.

5.2 Policy Implications

Results associated with the location choice analyses suggest that even though economic factors (such as expected revenues and costs) influence site choosing behavior among Gulf shrimpers, the influence of these factors is less significant than fishermen's past experience. In other words, site fidelity explains to a large extent why an individual selects a certain site. This can be illustrated by comparing the hit rate of the full model used in chapters 2 and 3 with that of the reduced model which includes only loyalty as an explanatory variable (Table 5.1). As indicated, the hit rate of the reduced model is close to that of the full model. This suggests that the use of market-based policy tool (e.g., a Pigovian tax) may not be as effective as command and control (such as area closure) in achieving a stated goal. Note though, that in some areas the effect of past experience do differ among the fishermen (such as LAM area). In addition, fishermen are different in many aspects such as risk attitudes, valuing trip costs, and tolerance towards congestion. Even though differences among individuals would make the development of a single market-based management tool that would achieve a policy goal difficult, policy makers could develop a series of tools for use among different categories of fishermen. Further, caution should be taken in using models that do not incorporate differences among individuals, since the parameters might be biased. An example is the welfare comparison of the conditional logit and mixed logit analyses. Nevertheless, if the model is used for prediction purpose only, conditional logit results do not differ significantly from mixed logit results. Therefore, given the computational burden associated with mixed logit, conditional logit may suffice in prediction (as illustrated in Table 5.1).

As for the consideration of implementing the limited entry policy to alleviate a by-catch problem, one must consider that the average trip length has increased over time. This implies that even if the number of vessels can be controlled, those who are left in the fleet may exert additional effort (i.e., an increase in effort per vessel) with a resultant increase in by-catch. Therefore, the limited entry tool might have to be combined with a market tool, such as imposing a tax on diesel price, to induce less fishing time to reach the goal of reducing by-catch effectively.

Table 5.1 Hit Rate in All Models

Logit	*Area*	*Year*	*Trips*	*Hits*	*Hit Rate*	*Hits*	*Hit Rate*
				Full model		Loyalty only	
Conditional	FL	1995-1999	9722	7109	0.731	6710	0.690
		2000-2004	13343	9680	0.725	9197	0.689
	LA	1995-1999	32357	21104	0.652	20456	0.632
		2000-2004	33545	20341	0.606	19015	0.567
	TX	1995-1999	32380	17888	0.552	16748	0.517
		2000-2004	41650	23153	0.556	20512	0.492
Mixed	FL	1995-1999	9722	7120	0.732	6710	0.690
		2000-2004	13343	9678	0.725	9213	0.690
	LA	1995-1999	32357	21160	0.654	20463	0.632
		2000-2004	33545	20391	0.608	19000	0.566
	TX	1995-1999	32380	18162	0.561	16772	0.518
		2000-2004	41650	23659	0.568	20510	0.492

5.3 Modeling Summary

Due to the nature of the panel dataset and many observations represent repeated decisions by the fishermen, the problem of unobserved heterogeneity possibly random effects needs to be considered in the analysis. As discussed by Cameron and Trivedi (2005) the role of unobserved heterogeneity is at the center of many empirical puzzles and conundrums. If the model is linear and the heterogeneous error is uncorrelated with the regressors, misspecification as a result of unobserved heterogeneity will not be significant. If the model is nonlinear in nature, however, which is the case of the models used in this particular study, the ignorance of unobserved heterogeneity can result in a significant (and complicated) bias associated with parameter estimation. For this reason, the current study incorporates the unobserved heterogeneity by distinguishing it from true state dependence in two of the models.

From the modeling perspective, since both duration model and logit model are nonlinear in nature, the problem that unobserved heterogeneity will cause cannot be ignored. This study is particularly interested in distinguishing true state dependence and unobserved heterogeneity in an empirical manner. Some of the inter-individual difference in the panel data can be measured by the explanatory variables such as individual characteristics, which is termed observed heterogeneity. The rest that cannot be measured by the regressors is referred to as unobserved heterogeneity, the neglect of whose influence will be confounded with the influence of other kinds of variations in the error term in logit model and with the impact of baseline hazard in duration model. In particular, accurate estimation and interpretation on state dependence (duration dependence in survival analysis) requires that models incorporate unobserved heterogeneity, especially in models where only a few individual specific variables are available, as in the case of this study.

The problems in ignoring unobserved heterogeneity in the logit model include overstating of the influence of state dependence, and possible bias in other parameter estimates. Also, if the certain welfare gain or loss is estimated based on a conditional model, the magnitude might be exaggerated. Likewise, in duration modeling if the unobserved heterogeneity is neglected, at least three kinds of problem will manifest according to Cameron and Trivedi (2005). First, it cannot be distinguished whether the aggregated increasing/decreasing hazard is due to the aggregation of a number of different individuals having constant hazard rate, or due to the increasing/decreasing hazard of each individual. In addition, as in the logit model, the neglect will generally result in serious bias in terms of underestimating the slope of the hazard function. Further, in the PH model the proportional impact of a change in a particular covariate is smaller and depends on time and is no longer of the PH type in the presence of unobserved heterogeneity. This should be taken into account in estimation.

The incorporation of the unobserved heterogeneity term in the model not only corrects the possible misspecification, but also provides more meaningful interpretation of the parameters. For example, in a Logit model, when mixed Logit, or random parameter Logit is used and the parameter of coefficient of variation of the expected revenue is randomized, the risk attitudes of the fishermen towards revenue change is no longer uniform in some areas, which might be more close to the reality. In the duration model, the Weibull shape parameter is larger in magnitude. One thing that is noteworthy is the improvement in the goodness of fit when incorporating unobserved heterogeneity in the hazard model. The goodness of fit might not be improved in all cases (the unemployment example in chapter 18 of Cameron and Travidi (2005) is an example, the reason for which is explained by the authors as possible interaction between state dependence and unobserved heterogeneity term), but in this study the improvement is very obvious.

5.4 Limitations

The way that each statistical grid is defined might be one of the reasons why loyalty has overwhelming effect on location choice. In other words, the statistical grids are some combinations of several smaller grids (as mentioned in chapter 2, originally there are 210 subarea and fathom zone combinations), if the area of the grid is large, the probability of visiting that area is going to be high. Also, the smoothing parameter (λ) estimate in loyalty variable has values around 0.75, which indicates that the past site choosing decision will not have too much effect on current behavior after about five trips. Or, the site fidelity phenomenon will not exist in the long run. In this case people's "old habit" does die before it becomes old. Another limitation in defining the variable is the calculation of tolerance towards congestion, which is proxied by total effort by area. However, total effort increase could be caused by the increases of vessels or by individual vessel effort, which is confounding in this case. In addition, one of the assumptions made in the models is that technology does not change over the years, which needs to be carefully verified with reality. One of the results of technology improvement is the fuel consumption efficiency, which might indicate different levels of welfare loss for the hypothetical area closure policy in chapter 3. In trip length decision model, even though both travel time and days fished model fit better after incorporating the unobserved heterogeneity, the interpretation of the explanatory variables needs to be related further to the policy and economic situations. Further, for travel time model more factors should be incorporated in the model since the trend of increasing travel time was not fully explained by the current covariates.

5.5 Implications for Future Research

Besides improvement over defining variables such as loyalty and crowding externality and checking of the robustness of the model for refined statistical grids, future studies should have intuitive interpretations on more of the random parameters. Further, different distributions of the random parameters should be explored. Another interesting attempt is to group the vessels according to size and analyze their site choosing behavior and trip length decision. It could be that larger vessels, say those that are over 90 feet, have different behavior from the rest vessels due to their large capacity.

The current study represents the only effort to examine location choice for the Gulf of Mexico shrimp fleet. The location choice modeling exercise utilizes the Shrimp Landings File to determine historical fishing locations of choice. In recent years, electronic logbooks have been increasingly placed on a growing sample of shrimp vessels and the resolution of the electronic logbook data is exceedingly fine. Specifically, it provides a longitude and latitude for each individual trawl. Use of logbook data, supplemented by the Shrimp Landings File (to estimate shrimp abundance by area), to examine location choice would be the most natural extension to this project.

While the results associated with this project are encouraging, one limitation relates to the paucity of continuous cost data that could be utilized in the analysis. With the exception of diesel price, specifically, little other time-series information is available on the individual cost components of the fishery. Additional cost information would allow for a more detailed examination of changes in different cost components on the behavior of fishermen. While use of additional cost information may not significantly influence results (especially crew share given its relatively fixed nature in relation to revenues), testing of this hypothesis is warranted.

REFERENCES

Agarwal, R. (1998), "Small Firm Survival and Technological Activity", *Small Business Economics* 11: 215-224, 1998

Anderson, L. G. (1982), "The economics of multi-purpose fleet behavior", *Essays in the Economics of Renewable Resources* L. J. Mirman and D. F. Spulber, eds. Amsterdam, New York and Oxford: North-Holland Publishing Company, 203-226, 1982.

Audretsch, D.B. and T. Mahmood (1995), "New Firm Survival: New Results Using a Hazard Function", the Review of Economics and Statistics, Vol.77, No.1: 97-103

Berck, P., and J.M. Perloff (1982), "An Open-Access Fishery with Rational Expectations" Working Paper No. 187, Giannini Foundation of Agricultural Economics, December 1982

Bhat, R. C. and S. Castelar (2002), "A Unified Mixed Logit Framework for Modeling Revealed and Stated Preferences: Formulation and Application to Congestion Pricing Analysis in the San Francisco Bay Area", Transportation Research Part B 36 (2002) 593-616

Brownstone, D. and K. Train (1999), "Forecasting New Product Penetration with Flexible Substitution Patterns", *Journal of Econometrics,* 89 (1999) 109-129

Breffle, W. S. and E. R. Morey (2000), "Investigating Preference Heterogeneity in a Repeated Discrete-Choice Recreation Demand Model of Atlantic Salmon Fishing", *Marine Resource Economics*, Vol 15, 1-20, 2000

Bockstael, N.E. and J. Opaluch (1983), "Discrete Modelling of Supply Response Under Uncertainty: The Case of the Fishery." *Journal of Environmental Economics and Management* 13(June) : 125-137,1983

Cameron, A. C. and P. K. Trivedi (2005), *Microeconometrics: Methods and Applications*, Cambridge University Press, Cambridge, UK, PP 573-637

Chen, M.Y. (2002), "Survival Duration of Plants: Evidence from the U.S. Petroleum Refining Industry". *International Journal of Industrial Organization* 20 (2002): 517-555

Cleves,M, W.W.Gould, G.G.Roberto (2004), *An Introduction to Survival Analysis Using Stata, Revised Edition*, Stata Press, College Station, TX

Charles, A.T., and G.R. Munro (1985), "Irreversible Investment and Optimal Fisheries Management: A Stochastic Analysis." *Marine Resour. Econ.*1(1985):247-64.

Clark, C.W., F.H. Clarke, and G.R. Munro (1979), "The Optimal Exploitation of Renewable Resource Stocks: Problems of Irreversible Investment." *Econometrica* 47(January 1979):25-47

Deily M.E. (1991), "Exit Strategies and Plant-closing Decisions: the Case of Steel". *RAND Journal of Economics* Vol.22, No.2: 250-263

Dunne, T. M.J. Roberts L. Samuelson (1989), "the Growth and Failure of U.S. Manufacturing Plants". *The Quarterly Journal of Economics*. Vol. 104 NO.4: 671-698

Dupont, D. P. (1993), "Price Uncertainty, Expectations Formation and Fishers' Location Choices", *Marine Resource Economics,* Vol. 8, pp 219-247

Evans, M.E. (1997), "An Analysis of Vessel Performance and Mobility in the California Commercial Salmon" *Fishery Ph.d dissertation,* 1997. Department of Agricultural and Resource Economics, University of California, Davis

Eales, J. and J. Wilen.(1986), "An Examination of Fishing Location Choice in the Pink Shrimp Fishery." *Marine Resource Economics,* Vol.2, number 4

Eggert, H. and R. Tveteras (2004), "Stochastic Production and Heterogeneous Risk Preferences: Commercial Fishers' Gear Choices", *American Journal of Agricultural Economics,* 86(1), 199-212, 2004

Fader, P. S., J. M. Lattin, J.D. C. Little (1992), "Estimating Nonlinear Parameters in the Multinomial Logit Model", *Marketing Science*, Vol. 11, No. 4. pp 372-385

Franses, P. H., R. Paap (2001), "Quantitative Models in Marketing Research", Cambridge University Press, Cambridge, UK, PP 77-111

Griffin, W.L., A.K. Shah, and J.M. Nance (1997), "Estimation of Standardized Effort in the Heterogeneous Gulf of Mexico Shrimp Fleet" *Marine Fisheries Review*, 59(3), 1997, 23-33

Griffin, W.L. (2006), "Days Fished Expansion in the Gulf of Mexico Shrimp Fishery" Texas A&M University, May 2006

Guadagni, P.M., J.D. Little (1983), "A Logit Model of Brand Choice Calibrated on Scanner Data", *Marketing Science*, 2 (1983) 203-238

Hanemann, W. M. (1999), "Welfare Analysis with Discrete Choice Models", *Valuing Recreation and the Environment: Revealed Preference Methods in Theory and Practice*, Edward Elgar, 1999

Heckman, J.J. (1981), "Heterogeneity and State Dependence", *Studies in Labor Markets*, University of Chicago Press, Chicago, IL, 1981

Herriges, J. A., D. J. Phaneuf, "Inducing Patterns of Correlation and Substitution in Repeated Logit Models of Recreation Demand", American Journal of Agricultural Economics 84(4) (November 2002): 1076-1090

Hernández, A. and J. Dresdner (2006), "The effect of Temporal Closures and Individual Quotas on Fishing Trip Duration: A Hazard Function Analysis", working paper

Holland, S.D. and J.G.Sutinen (2000), "Location Choice in New England Trawl Fisheries: Old Habits Die Hard" *Land Economics* 76(1): 133-149

Ikiara, M. M., J. G. Odink (2000), "Fishermen Resistance to Exit Fisheries", *Marine Resource Economics*, Vol.14, pp 199-213

Kahneman, D, A. Tversky (1979), "Prospect Theory: an Analysis of Decision under Risk", Econometrica, Vol. 47, No. 2. PP 263-292

Keane, M. P. (1997), “Modeling Heterogeneity and State Dependence in Consumer Choice Behavior”, *Journal of Business & Economics Statistics*, Vol. 15, No. 3

Keithly, W. R. and P. Poudel (in press). “The Southeast U.S. Shrimp Industry: Issues Related to Trade and Antidumping Duties.” *Marine Resource Economics*

Kiefer, N. M. (1988), “Economic Duration Data and Hazard Functions”, *Journal of Economic Literature*, Vol. 26, No.2. pp. 646-679

Koundouri, P., C. Nauges, and V. Tzouvelekas. (2006), “Technology Adoption Under Production Uncertainty: Theory and Application to Irrigation Technology.” *AJAE* 88(3): 657-670

Koundouri, P. and M. Laukkanen. 2004, “Stochastic Production in a Regulated Fishery: The Importance of Risk Considerations” *Econometrics Informing Natural Resources Management: Selected Case Studies.* Edward-Elgar Publishers, 2004: 247-262

Leung, M.K. (2003), “Entry of Foreign Banks in the People’s Republic of China: a Survial Analysis”. *Applied Economics*, 2003, 35, 21-31

Malhotra, N.K. (1987), “Comment: Testing the Homogeneity of Segments for Estimating Disaggregate Choice Models”, *Marketing Science,* Vol.6, No.1

McFadden, D. (1973), "Conditional Logit Analysis of Qualitative Choice Behavior." *Frontiers in Econometrics.* P. Zarembka, ed. New York: Academic Press, 1973

McFadden, D. and K. Train (2000), “Mixed MNL Models for Discrete Response”, *Journal of Applied Econometrics*, Vol. 15, No. 5. pp 447-470

Mistiaen, J. A., I. E. Strand (2000), “Location Choice of Commercial Fishermen with Heterogeneous Risk Preferences”, *American Journal of Agricultural Economics,* 82(5), 2000

McKelvey, R. (1983), "The Fishery in a Fluctuating Environment: Coexistence of Specialist and Generalist Fishing Vessels in a Multipurpose Fleet." *JEEM* 10 (1983):287-309.

Parsons, G.R., M.J.Kealy, (1992), “Randomly Drawn Opportunity Sets in a Random Utility Model of Lake Recreation”, *Land Economics*, Vol. 68, No. 1. pp. 93-106

Paterson, D.G., and J. Wilen. (1977), "Depletion and Diplomacy: The North Pacific Seal Hunt, 1886-1910." *Res. in Econ. Hist.* 2(1977):81-139.

Penson, J.B., Jr., E.O. Tettey, and W.L. Griffin (1987), "An Econometric Analysis of Net Investment in Gulf Shrimp Fishing Vessels" Texas A&M University Agr. Exp. Sta. Tech. Article No. TA-20803,1987

Reynolds, S.S. (1988), “Plant Closing and Exit Behavior in Declining Industries”. *Economica,* Vol. 55, No.220: 493-503

Seetharaman, P. B. (2004), “Modeling Multiple Sources of State Dependence in Random Utility Models: A Distributed Lag Approach”, *Marketing Science,* Vol. 23, No.2, pp 263-271

Small, K.A., H.S. Rosen, “Applied Welfare Economics with Discrete Choice Models”, *Econometrica*, Vol. 49, No. 1. pp. 105-130

Smith, C., and R. McKelvey (1986), "Specialist and Generalists: Roles for Coping with Variability." *N. Amer. J. Fish. Manage.* 6(1986):88-99.

Smith M.D. and J.E. Wilen (2003), “Economic Impacts of Marine Reserves: The Importance of Spatial Behavior” *Journal of Environmental Economics and Management* 46(2003): 183-206, 2003

Smith, M. D. (2004), “Limited-Entry Licensing: Insights from a Duration Model”, *American Journal of Agricultural Economics*, 86(3): 605-618

Smith, B. D. (1999), “A Probabilistic Analysis of Decision-Making about Trip Duration by Strait of Georgia Sport Anglers”, Canadian Journal of Fisheries and Aquatic Sciences, 56: 960-972

Smith M.D.(2005), “State Dependence and Heterogeneity in Fishing Location Choice”, *Journal of Environmental Economics and Management* 50: 319-340

Thompson, P. (2005), “Selection and Firm Survival: Evidence from the Shipbuilding Industry, 1825-1914”, *The Review of Economics and Statistics*, February 2005, 87(1): 26-36

Train, K. E. (1998), “Recreation Demand Models with Taste Differences over People”, *Land Economics,* Vol.74, No.2, PP 230-239

Train, K. E. (2003), Discrete Choice Methods with Simulation, Cambridge University Press, PP 138-151

Walters, C. J. (1998), “Designing Fisheries Management Systems that do not Depend upon Accurate Stock Assessment”, P 279 – 288 in T. J. Pitcher, P. J. B. Hart and D. Pauly, eds. Reinventing Fisheries Management, Chapman & Hall, London

Walters, C. J. (2000), “Impacts of Dispersal, Ecological Interactions, and Fishing Effort Dynamics on Efficacy of Marine Protected Areas: How Large Should Protected Areas Be?” Bulletin of Marine Science, 66: 745-757

Ward, J. M. and W. R. Keithly 2000. "Determining the Impacts of Adopting Property Rights as a Fishery Management Tool in Regulated Open Access Fisheries." FAO Fishing Rights 99 Conference: Use of Property Rights in Fisheries Management.

Wilen, J.E. et al (2002), “Avoiding Surprises: Incorporating Fisherman Behavior into Management Models” *Bulletin of Marine Science*, 70(2): 553-575, 2002

APPENDIX A. GEOGRAPHICAL ILLUSTRATIONS OF THE GRIDS IN LOCATION CHOICE

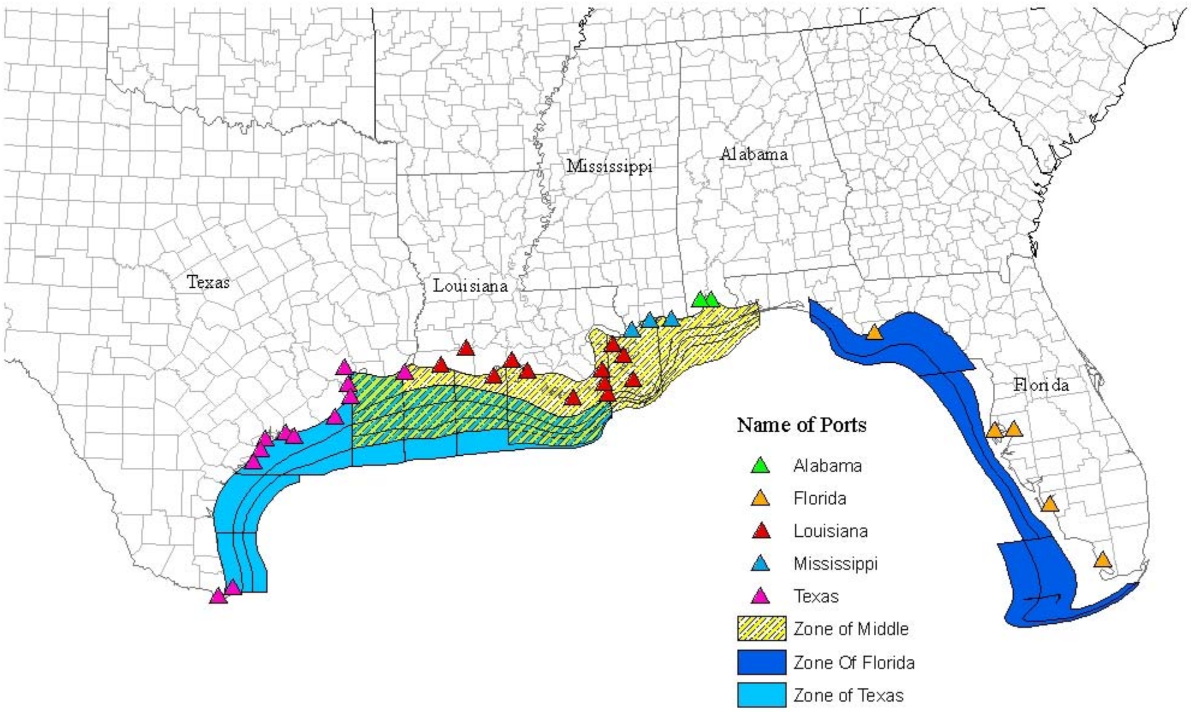

Figure A.1 Gulf of Mexico area

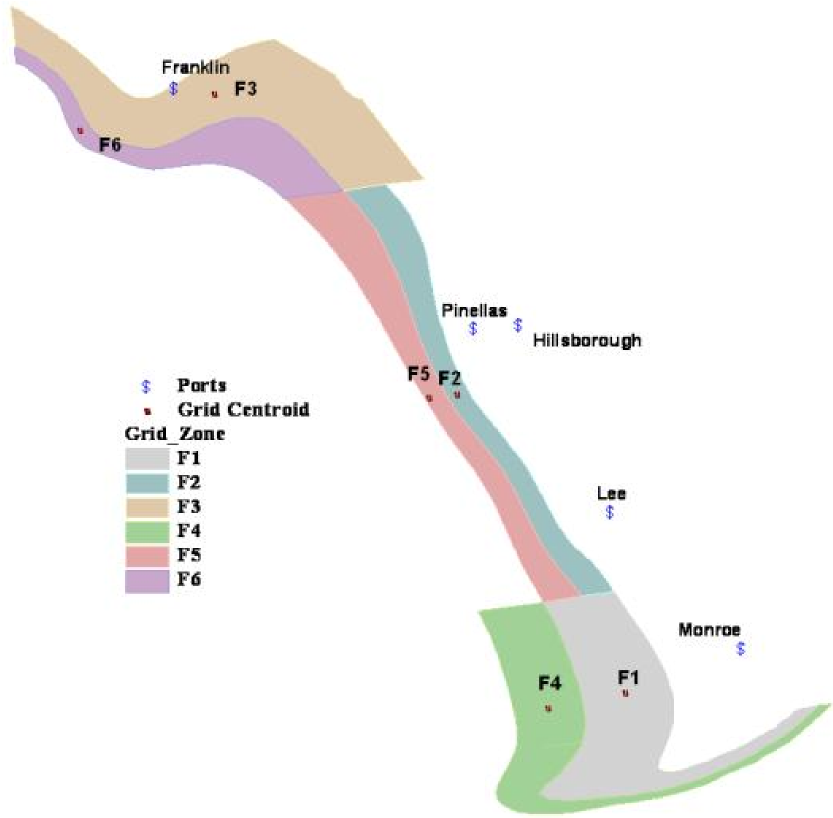

Figure A.2 Location choices (grids) in FL area

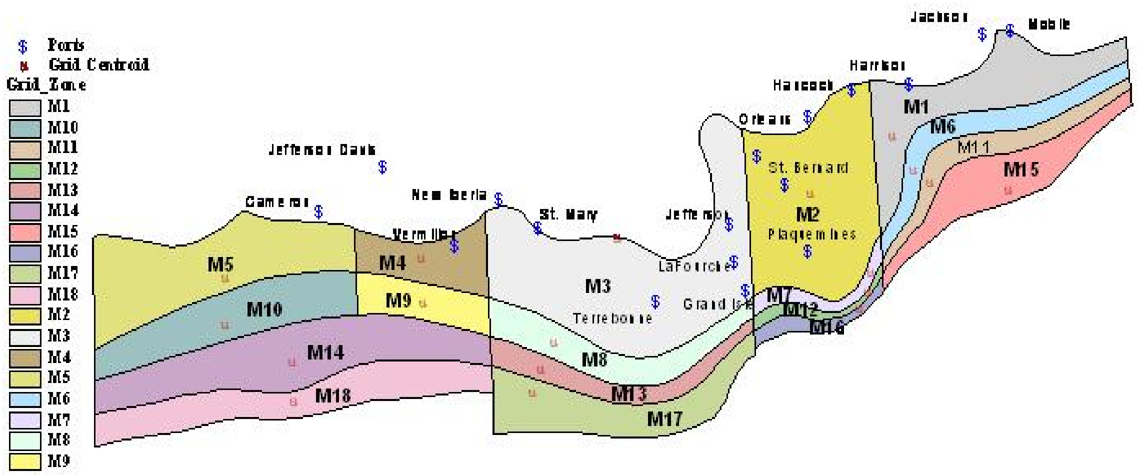

Figure A.3 Location choices (grids) in LAM area

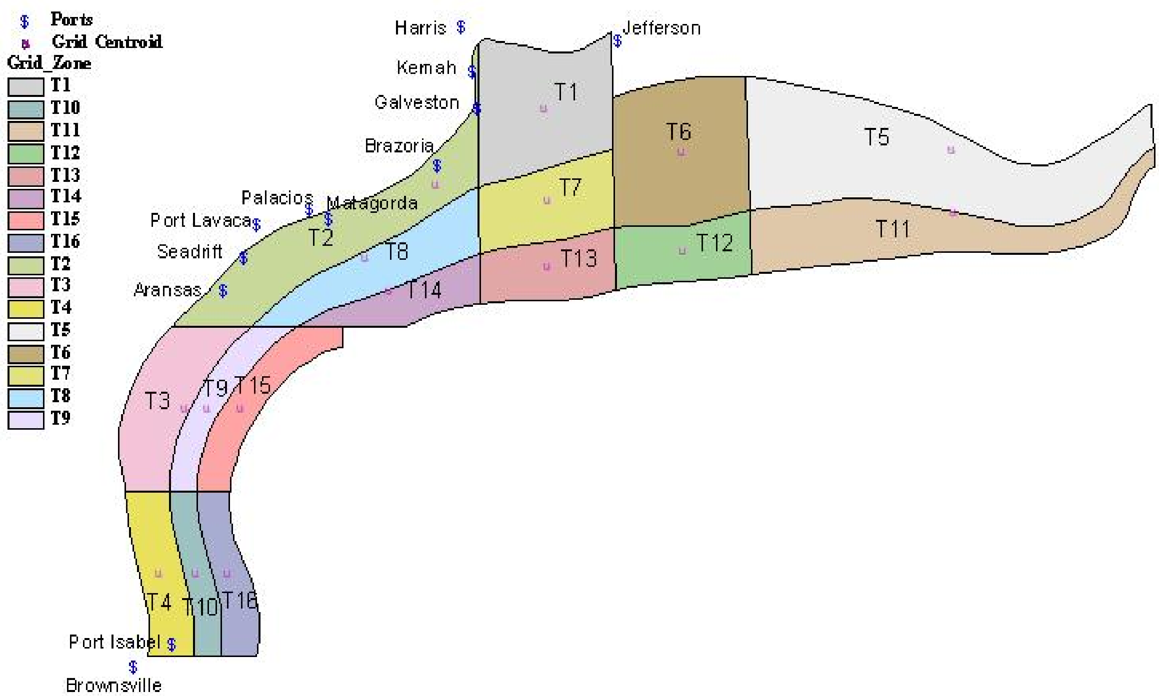

Figure A.4 Location choices (grids) in TX area

APPENDIX B. GENERAL VESSEL MOBILITY INFORMATION

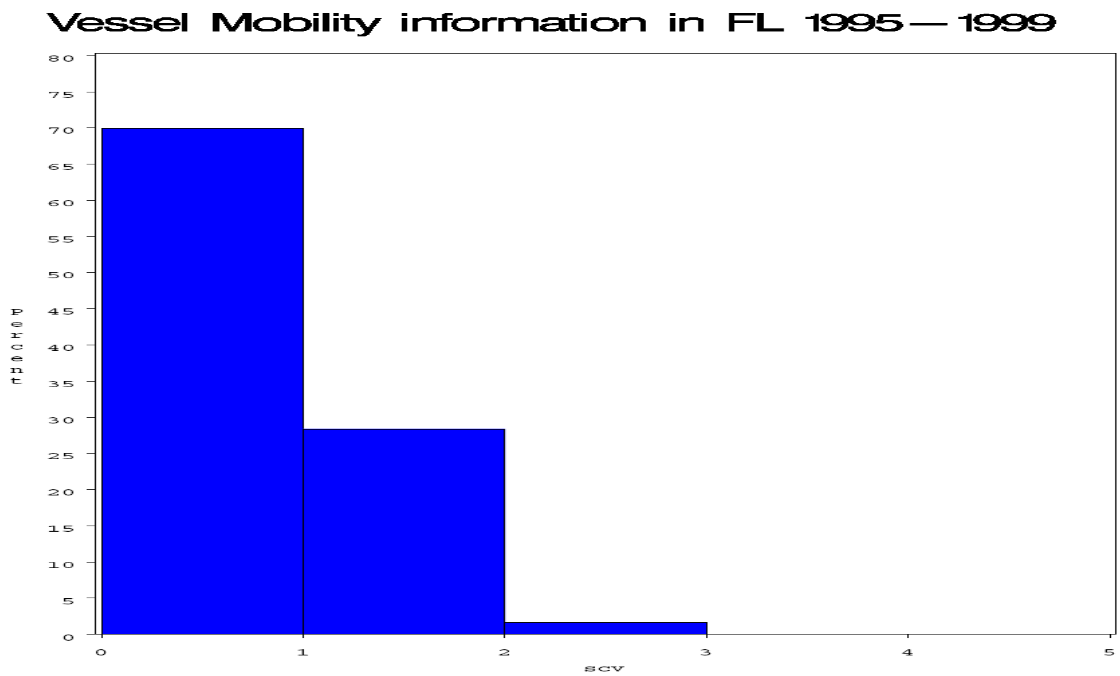

Figure B.1 Vessel mobility information in FL 1995-1999

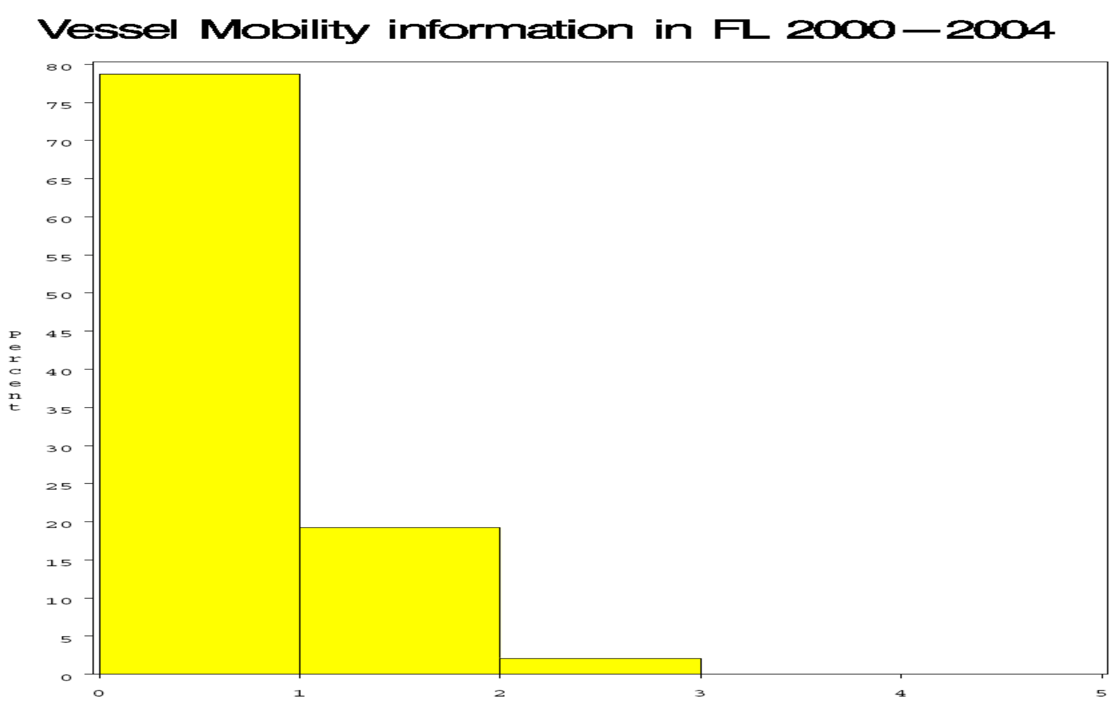

Figure B.2 Vessel mobility information in FL 2000-2004

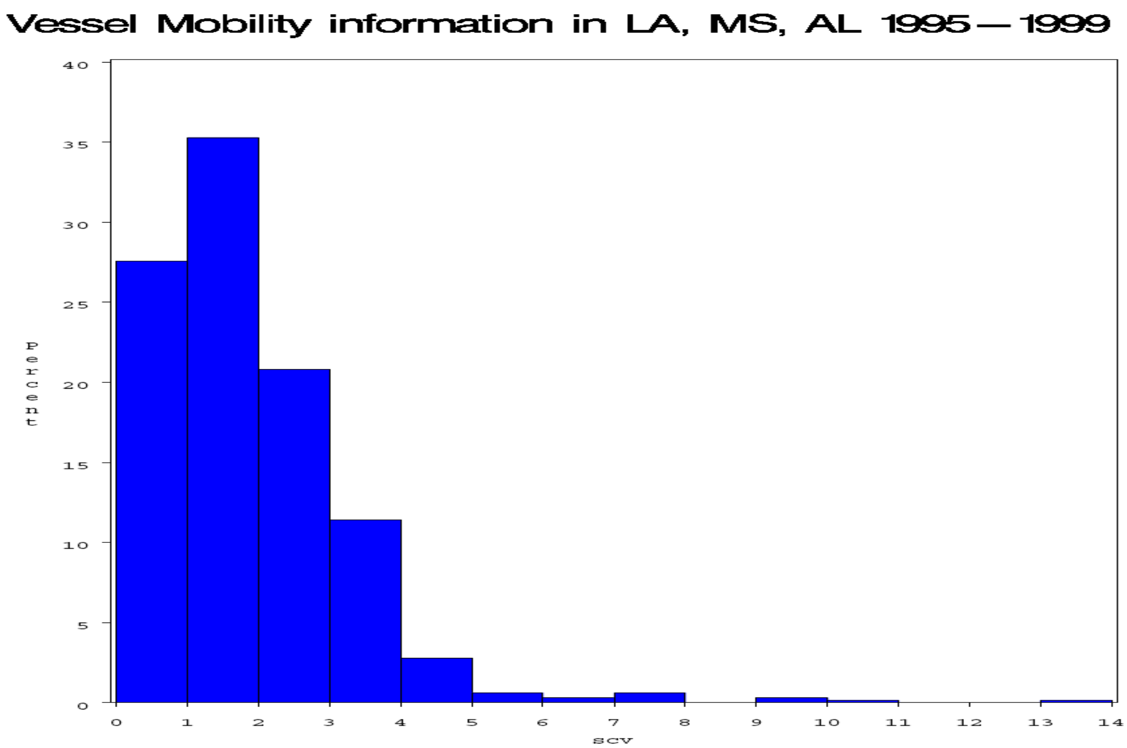

Figure B.3 Vessel mobility information in LAM 1995-1999

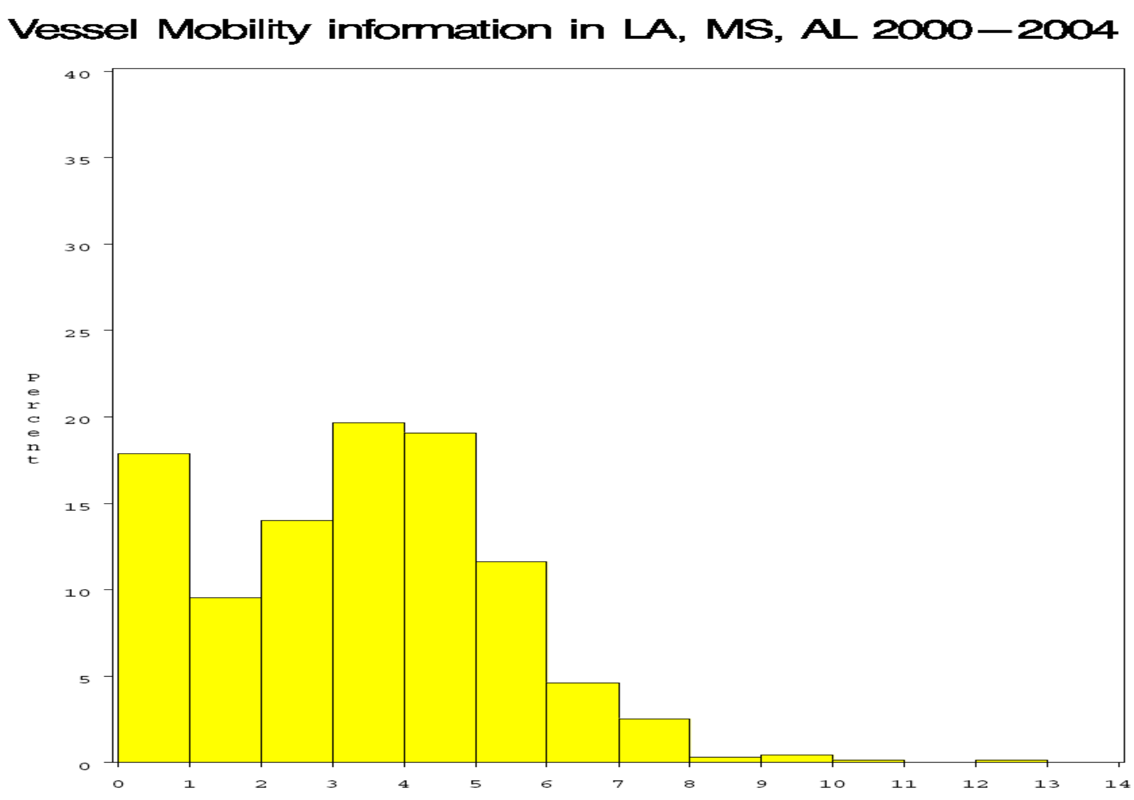

Figure B.4 Vessel mobility information in LAM 2000-2004

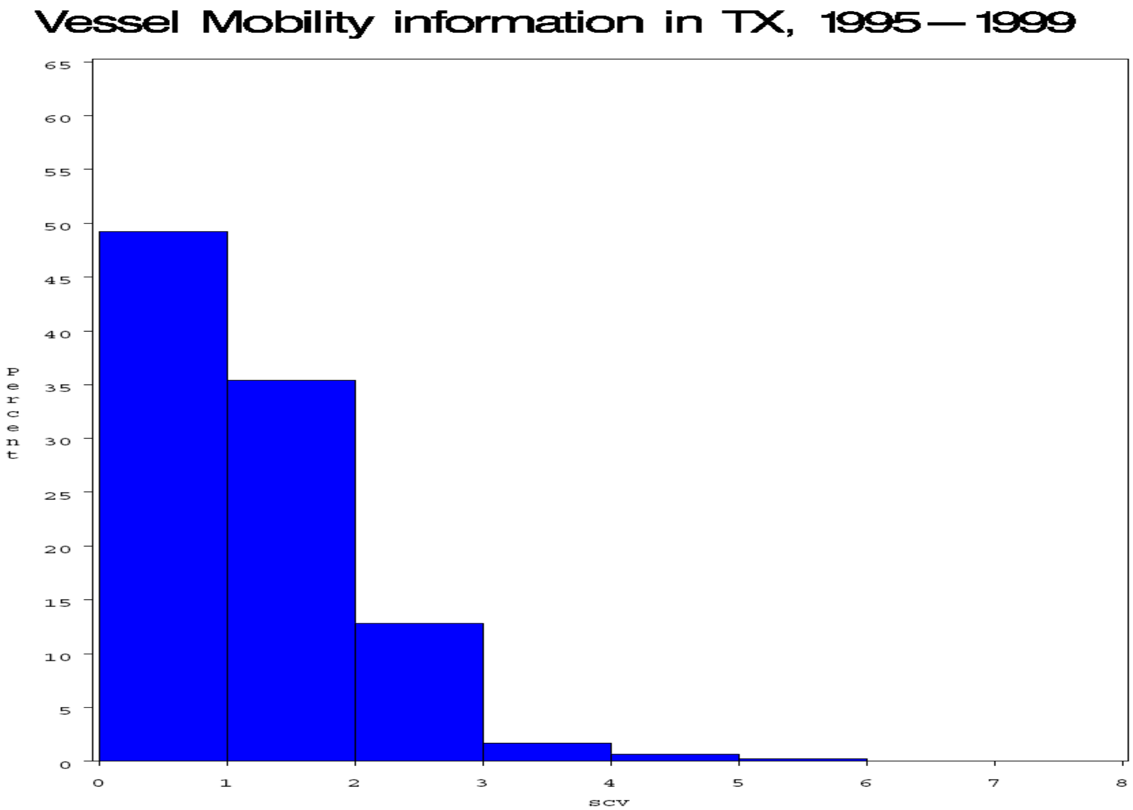

Figure B.5 Vessel mobility information in TX 1995-1999

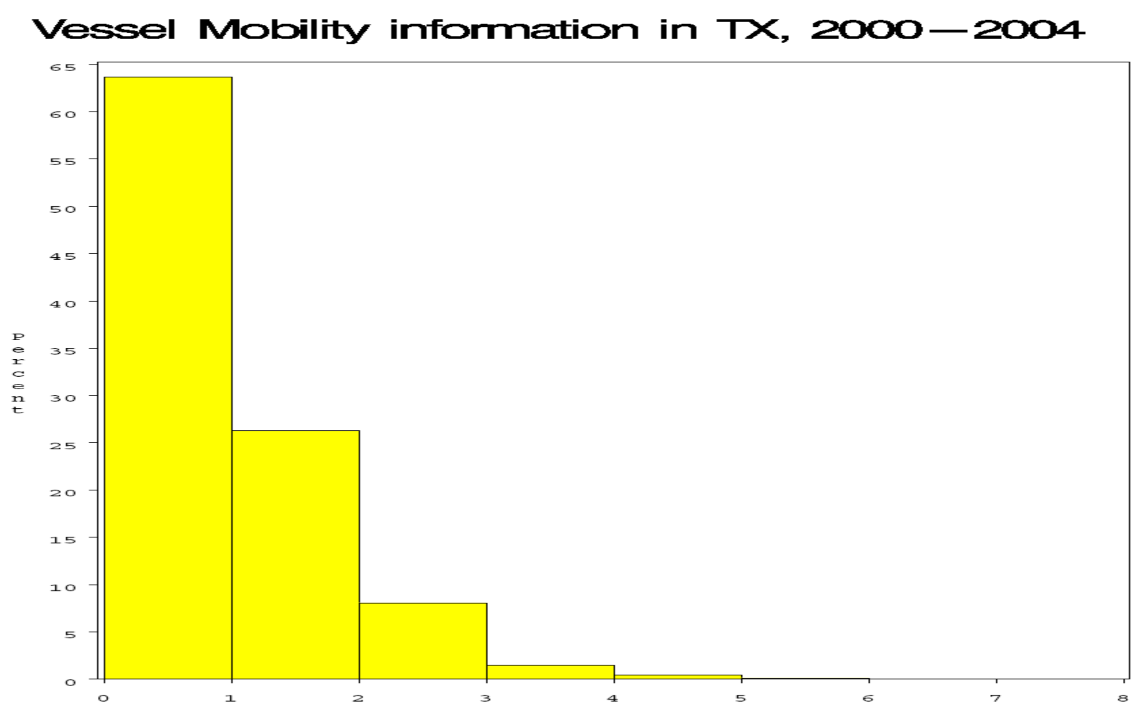

Figure B.6 Vessel mobility information in TX 2000-2004

APPENDIX C. SUMMARY STATISTICS FOR EACH AREA

Table C.1 Summary statistics---FL Area (1995-1999)

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Loyalty	1	0.00	0.34	1.00	Expected revenue	1	0.32	3.37	18.62
	2	0.00	0.08	0.93	(thousands of dollars)	2	0.22	2.68	16.83
	3	0.00	0.12	1.00		3	0.19	1.90	9.57
	4	0.00	0.25	1.00		4	0.47	3.34	19.36
	5	0.00	0.15	1.00		5	0.09	2.98	17.05
	6	0.00	0.04	0.77		6	0.18	3.27	19.90
Variation of ER	1	0.16	0.44	0.92	Distance (kilometers)	1	83.75	226.52	696.08
	2	0.00	0.41	1.36		2	45.29	194.12	384.40
	3	0.30	0.57	0.91		3	26.91	405.42	707.56
	4	0.00	0.40	1.06		4	135.99	246.55	668.05
	5	0.00	0.38	1.42		5	55.27	206.20	370.43
	6	0.00	0.37	1.21		6	69.46	467.86	776.50
Vessel length (feet)	1	60.00	66.89	94.00	Crowdedness	1	0.35	6.06	24.64
	2	60.00	66.89	94.00		2	0.00	1.92	9.39
	3	60.00	66.89	94.00		3	0.23	2.46	8.08
	4	60.00	66.89	94.00		4	0.03	6.17	26.66
	5	60.00	66.89	94.00		5	0.00	4.04	24.80
	6	60.00	66.89	94.00		6	0.00	2.25	16.24
Crowdedness squared	1	0.12	53.73	607.32					
	2	0.00	6.45	88.21					
	3	0.05	7.64	65.28					
	4	0.00	55.67	710.51					
	5	0.00	31.23	615.01					
	6	0.00	11.21	263.74					

Table C.2 Summary statistics---FL Area (2000-2004)

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Loyalty	1	0.00	0.35	1.00	Expected revenue	1	0.05	2.51	16.88
	2	0.00	0.04	0.87	(thousands of dollars)	2	0.02	2.43	23.37
	3	0.00	0.11	1.00		3	0.03	1.96	17.71
	4	0.00	0.31	1.00		4	0.03	2.59	15.99
	5	0.00	0.15	1.00		5	0.02	2.75	20.62
	6	0.00	0.03	0.99		6	0.02	1.94	33.41
Variation of ER	1	0.00	0.77	5.59	Distance (kilometers)	1	80.61	232.80	901.77
	2	0.00	0.68	6.61		2	43.60	201.14	498.00
	3	0.00	1.00	8.27		3	25.90	426.79	916.66
	4	0.00	0.76	6.37		4	130.90	254.22	865.46
	5	0.00	0.64	5.07		5	53.19	214.17	479.90
	6	0.00	0.99	12.00		6	66.85	492.26	1005.96
Vessel length	1	60.00	68.09	95.00	Crowdedness	1	0.00	7.17	26.11
(feet)	2	60.00	68.09	95.00		2	0.00	0.93	10.38
	3	60.00	68.09	95.00		3	0.00	2.34	14.95
	4	60.00	68.09	95.00		4	0.00	8.22	40.13
	5	60.00	68.09	95.00		5	0.00	3.78	32.19
	6	60.00	68.09	95.00		6	0.00	4.89	68.89
Crowdedness	1	0.00	74.09	681.69					
squared	2	0.00	2.30	107.68					
	3	0.00	9.74	223.44					
	4	0.00	100.04	1610.27					
	5	0.00	30.75	1036.01					
	6	0.00	77.12	4745.33					

Table C.3 Summary statistics---LAM Area (1995-1999)

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Loyalty	1	0.00	0.03	0.99	Expected revenue	1	0.05	2.18	43.67
	2	0.00	0.24	1.00	(thousands of dollars)	2	0.15	2.22	37.95
	3	0.00	0.10	1.00		3	0.13	2.18	46.27
	4	0.00	0.14	1.00		4	0.02	2.92	53.02
	5	0.00	0.06	1.00		5	0.02	2.05	35.89
	6	0.00	0.05	0.93		6	0.04	3.55	81.03
	7	0.00	0.03	0.85		7	0.04	2.47	43.15
	8	0.00	0.06	0.99		8	0.05	2.59	47.69
	9	0.00	0.04	0.95		9	0.00	2.35	49.91
	10	0.00	0.04	1.00		10	0.18	2.29	198.55
	11	0.00	0.05	0.94		11	0.06	4.61	90.00
	12	0.00	0.01	0.69		12	0.00	2.33	57.37
	13	0.00	0.02	0.79		13	0.04	2.70	73.74
	14	0.00	0.01	0.54		14	0.00	2.00	113.84
	15	0.00	0.02	1.00		15	0.01	3.93	65.53
	16	0.00	0.02	0.98		16	0.01	3.06	54.78
	17	0.00	0.04	1.00		17	0.19	3.05	50.22
	18	0.00	0.02	0.94		18	0.13	2.63	42.64
Variation of ER	1	0.01	0.47	2.60	Distance (kilometers)	1	33.78	209.80	517.41
	2	0.20	0.60	6.56		2	18.17	168.27	440.94
	3	0.01	0.55	1.87		3	45.41	159.74	394.06
	4	0.01	0.46	2.60		4	24.69	219.28	562.73
	5	0.01	0.54	2.60		5	74.34	352.04	736.27
	6	0.00	0.37	6.56		6	50.49	218.37	533.89
	7	0.00	0.55	2.09		7	41.95	200.03	496.39
	8	0.00	0.38	3.26		8	68.59	193.95	485.26
	9	0.00	0.52	4.95		9	41.67	228.64	575.02
	10	0.15	0.55	1.93		10	91.55	358.77	746.80
	11	0.00	0.31	1.63		11	60.22	227.61	548.10
	12	0.00	0.39	6.56		12	45.32	203.16	496.05
	13	0.00	0.38	2.41		13	84.15	207.09	505.79
	14	0.00	0.74	5.61		14	91.38	322.05	701.57
	15	0.00	0.39	2.41		15	88.84	277.27	617.55
	16	0.00	0.37	2.41		16	47.60	203.79	491.07
	17	0.00	0.47	2.17		17	96.92	219.33	522.87
	18	0.00	0.66	2.14		18	114.42	333.96	713.99

Table C.3, continued

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Vessel length	1	60.00	70.39	130.00	Crowdedness	1	0.00	4.35	35.30
(feet)	2	60.00	70.39	130.00		2	0.26	18.85	70.78
	3	60.00	70.39	130.00		3	0.00	10.66	38.94
	4	60.00	70.39	130.00		4	0.00	28.32	99.68
	5	60.00	70.39	130.00		5	0.00	3.00	13.39
	6	60.00	70.39	130.00		6	0.00	6.23	35.99
	7	60.00	70.39	130.00		7	0.00	31.90	102.87
	8	60.00	70.39	130.00		8	0.00	11.39	38.41
	9	60.00	70.39	130.00		9	0.00	14.43	98.04
	10	60.00	70.39	130.00		10	0.62	26.52	86.53
	11	60.00	70.39	130.00		11	0.00	10.45	49.19
	12	60.00	70.39	130.00		12	0.01	23.13	98.40
	13	60.00	70.39	130.00		13	0.00	7.75	61.24
	14	60.00	70.39	130.00		14	0.00	4.26	30.68
	15	60.00	70.39	130.00		15	0.00	2.77	12.80
	16	60.00	70.39	130.00		16	0.00	20.26	81.72
	17	60.00	70.39	130.00		17	0.00	8.58	38.61
	18	60.00	70.39	130.00		18	0.00	19.49	72.56
Crowdedness	1	0.00	44.41	1246.41					
squared	2	0.07	559.27	5009.15					
	3	0.00	175.07	1516.07					
	4	0.00	1110.65	9936.45					
	5	0.00	15.42	179.33					
	6	0.00	61.36	1295.33					
	7	0.00	1472.24	10581.46					
	8	0.00	197.62	1475.30					
	9	0.00	476.38	9612.82					
	10	0.38	893.48	7487.97					
	11	0.00	172.80	2419.97					
	12	0.00	919.58	9683.14					
	13	0.00	122.33	3750.02					
	14	0.00	45.25	941.47					
	15	0.00	11.61	163.77					
	16	0.00	655.59	6678.54					
	17	0.00	112.04	1491.09					
	18	0.00	526.75	5264.39					

Table C.4 Summary statistics---LAM Area (2000-2004)

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Loyalty	1	0.00	0.07	1.00	Expected revenue	1	0.00	1.06	28.14
	2	0.00	0.34	1.00	(thousands of dollars)	2	0.01	0.86	21.11
	3	0.00	0.20	1.00		3	0.01	1.09	23.60
	4	0.00	0.08	1.00		4	0.00	1.28	28.95
	5	0.00	0.04	1.00		5	0.00	0.68	36.99
	6	0.00	0.02	0.88		6	0.00	1.04	43.85
	7	0.00	0.02	0.85		7	0.00	0.93	32.72
	8	0.00	0.03	0.87		8	0.00	0.75	31.01
	9	0.00	0.01	0.60		9	0.00	1.22	74.08
	10	0.00	0.01	0.64		10	0.01	1.30	25.52
	11	0.00	0.02	0.95		11	0.00	1.40	47.82
	12	0.00	0.01	0.65		12	0.00	0.94	23.62
	13	0.00	0.01	0.76		13	0.00	0.54	14.78
	14	0.00	0.00	0.38		14	0.00	0.61	32.81
	15	0.00	0.02	1.00		15	0.00	1.13	39.35
	16	0.00	0.03	0.98		16	0.00	0.72	34.82
	17	0.00	0.05	1.00		17	0.00	0.76	20.01
	18	0.00	0.03	0.89		18	0.00	0.80	17.98
Variation of ER	1	0.00	2.14	21.92	Distance	1	0.00	26.37	173.47
	2	0.39	2.25	9.92	(kilometers)	2	0.95	97.51	495.64
	3	0.24	1.77	15.28		3	0.13	71.12	383.11
	4	0.00	1.58	8.37		4	0.00	68.27	224.97
	5	0.00	1.59	37.43		5	0.00	27.06	276.37
	6	0.00	1.38	21.92		6	0.00	19.24	138.30
	7	0.00	1.86	21.92		7	0.00	107.71	959.27
	8	0.00	2.47	37.43		8	0.00	19.27	243.78
	9	0.00	2.33	37.43		9	0.00	38.00	533.14
	10	0.00	1.69	6.04		10	0.66	106.72	428.58
	11	0.00	1.15	21.92		11	0.00	37.74	407.25
	12	0.00	1.77	21.92		12	0.01	108.67	769.23
	13	0.00	2.13	37.43		13	0.00	29.55	387.42
	14	0.00	1.99	21.92		14	0.00	16.17	219.25
	15	0.00	1.60	17.72		15	0.00	26.15	162.90
	16	0.00	1.26	11.62		16	0.00	521.98	2520.26
	17	0.00	1.32	4.37		17	0.00	133.59	713.88
	18	0.10	1.72	6.06		18	1.67	113.16	601.38

Table C.4, continued

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Vessel length	1	60.00	71.21	131.00	Crowdedness	1	0.00	26.37	173.47
(feet)	2	60.00	71.21	131.00		2	0.95	97.51	495.64
	3	60.00	71.21	131.00		3	0.13	71.12	383.11
	4	60.00	71.21	131.00		4	0.00	68.27	224.97
	5	60.00	71.21	131.00		5	0.00	27.06	276.37
	6	60.00	71.21	131.00		6	0.00	19.24	138.30
	7	60.00	71.21	131.00		7	0.00	107.71	959.27
	8	60.00	71.21	131.00		8	0.00	19.27	243.78
	9	60.00	71.21	131.00		9	0.00	38.00	533.14
	10	60.00	71.21	131.00		10	0.66	106.72	428.58
	11	60.00	71.21	131.00		11	0.00	37.74	407.25
	12	60.00	71.21	131.00		12	0.01	108.67	769.23
	13	60.00	71.21	131.00		13	0.00	29.55	387.42
	14	60.00	71.21	131.00		14	0.00	16.17	219.25
	15	60.00	71.21	131.00		15	0.00	26.15	162.90
	16	60.00	71.21	131.00		16	0.00	521.98	2520.26
	17	60.00	71.21	131.00		17	0.00	133.59	713.88
	18	60.00	71.21	131.00		18	1.67	113.16	601.38
Crowdedness	1	0.00	1510.8	30093.25					
squared	2	0.91	19394.	245657.1					
	3	0.02	9896.3	146774.6					
	4	0.00	7250.5	50612.79					
	5	0.00	1761.2	76379.34					
	6	0.00	871.98	19126.23					
	7	0.00	33803.	920191.9					
	8	0.00	1444.3	59427.46					
	9	0.00	6823.6	284238.3					
	10	0.44	17658.	183681.1					
	11	0.00	3955.4	165849.2					
	12	0.00	33210.	591707.6					
	13	0.00	3742.6	150097.6					
	14	0.00	1279.6	48069.14					
	15	0.00	1376.4	26535.17					
	16	0.00	576623	6351729.					
	17	0.00	38173.	509629.1					
	18	2.79	20971.	361658.1					

Table C.5 Summary statistics---TX Area (1995-1999)

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Loyalty	1	0.00	0.05	1.00	Expected revenue	1	0.02	2.90	75.83
	2	0.00	0.04	1.00	(thousands of dollars)	2	0.00	2.34	68.40
	3	0.00	0.01	0.94		3	0.00	2.72	99.34
	4	0.00	0.02	0.79		4	0.00	3.42	183.30
	5	0.00	0.04	0.86		5	0.18	3.48	66.51
	6	0.00	0.19	1.00		6	0.10	3.30	74.84
	7	0.00	0.04	1.00		7	0.01	2.60	81.00
	8	0.00	0.15	1.00		8	0.02	3.16	91.99
	9	0.00	0.06	0.97		9	0.01	3.61	106.33
	10	0.00	0.10	0.98		10	0.01	4.06	114.31
	11	0.00	0.02	0.77		11	0.09	4.01	70.80
	12	0.00	0.02	0.82		12	0.01	3.94	163.47
	13	0.00	0.01	0.74		13	0.01	4.09	124.85
	14	0.00	0.06	0.95		14	0.01	3.59	107.21
	15	0.00	0.06	0.79		15	0.01	4.11	241.77
	16	0.00	0.09	0.98		16	0.01	4.34	208.36
Variation of ER	1	0.00	0.55	4.73	Distance	1	41.73	264.09	577.71
	2	0.00	0.71	4.26	(kilometers)	2	12.19	221.10	470.69
	3	0.00	0.57	10.15		3	73.95	235.19	484.70
	4	0.00	0.58	10.15		4	42.58	253.81	591.71
	5	0.18	0.48	1.81		5	220.48	507.98	829.75
	6	0.17	0.52	2.25		6	76.14	325.43	635.26
	7	0.00	0.64	10.15		7	69.40	255.33	522.18
	8	0.00	0.56	7.29		8	31.46	212.34	388.80
	9	0.00	0.58	6.97		9	70.51	230.13	470.44
	10	0.00	0.51	2.89		10	43.32	248.03	570.90
	11	0.00	0.46	1.64		11	235.56	505.04	807.29
	12	0.00	0.52	11.83		12	129.98	325.38	587.46
	13	0.00	0.57	11.83		13	90.96	257.76	486.30
	14	0.00	0.63	11.83		14	56.23	215.51	377.53
	15	0.00	0.53	11.83		15	70.24	224.14	447.13
	16	0.00	0.49	7.29		16	53.28	246.92	552.91

Table C.5, continued

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Vessel length	1	60.00	68.88	94.00	Crowdedness	1	0.00	6.08	31.44
(feet)	2	60.00	68.88	94.00		2	0.00	5.14	32.82
	3	60.00	68.88	94.00		3	0.00	1.24	20.15
	4	60.00	68.88	94.00		4	0.00	0.88	12.02
	5	60.00	68.88	94.00		5	0.30	7.37	29.15
	6	60.00	68.88	94.00		6	0.42	13.46	39.73
	7	60.00	68.88	94.00		7	0.00	8.50	65.23
	8	60.00	68.88	94.00		8	0.00	26.78	138.51
	9	60.00	68.88	94.00		9	0.00	19.32	108.89
	10	60.00	68.88	94.00		10	0.00	20.99	132.02
	11	60.00	68.88	94.00		11	0.00	4.26	21.63
	12	60.00	68.88	94.00		12	0.00	3.51	21.79
	13	60.00	68.88	94.00		13	0.00	2.46	29.80
	14	60.00	68.88	94.00		14	0.00	20.33	178.44
	15	60.00	68.88	94.00		15	0.00	13.30	82.82
	16	60.00	68.88	94.00		16	0.00	14.47	98.51
Crowdedness	1	0.00	63.39	988.34					
squared	2	0.00	52.18	1077.46					
	3	0.00	6.62	406.08					
	4	0.00	2.74	144.43					
	5	0.09	80.72	849.57					
	6	0.18	244.00	1578.58					
	7	0.00	202.47	4255.51					
	8	0.00	1256.36	19184.76					
	9	0.00	893.26	11856.91					
	10	0.00	944.61	17430.39					
	11	0.00	27.68	467.88					
	12	0.00	31.67	474.62					
	13	0.00	20.28	888.14					
	14	0.00	1179.27	31839.89					
	15	0.00	359.68	6859.56					
	16	0.00	452.00	9704.83					

Table C.6 Summary statistics---TX Area (2000-2004)

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Loyalty	1	0.00	0.08	1.00	Expected revenue	1	0.00	1.56	64.59
	2	0.00	0.01	0.83	(thousands of dollars)	2	0.00	0.75	84.33
	3	0.00	0.01	0.57		3	0.00	0.69	48.78
	4	0.00	0.01	0.55		4	0.00	1.15	93.60
	5	0.00	0.06	0.62		5	0.00	0.84	38.43
	6	0.00	0.18	1.00		6	0.01	1.45	81.66
	7	0.00	0.02	0.90		7	0.00	0.73	33.35
	8	0.00	0.19	1.00		8	0.00	1.15	44.83
	9	0.00	0.05	1.00		9	0.00	1.49	63.77
	10	0.00	0.07	0.91		10	0.00	1.72	75.98
	11	0.00	0.03	0.78		11	0.00	1.17	38.01
	12	0.00	0.02	0.83		12	0.00	1.46	64.74
	13	0.00	0.02	0.70		13	0.00	1.15	33.67
	14	0.00	0.08	0.96		14	0.00	1.37	66.78
	15	0.00	0.06	0.73		15	0.00	1.73	68.23
	16	0.00	0.09	0.95		16	0.00	1.84	76.11
Variation of ER	1	0.00	1.57	8.80	Distance	1	40.16	266.68	748.43
	2	0.00	2.45	23.07	(kilometers)	2	11.73	224.06	609.79
	3	0.00	2.31	11.34		3	71.18	252.36	627.93
	4	0.00	2.17	23.07		4	40.98	275.67	766.57
	5	0.00	1.94	8.78		5	212.22	524.37	1074.95
	6	0.00	1.57	6.45		6	73.29	332.30	822.99
	7	0.00	1.77	11.34		7	66.80	259.72	676.49
	8	0.00	1.35	7.80		8	29.98	216.88	503.69
	9	0.00	1.26	8.80		9	67.87	246.69	609.47
	10	0.00	0.91	11.34		10	41.70	269.19	739.61
	11	0.00	1.84	10.60		11	226.72	522.02	1045.85
	12	0.00	1.19	10.83		12	125.11	334.12	761.06
	13	0.00	1.65	23.07		13	87.55	263.94	630.01
	14	0.00	1.46	8.80		14	53.59	221.55	489.10
	15	0.00	1.12	8.80		15	67.61	239.57	579.26
	16	0.00	0.96	8.80		16	51.29	267.40	716.30

Table C.6, continued

Variable	*Grid*	*Min*	*Mean*	*Max*	*Variable*	*Grid*	*Min*	*Mean*	*Max*
Vessel length	1	60.00	72.18	95.00	Crowdedness	1	0.00	31.86	209.00
(feet)	2	60.00	72.18	95.00		2	0.00	12.72	221.05
	3	60.00	72.18	95.00		3	0.00	2.06	41.43
	4	60.00	72.18	95.00		4	0.00	1.24	13.03
	5	60.00	72.18	95.00		5	0.00	51.78	307.06
	6	60.00	72.18	95.00		6	0.34	59.06	247.59
	7	60.00	72.18	95.00		7	0.00	37.64	356.05
	8	60.00	72.18	95.00		8	0.00	116.76	554.63
	9	60.00	72.18	95.00		9	0.00	27.73	186.57
	10	60.00	72.18	95.00		10	0.00	32.16	288.11
	11	60.00	72.18	95.00		11	0.00	24.08	144.39
	12	60.00	72.18	95.00		12	0.00	12.42	68.44
	13	60.00	72.18	95.00		13	0.00	13.87	93.79
	14	60.00	72.18	95.00		14	0.00	60.82	601.46
	15	60.00	72.18	95.00		15	0.00	21.27	141.23
	16	60.00	72.18	95.00		16	0.00	31.23	188.81
Crowdedness	1	0.00	2751.32	43680.69					
squared	2	0.00	1026.23	48864.62					
	3	0.00	27.65	1716.23					
	4	0.00	7.58	169.74					
	5	0.00	5644.12	94285.04					
	6	0.11	6243.52	61301.64					
	7	0.00	5191.40	126768.87					
	8	0.00	27654.51	307619.91					
	9	0.00	1637.18	34807.21					
	10	0.00	2398.25	83004.58					
	11	0.00	1149.79	20847.69					
	12	0.00	266.55	4684.32					
	13	0.00	464.88	8796.51					
	14	0.00	16146.64	361748.23					
	15	0.00	934.09	19946.44					
	16	0.00	2021.78	35649.58					

APPENDIX D. RESULTS OF DAYS FISHED ESTIMATIONS USING GULF-WIDE DATA 1995-1999 AND 2000-2004

Table D.1 Days Fished Estimation Results

Period	Variable	Parameter Estimate	Standard Error	t-value	Pr>|t|
95-99	intercept	-3.5872	0.0482	-74.46	< 0.0001
	ln(catch/trip)	0.5763	0.0035	163.48	< 0.0001
	ln(price)	1.0314	0.0323	31.94	< 0.0001
	$\ln(\text{price})^2$	-0.0822	0.0145	-5.68	< 0.0001
	vessel length	0.2660	0.0170	15.69	< 0.0001
	Area 1	-0.4612	0.0440	-10.48	< 0.0001
	Area 2	-0.3841	0.0462	-8.31	< 0.0001
	Area 3	-0.3389	0.0464	-7.30	< 0.0001
	Area 4	-0.6305	0.0344	-18.33	< 0.0001
	Area 5	-0.0919	0.0327	-2.81	0.0049
	Area 6	-0.3273	0.0322	-10.15	< 0.0001
	Area 7	-0.3063	0.0319	-9.59	< 0.0001
	Area 8	-0.5427	0.0322	-16.87	< 0.0001
	Depth 1	-0.2803	0.0206	-13.62	< 0.0001
	Depth 2	-0.0219	0.0206	-1.06	0.2870
	Depth 3	0.1522	0.0212	7.19	< 0.0001
	Depth 4	0.1199	0.0240	4.99	< 0.0001
	Depth 5	0.0863	0.0265	3.26	0.0011
	Month 1	-0.1367	0.0244	-5.61	< 0.0001
	Month 2	0.2212	0.0231	9.58	< 0.0001
	Month 3	0.2907	0.0243	11.95	< 0.0001
	Month 4	0.2297	0.0245	9.39	< 0.0001
	Month 5	0.3108	0.0218	14.23	< 0.0001
	Month 6	0.2875	0.0231	12.45	< 0.0001
	Month 7	-0.1781	0.0213	-8.37	< 0.0001
	Month 8	-0.0785	0.0205	-3.84	< 0.0001
	Month 9	-0.0581	0.0205	-2.83	0.0046
	Month 10	-0.0655	0.0203	-3.23	0.0012
	Month 11	-0.0179	0.0210	-0.86	0.3920
	Gear 0	-0.0219	0.0236	-0.93	0.3529
	Year 95	-0.0700	0.0130	-5.40	< 0.0001
	Year 96	0.0346	0.0132	2.62	0.0087
	Year 97	-0.0162	0.0134	-1.21	0.2272
	Year 98	0.0373	0.0128	2.91	0.0036
	Pink Shrimp	-0.3655	0.0208	-17.56	< 0.0001
	Brown Shrimp	-0.4677	0.0341	-13.70	< 0.0001
	White Shrimp	-0.1458	0.0195	-7.50	< 0.0001
	Pr > F	< 0.0001			
	Adjusted R^2	0.7286			

Table D.1, continued

Period	Variable	Parameter Estimate	Standard Error	t-value	P>|t|
00-04	intercept	-1.9314	0.0800	-24.15	< 0.0001
	ln(catch/trip)	0.1331	0.0037	36.38	< 0.0001
	ln(price)	-0.2617	0.0314	-8.34	< 0.0001
	$\ln(\text{price})^2$	0.1873	0.0123	15.29	< 0.0001
	vessel length	0.8066	0.0265	30.41	< 0.0001
	Area 1	-0.1769	0.0526	-3.36	0.0008
	Area 2	-0.1936	0.0593	-3.27	0.0011
	Area 3	-0.3808	0.0522	-7.29	< 0.0001
	Area 4	-0.5226	0.0374	-13.99	< 0.0001
	Area 5	-0.1399	0.0334	-4.18	< 0.0001
	Area 6	-0.3187	0.0326	-9.77	< 0.0001
	Area 7	-0.3178	0.0330	-9.61	< 0.0001
	Area 8	-0.6383	0.0338	-18.91	< 0.0001
	Depth 1	0.7283	0.0299	24.39	< 0.0001
	Depth 2	0.8946	0.0359	34.93	< 0.0001
	Depth 3	1.2806	0.0333	38.47	< 0.0001
	Depth 4	1.4139	0.0355	39.87	< 0.0001
	Depth 5	1.5693	0.0377	41.62	< 0.0001
	Month 1	-0.3018	0.0354	-8.52	< 0.0001
	Month 2	0.1101	0.0326	3.38	0.0007
	Month 3	0.0513	0.0374	1.37	0.1699
	Month 4	-0.1448	0.0352	-4.12	< 0.0001
	Month 5	0.0925	0.0315	2.94	0.0033
	Month 6	0.2540	0.0317	8.02	< 0.0001
	Month 7	-0.1932	0.0298	-6.48	< 0.0001
	Month 8	0.0619	0.0293	2.12	0.0343
	Month 9	0.0297	0.0299	0.99	0.3211
	Month 10	-0.1284	0.0296	-4.33	< 0.0001
	Month 11	-0.0085	0.0314	-0.27	0.7856
	Gear 0	0.2152	0.0318	6.77	< 0.0001
	Year 01	0.0693	0.0163	4.26	< 0.0001
	Year 02	0.0729	0.0181	4.02	< 0.0001
	Year 03	0.1232	0.0182	6.78	< 0.0001
	Year 04	0.0178	0.0187	0.95	0.3424
	Pink Shrimp	1.2491	0.0671	18.62	< 0.0001
	Brown Shrimp	0.4923	0.0745	6.61	< 0.0001
	White Shrimp	1.2265	0.0669	18.35	< 0.0001
	Pr > F	< 0.0001			
	Adjusted R^2	0.5463			

APPENDIX E. TX CLOSURE AREA AND TIME

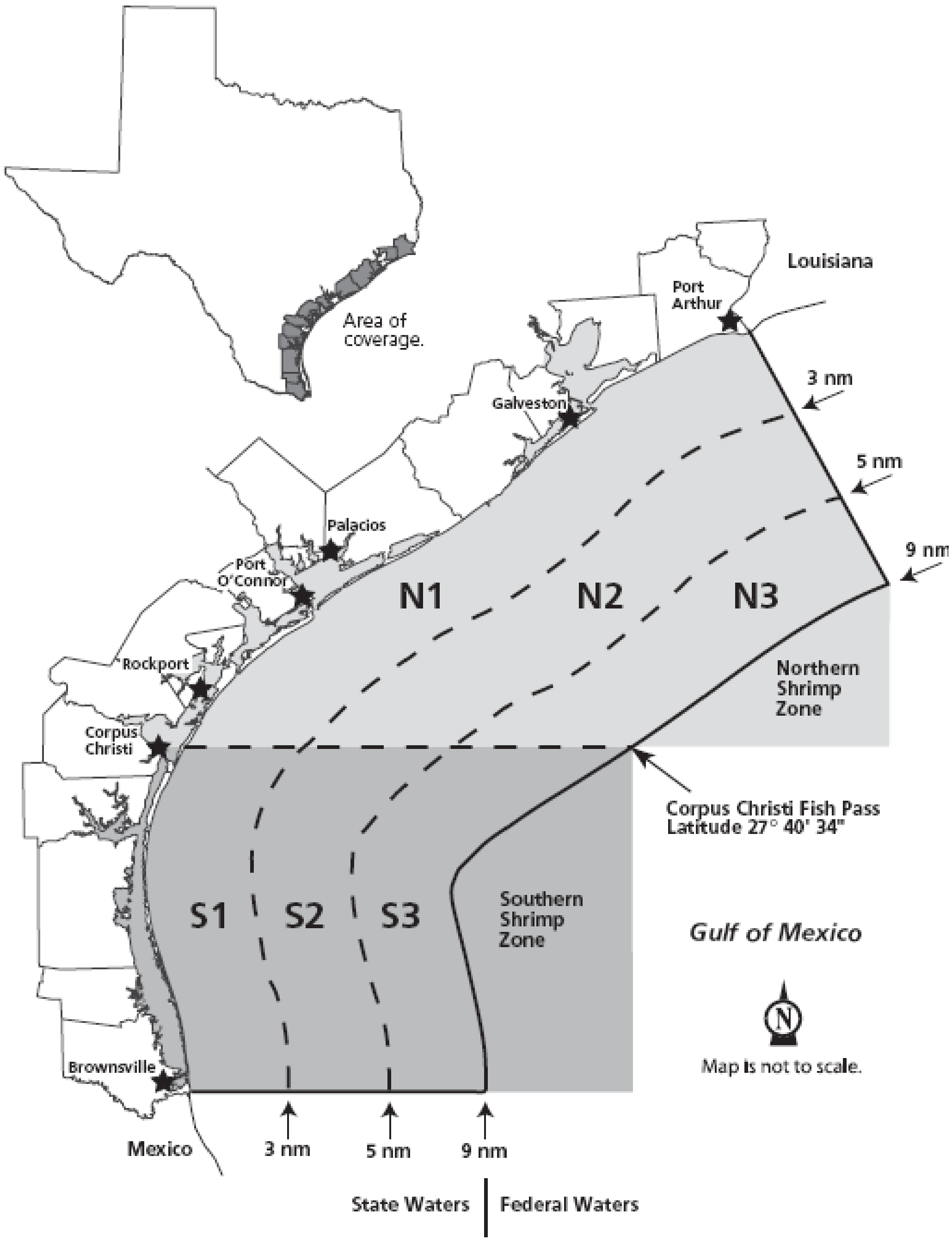

Figure E.1 TX closure area

Source: 2007-2008 Texas Commmercial Fishing Guide

Table E.1 Texas Closure Time for Each Year

Year	Date Closed	Date Opened
1995	5/15	7/7
1996	6/1	7/15
1997	5/15	7/15
1998	5/15	7/8
1999	5/15	7/15
2000	5/5	7/5
2001	5/15	7/8
2002	5/15	7/15
2003	5/15	7/15
2004	5/15	7/15

APPENDIX F. CONDITIONAL LOGIT RESULTS

Table F.1 Parameter Estimates---FL Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	1.2678	1.0656	1.19	0.2341
Grid 2	1	7.0714	1.2173	5.81	<.0001
Grid 3	1	4.9853	1.1869	4.2	<.0001
Grid 4	1	5.0865	1.1326	4.49	<.0001
Grid 5	1	3.0351	1.07	2.84	0.0046
Loyalty	1	3.0573	0.0435	70.24	<.0001
Season 1grid 1	1	0.8575	0.1508	5.69	<.0001
Season 1grid 2	1	1.0694	0.1585	6.75	<.0001
Season 1grid 3	1	0.4561	0.1438	3.17	0.0015
Season 1grid 4	1	0.9444	0.1551	6.09	<.0001
Season 1grid 5	1	1.0473	0.146	7.17	<.0001
Vessel length grid 1	1	-0.0239	0.0157	-1.52	0.1293
Vessel length grid 2	1	-0.1205	0.0181	-6.66	<.0001
Vessel length grid 3	1	-0.0841	0.0177	-4.76	<.0001
Vessel length grid 4	1	-0.083	0.0168	-4.95	<.0001
Vessel length grid 5	1	-0.0584	0.0158	-3.7	0.0002
Expected revenue	1	-0.0259	0.0226	-1.15	0.2506
Variance of ER	1	0.1489	0.1037	1.44	0.1509
Distance	1	-0.00652	0.000141	-46.39	<.0001
Crowdedness	1	0.1795	0.013	13.82	<.0001
Crowdedness squared	1	-0.00559	0.000677	-8.25	<.0001

Note: The MDC Procedure

Conditional Logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	13343
Number of Cases	80058
Log Likelihood	-10711
Maximum Absolute Gradient	0.00153
Number of Iterations	6
Optimization Method	Newton-Raphson
AIC	21463
Schwarz Criterion	21620

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	4917	36.85
1	2	864	6.48
2	3	1501	11.25
3	4	3630	27.21
4	5	2114	15.84
5	6	317	2.38

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	26394	2 * (LogL - LogL0)
Upper Bound of R (U)	47815	- 2 * LogL0
Aldrich-Nelson	0.6642	R / (R+N)
Cragg-Uhler 1	0.8617	1 - exp(-R/N)
Cragg-Uhler 2	0.8863	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9437	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9433	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.552	R / U
Veall-Zimmermann	0.8496	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table F.2 Parameter Estimates---FL Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-1.0595	1.3145	-0.81	0.4202
Grid 2	1	5.9933	1.6683	3.59	0.0003
Grid 3	1	0.2057	1.1601	0.18	0.8592
Grid 4	1	1.8229	1.3446	1.36	0.1752
Grid 5	1	0.3439	1.3441	0.26	0.7981
Loyalty	1	2.6487	0.0511	51.87	<.0001
Season 1grid 1	1	0.1354	0.1888	0.72	0.4733
Season 1grid 2	1	0.2928	0.2099	1.4	0.163
Season 1grid 3	1	-0.0046	0.1671	-0.03	0.978
Season 1grid 4	1	0.1579	0.1908	0.83	0.4078
Season 1grid 5	1	0.5576	0.1835	3.04	0.0024
Vessel length grid 1	1	0.018	0.0192	0.94	0.349
Vessel length grid 2	1	-0.1069	0.0246	-4.34	<.0001
Vessel length grid 3	1	-0.00823	0.017	-0.48	0.6284
Vessel length grid 4	1	-0.0248	0.0196	-1.26	0.2066
Vessel length grid 5	1	-0.0204	0.0197	-1.04	0.2984
Expected revenue	1	0.1107	0.0163	6.8	<.0001
Variance of ER	1	0.0146	0.0319	0.46	0.6463
Distance	1	-0.00776	0.000209	-37.22	<.0001
Crowdedness	1	0.1054	0.0108	9.79	<.0001
Crowdedness squared	1	-0.00228	0.000362	-6.29	<.0001

Note: The MDC Procedure

Conditional Logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	9722
Number of Cases	58332
Log Likelihood	-7257
Maximum Absolute Gradient	0.00657
Number of Iterations	6
Optimization Method	Newton-Raphson
AIC	14556
Schwarz Criterion	14707

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	3563	36.65
1	2	340	3.50
2	3	981	10.09
3	4	3141	32.31
4	5	1398	14.38
5	6	299	3.08

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	20325	2 * (LogL - LogL0)
Upper Bound of R (U)	34839	- 2 * LogL0
Aldrich-Nelson	0.6764	R / (R+N)
Cragg-Uhler 1	0.8764	1 - exp(-R/N)
Cragg-Uhler 2	0.9014	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9566	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9562	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.5834	R / U
Veall-Zimmermann	0.8652	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table F.3 Parameter Estimates---LAM Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	7.4164	0.7391	10.03	<.0001
Grid 2	1	4.1119	0.6455	6.37	<.0001
Grid 3	1	4.2216	0.6127	6.89	<.0001
Grid 4	1	4.8615	0.5946	8.18	<.0001
Grid 5	1	5.1136	0.7235	7.07	<.0001
Grid 6	1	3.3551	0.7038	4.77	<.0001
Grid 7	1	0.9585	0.7226	1.33	0.1847
Grid 8	1	1.8289	0.6546	2.79	0.0052
Grid 9	1	3.3737	0.6375	5.29	<.0001
Grid 10	1	4.2358	0.6884	6.15	<.0001
Grid 11	1	-0.2819	0.7154	-0.39	0.6935
Grid 12	1	0.7975	0.9541	0.84	0.4032
Grid 13	1	1.0883	0.7598	1.43	0.1521
Grid 14	1	1.5863	0.8591	1.85	0.0648
Grid 15	1	0.8888	0.7606	1.17	0.2426
Grid 16	1	-0.359	0.8779	-0.41	0.6826
Grid 17	1	0.7197	0.7612	0.95	0.3444
Loyalty	1	4.0161	0.0284	141.3	<.0001
Season 1 grid 1	1	0.034	0.1852	0.18	0.8543
Season 1 grid 2	1	0.4127	0.1392	2.96	0.003
Season 1 grid 3	1	-0.097	0.1267	-0.77	0.4439
Season 1 grid 4	1	-0.3513	0.1164	-3.02	0.0025
Season 1 grid 5	1	-1.0482	0.1504	-6.97	<.0001
Season 1 grid 6	1	0.3827	0.1571	2.44	0.0149
Season 1 grid 7	1	0.7459	0.1531	4.87	<.0001
Season 1 grid 8	1	-0.2683	0.1351	-1.99	0.047
Season 1 grid 9	1	-0.6578	0.1329	-4.95	<.0001
Season 1 grid 10	1	-0.8116	0.1499	-5.42	<.0001
Season 1 grid 11	1	0.0547	0.1563	0.35	0.7266
Season 1 grid 12	1	0.7678	0.188	4.08	<.0001
Season 1 grid 13	1	-0.0177	0.1472	-0.12	0.904
Season 1 grid 14	1	-1.3663	0.2127	-6.43	<.0001
Season 1 grid 15	1	0.5581	0.1701	3.28	0.001

Table F.3, continued

Parameter	D.F.	Estimate	Standard error	t-value	Approximate
Season 1 grid 16	1	0.3424	0.1663	2.06	0.0395
Season 1 grid 17	1	-0.3059	0.1409	-2.17	0.0299
Season 2 grid 1	1	3.4138	0.2416	14.13	<.0001
Season 2 grid 2	1	3.9501	0.206	19.18	<.0001
Season 2 grid 3	1	3.0122	0.1975	15.25	<.0001
Season 2 grid 4	1	0.5974	0.1932	3.09	0.002
Season 2 grid 5	1	1.1546	0.2293	5.03	<.0001
Season 2 grid 6	1	3.173	0.2249	14.11	<.0001
Season 2 grid 7	1	3.2421	0.2253	14.39	<.0001
Season 2 grid 8	1	1.8704	0.2055	9.1	<.0001
Season 2 grid 9	1	1.6879	0.2029	8.32	<.0001
Season 2 grid 10	1	-0.5828	0.2431	-2.4	0.0165
Season 2 grid 11	1	3.0404	0.231	13.16	<.0001
Season 2 grid 12	1	2.7259	0.2958	9.22	<.0001
Season 2 grid 13	1	1.4319	0.2489	5.75	<.0001
Season 2 grid 14	1	0.8714	0.2242	3.89	0.0001
Season 2 grid 15	1	2.5857	0.269	9.61	<.0001
Season 2 grid 16	1	2.3768	0.2848	8.34	<.0001
Season 2 grid 17	1	0.8337	0.2699	3.09	0.002
TX closure grid 1	1	0.9856	0.215	4.58	<.0001
TX closure grid 2	1	-0.1333	0.1818	-0.73	0.4634
TX closure grid 3	1	0.5094	0.1795	2.84	0.0045
TX closure grid 4	1	-0.1963	0.182	-1.08	0.2808
TX closure grid 5	1	-0.0755	0.2209	-0.34	0.7327
TX closure grid 6	1	0.6632	0.1944	3.41	0.0006
TX closure grid 7	1	0.3902	0.2008	1.94	0.052
TX closure grid 8	1	0.5539	0.1877	2.95	0.0032
TX closure grid 9	1	-0.6513	0.199	-3.27	0.0011
TX closure grid 10	1	0.5734	0.2299	2.49	0.0126
TX closure grid 11	1	0.2668	0.1997	1.34	0.1815
TX closure grid 12	1	0.5112	0.2791	1.83	0.067
TX closure grid 13	1	-0.0146	0.2348	-0.06	0.9504
TX closure grid 14	1	-0.0626	0.2146	-0.29	0.7705

Table F.3, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
TX closure grid 15	1	-0.1702	0.2443	-0.7	0.486
TX closure grid 16	1	0.0173	0.2683	0.06	0.9487
TX closure grid 17	1	-0.6635	0.2653	-2.5	0.0124
Vessel length grid 1	1	-0.1571	0.0103	-15.31	<.0001
Vessel length grid 2	1	-0.0959	0.008737	-10.98	<.0001
Vessel length grid 3	1	-0.0827	0.008318	-9.94	<.0001
Vessel length grid 4	1	-0.0832	0.00802	-10.37	<.0001
Vessel length grid 5	1	-0.0621	0.009933	-6.25	<.0001
Vessel length grid 6	1	-0.0899	0.00962	-9.34	<.0001
Vessel length grid 7	1	-0.0601	0.009828	-6.12	<.0001
Vessel length grid 8	1	-0.0416	0.008872	-4.68	<.0001
Vessel length grid 9	1	-0.0603	0.008615	-7	<.0001
Vessel length grid 10	1	-0.0551	0.0094	-5.86	<.0001
Vessel length grid 11	1	-0.0392	0.009667	-4.05	<.0001
Vessel length grid 12	1	-0.0657	0.0131	-5.01	<.0001
Vessel length grid 13	1	-0.0322	0.0103	-3.11	0.0019
Vessel length grid 14	1	-0.0208	0.0117	-1.78	0.0753
Vessel length grid 15	1	-0.0579	0.0103	-5.6	<.0001
Vessel length grid 16	1	-0.0381	0.012	-3.18	0.0015
Vessel length grid 17	1	-0.0185	0.0103	-1.79	0.0729
Expected revenue	1	0.0387	0.007106	5.45	<.0001
Variation of ER	1	-0.0346	0.0364	-0.95	0.3415
Distance	1	-0.0167	0.000187	-89.3	<.0001
Crowdedness	1	0.0407	0.001954	20.84	<.0001
Crowdedness squared	1	-0.0003	2.43E-05	-12.55	<.0001

Note: The MDC Procedure

Conditional Logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	33545
Number of Cases	603810
Log Likelihood	-41154
Maximum Absolute Gradient	595.50146
Number of Iterations	171
Optimization Method	Dual Quasi-Newton
AIC	82489
Schwarz Criterion	83256

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	1015	3.03
1	2	8329	24.83
2	3	3370	10.05
3	4	4851	14.46
4	5	2310	6.89
5	6	1536	4.58
6	7	1017	3.03
7	8	1932	5.76
8	9	1218	3.63
9	10	1411	4.21
10	11	1611	4.80
11	12	321	0.96
12	13	769	2.29
13	14	357	1.06
14	15	833	2.48
15	16	678	2.02
16	17	1444	4.30
17	18	543	1.62

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	111608	2 * (LogL - LogL0)
Upper Bound of R (U)	193915	- 2 * LogL0
Aldrich-Nelson	0.7689	R / (R+N)
Cragg-Uhler 1	0.9641	1 - exp(-R/N)
Cragg-Uhler 2	0.9671	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9929	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9929	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.5755	R / U
Veall-Zimmermann	0.9019	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table F.4 Parameter Estimates---LAM Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	5.0636	0.4724	10.72	<.0001
Grid 2	1	4.1757	0.422	9.9	<.0001
Grid 3	1	2.4449	0.3937	6.21	<.0001
Grid 4	1	3.1985	0.435	7.35	<.0001
Grid 5	1	1.244	0.5338	2.33	0.0198
Grid 6	1	2.6867	0.5707	4.71	<.0001
Grid 7	1	-1.0253	0.6193	-1.66	0.0978
Grid 8	1	-1.1248	0.6325	-1.78	0.0753
Grid 9	1	-1.5243	1.3213	-1.15	0.2487
Grid 10	1	-6.4872	1.0563	-6.14	<.0001
Grid 11	1	-2.3206	0.6331	-3.67	0.0002
Grid 12	1	-4.4753	0.8471	-5.28	<.0001
Grid 13	1	-3.5587	0.9741	-3.65	0.0003
Grid 14	1	-2.004	1.6037	-1.25	0.2115
Grid 15	1	0.2805	0.5211	0.54	0.5904
Grid 16	1	-0.3613	0.5374	-0.67	0.5014
Grid 17	1	-0.2033	0.4835	-0.42	0.6742
Loyalty	1	3.9959	0.0274	145.77	<.0001
Season 1 grid 1	1	-0.401	0.1321	-3.03	0.0024
Season 1 grid 2	1	0.5805	0.1044	5.56	<.0001
Season 1 grid 3	1	0.1673	0.0989	1.69	0.0907
Season 1 grid 4	1	-0.5737	0.1069	-5.37	<.0001
Season 1 grid 5	1	-0.3216	0.139	-2.31	0.0207
Season 1 grid 6	1	-0.3897	0.1538	-2.53	0.0113
Season 1 grid 7	1	0.5435	0.1415	3.84	0.0001
Season 1 grid 8	1	0.0153	0.1351	0.11	0.9098
Season 1 grid 9	1	0.9128	0.261	3.5	0.0005
Season 1 grid 10	1	-1.1362	0.3492	-3.25	0.0011
Season 1 grid 11	1	-0.1006	0.1474	-0.68	0.4951
Season 1 grid 12	1	0.1569	0.1881	0.83	0.4044
Season 1 grid 13	1	0.1001	0.1857	0.54	0.5899
Season 1 grid 14	1	-1.472	0.4914	-3	0.0027
Season 1 grid 15	1	0.449	0.1426	3.15	0.0016

Table F.4, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 1 grid 16	1	0.8807	0.1314	6.7	<.0001
Season 1 grid 17	1	0.218	0.1161	1.88	0.0605
Season 2 grid 1	1	0.382	0.1614	2.37	0.0179
Season 2 grid 2	1	0.3189	0.1338	2.38	0.0171
Season 2 grid 3	1	-0.8033	0.1184	-6.79	<.0001
Season 2 grid 4	1	-1.2662	0.1445	-8.76	<.0001
Season 2 grid 5	1	-0.5782	0.1705	-3.39	0.0007
Season 2 grid 6	1	0.1553	0.1995	0.78	0.4364
Season 2 grid 7	1	0.2829	0.2332	1.21	0.225
Season 2 grid 8	1	-0.5798	0.1996	-2.9	0.0037
Season 2 grid 9	1	-0.8286	0.4415	-1.88	0.0605
Season 2 grid 10	1	-1.807	0.2623	-6.89	<.0001
Season 2 grid 11	1	0.5598	0.1989	2.81	0.0049
Season 2 grid 12	1	-0.2988	0.3398	-0.88	0.3791
Season 2 grid 13	1	0.0475	0.2785	0.17	0.8646
Season 2 grid 14	1	-1.1661	0.5717	-2.04	0.0414
Season 2 grid 15	1	0.6163	0.1923	3.2	0.0014
Season 2 grid 16	1	-0.0361	0.1764	-0.2	0.838
Season 2 grid 17	1	0.8016	0.136	5.89	<.0001
TX closure grid 1	1	0.3105	0.1592	1.95	0.0512
TX closure grid 2	1	-0.6415	0.1313	-4.88	<.0001
TX closure grid 3	1	-0.0308	0.1181	-0.26	0.7942
TX closure grid 4	1	-0.6339	0.1506	-4.21	<.0001
TX closure grid 5	1	0.0901	0.1779	0.51	0.6124
TX closure grid 6	1	0.087	0.1986	0.44	0.6613
TX closure grid 7	1	-0.7619	0.2386	-3.19	0.0014
TX closure grid 8	1	-0.2432	0.2028	-1.2	0.2306
TX closure grid 9	1	0.1045	0.4319	0.24	0.8089
TX closure grid 10	1	2.1766	0.2526	8.62	<.0001
TX closure grid 11	1	-0.0727	0.1974	-0.37	0.7127
TX closure grid 12	1	-0.0534	0.3271	-0.16	0.8703
TX closure grid 13	1	0.1217	0.278	0.44	0.6615
TX closure grid 14	1	0.8385	0.5403	1.55	0.1206

Table F.4, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
TX closure grid 15	1	-0.0892	0.1937	-0.46	0.645
TX closure grid 16	1	0.1005	0.1796	0.56	0.576
TX closure grid 17	1	-0.7708	0.1365	-5.65	<.0001
Vessel length grid 1	1	-0.0915	0.006336	-14.44	<.0001
Vessel length grid 2	1	-0.0722	0.005602	-12.89	<.0001
Vessel length grid 3	1	-0.0365	0.005228	-6.98	<.0001
Vessel length grid 4	1	-0.0499	0.005899	-8.46	<.0001
Vessel length grid 5	1	-0.0204	0.007441	-2.75	0.006
Vessel length grid 6	1	-0.0625	0.007671	-8.15	<.0001
Vessel length grid 7	1	-0.0166	0.008147	-2.04	0.0411
Vessel length grid 8	1	0.000584	0.008377	0.07	0.9444
Vessel length grid 9	1	-0.0193	0.0173	-1.12	0.2644
Vessel length grid 10	1	0.0636	0.0133	4.79	<.0001
Vessel length grid 11	1	0.000734	0.008189	0.09	0.9286
Vessel length grid 12	1	0.0214	0.0108	1.97	0.0484
Vessel length grid 13	1	0.0221	0.0127	1.74	0.082
Vessel length grid 14	1	0.001054	0.0215	0.05	0.9608
Vessel length grid 15	1	-0.0328	0.006836	-4.8	<.0001
Vessel length grid 16	1	-0.0292	0.007054	-4.14	<.0001
Vessel length grid 17	1	-0.00514	0.006369	-0.81	0.4201
Expected revenue	1	0.0474	0.0117	4.03	<.0001
Variation of ER	1	-0.0273	0.008083	-3.38	0.0007
Distance	1	-0.00952	0.000127	-75.18	<.0001
Crowdedness	1	0.00295	0.000142	20.74	<.0001
Crowdedness squared	1	-9.90E-07	7.38E-08	-13.41	<.0001

Note: The MDC Procedure

Conditional Logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	32357
Number of Cases	582426
Log Likelihood	-36448
Maximum Absolute Gradient	182817
Number of Iterations	142
Optimization Method	Dual Quasi-Newton
AIC	73079
Schwarz Criterion	73842

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2619	8.09
1	2	11190	34.58
2	3	7054	21.80
3	4	2313	7.15
4	5	1293	4.00
5	6	695	2.15
6	7	534	1.65
7	8	674	2.08
8	9	87	0.27
9	10	131	0.40
10	11	729	2.25
11	12	240	0.74
12	13	265	0.82
13	14	57	0.18
14	15	736	2.27
15	16	1046	3.23
16	17	1802	5.57
17	18	892	2.76

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	114151	2 * (LogL - LogL0)
Upper Bound of R (U)	187048	- 2 * LogL0
Aldrich-Nelson	0.7791	R / (R+N)
Cragg-Uhler 1	0.9706	1 - exp(-R/N)
Cragg-Uhler 2	0.9736	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9957	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9956	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.6103	R / U
Veall-Zimmermann	0.9139	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table F.5 Parameter Estimates---TX Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-1.3439	0.6174	-2.18	0.0295
Grid 2	1	-3.3457	0.5623	-5.95	<.0001
Grid 3	1	-0.8736	1.0904	-0.8	0.423
Grid 4	1	1.0064	1.1354	0.89	0.3754
Grid 5	1	2.3341	0.5953	3.92	<.0001
Grid 6	1	0.4201	0.5643	0.74	0.4566
Grid 7	1	-1.2887	0.6153	-2.09	0.0362
Grid 8	1	-1.4874	0.4904	-3.03	0.0024
Grid 9	1	0.0598	0.4947	0.12	0.9038
Grid 10	1	-0.0499	0.4582	-0.11	0.9133
Grid 11	1	6.2117	0.6179	10.05	<.0001
Grid 12	1	-0.2276	0.6521	-0.35	0.727
Grid 13	1	0.1	0.8013	0.12	0.9007
Grid 14	1	-0.0396	0.4959	-0.08	0.9363
Grid 15	1	-0.2329	0.4512	-0.52	0.6058
Loyalty	1	3.8019	0.0296	128.53	<.0001
Season 1 grid 1	1	0.0638	0.1178	0.54	0.588
Season 1 grid 2	1	-0.1262	0.1014	-1.24	0.2132
Season 1 grid 3	1	1.2379	0.1742	7.11	<.0001
Season 1 grid 4	1	1.152	0.1297	8.88	<.0001
Season 1 grid 5	1	0.9703	0.1349	7.19	<.0001
Season 1 grid 6	1	0.1766	0.1202	1.47	0.1418
Season 1 grid 7	1	-0.6573	0.1379	-4.77	<.0001
Season 1 grid 8	1	0.2261	0.0795	2.84	0.0045
Season 1 grid 9	1	-0.0265	0.0788	-0.34	0.7364
Season 1 grid 10	1	0.006405	0.0616	0.1	0.9172
Season 1 grid 11	1	0.9182	0.0904	10.16	<.0001
Season 1 grid 12	1	-0.00415	0.1148	-0.04	0.9711
Season 1 grid 13	1	-0.288	0.1252	-2.3	0.0214
Season 1 grid 14	1	-0.1005	0.0687	-1.46	0.1436
Season 1 grid 15	1	-0.1137	0.0604	-1.88	0.0597
Season 2 grid 1	1	-0.9584	0.1067	-8.98	<.0001
Season 2 grid 2	1	-1.1975	0.1019	-11.75	<.0001

Table F.5, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 2 grid 3	1	1.4234	0.1775	8.02	<.0001
Season 2 grid 4	1	1.1528	0.137	8.42	<.0001
Season 2 grid 5	1	-0.267	0.1327	-2.01	0.0442
Season 2 grid 6	1	-0.6823	0.1037	-6.58	<.0001
Season 2 grid 7	1	0.2789	0.0985	2.83	0.0046
Season 2 grid 8	1	0.2349	0.0732	3.21	0.0013
Season 2 grid 9	1	1.0341	0.0663	15.59	<.0001
Season 2 grid 10	1	1.0738	0.0561	19.12	<.0001
Season 2 grid 11	1	-1.4595	0.1369	-10.66	<.0001
Season 2 grid 12	1	-1.4465	0.1447	-10	<.0001
Season 2 grid 13	1	-1.1561	0.1457	-7.93	<.0001
Season 2 grid 14	1	-0.3422	0.078	-4.39	<.0001
Season 2 grid 15	1	-0.2729	0.0691	-3.95	<.0001
TX closure grid 1	1	-3.0439	0.2208	-13.79	<.0001
TX closure grid 2	1	-4.1329	0.3664	-11.28	<.0001
TX closure grid 3	1	-4.7741	0.3903	-12.23	<.0001
TX closure grid 4	1	-6.5559	0.7253	-9.04	<.0001
TX closure grid 5	1	1.31	0.1631	8.03	<.0001
TX closure grid 6	1	0.3826	0.1553	2.46	0.0138
TX closure grid 7	1	-3.4039	0.2353	-14.47	<.0001
TX closure grid 8	1	-3.7302	0.1667	-22.37	<.0001
TX closure grid 9	1	-4.0642	0.1766	-23.01	<.0001
TX closure grid 10	1	-4.6309	0.178	-26.01	<.0001
TX closure grid 11	1	-0.4181	0.2039	-2.05	0.0403
TX closure grid 12	1	-3.8079	0.5323	-7.15	<.0001
TX closure grid 13	1	-4.1329	0.2169	-19.06	<.0001
TX closure grid 14	1	-4.9538	0.2476	-20.01	<.0001
TX closure grid 15	1	-5.3215	0.2356	-22.58	<.0001
Vessel length grid 1	1	0.0579	0.008907	6.51	<.0001
Vessel length grid 2	1	0.079	0.00811	9.74	<.0001
Vessel length grid 3	1	-0.00486	0.0161	-0.3	0.7631
Vessel length grid 4	1	-0.0434	0.0172	-2.53	0.0114
Vessel length grid 5	1	0.0303	0.008376	3.62	0.0003

Table F.5, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Vessel length grid 6	1	0.041	0.008089	5.07	<.0001
Vessel length grid 7	1	0.0512	0.008907	5.75	<.0001
Vessel length grid 8	1	0.0475	0.007202	6.6	<.0001
Vessel length grid 9	1	0.006942	0.00737	0.94	0.3462
Vessel length grid 10	1	-0.00873	0.006855	-1.27	0.2031
Vessel length grid 11	1	-0.0131	0.00881	-1.49	0.1361
Vessel length grid 12	1	0.0485	0.009374	5.17	<.0001
Vessel length grid 13	1	0.0296	0.0117	2.53	0.0113
Vessel length grid 14	1	0.0322	0.007285	4.42	<.0001
Vessel length grid 15	1	0.0226	0.006692	3.38	0.0007
Expected revenue	1	0.0159	0.002893	5.49	<.0001
Variation of ER	1	-0.0312	0.0224	-1.39	0.1634
Distance	1	-0.0127	0.000181	-70.03	<.0001
Crowdedness	1	0.0267	0.001115	23.92	<.0001
Crowdedness squared	1	-0.0001	1.04E-05	-9.73	<.0001

```
Note:        The MDC Procedure

        Conditional Logit Estimates Algorithm converged.

                        Model Fit Summary

           Dependent Variable            decision
           Number of Observations           41650
           Number of Cases                666400
           Log Likelihood                 -57214
           Maximum Absolute Gradient      250.41578
           Number of Iterations               136
           Optimization Method       Dual Quasi-Newton
           AIC                           114589
           Schwarz Criterion              115289
```

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2403	5.77
1	2	1679	4.03
2	3	340	0.82
3	4	524	1.26
4	5	1564	3.76
5	6	8460	20.31
6	7	1472	3.53
7	8	6629	15.92
8	9	2635	6.33
9	10	4208	10.10
10	11	874	2.10
11	12	644	1.55
12	13	408	0.98
13	14	3148	7.56
14	15	2808	6.74
15	16	3854	9.25

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	116530	2 * (LogL - LogL0)
Upper Bound of R (U)	230957	- 2 * LogL0
Aldrich-Nelson	0.7367	R / (R+N)
Cragg-Uhler 1	0.9391	1 - exp(-R/N)
Cragg-Uhler 2	0.9427	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9796	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9795	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.5046	R / U
Veall-Zimmermann	0.8695	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table F.6 Parameter Estimates---TX Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-3.0357	0.5468	-5.55	<.0001
Grid 2	1	-7.8153	0.7761	-10.07	<.0001
Grid 3	1	0.3302	1.8161	0.18	0.8557
Grid 4	1	1.0085	1.7837	0.57	0.5718
Grid 5	1	-0.9822	0.5384	-1.82	0.0681
Grid 6	1	-1.1895	0.5178	-2.3	0.0216
Grid 7	1	-1.998	0.5814	-3.44	0.0006
Grid 8	1	-2.7172	0.4612	-5.89	<.0001
Grid 9	1	1.8518	0.5393	3.43	0.0006
Grid 10	1	0.8342	0.464	1.8	0.0722
Grid 11	1	5.5267	0.5788	9.55	<.0001
Grid 12	1	3.2592	0.6174	5.28	<.0001
Grid 13	1	3.8992	0.6936	5.62	<.0001
Grid 14	1	-0.8046	0.4682	-1.72	0.0857
Grid 15	1	1.3709	0.4685	2.93	0.0034
Loyalty	1	3.9157	0.0315	124.33	<.0001
Season 1 grid 1	1	0.2563	0.1297	1.98	0.0482
Season 1 grid 2	1	1.9951	0.2034	9.81	<.0001
Season 1 grid 3	1	2.6431	0.3883	6.81	<.0001
Season 1 grid 4	1	0.3826	0.2685	1.43	0.1542
Season 1 grid 5	1	2.238	0.1637	13.67	<.0001
Season 1 grid 6	1	0.5356	0.1272	4.21	<.0001
Season 1 grid 7	1	-0.5576	0.176	-3.17	0.0015
Season 1 grid 8	1	0.1099	0.093	1.18	0.2372
Season 1 grid 9	1	-0.0266	0.1001	-0.27	0.7903
Season 1 grid 10	1	0.3764	0.0835	4.51	<.0001
Season 1 grid 11	1	0.9586	0.0926	10.35	<.0001
Season 1 grid 12	1	-0.00753	0.1116	-0.07	0.9462
Season 1 grid 13	1	-0.4054	0.1216	-3.33	0.0009
Season 1 grid 14	1	-0.875	0.0892	-9.81	<.0001
Season 1 grid 15	1	-0.0357	0.0774	-0.46	0.6447
Season 2 grid 1	1	-0.8471	0.1225	-6.91	<.0001
Season 2 grid 2	1	-0.7267	0.2674	-2.72	0.0066

Table F.6, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 2 grid 3	1	1.3325	0.4098	3.25	0.0011
Season 2 grid 4	1	0.3004	0.2328	1.29	0.1969
Season 2 grid 5	1	0.7493	0.1627	4.61	<.0001
Season 2 grid 6	1	-1.1435	0.1203	-9.5	<.0001
Season 2 grid 7	1	0.0954	0.1223	0.78	0.4356
Season 2 grid 8	1	-0.3886	0.0822	-4.73	<.0001
Season 2 grid 9	1	0.2849	0.0782	3.64	0.0003
Season 2 grid 10	1	0.9038	0.0647	13.97	<.0001
Season 2 grid 11	1	-2.2423	0.1626	-13.79	<.0001
Season 2 grid 12	1	-1.8299	0.1449	-12.63	<.0001
Season 2 grid 13	1	-1.0858	0.1173	-9.26	<.0001
Season 2 grid 14	1	-0.5617	0.0762	-7.37	<.0001
Season 2 grid 15	1	-0.213	0.0688	-3.1	0.0019
TX closure grid 1	1	0.0734	0.201	0.37	0.715
TX closure grid 2	1	-0.3815	0.3795	-1.01	0.3148
TX closure grid 3	1	-2.6735	0.7825	-3.42	0.0006
TX closure grid 4	1	-1.6992	0.3984	-4.26	<.0001
TX closure grid 5	1	2.063	0.1938	10.65	<.0001
TX closure grid 6	1	1.3042	0.1923	6.78	<.0001
TX closure grid 7	1	-0.0423	0.2026	-0.21	0.8344
TX closure grid 8	1	-0.3782	0.1877	-2.02	0.0439
TX closure grid 9	1	-2.193	0.2149	-10.2	<.0001
TX closure grid 10	1	-2.7679	0.2099	-13.19	<.0001
TX closure grid 11	1	1.0795	0.2486	4.34	<.0001
TX closure grid 12	1	-2.312	0.3319	-6.97	<.0001
TX closure grid 13	1	-1.9697	0.211	-9.33	<.0001
TX closure grid 14	1	-2.8279	0.2339	-12.09	<.0001
TX closure grid 15	1	-3.5877	0.2393	-14.99	<.0001
Vessel length grid 1	1	0.0689	0.00761	9.05	<.0001
Vessel length grid 2	1	0.1005	0.0107	9.39	<.0001
Vessel length grid 3	1	-0.0532	0.027	-1.97	0.0487
Vessel length grid 4	1	-0.0555	0.0264	-2.1	0.036
Vessel length grid 5	1	0.0518	0.007089	7.3	<.0001

Table F.6, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Vessel length grid 6	1	0.0538	0.00713	7.54	<.0001
Vessel length grid 7	1	0.0475	0.008208	5.79	<.0001
Vessel length grid 8	1	0.0658	0.006595	9.98	<.0001
Vessel length grid 9	1	-0.0209	0.007907	-2.65	0.0081
Vessel length grid 10	1	-0.0233	0.006846	-3.41	0.0006
Vessel length grid 11	1	-0.0177	0.008075	-2.19	0.0287
Vessel length grid 12	1	-0.00798	0.008734	-0.91	0.3611
Vessel length grid 13	1	-0.0273	0.009948	-2.74	0.0061
Vessel length grid 14	1	0.0381	0.006745	5.64	<.0001
Vessel length grid 15	1	-0.00739	0.006833	-1.08	0.2792
Expected revenue	1	0.008374	0.006162	1.36	0.1741
Variation of ER	1	-0.0228	0.008118	-2.81	0.0049
Distance	1	-0.0094	0.000163	-57.55	<.0001
Crowdedness	1	-0.00011	0.000337	-0.32	0.7512
Crowdedness squared	1	2.70E-06	7.24E-07	3.73	0.0002

```
Note:      The MDC Procedure

        Conditional Logit Estimates Algorithm converged.


                      Model Fit Summary

        Dependent Variable          decision
        Number of Observations         32380
        Number of Cases              518080
        Log Likelihood               -44440
        Maximum Absolute Gradient       47375
        Number of Iterations            136
        Optimization Method     Dual Quasi-Newton
        AIC                        89042
        Schwarz Criterion            89722


                   Discrete Response Profile

        Index   CHOICE   Frequency   Percent

          0       1       2770    8.55
          1       2        254    0.78
          2       3         87    0.27
          3       4        111    0.34
          4       5       2097    6.48
          5       6       6068   18.74
```

6	7	818	2.53
7	8	7247	22.38
8	9	1443	4.46
9	10	2159	6.67
10	11	917	2.83
11	12	673	2.08
12	13	613	1.89
13	14	2165	6.69
14	15	1857	5.74
15	16	3101	9.58

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	90673	2 * (LogL - LogL0)
Upper Bound of R (U)	179553	- 2 * LogL0
Aldrich-Nelson	0.7369	R / (R+N)
Cragg-Uhler 1	0.9392	1 - exp(-R/N)
Cragg-Uhler 2	0.9429	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9797	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9795	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.505	R / U
Veall-Zimmermann	0.8697	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

APPENDIX G. HOMOGENEOUS PARAMETERS TEST RESULTS

Table G.1 Homogeneous Tests

Area	Llikelihood			Chi-2 test	d.f	p-value
	full model	1995-1999	2000-2004			
FL	-18051	-10711	-7257	166	21	1.52235E-24
LAM	-80626	-41154	-36448	6048	91	0
TX	-104063	-57214	-44440	4818	81	0

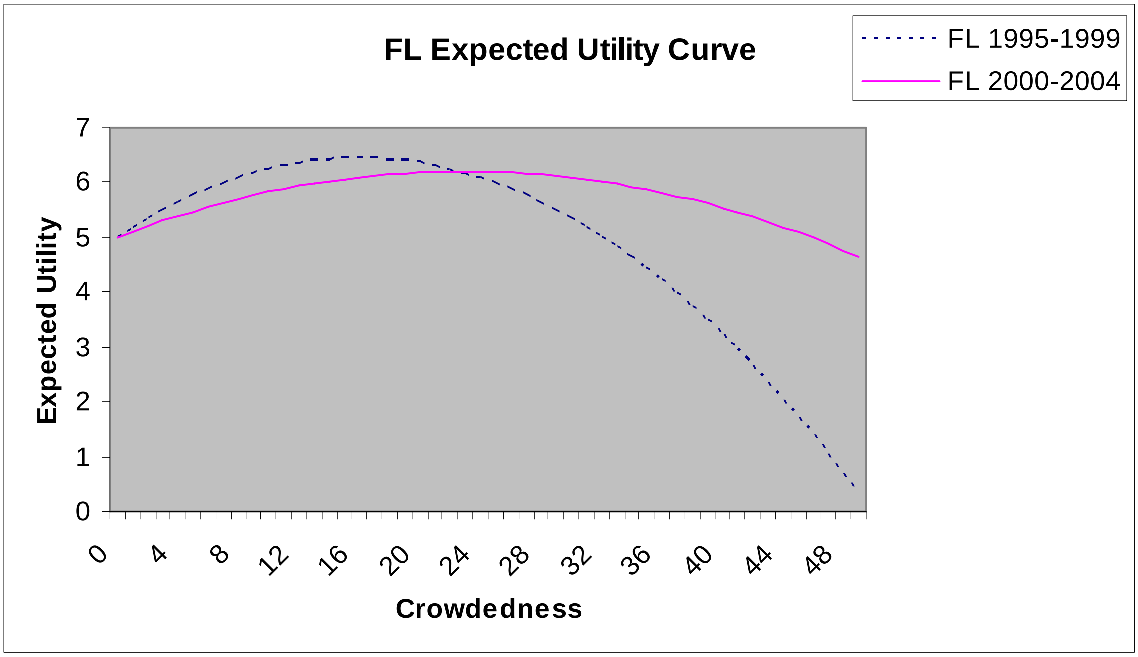

Figure H.1 FL area

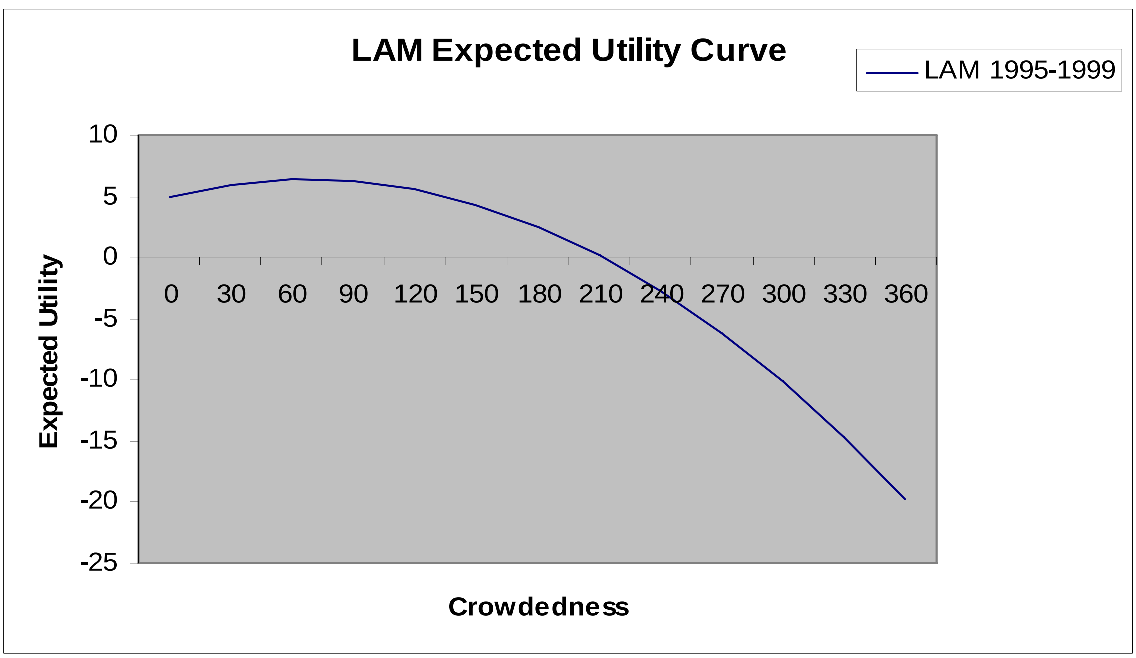

Figure H.2 LAM area 1995-1999

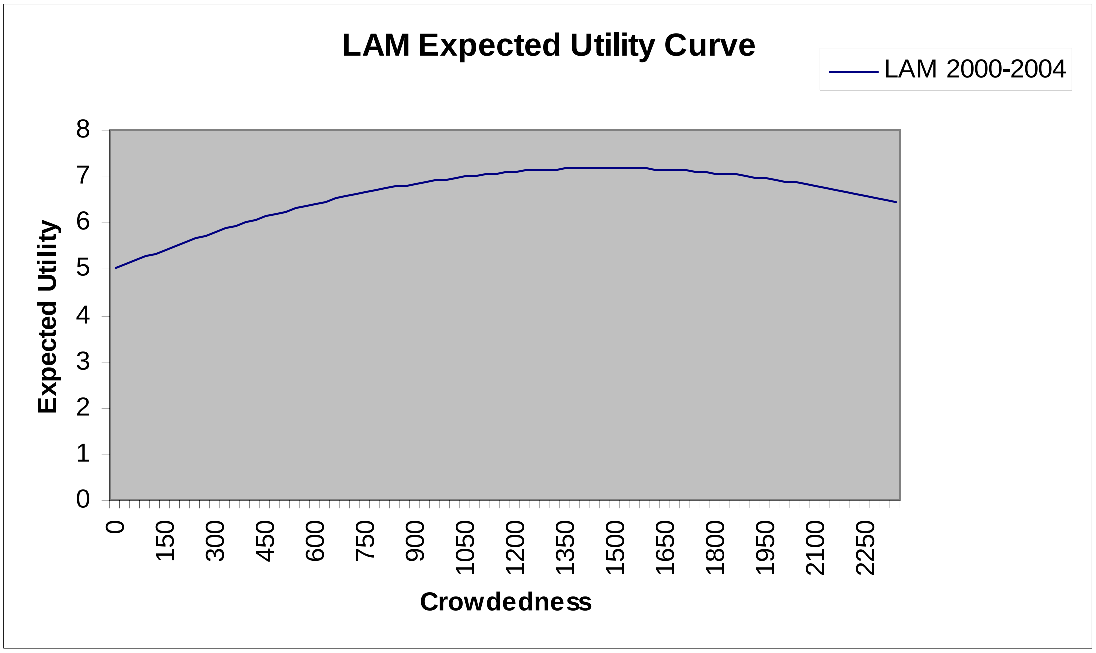

Figure H.3 LAM area 2000-2004

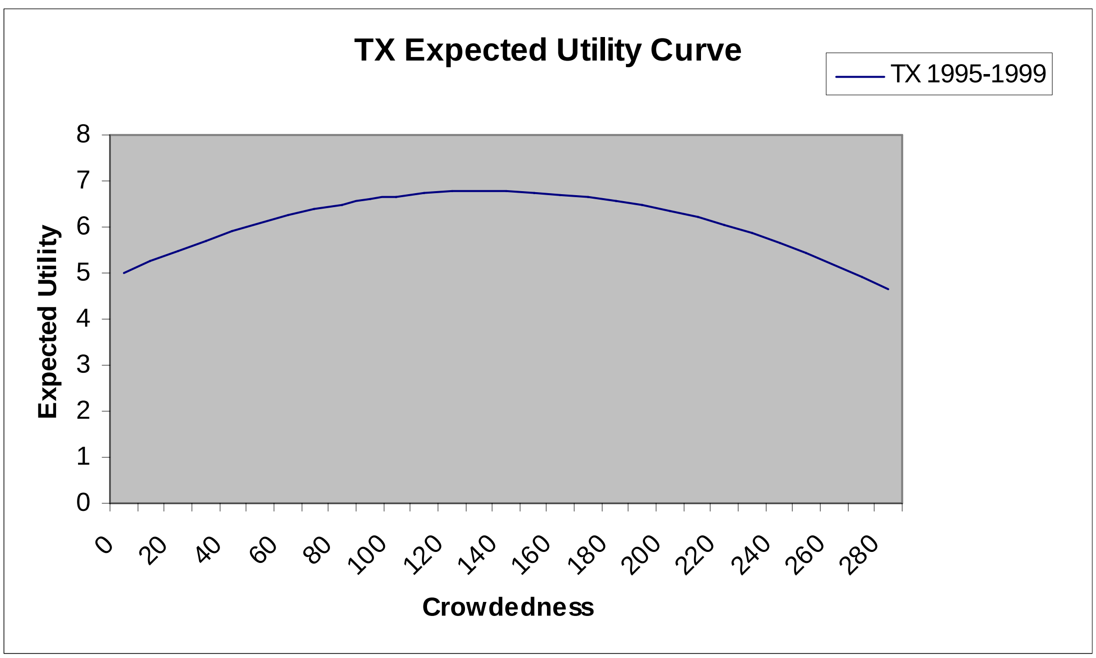

Figure H.4 TX area 1995-1999

APPENDIX I. SEMI-ELASTICITY

Table I.1 Semi-elasticity for FL Area in 1995-1999

Season 1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
1	0	1	0.43	0.25	not significant	not significant	-0.39	0.27
1	0	2	0.10	0.02	not significant	not significant	-0.12	0.03
1	0	3	0.02	0.01	not significant	not significant	-0.07	0.01
1	0	4	0.28	0.16	not significant	not significant	-0.35	0.22
1	0	5	0.16	0.06	not significant	not significant	-0.19	0.10
1	0	6	0.01	0.00	not significant	not significant	-0.04	0.01
0	1	1	0.45	0.25	not significant	not significant	-0.39	0.27
0	1	2	0.08	0.02	not significant	not significant	-0.10	0.03
0	1	3	0.04	0.01	not significant	not significant	-0.10	0.02
0	1	4	0.27	0.15	not significant	not significant	-0.34	0.22
0	1	5	0.13	0.05	not significant	not significant	-0.17	0.08
0	1	6	0.03	0.00	not significant	not significant	-0.10	0.01

Table I.2 Semi-elasticity for FL Area in 2000-2004

Season 1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowded-ness*
1	0	1	0.45	0.23	0.07	not significant	-0.46	0.19
1	0	2	0.04	0.00	0.01	not significant	-0.07	0.00
1	0	3	0.02	0.01	0.00	not significant	-0.06	0.00
1	0	4	0.37	0.19	0.07	not significant	-0.47	0.20
1	0	5	0.11	0.04	0.03	not significant	-0.17	0.04
1	0	6	0.01	0.00	0.00	not significant	-0.05	0.01
0	1	1	0.47	0.23	0.07	not significant	-0.46	0.19
0	1	2	0.04	0.00	0.01	not significant	-0.06	0.00
0	1	3	0.02	0.01	0.00	not significant	-0.07	0.01
0	1	4	0.38	0.20	0.07	not significant	-0.48	0.20
0	1	5	0.08	0.03	0.02	not significant	-0.12	0.03
0	1	6	0.02	0.00	0.00	not significant	-0.07	0.01

Table I.3 Semi-elasticity for LAM Area in 1995-1999

Season 1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
1	0	1	0.01	0.00	0.00	not significant	-0.02	0.00
1	0	2	0.16	0.13	0.01	not significant	-0.39	0.10
1	0	3	0.15	0.05	0.01	not significant	-0.34	0.05
1	0	4	0.15	0.07	0.01	not significant	-0.46	0.14
1	0	5	0.02	0.00	0.00	not significant	-0.10	0.00
1	0	6	0.02	0.00	0.00	not significant	-0.06	0.00
1	0	7	0.04	0.00	0.00	not significant	-0.13	0.05
1	0	8	0.10	0.02	0.01	not significant	-0.31	0.04
1	0	9	0.05	0.01	0.00	not significant	-0.18	0.03
1	0	10	0.02	0.00	0.00	not significant	-0.14	0.02
1	0	11	0.01	0.00	0.00	not significant	-0.05	0.00
1	0	12	0.02	0.00	0.00	not significant	-0.06	0.02
1	0	13	0.08	0.01	0.01	not significant	-0.25	0.02
1	0	14	0.01	0.00	0.00	not significant	-0.05	0.00
1	0	15	0.01	0.00	0.00	not significant	-0.02	0.00
1	0	16	0.03	0.00	0.00	not significant	-0.09	0.02
1	0	17	0.10	0.02	0.01	not significant	-0.33	0.03
1	0	18	0.04	0.00	0.00	not significant	-0.23	0.03
0	1	1	0.01	0.00	0.00	not significant	-0.05	0.00
0	1	2	0.43	0.23	0.02	not significant	-0.70	0.18
0	1	3	0.25	0.07	0.02	not significant	-0.51	0.08
0	1	4	0.03	0.01	0.00	not significant	-0.10	0.03
0	1	5	0.01	0.00	0.00	not significant	-0.07	0.00
0	1	6	0.02	0.00	0.00	not significant	-0.08	0.01
0	1	7	0.04	0.00	0.00	not significant	-0.12	0.05

Table I.3, continued

Season 1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
0	1	8	0.07	0.01	0.01	not significant	-0.21	0.03
0	1	9	0.04	0.01	0.00	not significant	-0.14	0.02
0	1	10	0.00	0.00	0.00	not significant	-0.01	0.00
0	1	11	0.02	0.00	0.00	not significant	-0.07	0.01
0	1	12	0.01	0.00	0.00	not significant	-0.03	0.01
0	1	13	0.03	0.00	0.00	not significant	-0.09	0.01
0	1	14	0.01	0.00	0.00	not significant	-0.03	0.00
0	1	15	0.00	0.00	0.00	not significant	-0.01	0.00
0	1	16	0.01	0.00	0.00	not significant	-0.05	0.01
0	1	17	0.02	0.00	0.00	not significant	-0.08	0.01
0	1	18	0.00	0.00	0.00	not significant	-0.02	0.00
0	0	1	0.00	0.00	0.00	not significant	-0.02	0.00
0	0	2	0.09	0.08	0.01	not significant	-0.24	0.06
0	0	3	0.14	0.05	0.01	not significant	-0.33	0.05
0	0	4	0.18	0.08	0.02	not significant	-0.54	0.16
0	0	5	0.04	0.01	0.00	not significant	-0.23	0.00
0	0	6	0.01	0.00	0.00	not significant	-0.04	0.00
0	0	7	0.02	0.00	0.00	not significant	-0.06	0.02
0	0	8	0.12	0.02	0.01	not significant	-0.34	0.05
0	0	9	0.08	0.01	0.01	not significant	-0.28	0.04
0	0	10	0.04	0.01	0.00	not significant	-0.26	0.05
0	0	11	0.01	0.00	0.00	not significant	-0.04	0.00
0	0	12	0.01	0.00	0.00	not significant	-0.02	0.01
0	0	13	0.07	0.01	0.01	not significant	-0.22	0.02
0	0	14	0.03	0.00	0.00	not significant	-0.16	0.00

Table I.3, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
0	0	15	0.00	0.00	0.00	not significant	-0.01	0.00
0	0	16	0.02	0.00	0.00	not significant	-0.05	0.01
0	0	17	0.11	0.02	0.01	not significant	-0.37	0.03
0	0	18	0.04	0.00	0.00	not significant	-0.20	0.03
0	1	1	0.03	0.00	0.00	not significant	-0.10	0.00
0	1	2	0.31	0.20	0.02	not significant	-0.61	0.16
0	1	3	0.35	0.09	0.02	not significant	-0.62	0.10
0	1	4	0.02	0.01	0.00	not significant	-0.07	0.02
0	1	5	0.01	0.00	0.00	not significant	-0.05	0.00
0	1	6	0.03	0.01	0.00	not significant	-0.12	0.01
0	1	7	0.05	0.01	0.00	not significant	-0.15	0.06
0	1	8	0.10	0.02	0.01	not significant	-0.29	0.04
0	1	9	0.02	0.00	0.00	not significant	-0.06	0.01
0	1	10	0.00	0.00	0.00	not significant	-0.02	0.00
0	1	11	0.02	0.00	0.00	not significant	-0.07	0.01
0	1	12	0.01	0.00	0.00	not significant	-0.04	0.01
0	1	13	0.02	0.00	0.00	not significant	-0.07	0.01
0	1	14	0.00	0.00	0.00	not significant	-0.03	0.00
0	1	15	0.00	0.00	0.00	not significant	-0.01	0.00
0	1	16	0.01	0.00	0.00	not significant	-0.04	0.01
0	1	17	0.01	0.00	0.00	not significant	-0.04	0.00
0	1	18	0.00	0.00	0.00	not significant	-0.02	0.00
0	0	1	0.01	0.00	0.00	not significant	-0.04	0.00
0	0	2	0.07	0.06	0.01	not significant	-0.20	0.05
0	0	3	0.21	0.06	0.01	not significant	-0.45	0.07

Table I.3, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowded -ness*
0	0	4	0.13	0.06	0.01	not significant	-0.43	0.13
0	0	5	0.03	0.01	0.00	not significant	-0.19	0.00
0	0	6	0.02	0.00	0.00	not significant	-0.06	0.00
0	0	7	0.02	0.00	0.00	not significant	-0.07	0.03
0	0	8	0.18	0.03	0.02	not significant	-0.49	0.07
0	0	9	0.04	0.01	0.00	not significant	-0.14	0.02
0	0	10	0.07	0.01	0.01	not significant	-0.41	0.07
0	0	11	0.01	0.00	0.00	not significant	-0.04	0.00
0	0	12	0.01	0.00	0.00	not significant	-0.04	0.01
0	0	13	0.06	0.01	0.01	not significant	-0.20	0.02
0	0	14	0.03	0.00	0.00	not significant	-0.13	0.00
0	0	15	0.00	0.00	0.00	not significant	-0.01	0.00
0	0	16	0.01	0.00	0.00	not significant	-0.05	0.01
0	0	17	0.05	0.01	0.01	not significant	-0.19	0.02
0	0	18	0.03	0.00	0.00	not significant	-0.18	0.02

Table I.4 Semi-elasticity for LAM Area in 2000-2004

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowded-ness*
1	0	1	0.02	0.01	0.00	0.00	-0.03	0.00
1	0	2	0.42	0.33	0.01	-0.01	-0.33	0.07
1	0	3	0.28	0.16	0.01	-0.01	-0.32	0.04
1	0	4	0.03	0.01	0.00	0.00	-0.06	0.01
1	0	5	0.01	0.00	0.00	0.00	-0.03	0.00
1	0	6	0.01	0.00	0.00	0.00	-0.02	0.00
1	0	7	0.03	0.00	0.00	0.00	-0.04	0.01
1	0	8	0.03	0.00	0.00	0.00	-0.05	0.00
1	0	9	0.01	0.00	0.00	0.00	-0.01	0.00
1	0	10	0.00	0.00	0.00	0.00	0.00	0.00
1	0	11	0.01	0.00	0.00	0.00	-0.02	0.00
1	0	12	0.01	0.00	0.00	0.00	-0.01	0.00
1	0	13	0.01	0.00	0.00	0.00	-0.02	0.00
1	0	14	0.00	0.00	0.00	0.00	0.00	0.00
1	0	15	0.01	0.00	0.00	0.00	-0.03	0.00
1	0	16	0.06	0.01	0.00	0.00	-0.09	0.08
1	0	17	0.06	0.01	0.00	0.00	-0.13	0.02
1	0	18	0.02	0.00	0.00	0.00	-0.07	0.01
0	1	1	0.06	0.02	0.00	0.00	-0.09	0.00
0	1	2	0.44	0.33	0.01	-0.01	-0.34	0.07
0	1	3	0.14	0.10	0.01	-0.01	-0.20	0.03
0	1	4	0.02	0.01	0.00	0.00	-0.04	0.00
0	1	5	0.01	0.00	0.00	0.00	-0.03	0.00
0	1	6	0.03	0.00	0.00	0.00	-0.05	0.00
0	1	7	0.03	0.00	0.00	0.00	-0.04	0.01

Table I.4, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowded -ness*
0	1	8	0.02	0.00	0.00	0.00	-0.04	0.00
0	1	9	0.00	0.00	0.00	0.00	0.00	0.00
0	1	10	0.00	0.00	0.00	0.00	0.00	0.00
0	1	11	0.02	0.00	0.00	0.00	-0.04	0.00
0	1	12	0.01	0.00	0.00	0.00	-0.01	0.00
0	1	13	0.01	0.00	0.00	0.00	-0.03	0.00
0	1	14	0.00	0.00	0.00	0.00	0.00	0.00
0	1	15	0.02	0.00	0.00	0.00	-0.04	0.00
0	1	16	0.03	0.00	0.00	0.00	-0.05	0.05
0	1	17	0.15	0.03	0.00	0.00	-0.29	0.05
0	1	18	0.03	0.00	0.00	0.00	-0.09	0.01
0	0	1	0.04	0.01	0.00	0.00	-0.07	0.00
0	0	2	0.32	0.29	0.01	-0.01	-0.30	0.06
0	0	3	0.32	0.17	0.01	-0.01	-0.34	0.05
0	0	4	0.06	0.02	0.00	0.00	-0.15	0.01
0	0	5	0.01	0.00	0.00	0.00	-0.05	0.00
0	0	6	0.02	0.00	0.00	0.00	-0.04	0.00
0	0	7	0.02	0.00	0.00	0.00	-0.03	0.01
0	0	8	0.03	0.00	0.00	0.00	-0.07	0.00
0	0	9	0.00	0.00	0.00	0.00	-0.01	0.00
0	0	10	0.00	0.00	0.00	0.00	-0.01	0.00
0	0	11	0.01	0.00	0.00	0.00	-0.02	0.00
0	0	12	0.01	0.00	0.00	0.00	-0.01	0.00
0	0	13	0.01	0.00	0.00	0.00	-0.02	0.00
0	0	14	0.00	0.00	0.00	0.00	-0.01	0.00

Table I.4, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowded-ness*
0	0	15	0.01	0.00	0.00	0.00	-0.02	0.00
0	0	16	0.03	0.00	0.00	0.00	-0.05	0.05
0	0	17	0.07	0.01	0.00	0.00	-0.14	0.02
0	0	18	0.03	0.00	0.00	0.00	-0.09	0.01
0	1	1	0.11	0.03	0.00	-0.01	-0.17	0.01
0	1	2	0.32	0.29	0.01	-0.01	-0.30	0.06
0	1	3	0.20	0.13	0.01	-0.01	-0.25	0.03
0	1	4	0.01	0.00	0.00	0.00	-0.03	0.00
0	1	5	0.01	0.00	0.00	0.00	-0.04	0.00
0	1	6	0.04	0.00	0.00	0.00	-0.07	0.00
0	1	7	0.02	0.00	0.00	0.00	-0.03	0.01
0	1	8	0.02	0.00	0.00	0.00	-0.04	0.00
0	1	9	0.00	0.00	0.00	0.00	-0.01	0.00
0	1	10	0.00	0.00	0.00	0.00	-0.02	0.00
0	1	11	0.03	0.00	0.00	0.00	-0.06	0.00
0	1	12	0.01	0.00	0.00	0.00	-0.01	0.00
0	1	13	0.02	0.00	0.00	0.00	-0.04	0.00
0	1	14	0.00	0.00	0.00	0.00	-0.01	0.00
0	1	15	0.02	0.00	0.00	0.00	-0.05	0.00
0	1	16	0.05	0.01	0.00	0.00	-0.08	0.07
0	1	17	0.10	0.02	0.00	0.00	-0.20	0.04
0	1	18	0.04	0.00	0.00	0.00	-0.13	0.01
0	0	1	0.07	0.02	0.00	0.00	-0.11	0.00
0	0	2	0.21	0.22	0.01	-0.01	-0.23	0.05
0	0	3	0.39	0.19	0.01	-0.01	-0.38	0.05

Table I.4, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowded-ness*
0	0	4	0.04	0.01	0.00	0.00	-0.10	0.01
0	0	5	0.02	0.00	0.00	0.00	-0.07	0.00
0	0	6	0.03	0.00	0.00	0.00	-0.05	0.00
0	0	7	0.01	0.00	0.00	0.00	-0.02	0.00
0	0	8	0.03	0.00	0.00	0.00	-0.06	0.00
0	0	9	0.00	0.00	0.00	0.00	-0.01	0.00
0	0	10	0.03	0.00	0.00	0.00	-0.10	0.01
0	0	11	0.01	0.00	0.00	0.00	-0.03	0.00
0	0	12	0.01	0.00	0.00	0.00	-0.02	0.00
0	0	13	0.02	0.00	0.00	0.00	-0.03	0.00
0	0	14	0.01	0.00	0.00	0.00	-0.03	0.00
0	0	15	0.01	0.00	0.00	0.00	-0.02	0.00
0	0	16	0.04	0.01	0.00	0.00	-0.07	0.07
0	0	17	0.04	0.01	0.00	0.00	-0.09	0.01
0	0	18	0.03	0.00	0.00	0.00	-0.11	0.01

Table I.5 Semi-elasticity for TX Area in 1995-1999

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowded nenesness*
1	0	1	0.09	0.02	0.00	not significant	-0.27	0.01
1	0	2	0.07	0.01	0.00	not significant	-0.18	0.01
1	0	3	0.01	0.00	0.00	not significant	-0.02	0.00
1	0	4	0.00	0.00	0.00	not significant	-0.01	0.00
1	0	5	0.06	0.01	0.00	not significant	-0.36	0.01
1	0	6	0.16	0.10	0.01	not significant	-0.58	0.06
1	0	7	0.03	0.00	0.00	not significant	-0.10	0.01
1	0	8	0.19	0.09	0.01	not significant	-0.42	0.12
1	0	9	0.02	0.00	0.00	not significant	-0.06	0.01
1	0	10	0.01	0.00	0.00	not significant	-0.02	0.00
1	0	11	0.12	0.01	0.01	not significant	-0.70	0.01
1	0	12	0.05	0.00	0.00	not significant	-0.20	0.01
1	0	13	0.03	0.00	0.00	not significant	-0.10	0.00
1	0	14	0.12	0.02	0.01	not significant	-0.29	0.06
1	0	15	0.04	0.01	0.00	not significant	-0.11	0.02
1	0	16	0.01	0.00	0.00	not significant	-0.03	0.00
0	1	1	0.05	0.01	0.00	not significant	-0.15	0.01
0	1	2	0.03	0.01	0.00	not significant	-0.09	0.01
0	1	3	0.01	0.00	0.00	not significant	-0.04	0.00
0	1	4	0.00	0.00	0.00	not significant	-0.01	0.00
0	1	5	0.03	0.00	0.00	not significant	-0.16	0.01
0	1	6	0.10	0.07	0.00	not significant	-0.40	0.04
0	1	7	0.12	0.01	0.00	not significant	-0.35	0.03
0	1	8	0.28	0.12	0.01	not significant	-0.56	0.16
0	1	9	0.09	0.02	0.00	not significant	-0.24	0.05
0	1	10	0.03	0.01	0.00	not significant	-0.08	0.02
0	1	11	0.02	0.00	0.00	not significant	-0.11	0.00
0	1	12	0.02	0.00	0.00	not significant	-0.07	0.00

Table I.5, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
0	1	13	0.02	0.00	0.00	not significant	-0.07	0.00
0	1	14	0.14	0.03	0.01	not significant	-0.33	0.07
0	1	15	0.05	0.01	0.00	not significant	-0.14	0.02
0	1	16	0.02	0.01	0.00	not significant	-0.05	0.01
0	0	1	0.09	0.02	0.00	not significant	-0.29	0.02
0	0	2	0.09	0.01	0.00	not significant	-0.23	0.01
0	0	3	0.00	0.00	0.00	not significant	-0.01	0.00
0	0	4	0.00	0.00	0.00	not significant	0.00	0.00
0	0	5	0.02	0.00	0.00	not significant	-0.16	0.01
0	0	6	0.16	0.09	0.01	not significant	-0.56	0.05
0	0	7	0.07	0.01	0.00	not significant	-0.21	0.02
0	0	8	0.17	0.08	0.01	not significant	-0.39	0.11
0	0	9	0.02	0.01	0.00	not significant	-0.07	0.01
0	0	10	0.01	0.00	0.00	not significant	-0.02	0.00
0	0	11	0.06	0.00	0.00	not significant	-0.34	0.01
0	0	12	0.06	0.00	0.00	not significant	-0.23	0.01
0	0	13	0.05	0.00	0.00	not significant	-0.15	0.00
0	0	14	0.15	0.03	0.01	not significant	-0.35	0.08
0	0	15	0.05	0.01	0.00	not significant	-0.14	0.02
0	0	16	0.01	0.00	0.00	not significant	-0.04	0.00
1	0	1	0.01	0.00	0.00	not significant	-0.02	0.00
1	0	2	0.00	0.00	0.00	not significant	-0.01	0.00
1	0	3	0.00	0.00	0.00	not significant	0.00	0.00
1	0	4	0.00	0.00	0.00	not significant	0.00	0.00
1	0	5	0.36	0.04	0.01	not significant	-1.52	0.05
1	0	6	0.40	0.17	0.01	not significant	-1.02	0.10
1	0	7	0.00	0.00	0.00	not significant	-0.01	0.00
1	0	8	0.01	0.00	0.00	not significant	-0.02	0.01

Table I.5, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
1	0	9	0.00	0.00	0.00	not significant	0.00	0.00
1	0	10	0.00	0.00	0.00	not significant	0.00	0.00
1	0	11	0.13	0.01	0.01	not significant	-0.76	0.01
1	0	12	0.08	0.01	0.00	not significant	-0.32	0.01
1	0	13	0.00	0.00	0.00	not significant	0.00	0.00
1	0	14	0.00	0.00	0.00	not significant	-0.01	0.00
1	0	15	0.00	0.00	0.00	not significant	0.00	0.00
1	0	16	0.00	0.00	0.00	not significant	0.00	0.00
0	1	1	0.01	0.00	0.00	not significant	-0.03	0.00
0	1	2	0.00	0.00	0.00	not significant	-0.01	0.00
0	1	3	0.00	0.00	0.00	not significant	0.00	0.00
0	1	4	0.00	0.00	0.00	not significant	0.00	0.00
0	1	5	0.32	0.03	0.01	not significant	-1.43	0.05
0	1	6	0.52	0.18	0.01	not significant	-1.06	0.10
0	1	7	0.01	0.00	0.00	not significant	-0.04	0.00
0	1	8	0.02	0.01	0.00	not significant	-0.06	0.02
0	1	9	0.01	0.00	0.00	not significant	-0.02	0.00
0	1	10	0.00	0.00	0.00	not significant	0.00	0.00
0	1	11	0.04	0.00	0.00	not significant	-0.24	0.00
0	1	12	0.06	0.00	0.00	not significant	-0.24	0.01
0	1	13	0.00	0.00	0.00	not significant	-0.01	0.00
0	1	14	0.01	0.00	0.00	not significant	-0.02	0.00
0	1	15	0.00	0.00	0.00	not significant	0.00	0.00
0	1	16	0.00	0.00	0.00	not significant	0.00	0.00

Table I.6 Semi-elasticity for TX Area in 2000-2004

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
1	0	1	0.09	0.02	not significant	0.00	-0.19	not significant
1	0	2	0.04	0.00	not significant	0.00	-0.09	not significant
1	0	3	0.00	0.00	not significant	0.00	-0.01	not significant
1	0	4	0.00	0.00	not significant	0.00	0.00	not significant
1	0	5	0.12	0.03	not significant	0.00	-0.48	not significant
1	0	6	0.19	0.11	not significant	0.00	-0.47	not significant
1	0	7	0.02	0.00	not significant	0.00	-0.04	not significant
1	0	8	0.22	0.13	not significant	0.00	-0.33	not significant
1	0	9	0.01	0.00	not significant	0.00	-0.03	not significant
1	0	10	0.01	0.00	not significant	0.00	-0.01	not significant
1	0	11	0.13	0.01	not significant	0.00	-0.53	not significant
1	0	12	0.06	0.00	not significant	0.00	-0.17	not significant
1	0	13	0.04	0.00	not significant	0.00	-0.08	not significant
1	0	14	0.04	0.01	not significant	0.00	-0.08	not significant
1	0	15	0.03	0.01	not significant	0.00	-0.05	not significant
1	0	16	0.01	0.00	not significant	0.00	-0.02	not significant
0	1	1	0.07	0.02	not significant	0.00	-0.15	not significant
0	1	2	0.01	0.00	not significant	0.00	-0.01	not significant
0	1	3	0.00	0.00	not significant	0.00	0.00	not significant
0	1	4	0.00	0.00	not significant	0.00	0.00	not significant
0	1	5	0.06	0.01	not significant	0.00	-0.28	not significant
0	1	6	0.09	0.06	not significant	0.00	-0.24	not significant
0	1	7	0.09	0.01	not significant	0.00	-0.19	not significant
0	1	8	0.31	0.16	not significant	-0.01	-0.42	not significant
0	1	9	0.05	0.01	not significant	0.00	-0.10	not significant
0	1	10	0.02	0.01	not significant	0.00	-0.05	not significant
0	1	11	0.01	0.00	not significant	0.00	-0.06	not significant
0	1	12	0.02	0.00	not significant	0.00	-0.07	not significant

Table I.6, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*Expected revenue*	*Variation of ER*	*Distance*	*Crowdedness*
0	1	13	0.04	0.00	not significant	0.00	-0.10	not significant
0	1	14	0.15	0.04	not significant	0.00	-0.25	not significant
0	1	15	0.05	0.01	not significant	0.00	-0.11	not significant
0	1	16	0.02	0.01	not significant	0.00	-0.06	not significant
0	0	1	0.09	0.03	not significant	0.00	-0.19	not significant
0	0	2	0.01	0.00	not significant	0.00	-0.02	not significant
0	0	3	0.00	0.00	not significant	0.00	0.00	not significant
0	0	4	0.00	0.00	not significant	0.00	0.00	not significant
0	0	5	0.02	0.00	not significant	0.00	-0.08	not significant
0	0	6	0.15	0.09	not significant	0.00	-0.38	not significant
0	0	7	0.05	0.00	not significant	0.00	-0.10	not significant
0	0	8	0.26	0.14	not significant	-0.01	-0.37	not significant
0	0	9	0.02	0.00	not significant	0.00	-0.04	not significant
0	0	10	0.01	0.00	not significant	0.00	-0.01	not significant
0	0	11	0.07	0.01	not significant	0.00	-0.29	not significant
0	0	12	0.08	0.01	not significant	0.00	-0.22	not significant
0	0	13	0.07	0.01	not significant	0.00	-0.16	not significant
0	0	14	0.14	0.04	not significant	0.00	-0.24	not significant
0	0	15	0.04	0.01	not significant	0.00	-0.07	not significant
0	0	16	0.01	0.00	not significant	0.00	-0.03	not significant
1	0	1	0.04	0.01	not significant	0.00	-0.09	not significant
1	0	2	0.01	0.00	not significant	0.00	-0.03	not significant
1	0	3	0.00	0.00	not significant	0.00	0.00	not significant
1	0	4	0.00	0.00	not significant	0.00	0.00	not significant
1	0	5	0.39	0.06	not significant	-0.01	-1.12	not significant
1	0	6	0.30	0.15	not significant	-0.01	-0.63	not significant
1	0	7	0.01	0.00	not significant	0.00	-0.02	not significant
1	0	8	0.06	0.04	not significant	0.00	-0.11	not significant

Table I.6, continued

Season1	*Season2*	*Grid*	*Predicted probability*	*Semi-elasticity*				
				loyalty	*ER*	*Variation of ER*	*Distance*	*Crowdedness*
1	0	9	0.00	0.00	not significant	0.00	0.00	not significant
1	0	10	0.00	0.00	not significant	0.00	0.00	not significant
1	0	11	0.16	0.02	not significant	0.00	-0.63	not significant
1	0	12	0.02	0.00	not significant	0.00	-0.07	not significant
1	0	13	0.00	0.00	not significant	0.00	0.00	not significant
1	0	14	0.00	0.00	not significant	0.00	-0.01	not significant
1	0	15	0.00	0.00	not significant	0.00	0.00	not significant
1	0	16	0.00	0.00	not significant	0.00	0.00	not significant
0	1	1	0.06	0.02	not significant	0.00	-0.13	not significant
0	1	2	0.00	0.00	not significant	0.00	-0.01	not significant
0	1	3	0.00	0.00	not significant	0.00	0.00	not significant
0	1	4	0.00	0.00	not significant	0.00	0.00	not significant
0	1	5	0.38	0.06	not significant	-0.01	-1.12	not significant
0	1	6	0.25	0.13	not significant	-0.01	-0.56	not significant
0	1	7	0.07	0.01	not significant	0.00	-0.15	not significant
0	1	8	0.17	0.11	not significant	0.00	-0.27	not significant
0	1	9	0.00	0.00	not significant	0.00	-0.01	not significant
0	1	10	0.00	0.00	not significant	0.00	0.00	not significant
0	1	11	0.03	0.00	not significant	0.00	-0.13	not significant
0	1	12	0.02	0.00	not significant	0.00	-0.05	not significant
0	1	13	0.00	0.00	not significant	0.00	-0.01	not significant
0	1	14	0.02	0.01	not significant	0.00	-0.03	not significant
0	1	15	0.00	0.00	not significant	0.00	-0.01	not significant
0	1	16	0.00	0.00	not significant	0.00	0.00	not significant

APPENDIX J. MIXED LOGIT RESULTS

Table J.1 Parameter Estimates---FL Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-2.3566	1.0084	-2.34	0.0194
Grid 2	1	3.6501	1.1993	3.04	0.0023
Grid 3	1	1.836	1.5073	1.22	0.2232
Grid 4	1	1.2484	1.1057	1.13	0.2589
Grid 5	1	-0.6872	0.9413	-0.73	0.4654
Loyalty (mean)	1	3.0818	0.0706	43.64	<.0001
Loyalty (s.d.)	1	0.0702	1.7296	0.04	0.9676
Season 1grid 1	1	0.8761	0.1341	6.53	<.0001
Season 1grid 2	1	1.088	0.1452	7.49	<.0001
Season 1grid 3	1	0.4561	0.1901	2.4	0.0164
Season 1grid 4	1	0.9643	0.1404	6.87	<.0001
Season 1grid 5	1	1.0737	0.1235	8.69	<.0001
Vessel length grid 1	1	0.0295	0.0149	1.98	0.0475
Vessel length grid 2	1	-0.0702	0.0178	-3.94	<.0001
Vessel length grid 3	1	-0.0375	0.0225	-1.67	0.0952
Vessel length grid 4	1	-0.0264	0.0164	-1.61	0.1065
Vessel length grid 5	1	-0.00376	0.0139	-0.27	0.7861
Expected revenue (mean)	1	-0.0277	0.023	-1.2	0.2283
Expected revenue (s.d.)	1	2.43E-05	0.8988	0	1
Variance of ER (mean)	1	0.1495	0.104	1.44	0.1507
Variance of ER (s.d.)	1	0.0249	5.5359	0	0.9964
Distance (mean)	1	-0.00667	0.000242	-27.63	<.0001
Distance (s.d.)	1	0.001295	0.000696	1.86	0.0629
Crowdedness (mean)	1	0.1799	0.0133	13.53	<.0001
Crowdedness (s.d.)	1	0.004807	0.1256	0.04	0.9695
Crowdedness squared (mean)	1	-0.0056	0.000689	-8.13	<.0001
Crowdedness squared (s.d.)	1	-0.00047	0.002799	-0.17	0.8675

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	13343
Number of Cases	80058
Log Likelihood	-10716
Maximum Absolute Gradient	16.87891
Number of Iterations	143
Optimization Method	Dual Quasi-Newton
AIC	21487
Schwarz Criterion	21689

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	4917	36.85
1	2	864	6.48
2	3	1501	11.25
3	4	3630	27.21
4	5	2114	15.84
5	6	317	2.38

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	26382	2 * (LogL - LogL0)
Upper Bound of R (U)	47815	- 2 * LogL0
Aldrich-Nelson	0.6641	R / (R+N)
Cragg-Uhler 1	0.8615	1 - exp(-R/N)
Cragg-Uhler 2	0.8862	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9436	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9432	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.5518	R / U
Veall-Zimmermann	0.8494	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table J.2, Parameter Estimates---FL Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-2.714	1.4084	-1.93	0.054
Grid 2	1	4.3893	1.7406	2.52	0.0117
Grid 3	1	-0.1809	1.6217	-0.11	0.9112
Grid 4	1	0.3052	1.4451	0.21	0.8327
Grid 5	1	-1.1864	1.3842	-0.86	0.3914
Loyalty (mean)	1	2.7703	0.0741	37.39	<.0001
Loyalty (s.d.)	1	-0.0983	1.1208	-0.09	0.9301
Season 1grid 1	1	0.202	0.1931	1.05	0.2955
Season 1grid 2	1	0.2442	0.2246	1.09	0.2769
Season 1grid 3	1	0.0749	0.2845	0.26	0.7925
Season 1grid 4	1	0.2069	0.1984	1.04	0.297
Season 1grid 5	1	0.6564	0.1898	3.46	0.0005
Vessel length grid 1	1	0.0424	0.0206	2.06	0.0395
Vessel length grid 2	1	-0.0832	0.0258	-3.22	0.0013
Vessel length grid 3	1	-0.00272	0.024	-0.11	0.9096
Vessel length grid 4	1	-0.00196	0.0212	-0.09	0.9261
Vessel length grid 5	1	0.001035	0.0203	0.05	0.9593
Expected revenue (mean)	1	0.1119	0.0174	6.42	<.0001
Expected revenue (s.d.)	1	-0.0378	0.0987	-0.38	0.7018
Variance of ER (mean)	1	0.006248	0.0358	0.17	0.8613
Variance of ER (s.d.)	1	0.000193	1.291	0	0.9999
Distance (mean)	1	-0.00856	0.000386	-22.2	<.0001
Distance (s.d.)	1	-0.00204	0.00057	-3.59	0.0003
Crowdedness (mean)	1	0.1424	0.0141	10.12	<.0001
Crowdedness (s.d.)	1	0.0985	0.0119	8.29	<.0001
Crowdedness squared (mean)	1	-0.00424	0.000571	-7.42	<.0001
Crowdedness squared (s.d.)	1	0.001747	0.000567	3.08	0.0021

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	9722
Number of Cases	58332
Log Likelihood	-7257
Maximum Absolute Gradient	0.00657
Number of Iterations	6
Optimization Method	Newton-Raphson
AIC	14556
Schwarz Criterion	14707

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	3563	36.65
1	2	340	3.50
2	3	981	10.09
3	4	3141	32.31
4	5	1398	14.38
5	6	299	3.08

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	20395	2 * (LogL - LogL0)
Upper Bound of R (U)	34839	- 2 * LogL0
Aldrich-Nelson	0.6772	R / (R+N)
Cragg-Uhler 1	0.8773	1 - exp(-R/N)
Cragg-Uhler 2	0.9023	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9574	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9569	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.5854	R / U
Veall-Zimmermann	0.8662	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table J.3 Parameter Estimates---LAM Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	7.8718	0.8066	9.76	<.0001
Grid 2	1	5.0108	0.7048	7.11	<.0001
Grid 3	1	4.644	0.6528	7.11	<.0001
Grid 4	1	5.5032	0.6363	8.65	<.0001
Grid 5	1	5.682	0.7484	7.59	<.0001
Grid 6	1	3.8433	0.7728	4.97	<.0001
Grid 7	1	1.3345	0.78	1.71	0.0871
Grid 8	1	2.1933	0.6901	3.18	0.0015
Grid 9	1	3.9083	0.672	5.82	<.0001
Grid 10	1	4.7362	0.7082	6.69	<.0001
Grid 11	1	0.2803	0.7861	0.36	0.7214
Grid 12	1	1.5128	0.9997	1.51	0.1302
Grid 13	1	1.405	0.7886	1.78	0.0748
Grid 14	1	1.6564	0.8716	1.9	0.0574
Grid 15	1	1.4366	0.8465	1.7	0.0897
Grid 16	1	-0.00203	0.9284	0	0.9983
Grid 17	1	0.9508	0.7921	1.2	0.23
Loyalty (mean)	1	4.3339	0.0468	92.61	<.0001
Loyalty (s.d.)	1	1.2605	0.094	13.42	<.0001
Season 1 grid 1	1	0.0455	0.2025	0.22	0.8222
Season 1 grid 2	1	0.4257	0.1533	2.78	0.0055
Season 1 grid 3	1	-0.1313	0.1359	-0.97	0.3339
Season 1 grid 4	1	-0.3449	0.1249	-2.76	0.0058
Season 1 grid 5	1	-1.018	0.1569	-6.49	<.0001
Season 1 grid 6	1	0.3728	0.175	2.13	0.0331
Season 1 grid 7	1	0.757	0.1661	4.56	<.0001
Season 1 grid 8	1	-0.3139	0.1428	-2.2	0.028
Season 1 grid 9	1	-0.6223	0.1391	-4.47	<.0001
Season 1 grid 10	1	-0.8053	0.1546	-5.21	<.0001
Season 1 grid 11	1	0.0186	0.1746	0.11	0.9153
Season 1 grid 12	1	0.7676	0.1993	3.85	0.0001
Season 1 grid 13	1	-0.0615	0.1536	-0.4	0.6888
Season 1 grid 14	1	-1.2587	0.2139	-5.88	<.0001

Table J.3, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 1 grid 15	1	0.4837	0.1898	2.55	0.0108
Season 1 grid 16	1	0.3459	0.1792	1.93	0.0536
Season 1 grid 17	1	-0.3463	0.1477	-2.34	0.0191
Season 2 grid 1	1	3.3996	0.2568	13.24	<.0001
Season 2 grid 2	1	4.0256	0.2151	18.71	<.0001
Season 2 grid 3	1	3.0516	0.203	15.04	<.0001
Season 2 grid 4	1	0.5116	0.2009	2.55	0.0109
Season 2 grid 5	1	1.0465	0.2331	4.49	<.0001
Season 2 grid 6	1	3.1132	0.2399	12.98	<.0001
Season 2 grid 7	1	3.2608	0.2353	13.86	<.0001
Season 2 grid 8	1	1.8422	0.2104	8.75	<.0001
Season 2 grid 9	1	1.5912	0.2075	7.67	<.0001
Season 2 grid 10	1	-0.7565	0.2475	-3.06	0.0022
Season 2 grid 11	1	2.9684	0.2471	12.01	<.0001
Season 2 grid 12	1	2.6979	0.3035	8.89	<.0001
Season 2 grid 13	1	1.4207	0.2524	5.63	<.0001
Season 2 grid 14	1	0.8206	0.2253	3.64	0.0003
Season 2 grid 15	1	2.3192	0.2865	8.09	<.0001
Season 2 grid 16	1	2.3683	0.2973	7.97	<.0001
Season 2 grid 17	1	0.7222	0.2809	2.57	0.0101
TX closure grid 1	1	1.1027	0.2386	4.62	<.0001
TX closure grid 2	1	0.007465	0.1979	0.04	0.9699
TX closure grid 3	1	0.6181	0.1892	3.27	0.0011
TX closure grid 4	1	-0.2869	0.1921	-1.49	0.1352
TX closure grid 5	1	-0.011	0.2247	-0.05	0.9609
TX closure grid 6	1	0.7822	0.2193	3.57	0.0004
TX closure grid 7	1	0.5324	0.2186	2.44	0.0149
TX closure grid 8	1	0.5643	0.1964	2.87	0.0041
TX closure grid 9	1	-0.7438	0.2046	-3.64	0.0003
TX closure grid 10	1	0.6541	0.2317	2.82	0.0048
TX closure grid 11	1	0.3958	0.226	1.75	0.0799
TX closure grid 12	1	0.6764	0.2919	2.32	0.0205
TX closure grid 13	1	-0.0414	0.2411	-0.17	0.8637

Table J.3, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
TX closure grid 14	1	-0.0411	0.2163	-0.19	0.8493
TX closure grid 15	1	0.0255	0.2717	0.09	0.9253
TX closure grid 16	1	0.0573	0.2864	0.2	0.8416
TX closure grid 17	1	-0.6488	0.2777	-2.34	0.0195
Vessel length grid 1	1	-0.1666	0.0112	-14.87	<.0001
Vessel length grid 2	1	-0.1117	0.009575	-11.67	<.0001
Vessel length grid 3	1	-0.0907	0.008878	-10.22	<.0001
Vessel length grid 4	1	-0.0943	0.008635	-10.92	<.0001
Vessel length grid 5	1	-0.0702	0.0103	-6.83	<.0001
Vessel length grid 6	1	-0.0986	0.0106	-9.31	<.0001
Vessel length grid 7	1	-0.0672	0.0106	-6.32	<.0001
Vessel length grid 8	1	-0.0465	0.009372	-4.96	<.0001
Vessel length grid 9	1	-0.0691	0.009107	-7.58	<.0001
Vessel length grid 10	1	-0.0622	0.00968	-6.42	<.0001
Vessel length grid 11	1	-0.0487	0.0107	-4.56	<.0001
Vessel length grid 12	1	-0.0771	0.0137	-5.61	<.0001
Vessel length grid 13	1	-0.0356	0.0108	-3.31	0.0009
Vessel length grid 14	1	-0.0216	0.0119	-1.82	0.0694
Vessel length grid 15	1	-0.0665	0.0116	-5.75	<.0001
Vessel length grid 16	1	-0.0445	0.0127	-3.51	0.0004
Vessel length grid 17	1	-0.0208	0.0107	-1.93	0.0534
Expected revenue (mean)	1	0.0423	0.009387	4.5	<.0001
Expected revenue (s.d.)	1	-0.00194	0.2418	-0.01	0.9936
Variation of ER (mean)	1	-0.0378	0.0377	-1	0.3152
Variation of ER (s.d.)	1	0.002145	1.0324	0	0.9983
Distance (mean)	1	-0.0205	0.000335	-61.28	<.0001
Distance (s.d.)	1	0.006567	0.000274	23.99	<.0001
Crowdedness (mean)	1	0.0488	0.002366	20.64	<.0001
Crowdedness (s.d.)	1	0.006447	0.006189	1.04	0.2976
Crowdedness squared (mean)	1	-0.00046	3.61E-05	-12.81	<.0001
Crowdedness squared (s.d.)	1	-0.00023	3.29E-05	-7.03	<.0001

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	33545
Number of Cases	603810
Log Likelihood	-41154
Maximum Absolute Gradient	595.50146
Number of Iterations	171
Optimization Method	Dual Quasi-Newton
AIC	82489
Schwarz Criterion	83256

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	1015	3.03
1	2	8329	24.83
2	3	3370	10.05
3	4	4851	14.46
4	5	2310	6.89
5	6	1536	4.58
6	7	1017	3.03
7	8	1932	5.76
8	9	1218	3.63
9	10	1411	4.21
10	11	1611	4.80
11	12	321	0.96
12	13	769	2.29
13	14	357	1.06
14	15	833	2.48
15	16	678	2.02
16	17	1444	4.30
17	18	543	1.62

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	112108	2 * (LogL - LogL0)
Upper Bound of R (U)	193915	- 2 * LogL0
Aldrich-Nelson	0.7697	R / (R+N)
Cragg-Uhler 1	0.9646	1 - exp(-R/N)
Cragg-Uhler 2	0.9676	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9932	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9931	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.5781	R / U
Veall-Zimmermann	0.9028	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table J.4 Parameter Estimates---LAM Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	5.3702	0.5076	10.58	<.0001
Grid 2	1	4.4039	0.4509	9.77	<.0001
Grid 3	1	2.475	0.4131	5.99	<.0001
Grid 4	1	3.3195	0.4583	7.24	<.0001
Grid 5	1	1.1592	0.5559	2.09	0.037
Grid 6	1	2.9119	0.5991	4.86	<.0001
Grid 7	1	-1.228	0.6401	-1.92	0.0551
Grid 8	1	-1.1371	0.6494	-1.75	0.0799
Grid 9	1	-1.5152	1.3278	-1.14	0.2538
Grid 10	1	-7.0138	1.0981	-6.39	<.0001
Grid 11	1	-2.1745	0.6677	-3.26	0.0011
Grid 12	1	-4.7716	0.8663	-5.51	<.0001
Grid 13	1	-3.567	0.9884	-3.61	0.0003
Grid 14	1	-2.2016	1.6111	-1.37	0.1718
Grid 15	1	0.5993	0.5691	1.05	0.2922
Grid 16	1	-1.0803	0.602	-1.79	0.0727
Grid 17	1	-0.2719	0.4939	-0.55	0.5819
Loyalty (mean)	1	4.2566	0.048	88.76	<.0001
Loyalty (s.d.)	1	-1.0585	0.0995	-10.64	<.0001
Season 1 grid 1	1	-0.5042	0.1433	-3.52	0.0004
Season 1 grid 2	1	0.55	0.1124	4.89	<.0001
Season 1 grid 3	1	0.1017	0.1044	0.97	0.3299
Season 1 grid 4	1	-0.5938	0.1128	-5.26	<.0001
Season 1 grid 5	1	-0.4006	0.1449	-2.77	0.0057
Season 1 grid 6	1	-0.5327	0.1626	-3.28	0.0011
Season 1 grid 7	1	0.5185	0.148	3.5	0.0005
Season 1 grid 8	1	-0.1109	0.1396	-0.79	0.4271
Season 1 grid 9	1	0.7951	0.2626	3.03	0.0025
Season 1 grid 10	1	-1.0731	0.3518	-3.05	0.0023
Season 1 grid 11	1	-0.2087	0.1571	-1.33	0.184
Season 1 grid 12	1	0.1433	0.1932	0.74	0.4585
Season 1 grid 13	1	0.006731	0.1895	0.04	0.9717
Season 1 grid 14	1	-1.5347	0.492	-3.12	0.0018

Table J.4, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 1 grid 15	1	0.3093	0.1548	2	0.0457
Season 1 grid 16	1	0.665	0.1399	4.75	<.0001
Season 1 grid 17	1	0.2027	0.1196	1.69	0.0902
Season 2 grid 1	1	0.2241	0.1764	1.27	0.2038
Season 2 grid 2	1	0.1244	0.1453	0.86	0.3918
Season 2 grid 3	1	-1.0008	0.1248	-8.02	<.0001
Season 2 grid 4	1	-1.4871	0.1555	-9.56	<.0001
Season 2 grid 5	1	-0.7138	0.1792	-3.98	<.0001
Season 2 grid 6	1	-0.00534	0.2108	-0.03	0.9798
Season 2 grid 7	1	0.1327	0.2408	0.55	0.5815
Season 2 grid 8	1	-0.7834	0.2043	-3.83	0.0001
Season 2 grid 9	1	-0.9377	0.4424	-2.12	0.034
Season 2 grid 10	1	-1.7104	0.2715	-6.3	<.0001
Season 2 grid 11	1	0.4019	0.2122	1.89	0.0583
Season 2 grid 12	1	-0.408	0.3447	-1.18	0.2365
Season 2 grid 13	1	-0.00419	0.282	-0.01	0.9881
Season 2 grid 14	1	-1.1654	0.576	-2.02	0.043
Season 2 grid 15	1	0.3835	0.208	1.84	0.0652
Season 2 grid 16	1	-0.2736	0.2315	-1.18	0.2373
Season 2 grid 17	1	0.6736	0.14	4.81	<.0001
TX closure grid 1	1	0.472	0.1753	2.69	0.0071
TX closure grid 2	1	-0.5613	0.1432	-3.92	<.0001
TX closure grid 3	1	0.004423	0.1238	0.04	0.9715
TX closure grid 4	1	-0.6351	0.161	-3.94	<.0001
TX closure grid 5	1	0.1623	0.1868	0.87	0.3849
TX closure grid 6	1	0.2187	0.2111	1.04	0.3001
TX closure grid 7	1	-0.6422	0.2471	-2.6	0.0094
TX closure grid 8	1	-0.1725	0.2069	-0.83	0.4045
TX closure grid 9	1	0.0814	0.4329	0.19	0.8508
TX closure grid 10	1	2.168	0.2621	8.27	<.0001
TX closure grid 11	1	0.0728	0.2121	0.34	0.7313
TX closure grid 12	1	0.0581	0.3326	0.17	0.8614
TX closure grid 13	1	0.0998	0.2813	0.35	0.7227

Table J.4, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
TX closure grid 14	1	0.8512	0.5444	1.56	0.1179
TX closure grid 15	1	0.1067	0.2109	0.51	0.613
TX closure grid 16	1	0.349	0.2319	1.51	0.1323
TX closure grid 17	1	-0.7061	0.1404	-5.03	<.0001
Vessel length grid 1	1	-0.095	0.006816	-13.94	<.0001
Vessel length grid 2	1	-0.0747	0.006003	-12.44	<.0001
Vessel length grid 3	1	-0.0349	0.005508	-6.34	<.0001
Vessel length grid 4	1	-0.052	0.006227	-8.35	<.0001
Vessel length grid 5	1	-0.0183	0.007736	-2.36	0.0181
Vessel length grid 6	1	-0.0638	0.008061	-7.91	<.0001
Vessel length grid 7	1	-0.0132	0.008445	-1.57	0.1176
Vessel length grid 8	1	0.003699	0.008623	0.43	0.6679
Vessel length grid 9	1	-0.0178	0.0174	-1.02	0.3061
Vessel length grid 10	1	0.0692	0.0138	5.01	<.0001
Vessel length grid 11	1	-3.8E-05	0.008674	0	0.9965
Vessel length grid 12	1	0.0262	0.0111	2.36	0.0184
Vessel length grid 13	1	0.0251	0.0129	1.94	0.0521
Vessel length grid 14	1	0.005407	0.0216	0.25	0.8019
Vessel length grid 15	1	-0.0353	0.007502	-4.7	<.0001
Vessel length grid 16	1	-0.0177	0.007936	-2.23	0.0258
Vessel length grid 17	1	-0.00263	0.006527	-0.4	0.6872
Expected revenue (mean)	1	0.0563	0.0122	4.61	<.0001
Expected revenue (s.d.)	1	0.002124	0.3159	0.01	0.9946
Variation of ER (mean)	1	-0.03	0.00842	-3.57	0.0004
Variation of ER (s.d.)	1	-0.00092	0.2353	0	0.9969
Distance (mean)	1	-0.0118	0.000216	-54.7	<.0001
Distance (s.d.)	1	-0.00498	0.000245	-20.31	<.0001
Crowdedness (mean)	1	0.004748	0.000241	19.67	<.0001
Crowdedness (s.d.)	1	0.000031	0.000467	0.07	0.9471
Crowdedness squared (mean)	1	-3.44E-06	3.23E-07	-10.65	<.0001
Crowdedness squared (s.d.)	1	1.45E-06	1.60E-07	9.06	<.0001

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	32357
Number of Cases	582426
Log Likelihood	-36448
Maximum Absolute Gradient	182817
Number of Iterations	142
Optimization Method	Dual Quasi-Newton
AIC	73079
Schwarz Criterion	73842

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2619	8.09
1	2	11190	34.58
2	3	7054	21.80
3	4	2313	7.15
4	5	1293	4.00
5	6	695	2.15
6	7	534	1.65
7	8	674	2.08
8	9	87	0.27
9	10	131	0.40
10	11	729	2.25
11	12	240	0.74
12	13	265	0.82
13	14	57	0.18
14	15	736	2.27
15	16	1046	3.23
16	17	1802	5.57
17	18	892	2.76

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	114542	2 * (LogL - LogL0)
Upper Bound of R (U)	187048	- 2 * LogL0
Aldrich-Nelson	0.7797	R / (R+N)
Cragg-Uhler 1	0.971	1 - exp(-R/N)
Cragg-Uhler 2	0.974	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9958	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9958	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.6124	R / U
Veall-Zimmermann	0.9146	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table J.5 Parameter Estimates---TX Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-1.7359	0.852	-2.04	0.0416
Grid 2	1	-3.395	0.7179	-4.73	<.0001
Grid 3	1	-0.1928	1.1312	-0.17	0.8646
Grid 4	1	1.4602	1.1523	1.27	0.2051
Grid 5	1	-1.1132	0.9314	-1.2	0.232
Grid 6	1	-0.064	0.8231	-0.08	0.938
Grid 7	1	-1.0424	0.8158	-1.28	0.2014
Grid 8	1	-0.0863	0.6569	-0.13	0.8955
Grid 9	1	1.5177	0.5681	2.67	0.0076
Grid 10	1	0.6824	0.4778	1.43	0.1532
Grid 11	1	3.1717	1.0417	3.04	0.0023
Grid 12	1	-0.4755	0.8511	-0.56	0.5764
Grid 13	1	0.7993	0.9165	0.87	0.3831
Grid 14	1	1.2606	0.6404	1.97	0.049
Grid 15	1	1.0948	0.5271	2.08	0.0378
Loyalty (mean)	1	3.7651	0.0354	106.43	<.0001
Loyalty (s.d.)	1	0.003252	0.8123	0	0.9968
Season 1 grid 1	1	0.0854	0.1743	0.49	0.624
Season 1 grid 2	1	0.0317	0.1306	0.24	0.8082
Season 1 grid 3	1	1.2454	0.18	6.92	<.0001
Season 1 grid 4	1	1.1457	0.131	8.74	<.0001
Season 1 grid 5	1	1.8087	0.2041	8.86	<.0001
Season 1 grid 6	1	0.2477	0.1858	1.33	0.1826
Season 1 grid 7	1	-0.4964	0.1773	-2.8	0.0051
Season 1 grid 8	1	0.3001	0.1101	2.73	0.0064
Season 1 grid 9	1	-0.00521	0.0888	-0.06	0.9532
Season 1 grid 10	1	0.0336	0.063	0.53	0.5936
Season 1 grid 11	1	1.7982	0.1798	10	<.0001
Season 1 grid 12	1	0.2792	0.1488	1.88	0.0607
Season 1 grid 13	1	-0.1177	0.1448	-0.81	0.4164
Season 1 grid 14	1	-0.0643	0.0904	-0.71	0.4771
Season 1 grid 15	1	-0.1145	0.0714	-1.6	0.1086
Season 2 grid 1	1	-1.5639	0.1416	-11.05	<.0001

Table J.5, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 2 grid 2	1	-1.7196	0.1222	-14.08	<.0001
Season 2 grid 3	1	1.135	0.1837	6.18	<.0001
Season 2 grid 4	1	1.1457	0.1379	8.31	<.0001
Season 2 grid 5	1	-0.4034	0.1945	-2.07	0.0381
Season 2 grid 6	1	-1.1186	0.1442	-7.76	<.0001
Season 2 grid 7	1	-0.2598	0.1266	-2.05	0.0402
Season 2 grid 8	1	-0.1614	0.0959	-1.68	0.0923
Season 2 grid 9	1	0.8375	0.0765	10.94	<.0001
Season 2 grid 10	1	1.1827	0.0588	20.12	<.0001
Season 2 grid 11	1	-1.8422	0.2087	-8.83	<.0001
Season 2 grid 12	1	-1.8792	0.1689	-11.13	<.0001
Season 2 grid 13	1	-1.6794	0.1604	-10.47	<.0001
Season 2 grid 14	1	-0.8644	0.0993	-8.71	<.0001
Season 2 grid 15	1	-0.5203	0.0779	-6.68	<.0001
TX closure grid 1	1	-3.9738	0.2411	-16.48	<.0001
TX closure grid 2	1	-6.157	0.3873	-15.9	<.0001
TX closure grid 3	1	-9.2584	0.4198	-22.06	<.0001
TX closure grid 4	1	-12.8827	0.7644	-16.85	<.0001
TX closure grid 5	1	3.5839	0.1895	18.92	<.0001
TX closure grid 6	1	0.5367	0.1626	3.3	0.001
TX closure grid 7	1	-4.3519	0.2467	-17.64	<.0001
TX closure grid 8	1	-6.3332	0.2012	-31.48	<.0001
TX closure grid 9	1	-8.4649	0.2491	-33.98	<.0001
TX closure grid 10	1	-10.2882	0.3072	-33.5	<.0001
TX closure grid 11	1	2.1732	0.2344	9.27	<.0001
TX closure grid 12	1	-4.937	0.5363	-9.21	<.0001
TX closure grid 13	1	-6.827	0.2351	-29.04	<.0001
TX closure grid 14	1	-9.3216	0.3063	-30.43	<.0001
TX closure grid 15	1	-11.0111	0.3376	-32.62	<.0001
Vessel length grid 1	1	0.073	0.0123	5.94	<.0001
Vessel length grid 2	1	0.0891	0.0104	8.53	<.0001
Vessel length grid 3	1	0.000494	0.0167	0.03	0.9765
Vessel length grid 4	1	-0.0548	0.0174	-3.15	0.0017

Table J.5, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Vessel length grid 5	1	0.0735	0.0131	5.63	<.0001
Vessel length grid 6	1	0.0613	0.0118	5.19	<.0001
Vessel length grid 7	1	0.0637	0.0118	5.38	<.0001
Vessel length grid 8	1	0.0434	0.009661	4.5	<.0001
Vessel length grid 9	1	0.000155	0.008459	0.02	0.9854
Vessel length grid 10	1	-0.0234	0.00715	-3.27	0.0011
Vessel length grid 11	1	0.0231	0.0148	1.56	0.1177
Vessel length grid 12	1	0.0691	0.0122	5.64	<.0001
Vessel length grid 13	1	0.0393	0.0134	2.95	0.0032
Vessel length grid 14	1	0.032	0.009416	3.4	0.0007
Vessel length grid 15	1	0.0188	0.007821	2.4	0.0163
Expected revenue (mean)	1	0.0187	0.003602	5.19	<.0001
Expected revenue (s.d.)	1	-0.00828	0.0103	-0.81	0.4203
Variation of ER (mean)	1	-0.0432	0.0246	-1.75	0.0795
Variation of ER (s.d.)	1	0.003507	0.4129	0.01	0.9932
Distance (mean)	1	-0.0222	0.000309	-71.86	<.0001
Distance (s.d.)	1	0.0118	0.000282	42.02	<.0001
Crowdedness (mean)	1	0.035	0.001433	24.38	<.0001
Crowdedness (s.d.)	1	-0.0152	0.00226	-6.7	<.0001
Crowdedness squared (mean)	1	-0.00018	1.46E-05	-12.3	<.0001
Crowdedness squared (s.d.)	1	0.000097	2.76E-05	3.52	0.0004

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	41650
Number of Cases	666400
Log Likelihood	-57214
Maximum Absolute Gradient	250.41578
Number of Iterations	136
Optimization Method	Dual Quasi-Newton
AIC	114589
Schwarz Criterion	115289

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2403	5.77
1	2	1679	4.03
2	3	340	0.82
3	4	524	1.26
4	5	1564	3.76
5	6	8460	20.31
6	7	1472	3.53
7	8	6629	15.92
8	9	2635	6.33
9	10	4208	10.10
10	11	874	2.10
11	12	644	1.55
12	13	408	0.98
13	14	3148	7.56
14	15	2808	6.74
15	16	3854	9.25

Goodness-of-Fit Measures

Measure	Value	Formula
Cragg-Uhler 2	0.9469	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9824	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9822	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.5172	R / U
Veall-Zimmermann	0.8752	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table J.6 Parameter Estimates---TX Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-2.7258	0.7946	-3.43	0.0006
Grid 2	1	-8.458	0.9158	-9.24	<.0001
Grid 3	1	0.37	1.8444	0.2	0.841
Grid 4	1	1.3401	1.7848	0.75	0.4528
Grid 5	1	-3.198	0.8321	-3.84	0.0001
Grid 6	1	-0.2523	0.7746	-0.33	0.7447
Grid 7	1	-1.1725	0.7896	-1.48	0.1375
Grid 8	1	-2.4538	0.6607	-3.71	0.0002
Grid 9	1	2.2451	0.5947	3.77	0.0002
Grid 10	1	1.1168	0.4728	2.36	0.0182
Grid 11	1	4.4658	0.9534	4.68	<.0001
Grid 12	1	3.8639	0.819	4.72	<.0001
Grid 13	1	4.6304	0.8351	5.54	<.0001
Grid 14	1	-0.2466	0.6378	-0.39	0.699
Grid 15	1	1.6445	0.5132	3.2	0.0014
Loyalty (mean)	1	3.8415	0.0403	95.43	<.0001
Loyalty (s.d.)	1	0.0485	0.9299	0.05	0.9584
Season 1 grid 1	1	0.6248	0.1882	3.32	0.0009
Season 1 grid 2	1	2.3327	0.225	10.37	<.0001
Season 1 grid 3	1	2.6448	0.3913	6.76	<.0001
Season 1 grid 4	1	0.3613	0.2689	1.34	0.1791
Season 1 grid 5	1	3.3734	0.2136	15.79	<.0001
Season 1 grid 6	1	1.0167	0.1875	5.42	<.0001
Season 1 grid 7	1	-0.1804	0.212	-0.85	0.3948
Season 1 grid 8	1	0.2987	0.1258	2.37	0.0176
Season 1 grid 9	1	0.031	0.1082	0.29	0.7747
Season 1 grid 10	1	0.4117	0.0845	4.87	<.0001
Season 1 grid 11	1	2.1547	0.1814	11.88	<.0001
Season 1 grid 12	1	0.5459	0.152	3.59	0.0003
Season 1 grid 13	1	-0.0726	0.1469	-0.49	0.6213
Season 1 grid 14	1	-0.7611	0.1124	-6.77	<.0001
Season 1 grid 15	1	-0.00545	0.0856	-0.06	0.9492
Season 2 grid 1	1	-1.254	0.1656	-7.57	<.0001

Table J.6, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 2 grid 2	1	-1.0585	0.2775	-3.81	0.0001
Season 2 grid 3	1	1.1502	0.4113	2.8	0.0052
Season 2 grid 4	1	0.2328	0.2344	0.99	0.3207
Season 2 grid 5	1	0.4539	0.203	2.24	0.0253
Season 2 grid 6	1	-1.6147	0.1661	-9.72	<.0001
Season 2 grid 7	1	-0.3425	0.1523	-2.25	0.0245
Season 2 grid 8	1	-0.7003	0.1079	-6.49	<.0001
Season 2 grid 9	1	0.1158	0.086	1.35	0.1784
Season 2 grid 10	1	0.9234	0.0656	14.07	<.0001
Season 2 grid 11	1	-2.6104	0.2219	-11.76	<.0001
Season 2 grid 12	1	-2.2717	0.1729	-13.14	<.0001
Season 2 grid 13	1	-1.4297	0.1389	-10.29	<.0001
Season 2 grid 14	1	-0.8457	0.0989	-8.55	<.0001
Season 2 grid 15	1	-0.3726	0.0759	-4.91	<.0001
TX closure grid 1	1	-0.486	0.2121	-2.29	0.0219
TX closure grid 2	1	-1.2545	0.3805	-3.3	0.001
TX closure grid 3	1	-4.0878	0.7924	-5.16	<.0001
TX closure grid 4	1	-3.3988	0.4389	-7.74	<.0001
TX closure grid 5	1	2.723	0.2024	13.45	<.0001
TX closure grid 6	1	1.2145	0.1984	6.12	<.0001
TX closure grid 7	1	-0.4769	0.2083	-2.29	0.0221
TX closure grid 8	1	-0.9293	0.1968	-4.72	<.0001
TX closure grid 9	1	-3.5083	0.237	-14.8	<.0001
TX closure grid 10	1	-4.3993	0.2735	-16.09	<.0001
TX closure grid 11	1	1.9597	0.2623	7.47	<.0001
TX closure grid 12	1	-2.7841	0.3342	-8.33	<.0001
TX closure grid 13	1	-2.7085	0.219	-12.37	<.0001
TX closure grid 14	1	-4.126	0.2595	-15.9	<.0001
TX closure grid 15	1	-5.1315	0.2916	-17.6	<.0001
Vessel length grid 1	1	0.0774	0.0111	6.96	<.0001
Vessel length grid 2	1	0.1228	0.0128	9.57	<.0001
Vessel length grid 3	1	-0.0392	0.0274	-1.43	0.1525
Vessel length grid 4	1	-0.0637	0.0265	-2.41	0.0161

Table J.6, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Vessel length grid 5	1	0.0905	0.0111	8.17	<.0001
Vessel length grid 6	1	0.0579	0.0107	5.41	<.0001
Vessel length grid 7	1	0.0546	0.0111	4.9	<.0001
Vessel length grid 8	1	0.0791	0.009526	8.3	<.0001
Vessel length grid 9	1	-0.013	0.008721	-1.49	0.1375
Vessel length grid 10	1	-0.0307	0.006979	-4.4	<.0001
Vessel length grid 11	1	0.003234	0.0132	0.25	0.8061
Vessel length grid 12	1	0.003829	0.0116	0.33	0.7407
Vessel length grid 13	1	-0.0162	0.012	-1.36	0.175
Vessel length grid 14	1	0.0498	0.009245	5.38	<.0001
Vessel length grid 15	1	0.003322	0.007484	0.44	0.6572
Expected revenue (mean)	1	0.0185	0.00665	2.79	0.0053
Expected revenue (s.d.)	1	-0.0039	0.1061	-0.04	0.9707
Variation of ER (mean)	1	-0.06	0.0109	-5.52	<.0001
Variation of ER (s.d.)	1	0.1286	0.0266	4.83	<.0001
Distance (mean)	1	-0.0162	0.000308	-52.65	<.0001
Distance (s.d.)	1	0.009207	0.000276	33.3	<.0001
Crowdedness (mean)	1	0.001298	0.000397	3.27	0.0011
Crowdedness (s.d.)	1	9.05E-05	0.002558	0.04	0.9718
Crowdedness squared (mean)	1	4.06E-07	8.26E-07	0.49	0.6228
Crowdedness squared (s.d.)	1	-1.28E-07	4.41E-06	-0.03	0.9768

Note: s.d. stands for standard deviation.

```
The MDC Procedure

Mixed logit Estimates Algorithm converged.


Model Fit Summary

Dependent Variable           decision
Number of Observations          32380
Number of Cases                518080
Log Likelihood                 -44440
Maximum Absolute Gradient       47375
Number of Iterations              136
Optimization Method     Dual Quasi-Newton
AIC                             89042
Schwarz Criterion               89722
```

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2770	8.55
1	2	254	0.78
2	3	87	0.27
3	4	111	0.34
4	5	2097	6.48
5	6	6068	18.74
6	7	818	2.53
7	8	7247	22.38
8	9	1443	4.46
9	10	2159	6.67
10	11	917	2.83
11	12	673	2.08
12	13	613	1.89
13	14	2165	6.69
14	15	1857	5.74
15	16	3101	9.58

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	90673	2 * (LogL - LogL0)
Upper Bound of R (U)	179553	- 2 * LogL0
Aldrich-Nelson	0.7369	R / (R+N)
Cragg-Uhler 1	0.9392	1 - exp(-R/N)
Cragg-Uhler 2	0.9429	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9797	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9795	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.505	R / U
Veall-Zimmermann	0.8697	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

APPENDIX K. DISTRIBUTION OF LOYALTY PARAMETER FOR LAM AREA

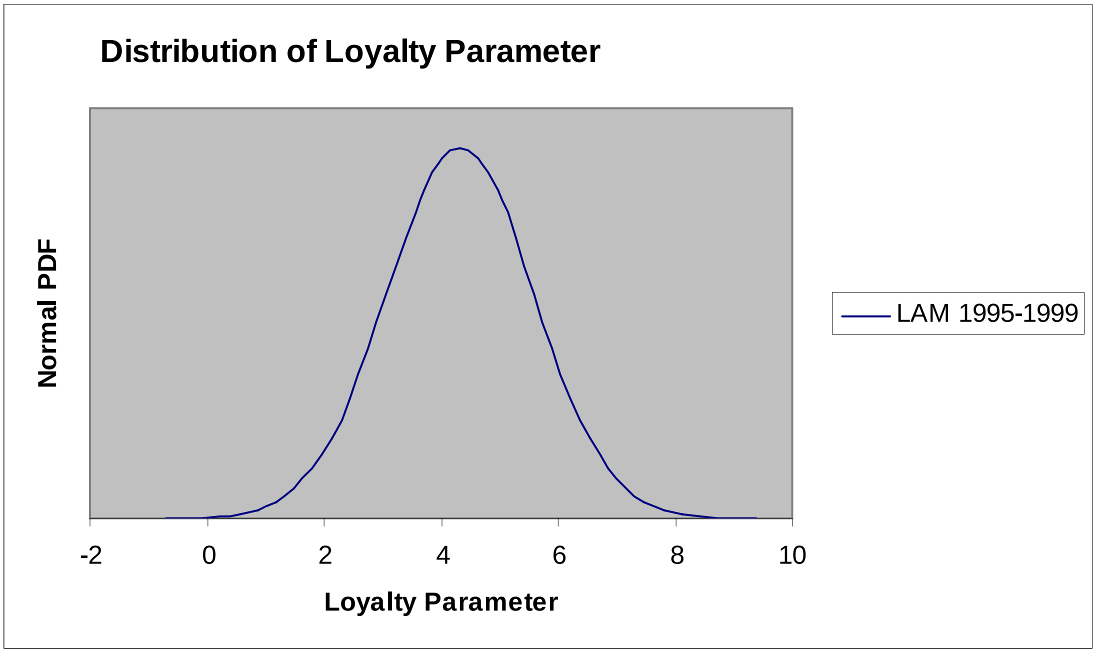

Figure K.1 --- 1995-1999

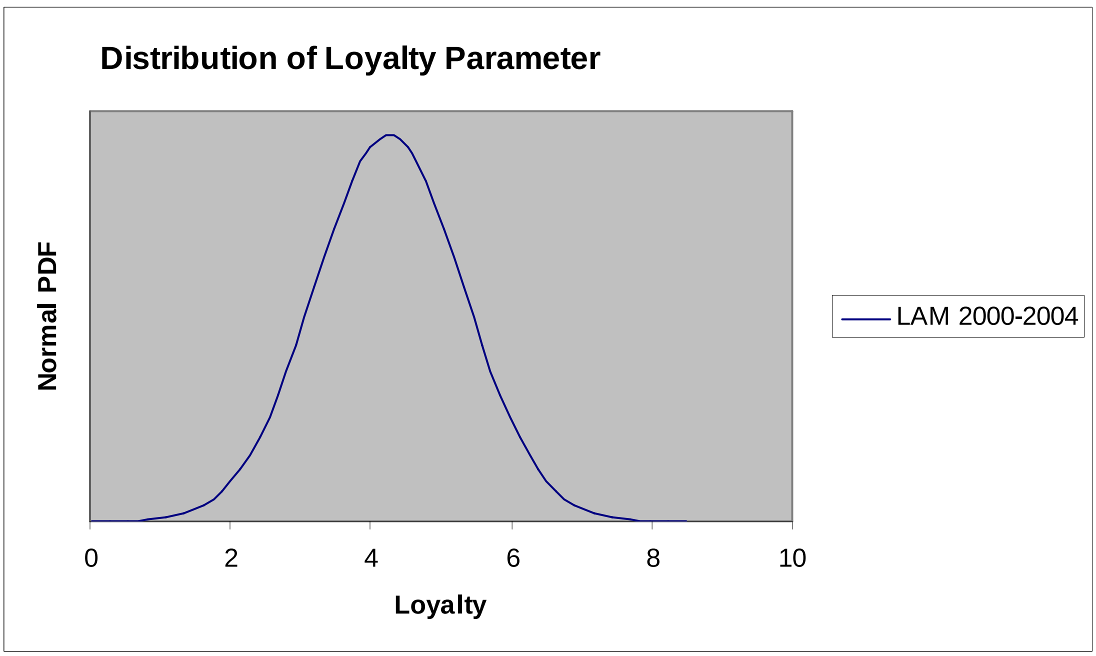

Figure K.2 --- 2000-2004

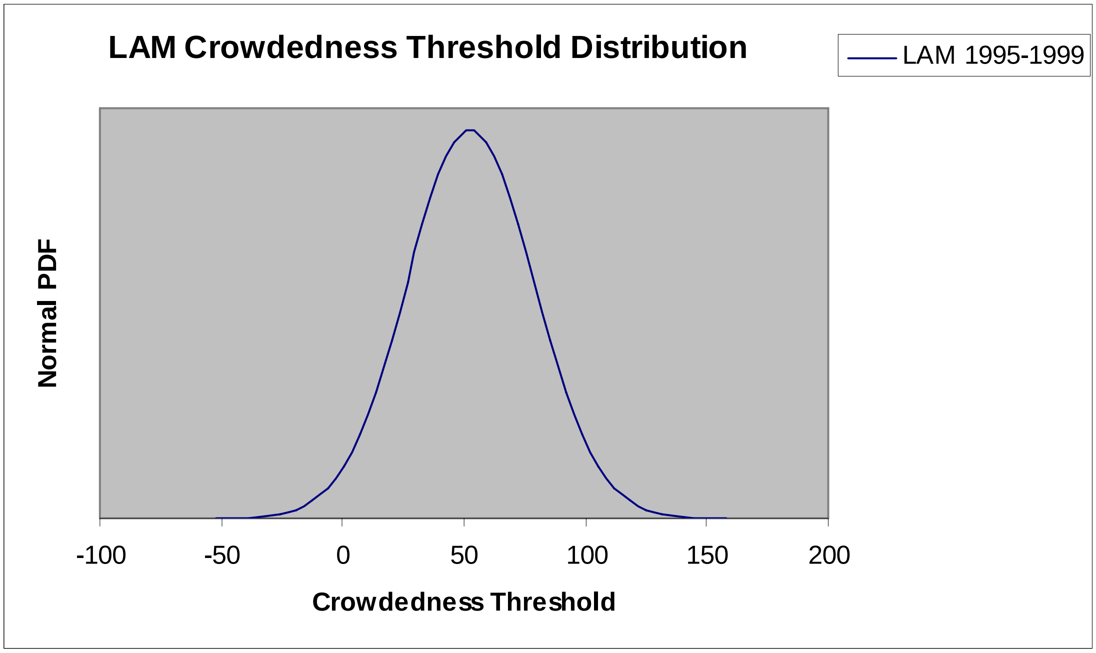

Figure L.1--- LAM area 1995-1999

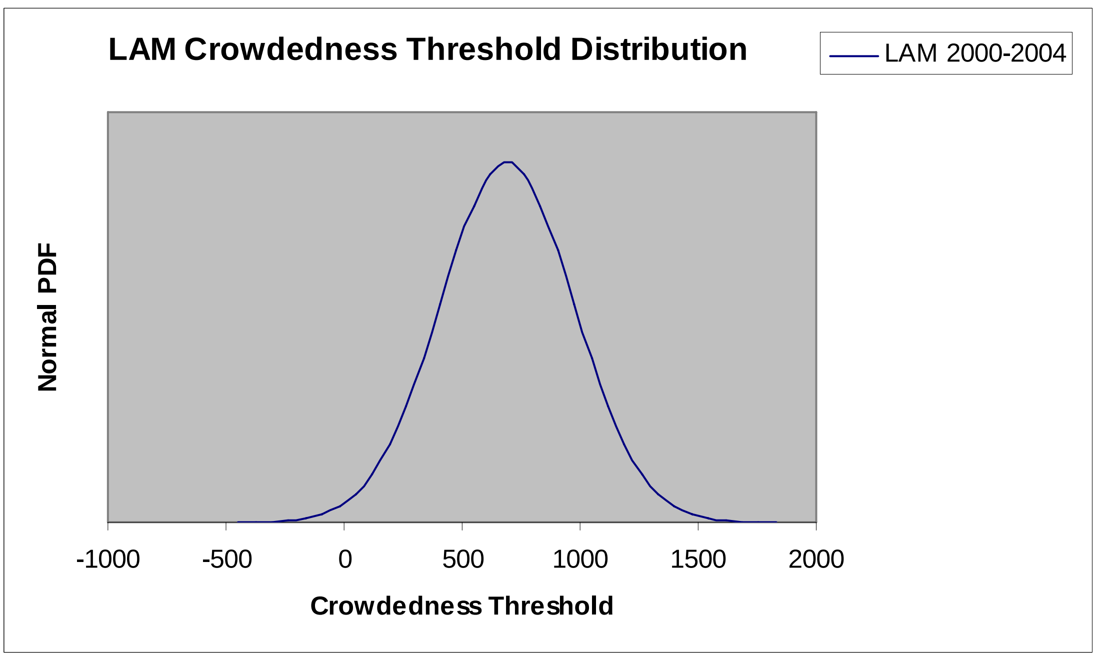

Figure L.2--- LAM area 2000-2004

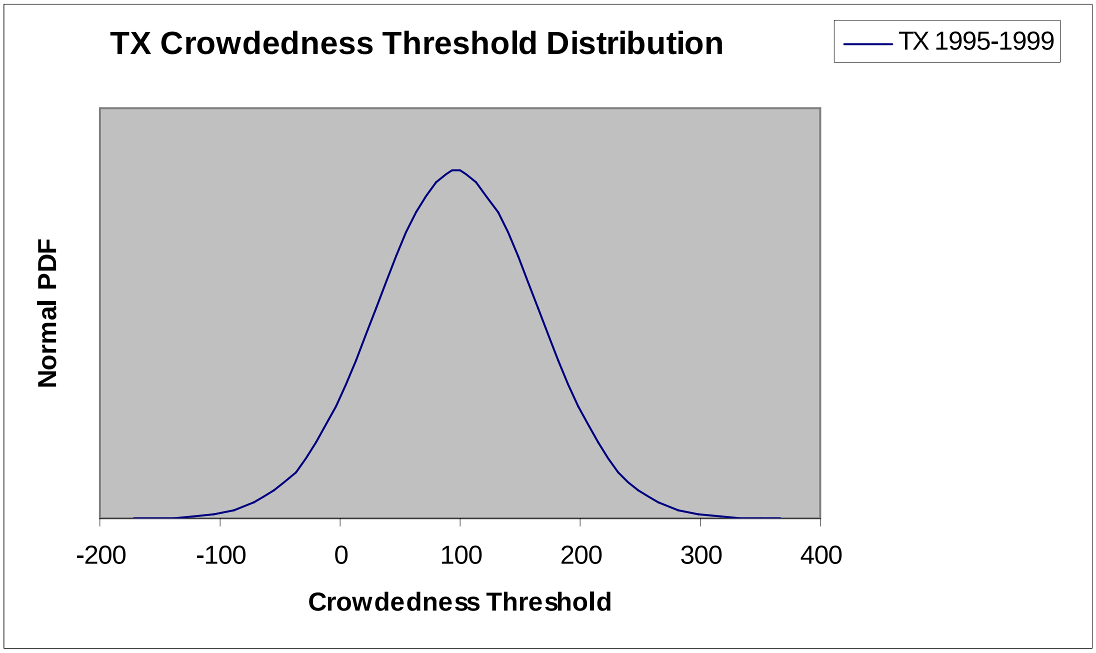

Figure L.3 --- TX area 1995-1999

APPENDIX M. MIXED LOGIT RESULTS WITHOUT STATE DEPENDENCE

Table M.1 Parameter Estimates---FL Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	3.0731	0.9739	3.16	0.0016
Grid 2	1	11.8611	1.1053	10.73	<.0001
Grid 3	1	11.5421	1.3927	8.29	<.0001
Grid 4	1	13.2228	1.033	12.8	<.0001
Grid 5	1	5.661	0.9394	6.03	<.0001
Season 1grid 1	1	0.846	0.1247	6.78	<.0001
Season 1grid 2	1	1.2804	0.1316	9.73	<.0001
Season 1grid 3	1	0.5196	0.1643	3.16	0.0016
Season 1grid 4	1	1.1351	0.1302	8.72	<.0001
Season 1grid 5	1	0.9065	0.1212	7.48	<.0001
Vessel length grid 1	1	-0.0299	0.0144	-2.08	0.0374
Vessel length grid 2	1	-0.1908	0.0164	-11.63	<.0001
Vessel length grid 3	1	-0.1628	0.0205	-7.95	<.0001
Vessel length grid 4	1	-0.1852	0.0153	-12.11	<.0001
Vessel length grid 5	1	-0.0824	0.0139	-5.95	<.0001
Expected revenue (mean)	1	-0.00963	0.0213	-0.45	0.6514
Expected revenue (s.d.)	1	-0.00065	1.1454	0	0.9995
Variance of ER (mean)	1	0.1137	0.0948	1.2	0.2307
Variance of ER (s.d.)	1	0.009606	4.2002	0	0.9982
Distance (mean)	1	-0.0101	0.000278	-36.17	<.0001
Distance (s.d.)	1	-0.00185	0.000524	-3.53	0.0004
Crowdedness (mean)	1	0.1979	0.0124	16.01	<.0001
Crowdedness (s.d.)	1	0.0538	0.0209	2.57	0.0101
Crowdedness squared (mean)	1	-0.00614	0.000624	-9.83	<.0001
Crowdedness squared (s.d.)	1	0.000207	0.006723	0.03	0.9755

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	13343
Number of Cases	80058
Log Likelihood	-13911
Maximum Absolute Gradient	1.18949
Number of Iterations	148
Optimization Method	Dual Quasi-Newton
AIC	27871
Schwarz Criterion	28059

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	4917	36.85
1	2	864	6.48
2	3	1501	11.25
3	4	3630	27.21
4	5	2114	15.84
5	6	317	2.38

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	19994	2 * (LogL - LogL0)
Upper Bound of R (U)	47815	- 2 * LogL0
Aldrich-Nelson	0.5998	R / (R+N)
Cragg-Uhler 1	0.7765	1 - exp(-R/N)
Cragg-Uhler 2	0.7987	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.8564	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.8556	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.4181	R / U
Veall-Zimmermann	0.7671	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table M.2 Parameter Estimates---FL Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-5.8798	1.4786	-3.98	<.0001
Grid 2	1	4.9453	1.7957	2.75	0.0059
Grid 3	1	1.9509	1.3993	1.39	0.1633
Grid 4	1	2.8419	1.4919	1.9	0.0568
Grid 5	1	-0.5876	1.553	-0.38	0.7051
Season 1grid 1	1	0.3132	0.1997	1.57	0.1168
Season 1grid 2	1	0.3853	0.2302	1.67	0.0942
Season 1grid 3	1	0.1903	0.1954	0.97	0.3303
Season 1grid 4	1	0.5737	0.2034	2.82	0.0048
Season 1grid 5	1	0.5324	0.2076	2.56	0.0103
Vessel length grid 1	1	0.1016	0.0217	4.67	<.0001
Vessel length grid 2	1	-0.1046	0.0267	-3.92	<.0001
Vessel length grid 3	1	-0.021	0.0204	-1.03	0.3024
Vessel length grid 4	1	-0.0248	0.0219	-1.13	0.2589
Vessel length grid 5	1	-0.00184	0.023	-0.08	0.936
Expected revenue (mean)	1	0.1081	0.0168	6.42	<.0001
Expected revenue (s.d.)	1	0.0253	0.1328	0.19	0.8491
Variance of ER (mean)	1	-0.0154	0.0361	-0.43	0.6689
Variance of ER (s.d.)	1	-0.0117	0.5941	-0.02	0.9843
Distance (mean)	1	-0.0166	0.000498	-33.37	<.0001
Distance (s.d.)	1	-0.00601	0.000433	-13.89	<.0001
Crowdedness (mean)	1	0.1783	0.0149	11.94	<.0001
Crowdedness (s.d.)	1	-0.1496	0.0131	-11.4	<.0001
Crowdedness squared (mean)	1	-0.00586	0.000668	-8.77	<.0001
Crowdedness squared (s.d.)	1	0.002979	0.000666	4.47	<.0001

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	9722
Number of Cases	58332
Log Likelihood	-8889
Maximum Absolute Gradient	10.59316
Number of Iterations	78
Optimization Method	Dual Quasi-Newton
AIC	17828
Schwarz Criterion	18008

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	3563	36.65
1	2	340	3.50
2	3	981	10.09
3	4	3141	32.31
4	5	1398	14.38
5	6	299	3.08

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	17061	2 * (LogL - LogL0)
Upper Bound of R (U)	34839	- 2 * LogL0
Aldrich-Nelson	0.637	R / (R+N)
Cragg-Uhler 1	0.8271	1 - exp(-R/N)
Cragg-Uhler 2	0.8507	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9103	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9095	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.4897	R / U
Veall-Zimmermann	0.8148	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table M.3 Parameter Estimates---LAM Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	14.8513	0.7883	18.84	<.0001
Grid 2	1	11.715	0.6787	17.26	<.0001
Grid 3	1	9.4004	0.6275	14.98	<.0001
Grid 4	1	8.5124	0.6261	13.6	<.0001
Grid 5	1	10.0648	0.6554	15.36	<.0001
Grid 6	1	7.6679	0.7586	10.11	<.0001
Grid 7	1	2.5707	0.7582	3.39	0.0007
Grid 8	1	4.7297	0.6658	7.1	<.0001
Grid 9	1	5.0144	0.6583	7.62	<.0001
Grid 10	1	8.2653	0.6686	12.36	<.0001
Grid 11	1	0.7927	0.7747	1.02	0.3062
Grid 12	1	2.2206	0.9764	2.27	0.023
Grid 13	1	2.9261	0.7678	3.81	0.0001
Grid 14	1	2.7688	0.8667	3.19	0.0014
Grid 15	1	1.3031	0.7892	1.65	0.0987
Grid 16	1	-0.129	0.8812	-0.15	0.8836
Grid 17	1	3.842	0.722	5.32	<.0001
Season 1 grid 1	1	-0.5781	0.187	-3.09	0.002
Season 1 grid 2	1	-0.092	0.1405	-0.66	0.5124
Season 1 grid 3	1	-0.5921	0.1244	-4.76	<.0001
Season 1 grid 4	1	-0.3536	0.1175	-3.01	0.0026
Season 1 grid 5	1	-0.8759	0.1254	-6.98	<.0001
Season 1 grid 6	1	-0.2614	0.1657	-1.58	0.1146
Season 1 grid 7	1	0.656	0.1569	4.18	<.0001
Season 1 grid 8	1	-0.5637	0.1327	-4.25	<.0001
Season 1 grid 9	1	-0.5741	0.1334	-4.3	<.0001
Season 1 grid 10	1	-0.7839	0.1349	-5.81	<.0001
Season 1 grid 11	1	-0.4151	0.163	-2.55	0.0109
Season 1 grid 12	1	0.5998	0.1911	3.14	0.0017
Season 1 grid 13	1	-0.2009	0.1441	-1.39	0.1633
Season 1 grid 14	1	-1.4265	0.2131	-6.69	<.0001

Table M.3, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 1 grid 15	1	0.0398	0.1785	0.22	0.8235
Season 1 grid 16	1	0.2421	0.1659	1.46	0.1444
Season 1 grid 17	1	-0.3677	0.1314	-2.8	0.0052
Season 2 grid 1	1	2.7251	0.2553	10.67	<.0001
Season 2 grid 2	1	3.0212	0.2104	14.36	<.0001
Season 2 grid 3	1	2.578	0.198	13.02	<.0001
Season 2 grid 4	1	0.6489	0.2004	3.24	0.0012
Season 2 grid 5	1	0.4222	0.208	2.03	0.0423
Season 2 grid 6	1	2.6285	0.2392	10.99	<.0001
Season 2 grid 7	1	3.0976	0.2326	13.32	<.0001
Season 2 grid 8	1	1.5839	0.2068	7.66	<.0001
Season 2 grid 9	1	1.3436	0.2074	6.48	<.0001
Season 2 grid 10	1	-0.6391	0.2375	-2.69	0.0071
Season 2 grid 11	1	2.5905	0.2467	10.5	<.0001
Season 2 grid 12	1	2.5289	0.3021	8.37	<.0001
Season 2 grid 13	1	1.3602	0.2479	5.49	<.0001
Season 2 grid 14	1	0.6698	0.2249	2.98	0.0029
Season 2 grid 15	1	2.227	0.2815	7.91	<.0001
Season 2 grid 16	1	2.1969	0.2824	7.78	<.0001
Season 2 grid 17	1	0.6697	0.2508	2.67	0.0076
TX closure grid 1	1	1.6206	0.2414	6.71	<.0001
TX closure grid 2	1	0.7974	0.1975	4.04	<.0001
TX closure grid 3	1	1.0976	0.186	5.9	<.0001
TX closure grid 4	1	-0.2626	0.1921	-1.37	0.1715
TX closure grid 5	1	0.4532	0.1974	2.3	0.0217
TX closure grid 6	1	1.2846	0.2243	5.73	<.0001
TX closure grid 7	1	1.0724	0.2211	4.85	<.0001
TX closure grid 8	1	0.685	0.1949	3.52	0.0004
TX closure grid 9	1	-0.6354	0.2037	-3.12	0.0018
TX closure grid 10	1	0.4304	0.2184	1.97	0.0487
TX closure grid 11	1	0.9396	0.2311	4.07	<.0001
TX closure grid 12	1	1.2309	0.2948	4.18	<.0001
TX closure grid 13	1	0.0328	0.2392	0.14	0.891

Table M.3, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
TX closure grid 14	1	-0.0436	0.2154	-0.2	0.8397
TX closure grid 15	1	0.6015	0.2741	2.19	0.0282
TX closure grid 16	1	0.7431	0.2765	2.69	0.0072
TX closure grid 17	1	-0.5277	0.2506	-2.11	0.0352
Vessel length grid 1	1	-0.2701	0.011	-24.46	<.0001
Vessel length grid 2	1	-0.1977	0.009304	-21.25	<.0001
Vessel length grid 3	1	-0.1572	0.008583	-18.32	<.0001
Vessel length grid 4	1	-0.1326	0.008533	-15.54	<.0001
Vessel length grid 5	1	-0.1179	0.00895	-13.17	<.0001
Vessel length grid 6	1	-0.1532	0.0105	-14.6	<.0001
Vessel length grid 7	1	-0.0987	0.0104	-9.49	<.0001
Vessel length grid 8	1	-0.0797	0.009093	-8.77	<.0001
Vessel length grid 9	1	-0.0874	0.008961	-9.76	<.0001
Vessel length grid 10	1	-0.1045	0.009151	-11.42	<.0001
Vessel length grid 11	1	-0.0572	0.0106	-5.4	<.0001
Vessel length grid 12	1	-0.1034	0.0135	-7.67	<.0001
Vessel length grid 13	1	-0.0597	0.0105	-5.68	<.0001
Vessel length grid 14	1	-0.0375	0.0118	-3.17	0.0015
Vessel length grid 15	1	-0.0631	0.0108	-5.83	<.0001
Vessel length grid 16	1	-0.058	0.0121	-4.81	<.0001
Vessel length grid 17	1	-0.0581	0.009845	-5.91	<.0001
Expected revenue (mean)	1	0.0683	0.0087	7.85	<.0001
Expected revenue (s.d.)	1	0.007357	0.1067	0.07	0.945
Variation of ER (mean)	1	-0.0908	0.0354	-2.56	0.0103
Variation of ER (s.d.)	1	0.0358	0.5536	0.06	0.9484
Distance (mean)	1	-0.0304	0.000345	-88.18	<.0001
Distance (s.d.)	1	0.0103	0.000247	41.78	<.0001
Crowdedness (mean)	1	0.0624	0.002204	28.31	<.0001
Crowdedness (s.d.)	1	0.000463	0.009165	0.05	0.9597
Crowdedness squared (mean)	1	-0.00057	3.53E-05	-16.18	<.0001
Crowdedness squared (s.d.)	1	-0.00021	2.58E-05	-8.29	<.0001

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable	decision
Number of Observations	33545
Number of Cases	603810
Log Likelihood	-52177
Maximum Absolute Gradient	389.53887
Number of Iterations	309
Optimization Method	Dual Quasi-Newton
AIC	104545
Schwarz Criterion	105344

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	1015	3.03
1	2	8329	24.83
2	3	3370	10.05
3	4	4851	14.46
4	5	2310	6.89
5	6	1536	4.58
6	7	1017	3.03
7	8	1932	5.76
8	9	1218	3.63
9	10	1411	4.21
10	11	1611	4.80
11	12	321	0.96
12	13	769	2.29
13	14	357	1.06
14	15	833	2.48
15	16	678	2.02
16	17	1444	4.30
17	18	543	1.62

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	89561	2 * (LogL - LogL0)
Upper Bound of R (U)	193915	- 2 * LogL0
Aldrich-Nelson	0.7275	R / (R+N)
Cragg-Uhler 1	0.9307	1 - exp(-R/N)
Cragg-Uhler 2	0.9336	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9722	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9719	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.4619	R / U
Veall-Zimmermann	0.8534	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table M.4, Parameter Estimates---LAM Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	11.3817	0.5085	22.38	<.0001
Grid 2	1	9.5603	0.4366	21.9	<.0001
Grid 3	1	4.2331	0.3878	10.92	<.0001
Grid 4	1	5.4266	0.4463	12.16	<.0001
Grid 5	1	4.5846	0.512	8.95	<.0001
Grid 6	1	3.6264	0.5888	6.16	<.0001
Grid 7	1	-4.3881	0.6301	-6.96	<.0001
Grid 8	1	-2.5893	0.6042	-4.29	<.0001
Grid 9	1	-2.3179	1.312	-1.77	0.0773
Grid 10	1	-9.8203	1.1093	-8.85	<.0001
Grid 11	1	-2.9368	0.6269	-4.68	<.0001
Grid 12	1	-7.7177	0.8624	-8.95	<.0001
Grid 13	1	-4.8406	0.9386	-5.16	<.0001
Grid 14	1	-3.1318	1.602	-1.95	0.0506
Grid 15	1	-1.3769	0.5434	-2.53	0.0113
Grid 16	1	-5.0962	0.6351	-8.02	<.0001
Grid 17	1	-0.8119	0.4609	-1.76	0.0782
Season 1 grid 1	1	-0.8369	0.1424	-5.88	<.0001
Season 1 grid 2	1	0.2028	0.1118	1.81	0.0696
Season 1 grid 3	1	-0.0857	0.1016	-0.84	0.3989
Season 1 grid 4	1	-0.1099	0.1134	-0.97	0.3324
Season 1 grid 5	1	-0.5443	0.1259	-4.32	<.0001
Season 1 grid 6	1	-1.0475	0.1628	-6.44	<.0001
Season 1 grid 7	1	0.5468	0.1461	3.74	0.0002
Season 1 grid 8	1	-0.0997	0.1331	-0.75	0.4538
Season 1 grid 9	1	1.0219	0.2609	3.92	<.0001
Season 1 grid 10	1	-0.8602	0.353	-2.44	0.0148
Season 1 grid 11	1	-0.6146	0.1527	-4.03	<.0001
Season 1 grid 12	1	0.1292	0.1931	0.67	0.5034
Season 1 grid 13	1	-0.0561	0.1801	-0.31	0.7555
Season 1 grid 14	1	-1.6043	0.4899	-3.27	0.0011

Table M.4, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 1 grid 15	1	-0.2253	0.1575	-1.43	0.1526
Season 1 grid 16	1	0.5865	0.1378	4.26	<.0001
Season 1 grid 17	1	0.3191	0.1116	2.86	0.0043
Season 2 grid 1	1	-0.6451	0.1811	-3.56	0.0004
Season 2 grid 2	1	-0.6055	0.1419	-4.27	<.0001
Season 2 grid 3	1	-0.9332	0.1213	-7.69	<.0001
Season 2 grid 4	1	-1.2402	0.1635	-7.59	<.0001
Season 2 grid 5	1	-0.84	0.1693	-4.96	<.0001
Season 2 grid 6	1	-0.5848	0.2115	-2.77	0.0057
Season 2 grid 7	1	-0.0882	0.2387	-0.37	0.7118
Season 2 grid 8	1	-0.8642	0.1939	-4.46	<.0001
Season 2 grid 9	1	-1.0975	0.4412	-2.49	0.0129
Season 2 grid 10	1	-1.6282	0.2756	-5.91	<.0001
Season 2 grid 11	1	-0.1857	0.2087	-0.89	0.3737
Season 2 grid 12	1	-0.6245	0.3445	-1.81	0.0699
Season 2 grid 13	1	-0.1217	0.272	-0.45	0.6547
Season 2 grid 14	1	-1.1234	0.5772	-1.95	0.0516
Season 2 grid 15	1	-0.2531	0.2098	-1.21	0.2277
Season 2 grid 16	1	-0.946	0.301	-3.14	0.0017
Season 2 grid 17	1	0.0254	0.1347	0.19	0.8504
TX closure grid 1	1	0.7168	0.1825	3.93	<.0001
TX closure grid 2	1	-0.0477	0.1415	-0.34	0.7362
TX closure grid 3	1	-0.1829	0.1217	-1.5	0.1328
TX closure grid 4	1	-0.6015	0.1693	-3.55	0.0004
TX closure grid 5	1	0.0672	0.1764	0.38	0.7031
TX closure grid 6	1	0.5001	0.2144	2.33	0.0196
TX closure grid 7	1	-0.3797	0.2496	-1.52	0.1282
TX closure grid 8	1	-0.1847	0.1991	-0.93	0.3536
TX closure grid 9	1	-0.097	0.4326	-0.22	0.8225
TX closure grid 10	1	2.146	0.2666	8.05	<.0001
TX closure grid 11	1	0.2275	0.2116	1.08	0.2823
TX closure grid 12	1	0.2588	0.3345	0.77	0.4391
TX closure grid 13	1	-0.075	0.2717	-0.28	0.7825

Table M.4, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
TX closure grid 14	1	0.9644	0.5451	1.77	0.0769
TX closure grid 15	1	0.4425	0.2158	2.05	0.0403
TX closure grid 16	1	1.087	0.3068	3.54	0.0004
TX closure grid 17	1	-0.3837	0.1375	-2.79	0.0052
Vessel length grid 1	1	-0.1693	0.006938	-24.4	<.0001
Vessel length grid 2	1	-0.1291	0.005898	-21.89	<.0001
Vessel length grid 3	1	-0.0443	0.005237	-8.46	<.0001
Vessel length grid 4	1	-0.0823	0.006129	-13.42	<.0001
Vessel length grid 5	1	-0.0528	0.007092	-7.45	<.0001
Vessel length grid 6	1	-0.071	0.008	-8.88	<.0001
Vessel length grid 7	1	0.024	0.008368	2.86	0.0042
Vessel length grid 8	1	0.0284	0.008046	3.53	0.0004
Vessel length grid 9	1	-0.0171	0.0172	-1	0.3194
Vessel length grid 10	1	0.0985	0.014	7.06	<.0001
Vessel length grid 11	1	0.0147	0.00821	1.8	0.0725
Vessel length grid 12	1	0.0591	0.0111	5.33	<.0001
Vessel length grid 13	1	0.0454	0.0123	3.7	0.0002
Vessel length grid 14	1	0.015	0.0214	0.7	0.4851
Vessel length grid 15	1	-0.00233	0.007238	-0.32	0.748
Vessel length grid 16	1	0.0312	0.008434	3.69	0.0002
Vessel length grid 17	1	0.0116	0.006147	1.88	0.0601
Expected revenue (mean)	1	0.0853	0.0106	8.01	<.0001
Expected revenue (s.d.)	1	0.000465	0.1557	0	0.9976
Variation of ER (mean)	1	-0.0336	0.00782	-4.3	<.0001
Variation of ER (s.d.)	1	-0.0008	0.1705	0	0.9963
Distance (mean)	1	-0.0232	0.000306	-75.9	<.0001
Distance (s.d.)	1	0.012	0.00027	44.4	<.0001
Crowdedness (mean)	1	0.0101	0.00037	27.34	<.0001
Crowdedness (s.d.)	1	-1.6E-05	0.000606	-0.03	0.9796
Crowdedness squared (mean)	1	-1.4E-05	9.01E-07	-15.53	<.0001
Crowdedness squared (s.d.)	1	6.00E-06	4.34E-07	13.84	<.0001

Note: s.d. stands for standard deviation.

The MDC Procedure

Mixed logit Estimates Algorithm converged.
Model Fit Summary

Dependent Variable	decision
Number of Observations	32357
Number of Cases	582426
Log Likelihood	-47903
Maximum Absolute Gradient	47188
Number of Iterations	186
Optimization Method	Dual Quasi-Newton
AIC	95996
Schwarz Criterion	96792

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2619	8.09
1	2	11190	34.58
2	3	7054	21.80
3	4	2313	7.15
4	5	1293	4.00
5	6	695	2.15
6	7	534	1.65
7	8	674	2.08
8	9	87	0.27
9	10	131	0.40
10	11	729	2.25
11	12	240	0.74
12	13	265	0.82
13	14	57	0.18
14	15	736	2.27
15	16	1046	3.23
16	17	1802	5.57
17	18	892	2.76

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	91242	2 * (LogL - LogL0)
Upper Bound of R (U)	187048	- 2 * LogL0
Aldrich-Nelson	0.7382	R / (R+N)
Cragg-Uhler 1	0.9404	1 - exp(-R/N)
Cragg-Uhler 2	0.9433	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9791	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9789	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.4878	R / U
Veall-Zimmermann	0.8659	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table M.5 Parameter Estimates---TX Area (1995-1999)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-7.2819	0.7905	-9.21	<.0001
Grid 2	1	0.1642	1.1621	0.14	0.8876
Grid 3	1	1.2689	1.1305	1.12	0.2616
Grid 4	1	-1.2637	1.1553	-1.09	0.274
Grid 5	1	-0.2942	0.9773	-0.3	0.7634
Grid 6	1	-1.5336	0.9182	-1.67	0.0949
Grid 7	1	2.0006	0.7579	2.64	0.0083
Grid 8	1	3.1357	0.6355	4.93	<.0001
Grid 9	1	2.5936	0.4863	5.33	<.0001
Grid 10	1	2.9046	1.2476	2.33	0.0199
Grid 11	1	-0.9673	0.9718	-1	0.3196
Grid 12	1	1.2064	1.002	1.2	0.2286
Grid 13	1	1.7746	0.7443	2.38	0.0171
Grid 14	1	1.6012	0.6013	2.66	0.0077
Grid 15	1	0.3439	0.1958	1.76	0.0791
Season 1 grid 1	1	0.2847	0.1379	2.06	0.039
Season 1 grid 2	1	1.0787	0.1819	5.93	<.0001
Season 1 grid 3	1	1.0349	0.1289	8.03	<.0001
Season 1 grid 4	1	2.2192	0.2528	8.78	<.0001
Season 1 grid 5	1	0.1197	0.2159	0.55	0.5793
Season 1 grid 6	1	-0.6853	0.1941	-3.53	0.0004
Season 1 grid 7	1	0.0971	0.1235	0.79	0.4315
Season 1 grid 8	1	-0.2924	0.0974	-3	0.0027
Season 1 grid 9	1	-0.3685	0.0628	-5.87	<.0001
Season 1 grid 10	1	2.2051	0.2354	9.37	<.0001
Season 1 grid 11	1	0.397	0.1764	2.25	0.0244
Season 1 grid 12	1	-0.0998	0.1614	-0.62	0.5364
Season 1 grid 13	1	-0.0777	0.1082	-0.72	0.4726
Season 1 grid 14	1	-0.2173	0.0816	-2.66	0.0077
Season 1 grid 15	1	-2.1278	0.1593	-13.36	<.0001
Season 2 grid 1	1	-7.2819	0.7905	-9.21	<.0001

Table M.5, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 2 grid 2	1	-2.4359	0.1343	-18.14	<.0001
Season 2 grid 3	1	0.9062	0.1852	4.89	<.0001
Season 2 grid 4	1	1.3469	0.1371	9.83	<.0001
Season 2 grid 5	1	-1.0056	0.2368	-4.25	<.0001
Season 2 grid 6	1	-1.7539	0.171	-10.26	<.0001
Season 2 grid 7	1	-1.0729	0.1421	-7.55	<.0001
Season 2 grid 8	1	-0.8401	0.1115	-7.54	<.0001
Season 2 grid 9	1	0.3881	0.086	4.51	<.0001
Season 2 grid 10	1	0.9133	0.0602	15.18	<.0001
Season 2 grid 11	1	-2.4092	0.2444	-9.86	<.0001
Season 2 grid 12	1	-2.3879	0.1874	-12.74	<.0001
Season 2 grid 13	1	-2.2107	0.1722	-12.84	<.0001
Season 2 grid 14	1	-1.394	0.1142	-12.21	<.0001
Season 2 grid 15	1	-0.7866	0.0869	-9.05	<.0001
TX closure grid 1	1	-4.1464	0.2648	-15.66	<.0001
TX closure grid 2	1	-7.5236	0.3988	-18.87	<.0001
TX closure grid 3	1	-13.1196	0.4267	-30.75	<.0001
TX closure grid 4	1	-17.251	0.7881	-21.89	<.0001
TX closure grid 5	1	5.0028	0.2012	24.87	<.0001
TX closure grid 6	1	-0.1207	0.1619	-0.75	0.4559
TX closure grid 7	1	-5.0179	0.2447	-20.51	<.0001
TX closure grid 8	1	-8.8553	0.2102	-42.12	<.0001
TX closure grid 9	1	-12.2174	0.2701	-45.24	<.0001
TX closure grid 10	1	-15.136	0.3586	-42.2	<.0001
TX closure grid 11	1	3.6996	0.2362	15.66	<.0001
TX closure grid 12	1	-5.8947	0.5359	-11	<.0001
TX closure grid 13	1	-8.6729	0.2485	-34.9	<.0001
TX closure grid 14	1	-12.7002	0.3268	-38.86	<.0001
TX closure grid 15	1	-15.4007	0.386	-39.9	<.0001
Vessel length grid 1	1	0.1082	0.0139	7.77	<.0001
Vessel length grid 2	1	0.1477	0.0116	12.77	<.0001
Vessel length grid 3	1	0.006485	0.0172	0.38	0.7063
Vessel length grid 4	1	-0.0693	0.0171	-4.05	<.0001

Table M.5, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Vessel length grid 5	1	0.0963	0.0163	5.92	<.0001
Vessel length grid 6	1	0.0997	0.014	7.1	<.0001
Vessel length grid 7	1	0.0888	0.0133	6.66	<.0001
Vessel length grid 8	1	0.0406	0.0111	3.64	0.0003
Vessel length grid 9	1	-0.00567	0.009462	-0.6	0.5493
Vessel length grid 10	1	-0.0517	0.007289	-7.09	<.0001
Vessel length grid 11	1	0.0483	0.0176	2.74	0.0061
Vessel length grid 12	1	0.0978	0.014	7	<.0001
Vessel length grid 13	1	0.0516	0.0146	3.53	0.0004
Vessel length grid 14	1	0.0446	0.011	4.07	<.0001
Vessel length grid 15	1	0.028	0.008929	3.14	0.0017
Expected revenue (mean)	1	0.0277	0.003687	7.5	<.0001
Expected revenue (s.d.)	1	0.0132	0.008185	1.61	0.1072
Variation of ER (mean)	1	-0.0658	0.0275	-2.39	0.0166
Variation of ER (s.d.)	1	0.0155	0.1467	0.11	0.9157
Distance (mean)	1	-0.0385	0.000426	-90.4	<.0001
Distance (s.d.)	1	-0.021	0.000375	-55.97	<.0001
Crowdedness (mean)	1	0.0503	0.001586	31.73	<.0001
Crowdedness (s.d.)	1	-0.0266	0.001535	-17.32	<.0001
Crowdedness squared (mean)	1	-0.00026	1.58E-05	-16.7	<.0001
Crowdedness squared (s.d.)	1	-9.21E-06	6.55E-05	-0.14	0.8881

Note: s.d. stands for standard deviation.

```
The MDC Procedure

Mixed logit Estimates Algorithm converged.

Model Fit Summary

Dependent Variable            decision
Number of Observations           41650
Number of Cases                 666400
Log Likelihood                  -62691
Maximum Absolute Gradient         1092
Number of Iterations               265
Optimization Method     Dual Quasi-Newton
AIC                             125551
Schwarz Criterion               126286
```

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2403	5.77
1	2	1679	4.03
2	3	340	0.82
3	4	524	1.26
4	5	1564	3.76
5	6	8460	20.31
6	7	1472	3.53
7	8	6629	15.92
8	9	2635	6.33
9	10	4208	10.10
10	11	874	2.10
11	12	644	1.55
12	13	408	0.98
13	14	3148	7.56
14	15	2808	6.74
15	16	3854	9.25

Goodness-of-Fit Measures

Measure	Value	Formula
Likelihood Ratio (R)	105575	2 * (LogL - LogL0)
Upper Bound of R (U)	230957	- 2 * LogL0
Aldrich-Nelson	0.7171	R / (R+N)
Cragg-Uhler 1	0.9207	1 - exp(-R/N)
Cragg-Uhler 2	0.9243	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9662	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.966	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.4571	R / U
Veall-Zimmermann	0.8464	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

Table M.6 Parameter Estimates---TX Area (2000-2004)

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Grid 1	1	-3.7723	1.2327	-3.06	0.0022
Grid 2	1	-20.7458	1.2385	-16.75	<.0001
Grid 3	1	1.1941	1.9586	0.61	0.5421
Grid 4	1	2.0238	1.777	1.14	0.2548
Grid 5	1	-8.2534	1.3022	-6.34	<.0001
Grid 6	1	-0.0506	1.2214	-0.04	0.9669
Grid 7	1	-1.4207	1.1947	-1.19	0.2344
Grid 8	1	-1.0117	1.0644	-0.95	0.3418
Grid 9	1	4.4386	0.8082	5.49	<.0001
Grid 10	1	1.7791	0.4939	3.6	0.0003
Grid 11	1	2.695	1.4301	1.88	0.0595
Grid 12	1	5.2698	1.2226	4.31	<.0001
Grid 13	1	5.4133	1.1956	4.53	<.0001
Grid 14	1	1.1324	1.0363	1.09	0.2745
Grid 15	1	2.4305	0.7257	3.35	0.0008
Season 1 grid 1	1	0.8361	0.2748	3.04	0.0023
Season 1 grid 2	1	4.1597	0.271	15.35	<.0001
Season 1 grid 3	1	2.2545	0.4024	5.6	<.0001
Season 1 grid 4	1	0.3508	0.2674	1.31	0.1895
Season 1 grid 5	1	4.3525	0.3235	13.45	<.0001
Season 1 grid 6	1	0.8425	0.2867	2.94	0.0033
Season 1 grid 7	1	-0.3122	0.2774	-1.13	0.2604
Season 1 grid 8	1	-0.2415	0.1862	-1.3	0.1947
Season 1 grid 9	1	-0.1368	0.1397	-0.98	0.3276
Season 1 grid 10	1	0.0471	0.0887	0.53	0.5956
Season 1 grid 11	1	3.1596	0.3249	9.73	<.0001
Season 1 grid 12	1	0.6545	0.2428	2.7	0.007
Season 1 grid 13	1	-0.2479	0.2106	-1.18	0.239
Season 1 grid 14	1	-0.542	0.1727	-3.14	0.0017
Season 1 grid 15	1	-0.1275	0.121	-1.05	0.2917
Season 2 grid 1	1	-1.6294	0.2362	-6.9	<.0001

Table M.6, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Season 2 grid 2	1	-0.9281	0.3069	-3.02	0.0025
Season 2 grid 3	1	0.8292	0.4185	1.98	0.0475
Season 2 grid 4	1	0.478	0.2329	2.05	0.0401
Season 2 grid 5	1	0.2249	0.2617	0.86	0.3902
Season 2 grid 6	1	-1.9314	0.2404	-8.03	<.0001
Season 2 grid 7	1	-0.917	0.2099	-4.37	<.0001
Season 2 grid 8	1	-1.3914	0.1641	-8.48	<.0001
Season 2 grid 9	1	-0.2361	0.1158	-2.04	0.0414
Season 2 grid 10	1	0.7787	0.0665	11.71	<.0001
Season 2 grid 11	1	-2.9486	0.3123	-9.44	<.0001
Season 2 grid 12	1	-2.9367	0.2347	-12.51	<.0001
Season 2 grid 13	1	-1.888	0.1934	-9.76	<.0001
Season 2 grid 14	1	-1.2008	0.1561	-7.69	<.0001
Season 2 grid 15	1	-0.6659	0.106	-6.28	<.0001
TX closure grid 1	1	-0.6278	0.2251	-2.79	0.0053
TX closure grid 2	1	-1.6556	0.3748	-4.42	<.0001
TX closure grid 3	1	-3.7178	0.8049	-4.62	<.0001
TX closure grid 4	1	-2.6188	0.5184	-5.05	<.0001
TX closure grid 5	1	2.657	0.2067	12.85	<.0001
TX closure grid 6	1	0.2361	0.2006	1.18	0.2392
TX closure grid 7	1	-0.8048	0.2085	-3.86	0.0001
TX closure grid 8	1	-0.7222	0.196	-3.68	0.0002
TX closure grid 9	1	-2.9442	0.2556	-11.52	<.0001
TX closure grid 10	1	-3.7172	0.3904	-9.52	<.0001
TX closure grid 11	1	2.0718	0.2612	7.93	<.0001
TX closure grid 12	1	-2.9415	0.3342	-8.8	<.0001
TX closure grid 13	1	-2.5094	0.2221	-11.3	<.0001
TX closure grid 14	1	-3.3634	0.287	-11.72	<.0001
TX closure grid 15	1	-4.3877	0.395	-11.11	<.0001
Vessel length grid 1	1	0.1181	0.0176	6.72	<.0001
Vessel length grid 2	1	0.2747	0.0177	15.51	<.0001
Vessel length grid 3	1	-0.0215	0.0291	-0.74	0.4595
Vessel length grid 4	1	-0.1016	0.0264	-3.85	0.0001

Table M.6, continued

Parameter	*D.F.*	*Estimate*	*Standard error*	*t-value*	*Approximate Pr > |t|*
Vessel length grid 5	1	0.1918	0.0179	10.73	<.0001
Vessel length grid 6	1	0.111	0.0173	6.42	<.0001
Vessel length grid 7	1	0.0938	0.0171	5.48	<.0001
Vessel length grid 8	1	0.1096	0.0155	7.09	<.0001
Vessel length grid 9	1	-0.0109	0.0118	-0.92	0.3584
Vessel length grid 10	1	-0.0504	0.007294	-6.9	<.0001
Vessel length grid 11	1	0.0624	0.0198	3.15	0.0016
Vessel length grid 12	1	0.0345	0.0174	1.99	0.0471
Vessel length grid 13	1	0.0186	0.0172	1.08	0.2809
Vessel length grid 14	1	0.0774	0.0151	5.12	<.0001
Vessel length grid 15	1	0.0281	0.0106	2.66	0.0079
Expected revenue (mean)	1	0.0664	0.006996	9.5	<.0001
Expected revenue (s.d.)	1	0.0307	0.0272	1.13	0.2587
Variation of ER (mean)	1	-0.0916	0.0116	-7.92	<.0001
Variation of ER (s.d.)	1	0.1233	0.0252	4.9	<.0001
Distance (mean)	1	-0.0412	0.000734	-56.16	<.0001
Distance (s.d.)	1	0.0294	0.000751	39.18	<.0001
Crowdedness (mean)	1	0.005492	0.000418	13.14	<.0001
Crowdedness (s.d.)	1	-5.1E-05	0.001678	-0.03	0.9759
Crowdedness squared (mean)	1	-4.07E-06	8.50E-07	-4.79	<.0001
Crowdedness squared (s.d.)	1	-1.81E-06	2.13E-06	-0.85	0.396

Note: s.d. stands for standard deviation.

```
                    The MDC Procedure

         Mixed logit Estimates Algorithm converged.


                    Model Fit Summary
          Dependent Variable            decision
         Number of Observations            32380
          Number of Cases                518080
           Log Likelihood                -49008
        Maximum Absolute Gradient          23802
          Number of Iterations               306
       Optimization Method       Dual Quasi-Newton
               AIC                      98185
          Schwarz Criterion               98898
```

Discrete Response Profile

Index	CHOICE	Frequency	Percent
0	1	2770	8.55
1	2	254	0.78
2	3	87	0.27
3	4	111	0.34
4	5	2097	6.48
5	6	6068	18.74
6	7	818	2.53
7	8	7247	22.38
8	9	1443	4.46
9	10	2159	6.67
10	11	917	2.83
11	12	673	2.08
12	13	613	1.89
13	14	2165	6.69
14	15	1857	5.74
15	16	3101	9.58

Goodness-of-Fit Measures

Likelihood Ratio (R)	81538	2 * (LogL - LogL0)
Upper Bound of R (U)	179553	- 2 * LogL0
Aldrich-Nelson	0.7158	R / (R+N)
Cragg-Uhler 1	0.9194	1 - exp(-R/N)
Cragg-Uhler 2	0.923	(1-exp(-R/N)) / (1-exp(-U/N))
Estrella	0.9652	1 - (1-R/U)^(U/N)
Adjusted Estrella	0.9648	1 - ((LogL-K)/LogL0)^(-2/N*LogL0)
McFadden's LRI	0.4541	R / U
Veall-Zimmermann	0.8448	(R * (U+N)) / (U * (R+N))

N = # of observations, K = # of regressors

APPENDIX N. WELFARE ANALYSIS RESULTS----CONDITIONAL LOGIT MODEL

Table N.1 Welfare Approximation Using the Conditional Logit Model for LAM (population)

Year	Trips to the Hypothetically Closed Area	Lower Bound Average Welfare Loss (dollars)	Upper Bound Average Welfare Loss (dollars)	Lower Bound Total Welfare Loss (dollars)	Upper Bound Total Welfare Loss (dollars)
1995	1194	-49.89	-143.85	-59,569	-171,757
1996	1103	-39.04	-112.56	-43,061	-124,154
1997	883	-53.46	-154.15	-47,205	-136,114
1998	533	-51.80	-149.38	-27,609	-79,619
1999	647	-37.23	-107.34	-24,088	-69,449
2000	538	-99.65	-197.95	-53,612	-106,497
2001	449	-99.89	-198.44	-44,851	-89,100
2002	1780	-124.32	-246.95	-221,290	-439,571
2003	1652	-106.78	-212.13	-176,401	-350,439
2004	1425	-93.33	-185.41	-132,995	-264,209

Note: Due to the fuel efficiency difference in vessels, the welfare loss is calculated within the range of the most efficient use of fuel and the least efficient use of fuel. For the period 1995-1999 (base January 1995), the most and least efficient use of fuel was $0.89 and $1.78 per kilometer, respectively. For the period 2000-2004 (base January 2000), the most and least efficient use of fuel was $1.10 and $2.20 per kilometer, respectively, or $0.737 and $1.47 per kilometer excluding state and federal diesel tax.

Table N.2 Welfare Approximation Using the Conditional Logit Model for TX (population)

Year	Trips to the Hypothetically Closed Area	Lower Bound Average Welfare Loss (dollars)	Upper Bound Average Welfare Loss (dollars)	Lower Bound Total Welfare Loss (dollars)	Upper Bound Total Welfare Loss (dollars)
1995	1610	-157.02	-452.76	-252,802	-728,944
1996	1260	-188.02	-542.81	-237,182	-683,941
1997	1419	-177.05	-510.54	-251,234	-724,456
1998	1306	-201.34	-580.58	-262,950	-758,237
1999	1900	-176.28	-508.33	-334,932	-965,827
2000	1775	-205.79	-408.80	-365,277	-725,620
2001	1667	-244.52	-485.75	-407,615	-809,745
2002	1725	-208.70	-414.58	-360,008	-715,151
2003	1744	-178.72	-355.02	-311,688	-619,515
2004	1177	-235.62	-468.05	-277,325	-550,895

Note: Due to the fuel efficiency difference in vessels, the welfare loss is calculated within the range of the most efficient use of fuel and the least efficient use of fuel. For the period 1995-1999 (base January 1995), the most and least efficient use of fuel was $0.89 and $1.78 per kilometer, respectively. For the period 2000-2004 (base January 2000), the most and least efficient use of fuel was $1.10 and $2.20 per kilometer, respectively, or $0.737 and $1.47 per kilometer excluding federal and state taxes.

APPENDIX O. WELFARE ANALYSIS RESULTS----MIXED LOGIT MODEL

Table O.1 Welfare Approximation Using the Mixed Logit Model for LAM (population)

Year	Trips to the Hypothetically Closed Area	Lower Bound Average Welfare Loss (dollars)	Upper Bound Average Welfare Loss (dollars)	Lower Bound Total Welfare Loss (dollars)	Upper Bound Total Welfare Loss (dollars)
1995	1194	-37.68	-108.67	-44,990	-129,752
1996	1103	-30.33	-87.46	-33,454	-96,468
1997	883	-41.91	-120.84	-37,007	-106,702
1998	533	-40.09	-115.59	-21,368	-61,610
1999	647	-25.98	-74.91	-16,809	-48,467
2000	538	-73.96	-146.90	-39,760	-79,038
2001	449	-76.82	-152.61	-34,492	-68,522
2002	1780	-78.70	-156.33	-140,086	-278,267
2003	1652	-66.66	-132.42	-110,112	-218,758
2004	1425	-53.30	-105.88	-75,952	-150,879

Note: Due to the fuel efficiency difference in vessels, the welfare loss is calculated within the range of the most efficient use of fuel and the least efficient use of fuel. For the period 1995-1999 (base January 1995), the most and least efficient use of fuel was \$0.89 and \$1.78 per kilometer, respectively. For the period 2000-2004 (base January 2000), the most and least efficient use of fuel was \$1.10 and \$2.20 per kilometer, respectively or \$0.737 and \$1.47 per kilometer excluding federal and state taxes.

Table O.2 Welfare Approximation Using the Mixed Logit Model for TX (population)

Year	Trips to the Hypothetically Closed Area	Lower Bound Average Welfare Loss (dollars)	Upper Bound Average Welfare Loss (dollars)	Lower Bound Total Welfare Loss (dollars)	Upper Bound Total Welfare Loss (dollars)
1995	1610	-113.93	-328.53	-183,427	-528,933
1996	1260	-134.05	-386.53	-168,903	-487,028
1997	1419	-124.75	-359.73	-177,020	-510,457
1998	1306	-144.64	-417.08	-188,900	-544,706
1999	1900	-128.23	-369.75	-246,637	-702,525
2000	1775	-102.61	-203.84	-182,133	-361,816
2001	1667	-125.07	-248.46	-208,492	-414,183
2002	1725	-106.67	-210.90	-183,143	-363,803
2003	1744	-91.75	-182.26	-160,012	-317,861
2004	1177	-134.63	-267.44	-158,460	-314,777

Note: Due to the fuel efficiency difference in vessels, the welfare loss is calculated within the range of the most efficient use of fuel and the least efficient use of fuel. For the period 1995-1999 (base January 1995), the most and least efficient use of fuel was $0.89 and $1.78 per kilometer, respectively. For the period 2000-2004 (base January 2000), the most and least efficient use of fuel was $1.10 and $2.20 per kilometer, respectively.

APPENDIX P. YEARLY TRIPS MADE FOR THE WHOLE FLEET AND INTERVIEW DATA

Table P.1 Yearly Trips

Year	Yearly Trips (interview data)	Yearly Trips (whole dataset)
1990	6798	50131
1991	6514	49751
1992	5819	53319
1993	5237	51756
1994	5186	54351
1995	5342	48622
1996	5391	45365
1997	4888	47134
1998	5475	45721
1999	4858	45921
2000	5030	46238
2001	4583	41223
2002	3472	43516
2003	3087	37834
2004	2988	34621

APPENDIX Q. TRIPS AND TRIP LENGTHS STATISTICS

Table Q.1 Trips across Vessels per Year for the Whole Fleet

Year	Trips	Vessels	Mean	Std	Coefficient of variation	Min	Max
1990	50131	3867	12.96	11.96	0.92	1	180
1991	49751	3819	13.03	11.13	0.85	1	123
1992	53319	3641	14.64	11.84	0.81	1	179
1993	51756	3700	13.99	12.16	0.87	1	143
1994	54351	4011	13.55	13.21	0.97	1	149
1995	48622	3962	12.27	11.52	0.94	1	156
1996	45365	3899	11.64	11.27	0.97	1	118
1997	47134	3756	12.55	11.46	0.91	1	114
1998	45721	3701	12.35	10.48	0.85	1	104
1999	45921	3601	12.75	12.23	0.96	1	171
2000	46238	3381	13.68	12.26	0.90	1	148
2001	41223	3476	11.86	10.19	0.86	1	123
2002	43516	3378	12.88	12.43	0.96	1	149
2003	37834	3040	12.45	12.61	1.01	1	138
2004	34621	2835	12.21	13.14	1.08	1	137

Table Q.2 Trip Length for Interview Data

Year	trips	vessels	mean	std	coefficient of variation	median	mode	max	min
1990	5027	1012	11.83	10.34	0.87	9	4	90	1
1991	5658	949	13.29	10.71	0.81	10	4	74	1
1992	4969	942	12.87	10.54	0.82	10	4	66	1
1993	4739	860	13.62	10.97	0.81	11	5	65	1
1994	4776	905	14.81	11.50	0.78	12	6	82	1
1995	4801	882	14.47	11.67	0.81	11	6	103	1
1996	4987	863	15.04	12.26	0.82	12	4	115	1
1997	4360	825	16.05	13.08	0.81	12	5	91	1
1998	4507	927	15.05	12.48	0.83	11	6	94	1
1999	3748	839	16.35	12.66	0.77	13	8	81	1
2000	4113	753	17.46	11.96	0.68	15	9	104	1
2001	4167	860	18.70	12.76	0.68	16	11	91	1
2002	3124	728	16.79	12.69	0.76	13	11	96	1
2003	2830	643	17.43	12.93	0.74	14	8	79	1
2004	2652	636	17.00	11.91	0.70	14	7	72	1

APPENDIX R. DAYS FISHED FOR INTERVIEW DATA

Table R.1 Days Fished Summary Statistics (Interview Data)

Year	trips	vessels	mean	std	coefficient of variation	median	mode	max	min
1990	5027	1012	5.60	5.60	1.00	4	4	48.5	0.1
1991	5658	949	6.29	5.55	0.88	4.7	2	53	0.1
1992	4969	942	6.11	5.48	0.90	4.5	2	46	0.1
1993	4739	860	6.32	5.67	0.90	5	2	63	0.1
1994	4776	905	6.75	5.72	0.85	5.5	2	51	0.1
1995	4801	882	6.58	5.65	0.86	5	2.5	40	0.1
1996	4987	863	6.66	5.67	0.85	5	1.5	41.6	0.1
1997	4360	825	7.06	6.06	0.86	5.4	1.5	41.5	0.1
1998	4507	927	7.03	6.11	0.87	5	5	41	0.1
1999	3748	839	7.84	6.60	0.84	6	5	45	0.1
2000	4113	753	8.37	6.27	0.75	7	3	42	0.1
2001	4167	860	8.43	6.21	0.74	7	5	38.5	0.1
2002	3124	728	7.60	6.01	0.79	6	5	41.6	0.1
2003	2830	643	7.77	6.00	0.77	6.3	5	40	0.1
2004	2652	636	7.55	5.75	0.76	6	5	41.6	0.1

APPENDIX S. AREAS TO CALCULATE SHRIMP ABUNDANCE

Table S.1 Grids by Fathom Zone and Subarea

Grid	Fathom	Subarea
F1	0-20	1,2,3,4,5,6,7
F2	>20	1,2,3,4,5,6,7
M1	0-5	8,9,10,11,12
M2	6-20	8,9,10,11,12
M3	>20	8,9,10,11,12
L1	0-10	13,14,15,16,17
L2	11-35	13,14,15,16,17
L3	>35	13,14,15,16,17
T1	0-5	18,19,20,21
T2	6-20	18,19,20,21
T3	21-35	18,19,20,21
T4	>35	18,19,20,21

APPENDIX T. SUMMARY STATISTICS, BY STATE

Table T.1 Summary Statistics by State for All the Variables

State	Variable	Mean	Median	Mode	Min	Max
AL	trip duration	18.08	16.00	15.00	1.00	71.00
AL	days fished	9.58	9.00	10.00	0.20	47.00
AL	vessel length	73.48	75.00	78.00	32.00	93.00
AL	diesel price index	1.04	1.03	1.11	0.77	1.49
AL	shrimp price	3.43	3.39	3.42	1.97	4.44
AL	price difference (large V.S medium)	2.33	2.28	3.40	1.43	3.75
AL	price difference (small V.S medium)	-1.52	-1.50	-0.84	-2.87	-0.76
AL	shrimp abundance	45.90	24.49	104.19	0.01	1375.02
AL	abundance difference (large V.S medium)	4.43	0.49	0.10	0.00	9633.00
AL	abundance difference (small V.S medium)	0.34	0.08	0.24	0.00	23.15
AL	BRD	0.48	0.00	0.00	0.00	1.00
AL	TX closure	0.00	0.00	0.00	0.00	0.00
AL	multiple site	0.12	0.00	0.00	0.00	1.00
AL	distance	189.82	159.69	167.62	27.93	716.04
FL	trip duration	12.27	11.00	6.00	2.00	57.00
FL	days fished	4.74	4.20	5.00	0.10	24.00
FL	vessel length	65.10	66.00	66.00	26.00	166.00
FL	diesel price index	1.05	1.03	0.87	0.77	1.49
FL	shrimp price	3.28	3.25	3.24	1.98	4.44
FL	price difference (large V.S medium)	2.19	2.17	1.54	1.30	3.75
FL	price difference (small V.S medium)	-1.56	-1.49	-1.71	-2.87	-0.61
FL	shrimp abundance	12.29	10.32	9.95	0.00	348.83
FL	abundance difference (large V.S medium)	0.37	0.31	0.34	0.00	9.87
FL	abundance difference (small V.S medium)	0.34	0.20	0.31	0.00	3.87
FL	BRD	0.41	0.00	0.00	0.00	1.00
FL	TX closure	0.00	0.00	0.00	0.00	0.00
FL	multiple site	0.05	0.00	0.00	0.00	1.00
FL	distance	95.52	92.03	92.03	10.64	932.88
LA	trip duration	7.34	7.00	5.00	1.00	50.00
LA	days fished	4.15	3.30	5.00	0.10	41.60
LA	vessel length	59.50	59.00	72.00	30.00	93.00
LA	diesel price index	1.05	1.04	1.06	0.77	1.49
LA	shrimp price	3.18	3.21	2.95	1.97	4.43
LA	price difference (large V.S medium)	2.22	2.18	1.61	1.30	3.75
LA	price difference (small V.S medium)	-1.44	-1.40	-1.38	-2.87	-0.61
LA	shrimp abundance	117.39	110.73	155.05	0.45	1202.97
LA	abundance difference (large V.S medium)	0.63	0.46	0.30	0.02	6.62
LA	abundance difference (small V.S medium)	1.64	0.87	0.45	0.01	21.78

Table T.1, continued

State	Variable	Mean	Median	Mode	Minimum	Maximum
LA	BRD	0.42	0.00	0.00	0.00	1.00
LA	TX closure	0.00	0.00	0.00	0.00	0.00
LA	multiple site	0.05	0.00	0.00	0.00	1.00
LA	distance	48.75	42.87	16.91	4.71	463.73
MI	trip duration	14.63	11.00	7.00	2.00	56.00
MI	days fished	5.53	4.60	5.00	0.60	21.50
MI	vessel length	57.17	56.00	56.00	33.00	86.00
MI	diesel price index	1.06	1.05	1.05	0.77	1.48
MI	shrimp price	3.14	3.17	2.00	2.00	4.42
MI	price difference (large V.S medium)	2.19	2.11	1.71	1.33	3.75
MI	price difference (small V.S medium)	-1.36	-1.39	-1.32	-2.35	-0.61
MI	shrimp abundance	60.51	30.15	12.08	0.14	618.69
MI	abundance difference (large V.S medium)	0.66	0.41	0.19	0.00	12.73
MI	abundance difference (small V.S medium)	0.56	0.10	0.04	0.00	21.78
MI	BRD	0.55	1.00	1.00	0.00	1.00
MI	TX closure	0.00	0.00	0.00	0.00	0.00
MI	multiple site	0.40	0.00	0.00	0.00	1.00
MI	distance	153.73	81.45	22.53	22.53	609.27
TX	trip duration	15.91	12.00	4.00	1.00	115.00
TX	days fished	7.20	5.50	2.00	0.10	63.00
TX	vessel length	66.29	66.00	64.00	27.00	195.00
TX	diesel price index	1.03	1.02	0.95	0.77	1.49
TX	shrimp price	3.29	3.26	3.30	1.97	4.44
TX	price difference (large V.S medium)	2.24	2.23	2.28	1.30	3.75
TX	price difference (small V.S medium)	-1.48	-1.44	-1.12	-2.87	-0.61
TX	shrimp abundance	104.17	69.13	322.69	0.00	2035.56
TX	abundance difference (large V.S medium)	1.56	0.74	0.15	0.00	7614.00
TX	abundance difference (small V.S medium)	0.58	0.08	0.03	0.00	156.00
TX	BRD	0.35	0.00	0.00	0.00	1.00
TX	TX closure	0.15	0.00	0.00	0.00	1.00
TX	multiple site	0.13	0.00	0.00	0.00	1.00
TX	distance	125.50	57.40	36.68	12.29	1042.79

APPENDIX U. SUMMARY STATISTICS, BY YEAR

Table U.1 Summary Statistics by Year for All the Variables

Year	Variable	Mean	Median	Mode	Min	Max
90	trip duration	11.88	9.00	6.00	1.00	90.00
90	days fished	5.54	4.00	5.00	0.10	48.50
90	vessel length	64.86	66.00	66.00	26.00	94.00
90	diesel price index	1.19	1.21	1.43	0.99	1.43
90	shrimp price	3.07	3.12	2.97	2.53	3.47
90	price difference (large V.S medium)	1.89	1.88	1.88	1.54	2.36
90	price difference (small V.S medium)	-1.36	-1.32	-1.29	-1.83	-1.07
90	shrimp abundance	82.76	43.15	348.83	0.00	750.53
90	abundance difference (large V.S medium)	4.49	0.49	0.11	0.00	7614.00
90	abundance difference (small V.S medium)	0.46	0.10	0.03	0.00	5.87
90	BRD	0.00	0.00	0.00	0.00	0.00
90	TX closure	0.12	0.00	0.00	0.00	1.00
90	multiple site	0.08	0.00	0.00	0.00	1.00
90	Distance	94.21	53.25	92.03	14.29	937.29
91	trip duration	13.35	10.00	4.00	1.00	74.00
91	days fished	6.26	4.60	2.00	0.10	53.00
91	vessel length	65.42	66.00	66.00	28.00	195.00
91	diesel price index	1.09	1.07	1.03	1.03	1.27
91	shrimp price	3.35	3.31	3.30	2.80	3.75
91	price difference (large V.S medium)	2.03	1.98	2.28	1.43	3.09
91	price difference (small V.S medium)	-1.52	-1.43	-1.12	-2.08	-1.12
91	shrimp abundance	112.62	50.18	433.11	0.13	2035.56
91	abundance difference (large V.S medium)	4.55	0.63	0.19	0.00	9633.00
91	abundance difference (small V.S medium)	0.33	0.06	0.04	0.00	3.41
91	BRD	0.00	0.00	0.00	0.00	0.00
91	TX closure	0.10	0.00	0.00	0.00	1.00
91	multiple site	0.07	0.00	0.00	0.00	1.00
91	Distance	95.21	53.25	35.06	14.29	923.09
92	trip duration	12.93	10.00	4.00	1.00	66.00
92	days fished	6.09	4.50	2.00	0.10	46.00
92	vessel length	64.49	66.00	66.00	27.00	195.00
92	diesel price index	1.05	1.06	1.06	1.01	1.08
92	shrimp price	3.06	3.05	3.05	2.56	3.59
92	price difference (large V.S medium)	2.12	2.20	2.59	1.56	2.59
92	price difference (small V.S medium)	-1.20	-1.15	-0.97	-1.73	-0.86
92	shrimp abundance	83.14	63.61	216.38	0.00	757.65
92	abundance difference (large V.S medium)	1.03	0.56	0.16	0.00	180.18
92	abundance difference (small V.S medium)	0.71	0.11	0.06	0.00	61.36

Table U.1, continued

Year	Variable	Mean	Median	Mode	Minimum	Maximum
92	BRD	0.00	0.00	0.00	0.00	0.00
92	TX closure	0.08	0.00	0.00	0.00	1.00
92	multiple site	0.04	0.00	0.00	0.00	1.00
92	Distance	95.37	52.98	35.06	11.81	937.29
93	trip duration	13.65	11.00	5.00	1.00	65.00
93	days fished	6.29	4.90	2.00	0.10	63.00
93	vessel length	65.78	66.00	66.00	28.00	100.00
93	diesel price index	1.02	1.01	0.99	0.97	1.11
93	shrimp price	3.03	3.02	2.86	2.51	3.38
93	price difference (large V.S medium)	2.18	2.07	2.07	1.71	2.73
93	price difference (small V.S medium)	-1.58	-1.73	-1.48	-1.88	-0.98
93	shrimp abundance	73.48	52.30	185.78	0.01	872.59
93	abundance difference (large V.S medium)	2.00	0.68	0.19	0.00	3025.00
93	abundance difference (small V.S medium)	0.56	0.12	0.12	0.00	5.13
93	BRD	0.00	0.00	0.00	0.00	0.00
93	TX closure	0.09	0.00	0.00	0.00	1.00
93	multiple site	0.05	0.00	0.00	0.00	1.00
93	Distance	98.09	53.25	36.68	12.29	845.13
94	trip duration	14.86	12.00	6.00	1.00	82.00
94	days fished	6.74	5.45	2.00	0.10	51.00
94	vessel length	65.71	66.00	66.00	29.00	90.00
94	diesel price index	0.99	0.99	0.99	0.98	1.00
94	shrimp price	3.80	3.90	3.79	2.68	4.37
94	price difference (large V.S medium)	1.90	1.81	1.57	1.57	2.27
94	price difference (small V.S medium)	-1.81	-1.85	-1.86	-2.34	-1.34
94	shrimp abundance	97.19	61.06	322.69	0.09	639.78
94	abundance difference (large V.S medium)	1.03	0.79	0.15	0.00	6.41
94	abundance difference (small V.S medium)	0.37	0.10	0.03	0.00	3.53
94	BRD	0.00	0.00	0.00	0.00	0.00
94	TX closure	0.11	0.00	0.00	0.00	1.00
94	multiple site	0.09	0.00	0.00	0.00	1.00
94	Distance	114.64	60.17	45.44	11.81	1042.79
95	trip duration	14.51	11.00	6.00	1.00	103.00
95	days fished	6.57	5.00	2.50	0.10	40.00
95	vessel length	65.95	66.00	66.00	30.00	91.00
95	diesel price index	0.96	0.96	0.95	0.95	0.98
95	shrimp price	3.54	3.44	3.35	3.05	4.19
95	price difference (large V.S medium)	2.39	2.42	2.66	1.61	3.23
95	price difference (small V.S medium)	-1.49	-1.40	-1.21	-2.35	-1.14
95	shrimp abundance	81.37	55.42	214.86	0.10	1003.62

Table U.1, continued

Year	Variable	Mean	Median	Mode	Minimum	Maximum
95	abundance difference (large V.S medium)	1.18	0.77	0.21	0.02	19.53
95	abundance difference (small V.S medium)	0.47	0.08	0.08	0.00	7.80
95	BRD	0.00	0.00	0.00	0.00	0.00
95	TX closure	0.06	0.00	0.00	0.00	1.00
95	multiple site	0.13	0.00	0.00	0.00	1.00
95	Distance	114.84	57.40	36.68	4.71	959.95
96	trip duration	15.10	12.00	4.00	1.00	115.00
96	days fished	6.65	5.00	1.50	0.10	41.60
96	vessel length	66.17	66.00	66.00	30.00	88.00
96	diesel price index	1.04	1.06	1.11	0.98	1.11
96	shrimp price	3.22	3.21	3.14	2.82	3.45
96	price difference (large V.S medium)	2.53	2.54	2.59	1.99	3.19
96	price difference (small V.S medium)	-1.51	-1.48	-1.48	-2.30	-1.03
96	shrimp abundance	84.84	55.90	160.63	0.02	726.24
96	abundance difference (large V.S medium)	1.15	0.70	0.11	0.00	25.63
96	abundance difference (small V.S medium)	0.67	0.09	0.08	0.00	38.55
96	BRD	0.00	0.00	0.00	0.00	0.00
96	TX closure	0.10	0.00	0.00	0.00	1.00
96	multiple site	0.13	0.00	0.00	0.00	1.00
96	Distance	132.52	64.69	35.06	4.71	959.95
97	trip duration	16.09	12.00	4.00	1.00	91.00
97	days fished	7.05	5.30	1.50	0.10	41.50
97	vessel length	66.35	66.00	68.00	30.00	88.00
97	diesel price index	0.99	0.97	0.95	0.91	1.07
97	shrimp price	3.72	3.76	3.91	2.73	4.27
97	price difference (large V.S medium)	2.38	2.33	2.29	1.98	2.84
97	price difference (small V.S medium)	-2.03	-2.05	-2.05	-2.87	-1.57
97	shrimp abundance	62.57	36.88	122.78	0.05	878.46
97	abundance difference (large V.S medium)	1.20	0.62	0.11	0.00	6.86
97	abundance difference (small V.S medium)	0.96	0.09	0.08	0.00	13.95
97	BRD	0.00	0.00	0.00	0.00	0.00
97	TX closure	0.12	0.00	0.00	0.00	1.00
97	multiple site	0.08	0.00	0.00	0.00	1.00
97	Distance	137.18	74.87	36.68	4.71	959.95
98	trip duration	15.07	11.00	6.00	1.00	94.00
98	days fished	7.03	5.00	5.00	0.10	41.00
98	vessel length	66.67	66.00	66.00	30.00	89.00
98	diesel price index	0.85	0.84	0.84	0.78	0.92
98	shrimp price	3.47	3.35	3.22	2.70	4.20

Table U.1, continued

Year	Variable	Mean	Median	Mode	Minimum	Maximum
98	price difference (large V.S medium)	2.88	2.88	2.88	1.98	3.75
98	price difference (small V.S medium)	-1.61	-1.45	-1.45	-2.39	-1.03
98	shrimp abundance	106.42	68.39	224.23	0.09	777.36
98	abundance difference (large V.S medium)	0.86	0.45	0.13	0.02	8.51
98	abundance difference (small V.S medium)	0.67	0.10	0.08	0.00	14.09
98	BRD	0.73	1.00	1.00	0.00	1.00
98	TX closure	0.11	0.00	0.00	0.00	1.00
98	multiple site	0.10	0.00	0.00	0.00	1.00
98	Distance	133.13	60.55	48.97	4.71	975.27
99	trip duration	16.36	13.00	8.00	1.00	81.00
99	days fished	7.82	6.00	5.00	0.10	45.00
99	vessel length	66.91	67.00	68.00	33.00	92.00
99	diesel price index	0.90	0.89	0.89	0.77	1.01
99	shrimp price	3.43	3.45	3.37	2.62	3.91
99	price difference (large V.S medium)	2.83	2.75	2.88	2.25	3.42
99	price difference (small V.S medium)	-1.56	-1.54	-1.23	-2.37	-1.19
99	shrimp abundance	95.99	70.47	107.27	0.02	661.81
99	abundance difference (large V.S medium)	0.93	0.61	0.34	0.02	5.40
99	abundance difference (small V.S medium)	0.39	0.07	0.06	0.00	12.84
99	BRD	1.00	1.00	1.00	1.00	1.00
99	TX closure	0.15	0.00	0.00	0.00	1.00
99	multiple site	0.12	0.00	0.00	0.00	1.00
99	Distance	137.86	81.57	57.40	4.71	959.95
2000	trip duration	17.49	15.00	9.00	1.00	104.00
2000	days fished	8.37	7.00	3.00	0.10	42.00
2000	vessel length	67.84	67.00	68.00	32.00	92.00
2000	diesel price index	1.14	1.12	1.10	1.06	1.25
2000	shrimp price	3.92	4.00	4.19	3.35	4.44
2000	price difference (large V.S medium)	2.26	2.37	2.37	1.66	2.85
2000	price difference (small V.S medium)	-1.65	-1.54	-1.59	-2.37	-1.29
2000	shrimp abundance	110.44	65.78	261.38	0.05	1375.02
2000	abundance difference (large V.S medium)	0.69	0.49	0.22	0.03	7.08
2000	abundance difference (small V.S medium)	0.35	0.11	0.07	0.00	5.31
2000	BRD	1.00	1.00	1.00	1.00	1.00
2000	TX closure	0.15	0.00	0.00	0.00	1.00
2000	multiple site	0.13	0.00	0.00	0.00	1.00
2000	Distance	140.41	104.25	36.68	4.71	943.00
2001	trip duration	18.70	16.00	11.00	1.00	91.00
2001	days fished	8.43	7.00	5.00	0.10	38.50

Table U.1, continued

Year	Variable	Mean	Median	Mode	Minimum	Maximum
2001	vessel length	68.41	68.00	68.00	27.00	94.00
2001	diesel price index	1.06	1.05	1.03	0.87	1.15
2001	shrimp price	3.48	3.39	3.39	2.88	4.07
2001	price difference (large V.S medium)	2.43	2.09	3.27	1.66	3.40
2001	price difference (small V.S medium)	-1.36	-1.30	-0.88	-2.04	-0.84
2001	shrimp abundance	92.12	50.34	278.86	0.01	1515.49
2001	abundance difference (large V.S medium)	0.73	0.59	0.19	0.00	4.03
2001	abundance difference (small V.S medium)	0.57	0.13	0.06	0.00	23.15
2001	BRD	1.00	1.00	1.00	1.00	1.00
2001	TX closure	0.12	0.00	0.00	0.00	1.00
2001	multiple site	0.18	0.00	0.00	0.00	1.00
2001	Distance	154.94	108.92	36.68	11.81	959.95
2002	trip duration	16.81	13.00	11.00	1.00	96.00
2002	days fished	7.61	6.00	5.00	0.10	41.60
2002	vessel length	66.58	66.00	68.00	27.00	93.00
2002	diesel price index	0.97	0.97	0.95	0.86	1.07
2002	shrimp price	2.80	2.76	2.76	2.46	3.38
2002	price difference (large V.S medium)	2.01	1.94	2.45	1.74	2.45
2002	price difference (small V.S medium)	-1.06	-0.92	-0.61	-1.85	-0.61
2002	shrimp abundance	86.66	45.86	136.27	0.06	679.05
2002	abundance difference (large V.S medium)	0.77	0.56	0.20	0.01	5.16
2002	abundance difference (small V.S medium)	1.05	0.08	0.08	0.00	22.47
2002	BRD	1.00	1.00	1.00	1.00	1.00
2002	TX closure	0.16	0.00	0.00	0.00	1.00
2002	multiple site	0.25	0.00	0.00	0.00	1.00
2002	Distance	145.97	98.74	36.68	13.06	960.58
2003	trip duration	17.45	14.00	8.00	1.00	79.00
2003	days fished	7.78	6.30	5.00	0.10	40.00
2003	vessel length	67.05	67.00	68.00	31.00	94.00
2003	diesel price index	1.06	1.06	1.03	1.03	1.23
2003	shrimp price	2.47	2.47	2.47	1.97	2.96
2003	price difference (large V.S medium)	1.67	1.73	1.73	1.30	2.00
2003	price difference (small V.S medium)	-1.12	-1.06	-0.90	-1.71	-0.82
2003	shrimp abundance	112.12	92.36	119.95	0.05	959.42
2003	abundance difference (large V.S medium)	0.65	0.43	0.23	0.00	6.71
2003	abundance difference (small V.S medium)	1.00	0.12	0.15	0.00	21.78
2003	BRD	1.00	1.00	1.00	1.00	1.00
2003	TX closure	0.09	0.00	0.00	0.00	1.00
2003	multiple site	0.25	0.00	0.00	0.00	1.00

Table U.1, continued

Year	Variable	Mean	Median	Mode	Minimum	Maximum
2003	Distance	151.42	103.84	48.97	11.81	959.95
2004	trip duration	17.03	14.00	7.00	1.00	72.00
2004	days fished	7.55	6.00	5.00	0.10	41.60
2004	vessel length	67.48	67.00	64.00	37.00	93.00
2004	diesel price index	1.28	1.23	1.22	1.10	1.49
2004	shrimp price	2.22	2.16	2.09	2.05	2.69
2004	price difference (large V.S medium)	1.92	1.86	2.02	1.64	2.25
2004	price difference (small V.S medium)	-1.00	-0.91	-0.84	-1.42	-0.76
2004	shrimp abundance	92.46	64.33	105.18	0.01	715.46
2004	abundance difference (large V.S medium)	0.77	0.70	0.55	0.00	9.03
2004	abundance difference (small V.S medium)	1.03	0.09	0.09	0.00	156.00
2004	BRD	1.00	1.00	1.00	1.00	1.00
2004	TX closure	0.14	0.00	0.00	0.00	1.00
2004	multiple site	0.22	0.00	0.00	0.00	1.00
2004	Distance	141.30	107.36	109.99	16.91	960.58

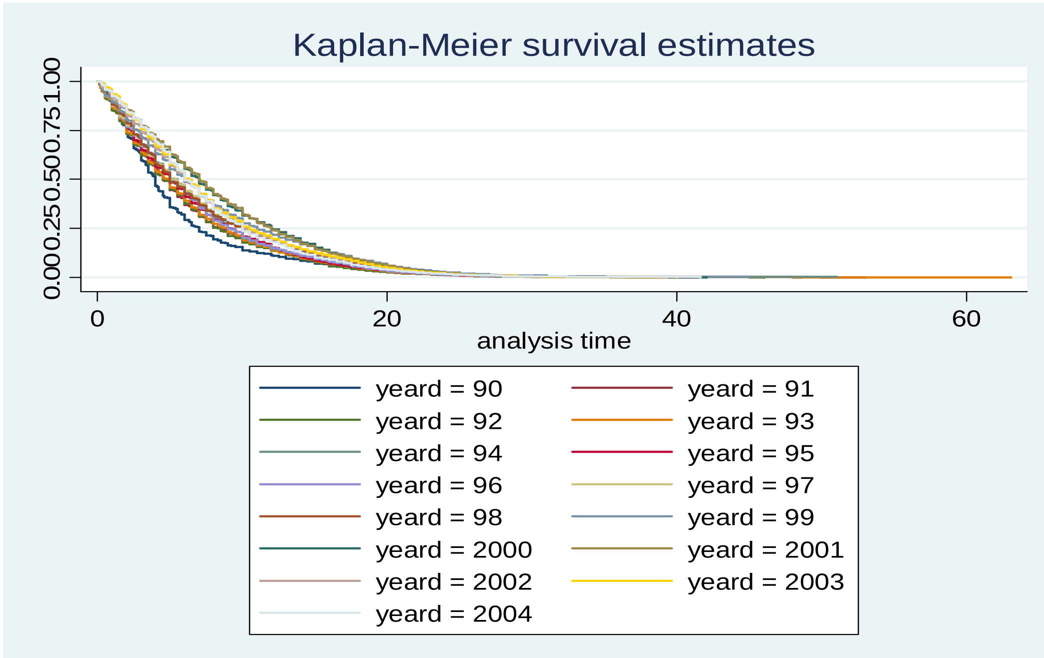

Figure V.1 Days fished by year

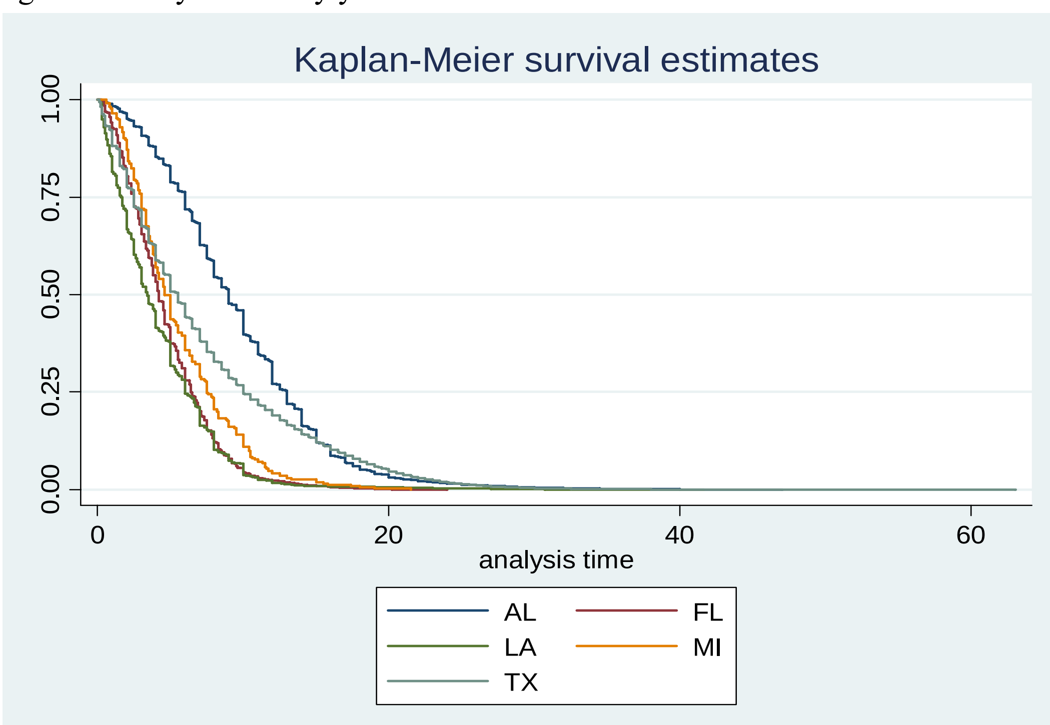

Figure V.2 Days fished by state

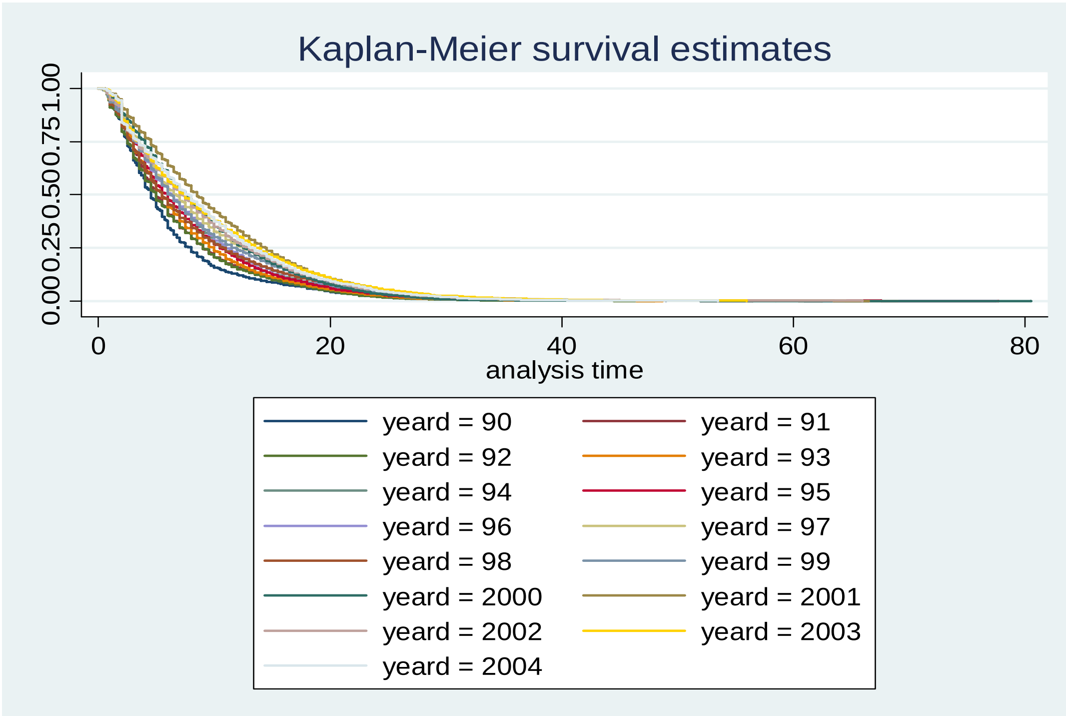

Figure V.3 Travel time by year

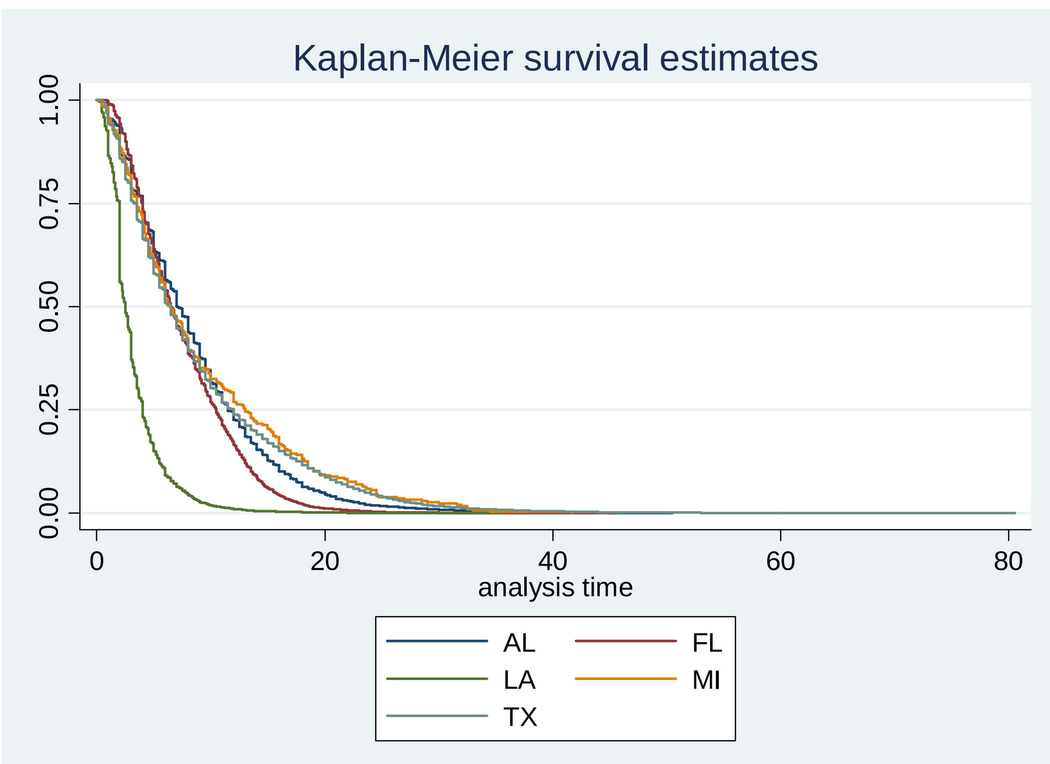

Figure V.4 Travel time by state

APPENDIX W. PARAMETRIC ESTIMATION RESULTS---WEIBULL DISTRIBUTION

Table W.1 Parametric Results by Stratifying State

Variables	Travel time	Days fished
year91	-0.101***	-0.0207
	(0.0270)	(0.0274)
year92	-0.155***	-0.0762**
	(0.0311)	(0.0320)
year93	-0.174***	-0.0471
	(0.0366)	(0.0380)
year94	-0.194***	0.142***
	(0.0403)	(0.0418)
year95	-0.207***	0.0207
	(0.0428)	(0.0432)
year96	-0.291***	-0.0218
	(0.0422)	(0.0407)
year97	-0.359***	0.0582
	(0.0441)	(0.0456)
year98	-0.558***	0.151***
	(0.0626)	(0.0577)
year99	-0.635***	0.136**
	(0.0706)	(0.0666)
year2000	-0.563***	0.0101
	(0.0707)	(0.0644)
year2001	-0.734***	-0.00154
	(0.0709)	(0.0627)
year2002	-0.595***	0.0228
	(0.0709)	(0.0696)
year2003	-0.676***	-0.019
	(0.0714)	(0.0682)
year2004	-0.651***	-0.171**
	(0.0717)	(0.0681)
vessel length	-0.0376***	-0.0425***
	(0.0043)	(0.0042)
diesel price index	-0.0677	0.540***
	(0.0781)	(0.0797)
shrimp price	-0.0289	-0.168***
	(0.0187)	(0.0164)
price difference	-0.0222	0.158***
(large V.S medium)	(0.0206)	(0.0223)
price difference	0.0771***	0.0417**
(small V.S medium)	(0.0214)	(0.0208)

Table W.1, continued

Variables	Travel time	Days fished
ln(abundance)	0.0429***	-0.0268***
	(0.0067)	(0.0071)
ln(abundance)	-0.0855***	-0.00846
(large V.S medium)	(0.0089)	(0.0084)
ln(abundance)	0.0299***	0.0581***
(small V.S medium)	(0.0091)	(0.0089)
TX closure	-0.346***	-0.182***
	(0.0208)	(0.0184)
BRD	0.434***	-0.247***
	(0.0460)	(0.0419)
Multiple site	-0.614***	-0.339***
	(0.0216)	(0.0198)
ln(distance)		-0.566***
		(0.0121)
FL	-0.916***	1.224***
	(0.1520)	(0.1750)
LA	0.736***	1.181***
	(0.1450)	(0.1950)
MS	-0.267	0.292
	(0.3320)	(0.2860)
TX	0.267**	1.676***
	(0.1090)	(0.1550)
Constant	0.0486	1.012***
	(0.3340)	(0.3500)
lnp(FL)	0.171***	-0.172***
	(0.0280)	(0.0340)
lnp(LA)	0.0632**	-0.313***
	(0.0318)	(0.0409)
lnp(MS)	-0.0689	-0.0155
	(0.0760)	(0.0627)
lnp(TX)	-0.154***	-0.439***
	(0.0241)	(0.0329)
lnp(AL)	0.434***	0.723***
	(0.0205)	(0.0279)
Observations	64038	64038
Log pseudolikelihood	-76721	-76981
*** p<0.01, ** p<0.05, * p<0.1		
Robust standard errors in parentheses		

APPENDIX X. SEMIPARAMETRIC ESTIMATION RESULTS---COX PROPORTIONAL HAZARD MODEL

Table X.1 Semi-parametric Results

	Travel time		Days fished	
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
year91	-0.101***	0.904***	-0.0129	0.987
	(0.0244)	(0.0221)	(0.0281)	(0.0278)
year92	-0.152***	0.859***	-0.0692**	0.933**
	(0.0285)	(0.0245)	(0.0327)	(0.0305)
year93	-0.167***	0.846***	-0.037	0.964
	(0.0337)	(0.0285)	(0.0382)	(0.0368)
year94	-0.186***	0.830***	0.154***	1.166***
	(0.0373)	(0.0310)	(0.0419)	(0.0489)
year95	-0.193***	0.824***	0.0387	1.039
	(0.0396)	(0.0327)	(0.0431)	(0.0448)
year96	-0.273***	0.761***	-0.00816	0.992
	(0.0393)	(0.0299)	(0.0406)	(0.0403)
year97	-0.340***	0.712***	0.0697	1.072
	(0.0411)	(0.0293)	(0.0454)	(0.0487)
year98	-0.515***	0.598***	0.155***	1.168***
	(0.0582)	(0.0348)	(0.0570)	(0.0666)
year99	-0.590***	0.554***	0.136**	1.146**
	(0.0660)	(0.0366)	(0.0655)	(0.0751)
year2000	-0.553***	0.575***	0.0302	1.031
	(0.0659)	(0.0379)	(0.0627)	(0.0647)
year2001	-0.705***	0.494***	0.0197	1.02
	(0.0653)	(0.0323)	(0.0610)	(0.0622)
year2002	-0.581***	0.559***	0.0519	1.053
	(0.0669)	(0.0374)	(0.0668)	(0.0703)
year2003	-0.660***	0.517***	0.0186	1.019
	(0.0669)	(0.0346)	(0.0647)	(0.0660)
year2004	-0.637***	0.529***	-0.122*	0.885*
	(0.0665)	(0.0352)	(0.0647)	(0.0573)
vessel length	-0.0361***	0.965***	-0.0417***	0.959***
	(0.0044)	(0.0042)	(0.0039)	(0.0037)
diesel price index	-0.0354	0.965	0.517***	1.677***
	(0.0705)	(0.0681)	(0.0799)	(0.1340)
shrimp price	-0.0330*	0.968*	-0.163***	0.850***
	(0.0172)	(0.0166)	(0.0163)	(0.0138)
price difference	-0.0186	0.982	0.163***	1.177***
(large V.S medium)	(0.0198)	(0.0194)	(0.0203)	(0.0239)

Table X.1, continued

	Travel time		Days fished	
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
ln(abundance)	0.0357***	1.036***	-0.0243***	0.976***
	(0.0064)	(0.0067)	(0.0065)	(0.0064)
ln(abundance)	-0.0853***	0.918***	-0.0056	0.994
(large V.S medium)	(0.0083)	(0.0076)	(0.0078)	(0.0077)
ln(abundance)	0.0327***	1.033***	0.0554***	1.057***
(small V.S medium)	(0.0088)	(0.0091)	(0.0082)	(0.0087)
TX closure	-0.331***	0.718***	-0.174***	0.840***
	(0.0192)	(0.0138)	(0.0187)	(0.0157)
BRD	0.400***	1.491***	-0.246***	0.782***
	(0.0430)	(0.0641)	(0.0411)	(0.0321)
Multiple site	-0.571***	0.565***	-0.356***	0.700***
	(0.0198)	(0.0112)	(0.0191)	(0.0134)
ln(distance)			-0.566***	0.568***
			(0.0127)	(0.0072)
Log pseudolikelihood	-587689		-581990	
Observations			64038	64038

*** p<0.01, ** p<0.05, * p<0.1
Standard errors in parentheses

APPENDIX Y. PARAMETRIC ESTIMATION RESULTS---DUMMY EXPLANATORY VARIABLES

Table Y.1 Parametric Results with Dummy Variables

	Travel time		Days fished	
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
year91	-0.179***	0.836***	-0.0824***	0.921***
	(0.0254)	(0.0212)	(0.0196)	(0.0180)
year92	-0.145***	0.865***	-0.0366*	0.964*
	(0.0262)	(0.0226)	(0.0202)	(0.0195)
year93	-0.209***	0.811***	-0.0685***	0.934***
	(0.0266)	(0.0215)	(0.0204)	(0.0191)
year94	-0.372***	0.689***	-0.142***	0.868***
	(0.0266)	(0.0183)	(0.0204)	(0.0177)
year95	-0.373***	0.689***	-0.141***	0.869***
	(0.0265)	(0.0183)	(0.0203)	(0.0177)
year96	-0.465***	0.628***	-0.149***	0.861***
	(0.0264)	(0.0166)	(0.0202)	(0.0174)
year97	-0.598***	0.550***	-0.235***	0.791***
	(0.0273)	(0.0150)	(0.0209)	(0.0165)
year98	-0.375***	0.687***	-0.217***	0.805***
	(0.0271)	(0.0186)	(0.0207)	(0.0166)
year99	-0.489***	0.613***	-0.354***	0.702***
	(0.0284)	(0.0174)	(0.0217)	(0.0153)
year2000	-0.610***	0.543***	-0.382***	0.682***
	(0.0278)	(0.0151)	(0.0213)	(0.0145)
year2001	-0.803***	0.448***	-0.378***	0.685***
	(0.0281)	(0.0126)	(0.0213)	(0.0146)
year2002	-0.613***	0.542***	-0.369***	0.692***
	(0.0299)	(0.0162)	(0.0229)	(0.0158)
year2003	-0.711***	0.491***	-0.413***	0.662***
	(0.0308)	(0.0151)	(0.0237)	(0.0157)
year2004	-0.716***	0.489***	-0.379***	0.685***
	(0.0314)	(0.0153)	(0.0242)	(0.0166)
FL	0.0746***	1.077***	0.822***	2.274***
	(0.0239)	(0.0257)	(0.0192)	(0.0437)
LA	1.472***	4.358***	0.988***	2.686***
	(0.0280)	(0.1220)	(0.0213)	(0.0572)
MS	-0.0633	0.939	0.679***	1.972***
	(0.0755)	(0.0708)	(0.0592)	(0.1170)
TX	-0.0847***	0.919***	0.262***	1.300***
	(0.0191)	(0.0175)	(0.0150)	(0.0194)

Table Y.1, continued

	Travel time		Days fished	
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
Weibull shape		1.586***		1.224***
		(0.0094)		(0.0038)
Gamma parameter (θ)		0.322***		3.7E-08
		(0.0107)		(0.0000)
Log Likelihood	-80490		-88137.7	
Observations	64038		64038	

*** p<0.01, ** p<0.05, * p<0.1
Standard errors in parentheses

APPENDIX Z. PARAMETRIC ESTIMATION RESULTS--- NO HETEROGENEITY SPECIFIED

Table Z.1 Parametric Results without Heterogeneity Specified

	Travel time		Days fished	
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
year91	-0.0921***	0.912***	-0.00499	0.995
	(0.0212)	(0.0194)	(0.0216)	(0.0215)
year92	-0.145***	0.865***	-0.0556**	0.946**
	(0.0224)	(0.0194)	(0.0226)	(0.0214)
year93	-0.157***	0.855***	-0.0236	0.977
	(0.0243)	(0.0208)	(0.0245)	(0.0240)
year94	-0.184***	0.832***	0.168***	1.183***
	(0.0270)	(0.0225)	(0.0274)	(0.0324)
year95	-0.187***	0.830***	0.0653**	1.067**
	(0.0268)	(0.0223)	(0.0270)	(0.0288)
year96	-0.268***	0.765***	0.00295	1.003
	(0.0244)	(0.0186)	(0.0244)	(0.0245)
year97	-0.349***	0.705***	0.0792***	1.082***
	(0.0288)	(0.0203)	(0.0291)	(0.0315)
year98	-0.565***	0.568***	0.172***	1.188***
	(0.0420)	(0.0238)	(0.0423)	(0.0502)
year99	-0.646***	0.524***	0.175***	1.192***
	(0.0482)	(0.0252)	(0.0485)	(0.0578)
year2000	-0.552***	0.576***	0.0339	1.034
	(0.0494)	(0.0284)	(0.0491)	(0.0508)
year2001	-0.711***	0.491***	0.0309	1.031
	(0.0465)	(0.0229)	(0.0460)	(0.0474)
year2002	-0.573***	0.564***	0.0659	1.068
	(0.0461)	(0.0260)	(0.0453)	(0.0484)
year2003	-0.660***	0.517***	0.00837	1.008
	(0.0454)	(0.0235)	(0.0447)	(0.0450)
year2004	-0.631***	0.532***	-0.134***	0.875***
	(0.0453)	(0.0241)	(0.0447)	(0.0391)
FL	-0.258***	0.773***	0.217***	1.243***
	(0.0202)	(0.0156)	(0.0204)	(0.0254)
LA	0.763***	2.144***	-0.268***	0.765***
	(0.0245)	(0.0525)	(0.0251)	(0.0192)
MS	-0.485***	0.616***	-0.127**	0.881**
	(0.0604)	(0.0372)	(0.0604)	(0.0532)
TX	-0.267***	0.765***	-0.117***	0.889***
	(0.0162)	(0.0124)	(0.0163)	(0.0145)

Table Z.1, Continued

	Travel time		Days fished	
	Coefficient	Hazard ratio	Coefficient	Hazard ratio
diesel price index	-0.068	0.934	0.568***	1.764***
	(0.0610)	(0.0570)	(0.0623)	(0.1100)
shrimp price	-0.0207	0.979	-0.168***	0.845***
	(0.0158)	(0.0155)	(0.0163)	(0.0138)
price difference	-0.017	0.983	0.148***	1.160***
(large V.S medium)	(0.0138)	(0.0136)	(0.0139)	(0.0161)
price difference	0.0754***	1.078***	0.0391**	1.040**
(small V.S medium)	(0.0161)	(0.0174)	(0.0165)	(0.0172)
ln(abundance)	0.0470***	1.048***	-0.0251***	0.975***
	(0.0028)	(0.0029)	(0.0027)	(0.0027)
ln(abundance)	-0.0875***	0.916***	-0.00729	0.993
(large V.S medium)	(0.0044)	(0.0041)	(0.0048)	(0.0048)
ln(abundance)	0.0291***	1.030***	0.0600***	1.062***
(small V.S medium)	(0.0034)	(0.0035)	(0.0034)	(0.0036)
TX closure	-0.358***	0.699***	-0.191***	0.826***
	(0.0148)	(0.0104)	(0.0150)	(0.0124)
BRD	0.459***	1.582***	-0.243***	0.784***
	(0.0368)	(0.0582)	(0.0371)	(0.0291)
multiple site	-0.638***	0.528***	-0.351***	0.704***
	(0.0128)	(0.0068)	(0.0131)	(0.0092)
ln(distance)			-0.576***	0.562***
			(0.0057)	(0.0032)
constant	0.262**	1.299**	2.522***	12.46***
	(0.1030)	(0.1340)	(0.1080)	(1.3410)
Weibull shape		1.390***		1.408***
		(0.0041)		(0.0043)
Log Likelihood	-77363		--77997.6	
Observations	64038		64038	

*** p<0.01, ** p<0.05, * p<0.1
Standard errors in parentheses

APPENDIX AA. GOODNESS-OF-FIT GRAPHS

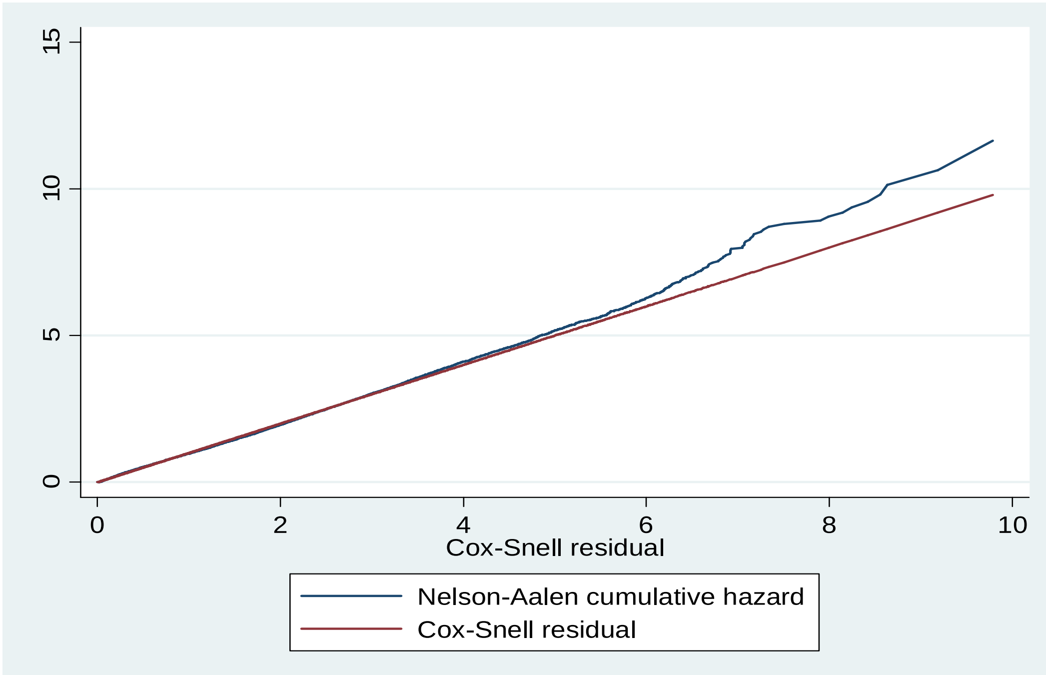

Figure AA.1 Goodness-of-fit for travel time (final model in Table 4.2)

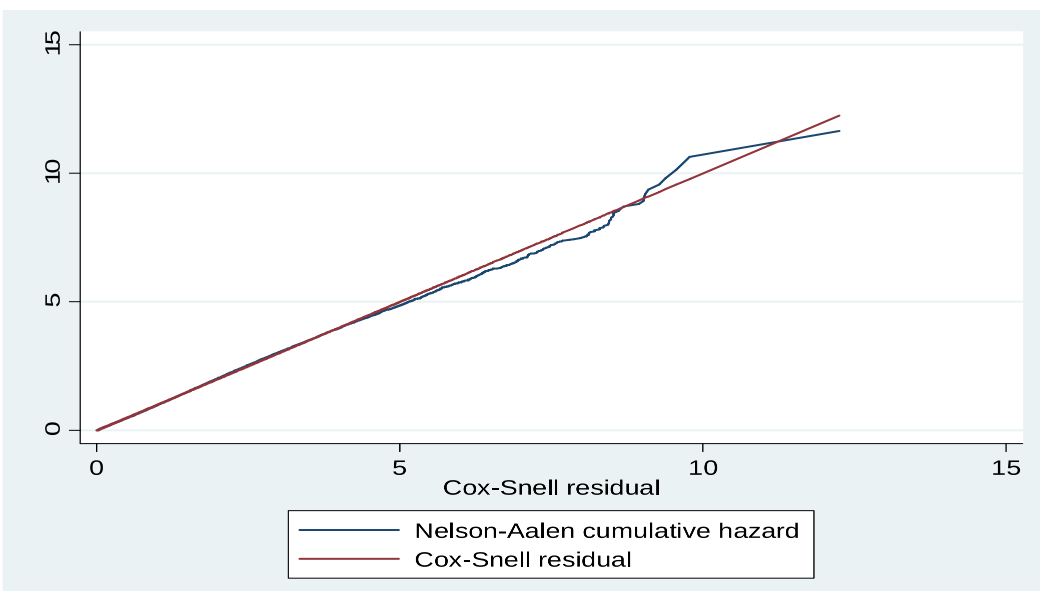

Figure AA.2 Goodness-of-fit for days fished (final model in Table 4.2)

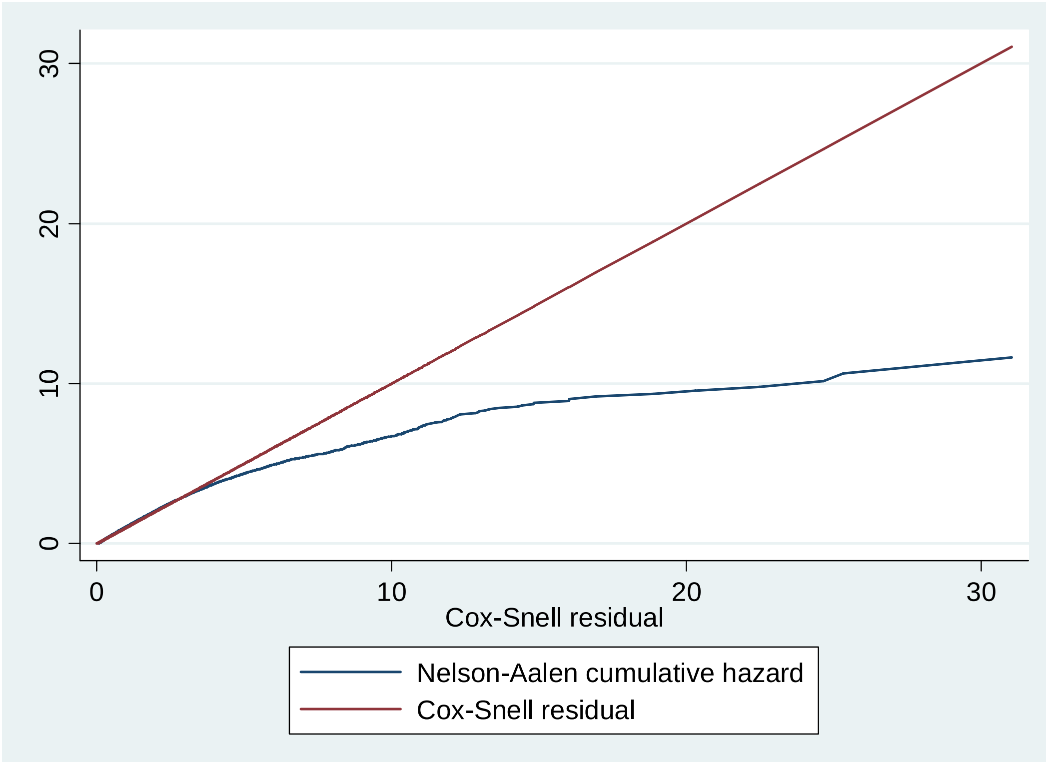

Figure AA.3 Goodness-of-fit for travel time (final model in Appendix Z)

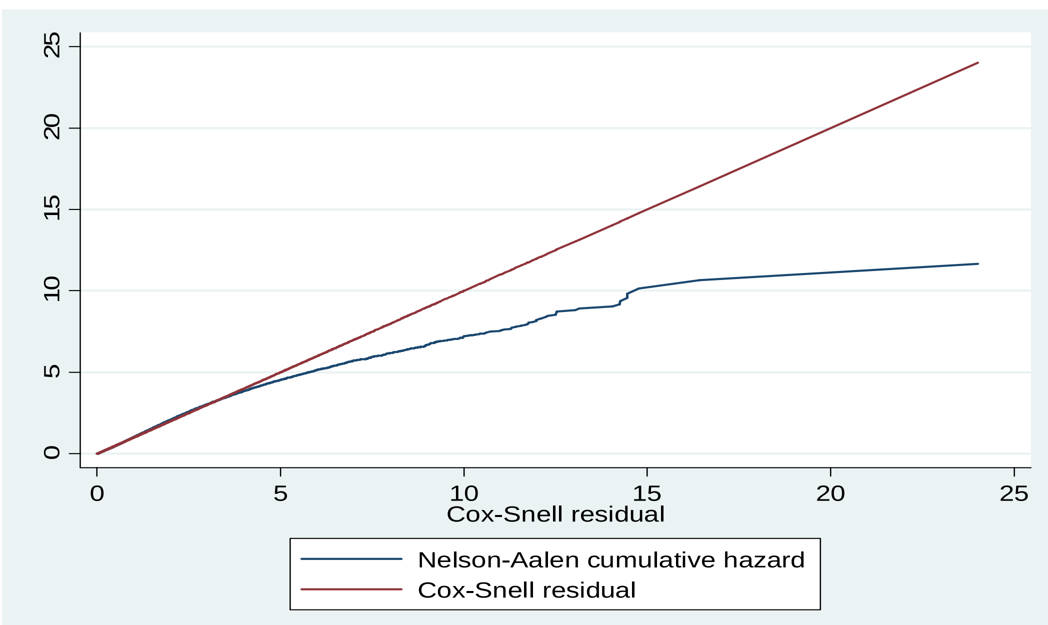

Figure AA.4 Goodness-of-fit for days fished (final model in Appendix Z)

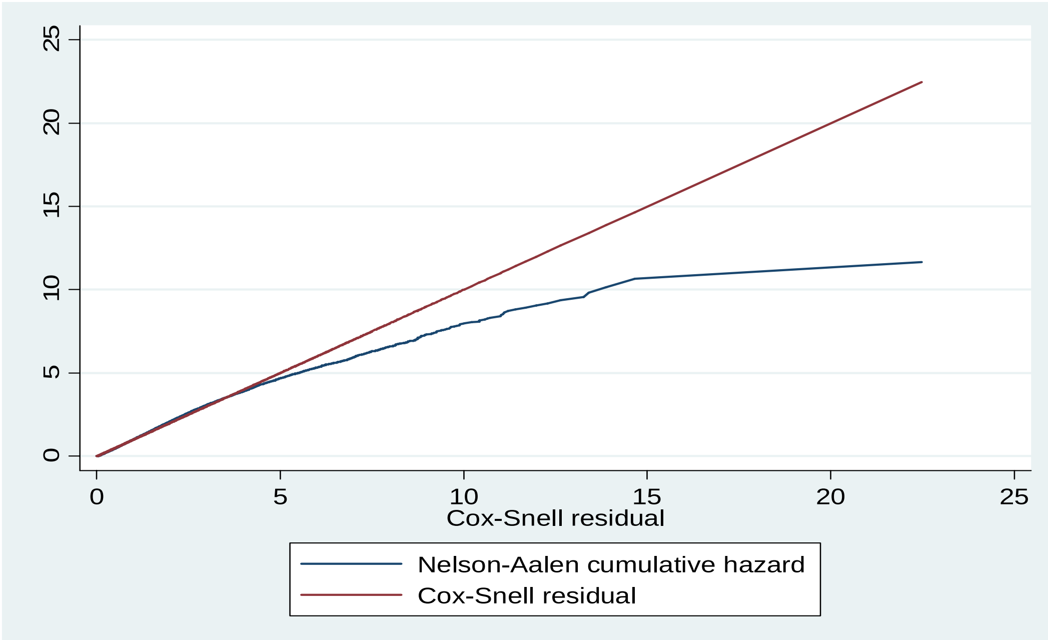

Figure AA.5 Goodness-of-fit for travel time (corresponding to Appendix X)

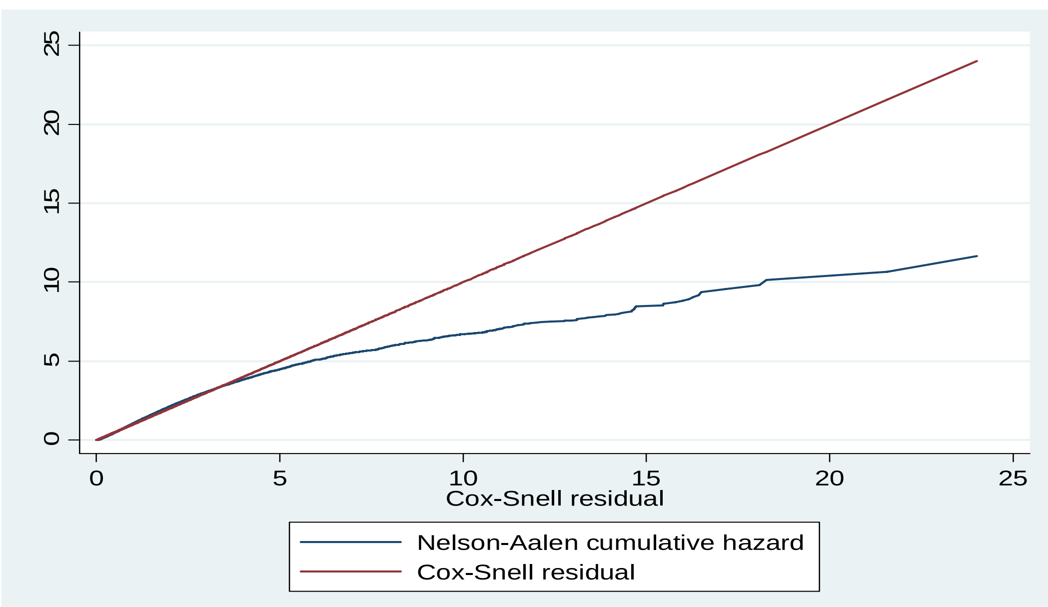

Figure AA.6 Goodness-of-fit for days fished (corresponding to Appendix X)

VITA

Tao Ran got her Bachelor of Arts degree from Nanjing Agricultural University in Jiangsu, China. After having some experience in further studying and working as an instructor at Yunnan University of Finance and Economics, she went to Iowa State University to pursue the Master of Science degree in economics in 2002. In 2004 Fall, she came to LSU for her doctoral degree studying at the Department of Agricultural Economics. She is also pursuing a dual Master of Science degree from the Department of Applied Statistics at LSU. She is expecting to get both degrees in Fall, 2008.