Scup Allocation Analysis

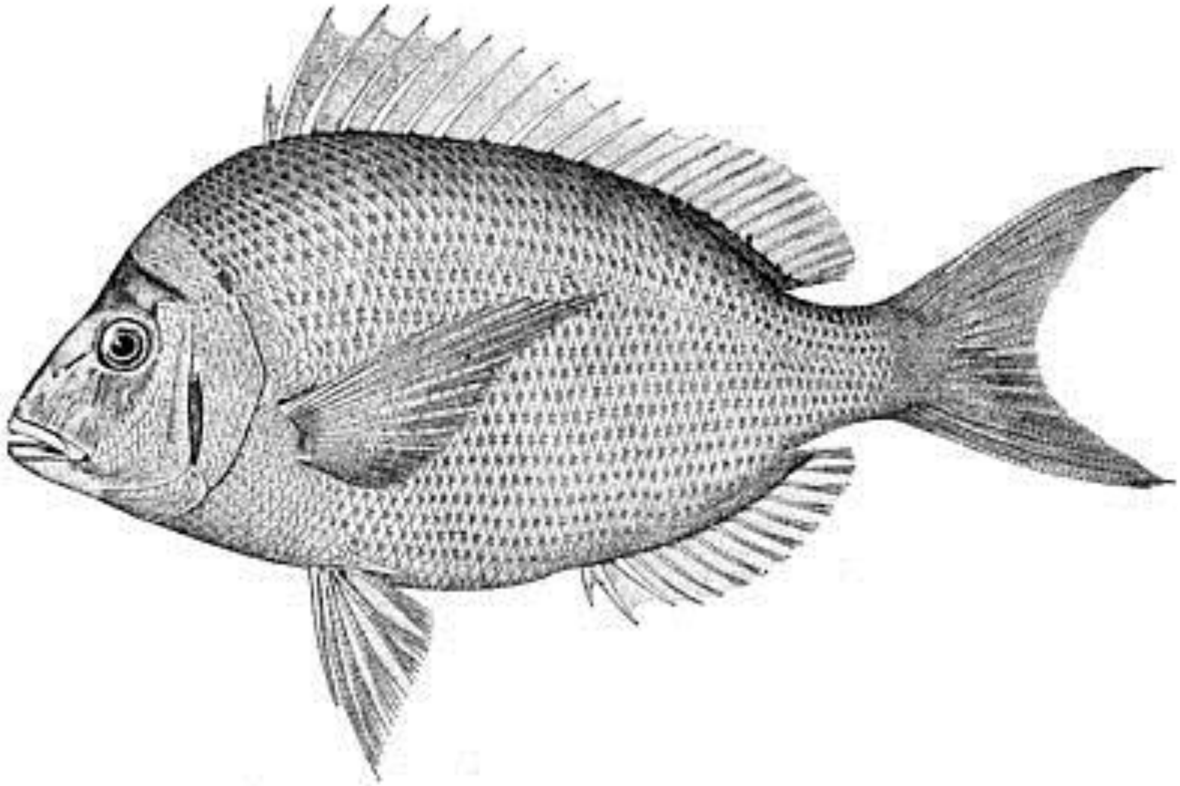

Photo Credit: National Marine Fisheries Service

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June, 2012

Table of Contents

1.0 Executive Summary

Overall, it is impossible to determine the efficiency of the current allocation given the sharp rise in recent harvest limits and the inability of either sector to catch their 2011 limits. However the results show that relaxing recreational regulations would increase the aggregate value in this fishery and that relaxing regulations to their biological limit would maximize value. Relaxing regulations to the maximum extent advisable, based on biological advice, would draw more fishing effort into the fishery and could require as much as a 1% allocation shift from the commercial sector to the recreational sector. This change should be palatable for the council and commercial fishermen as the commercial sector left 26% of their harvest limit in the water in 2011.

The scup stock was under a rebuilding plan from 1999 until it was declared rebuilt in 2009. The rebuilding was so successful that the Mid-Atlantic Fishery Management Council (MAFMC) increased the allowable harvest in 2012 to over twice the 2010 limit. Currently, recreational anglers faced some of the tightest scup regulations the sector has ever faced and, before the 2011 increase, were regularly exceeding their harvest limits. Anglers also face extremely tight regulations in many Northeast fisheries and would like to see a loosening of regulations in scup. The new higher limit should allow for liberalizing recreational regulations. On the other side of the coin scup prices are weak and there is anecdotal evidence of seasonal market gluts that can drive commercial prices very low. As a result of these conditions in the fishery, the MAFMC asked for this examination of the economic efficiency of current allocations.

Currently the recreational fishery is allowed 22% of the total harvest. Additionally, to protect smaller inshore commercial boats, the 78% commercial allocation is broken into Winter I, Summer and Winter II seasons, with any uncaught allocation from Winter I rolling over into Winter II. This report details the examination of the allocation of harvests between commercial and recreational sectors and also the allocation between commercial seasons. The efficiency of these sectoral and seasonal allocations were examined using the economic value generated by each sector and across seasons.

Gentner Consulting Group, Inc. estimated commercial production functions based on the otter trawl gear used to catch the vast majority of scup landings. While it would have been ideal to estimate value for other gear types, data limitations prevented estimation of marginal or aggregate value in any other gear type. As a result, if the other gears have different revenue or cost structures, they would have different marginal and aggregate values for scup harvest; however, these gears are responsible for a small amount of total harvest. Consumer surplus for scup was calculated using a synthetic inverse demand function and attempts were made to estimate a for-hire sector production function. However, due to data limitations, for-hire economic profit per trip was calculated arithmetically. Finally, the National Marine Fisheries Service estimated a bioeconomic model of the recreational scup fishery and their valuation estimates were used for this examination.

A suite of allocation changes, rather than the optimal allocation, were analyzed including; +6% commercial/-6% recreational, +3% commercial/-3% recreational, status quo, -3% commercial/+3% recreational, -6% commercial/+6% recreational and -9% commercial/+9% recreational. Optimal allocations were not examined for two reasons. One, NMFS economist responsible for the recreational bioeconomic model felt that it would be inappropriate to examine allocations beyond a certain range around the current allocation. Two, the NMFS recreational bioeconomic model was computationally intensive and it would take too much time to simulate all allocation levels.

Total net benefits are potentially maximized by allocating more fish to the recreational sector. However, there are various caveats to this conclusion. Under a 29.96 million pound harvest, the limit selected for this analysis, the recreational allocation does not bind nor does the commercial allocation bind. A harvest limit this high represents more than a doubling of the allowable harvest and all simulations to develop marginal willingness to pay for allocation estimates are made well outside the catch levels used to develop the models. 2011 harvests were not available when these models were formulated, but under the higher harvest limits in 2011 neither the recreational sector nor the commercial sector caught their allocations. Across all three commercial seasons, the commercial sector only caught 74% of their allocation while the recreational sector only caught 64% of their allocation. The non-binding harvest limit in 2011 was 26.1 million pounds, which is lower than the 29.96 million pound harvest limit used for this analysis. When allocations are not binding, there cannot be positive valuations for increases in allocations. As a result, it is impossible to determine if the current allocation percentages under a 29.96 million pound harvest limit are efficient or not.

On the recreational side, the NMFS recreational bioeconomic model could not show a positive willingness to pay for increases in quota because the new increased quota was far outside the level of recreational catch during the year of the special data collection used for this model or, for that matter, any year in recent history. That is, under the new, higher catch limit and existing tight regulations, modeled anglers could not catch what will be the new quota and therefore would not be willing to pay for more fish. At the same time, the NMFS bioeconomic model found that if additional allocation were coupled with liberalization of recreational regulations that recreational effort would increase. Increases in effort at the same willingness to pay increase aggregate value.

Total aggregate benefits are maximized when the recreational sector has a 9" minimum size limit and a 50 fish bag limit. To achieve this level of liberalization, less than 1% of the total harvest limit would need to be transferred to the recreational sector. Council staff feels that a 9" minimum size limit is the lowest biological sustainable minimum size. Harvesting fish any smaller creates a risk of recruitment overfishing or catching scup before they have had their first chance to spawn. Reinforcing this conclusion, the NMFS model did find a negative marginal willingness to pay for allocation reductions leading to the conclusion that reducing recreational allocations would certainly produce lower net benefits than the status quo. Recreational aggregate net benefits were found to be higher than commercial plus consumer benefits in all scenarios examined, even if the for-hire economic profit estimates are ignored.

A positive marginal willingness to pay for recreational scup catch may exist in reality, however the recreational model employed does not allow for changing catch rates that would result from increased recreational allocations that were not harvested in a given year. That is, if recreational harvests increased, but did not bind, the additional fish that were not harvested would grow larger and spawn one more time, increasing catch rates. Other research has shown that thicker stocks do generate positive willingness to pay. Recreational anglers have preferences for catch and catch rates above and beyond harvest and harvest rates that are not captured in this model.

On the commercial side, the simulation forced the commercial sector to harvest the entire increased allocation producing a small marginal willingness to pay for allocation increases. However, if modeled in a bioeconomic framework the higher harvest limits would not bind the commercial sector either as shown by the sector not harvesting their allocation in 2011. Additionally, because scup is caught in joint production with other, more valuable species that are also heavily regulated, it might be difficult to increase scup commercial allocation if limits on these other groundfish species bind catch of scup. Also, low prices during seasonal market gluts may keep the commercial sector from achieving its harvest limit.

The analysis of seasonal allocations indicate those allocations are inefficient. This analysis did not look for the efficiency maximizing allocation, but instead examined increases and decreases up to 9%. Winter I and Winter II were combined because of lack of separate model reliability and because all uncaught Winter I quota rolls over into Winter II. This analysis showed that economic value would be increased by moving allocation out of the winter seasons and in to the summer season and that moving as much as 9% more to the Summer season would provide more benefits than the status quo.

Finally, while this effort was unable to determine the efficiency of the current allocation or the efficiency maximizing allocation, this effort has created a flexible and robust framework that will allow the examination of other harvest limits as they change. It is expected that harvest limits will be reduced from their high 2011 levels and this framework will be far more useful in examining harvest limits that lie closer to the average harvest limits across the years used in the construction of these models. As allocations bind harvest, the economic allocation of these resources will become more critical.

2.0 Introduction

The scup stock has been under a rebuilding plan since 1999 (Amendment 12) and the stock was declared rebuilt in 2009. The most recent stock information indicates that the stock is not overfished and that overfishing is not occurring and the 2010 spawning stock is about 202% of the biomass goal. With the scup stock rebuilt, recreational and commercial users are advocating for changes in catch allocation strategies. Recreational anglers feel that their 22% allocation is unfair. First, recreational anglers, with tightening regulations in other Northeast fisheries, feel that they have few options left when trying to catch fish for the table. As a result of tightening regulations in other fisheries, recreational anglers and for-hire recreational service providers are becoming increasingly reliant on scup trips. Counter to this increased demand for scup trips and scup's increased availability, recreational anglers face some of the most restrictive regulations imposed in this fishery. Second, there is evidence that commercial harvest gluts during certain commercial seasons drive dockside prices extremely low.[1] As a result, recreational anglers feel that their allocation is unfair and they should receive more of the scup allocation. At the same time, the Mid-Atlantic Fishery Management Council (MAFMC) is looking to increase harvest limits by more than double the 2010 level.

In addition to the split between recreational and commercial sectors, commercial harvesters feel it is time to examine the allocation of the commercial harvest limit between seasons. Currently the MAFMC allocates the limit across seasons so that the entire catch is not harvested during the winter season by the larger offshore boats. The majority of the scup (45.11%) are allocated to the Winter I season (January – April) which is caught offshore by large trawlers. Any of the allocation not taken during Winter I rolls over to Winter II (November and December) but not the Summer (May to October) season. The summer allocation (38.95%) is caught primarily by smaller, inshore vessels that receive a higher price for their product, typically, than the fish caught in Winter I or Winter II. This seasonal allocation was established for distributional reasons to give the smaller inshore boats access to a portion of the harvest limit. Because prices are higher for the summer season fish, the smaller inshore fleet feels the current seasonal allocation is unfair and would like more fish allocated to the summer season. Tempering this, however, is that Winter II fish, at least 15.94% of the harvest limit, typically receive the highest price for scup. MAFMC has decided to contract for the examination of both the allocation between sectors and the seasonal allocations in the commercial fishery.

2.1 Background and Trends

Scup, *Stenotomus chrysops,* has become an important commercial and recreational species occurring primarily from Massachusetts to South Carolina. Scup is sometimes called porgy in the Mid-Atlantic. They spawn around the inner continental shelf and the larvae grow in estuaries and other inshore areas. They winter on the mid and outer continental shelf following warm water inshore in the spring. Scup can grow as large as four pounds, but typically average much smaller in size. While small, they are considered excellent table fare and have become a popular food species for the for-hire fleet.

2.1.1 Commercial Background

The scup commercial fishery is managed using gear regulations and possession limits. Trawl vessels with a scup moratorium permit may not possess 500 pounds or more of scup from November 1 through April 30 or 200 pounds or more of scup form May 1 through October 31 unless fishing with nets having a

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[1] Coakley, Jessica, Memorandum to Science and Statistical Committee and Scup Monitoring Committee, June 30, 2010, Table 6, p. 10.

minimum mesh size of 5.0 inches diamond mesh, applied throughout the codend for at least 75 continuous meshes forward of the terminus of the net, and all other nets are stowed in accordance with Title 50: Wildlife and Fisheries Code of Federal Regulations (50 CFR) §648.23(b)(1). For trawl nets with codends (including an extension) of fewer than 75 meshes, the entire trawl net must have a minimum mesh size of 5.0 inches (12.7 cm) throughout the net. Scup on board these vessels must be stowed separately and kept readily available for inspection. Measurement of nets will be in conformity with 50 CFR §648.80(f)(2)(ii).

The commercial season has been divided into three seasons; Winter I, Summer and Winter II. Winter I has been allocated 45.11% of the harvest limit and runs from January through April. The Summer season runs from May through October and has been allocated 38.95% of the harvest limit. Winter II has been allocated 15.94% of the harvest limit, plus whatever Winter I harvest limit that was not harvested. This season allocation was put in place to protect the smaller inshore fleet and ensure that the larger offshore otter trawl fleet did not catch the entire allocation before the scup moved inshore in the summer. The winter fishery is predominately a bycatch fishery in the larger offshore otter trawl multispecies groundfish fishery.

This analysis will use a variety of data sources to describe and model the commercial fishery. Figure 2.1 details commercial landings in metric tons by state as taken from National Marine Fisheries Service (NMFS) online data queries.[2] Total landings rose dramatically at the beginning of this period, plateaued in 2003 and remained relatively stable until 2007 when landings dropped dramatically. Since 2008, however, commercial landings have again significantly increased approaching 5,000 metric tons. Across all states, Rhode Island consistently lands the most scup with New York and New Jersey a distant second and third.

Figure 2.2 displays total landed value and landed value by state from 2000 to 2010 as taken from the NMFS online queries. Total value peak in 2007 slightly over $8 million before declining with catch in 2008. The increase in value has lagged the increase in catches shown in Figure 2.1 as prices are lower now than they were at the peak in 2007. Rhode Island also lands the most value. New York, however receives a higher price for their product as their value position is closer to Rhode Island's than it was in the catch figure (Figure 2.1). In 2010 the entire fishery was worth roughly $7 million.

The remainder of this report will utilize the vessel trip report (VTR) database merged with dealer value data and cost data provided by onboard fishery observers.[3] All federally permitted vessels in the Northeast are required to submit a VTR on a weekly basis. The VTR requires reporting on the trip as a whole and for each set. These files are then linked to the dealer data for values and to the observer collected cost data. NMFS delivered five years of matched data from 2005 through 2009. NMFS delivered all trips with scup landings, and, across this period, there were 38,101 trips that caught scup. VTRs are not required from boats fishing without federal permits, producing a deficiency in this data that will be discussed at length below.

Table 2.1 details the gears types used in each season across the entire sample. Summer is far more diverse in the gear types used but is still dominated by bottom trawls (68.98%). The second most utilized gear in the Summer are pots and traps (20.97%) followed by gill nets (10.02%). Both Winter seasons are

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[2] Last accessed 4/1/2012: http://www.st.nmfs.noaa.gov/st1/commercial/index.html

[3] Confidential data merged and delivered under confidentiality agreement with Northeast Region Office of the National Marine Fisheries Service. Provided by John Witzig on August 29, 2011.

dominated by the bottom trawl at 96% and 93.42% for Winter I and Winter II, respectively. The second most used gear in Winter I are gill nets (3%) and in Winter II are pots and traps (5.43%).

Figure 2.1. Commercial Landings in Metric Tons by State 2000-2010.

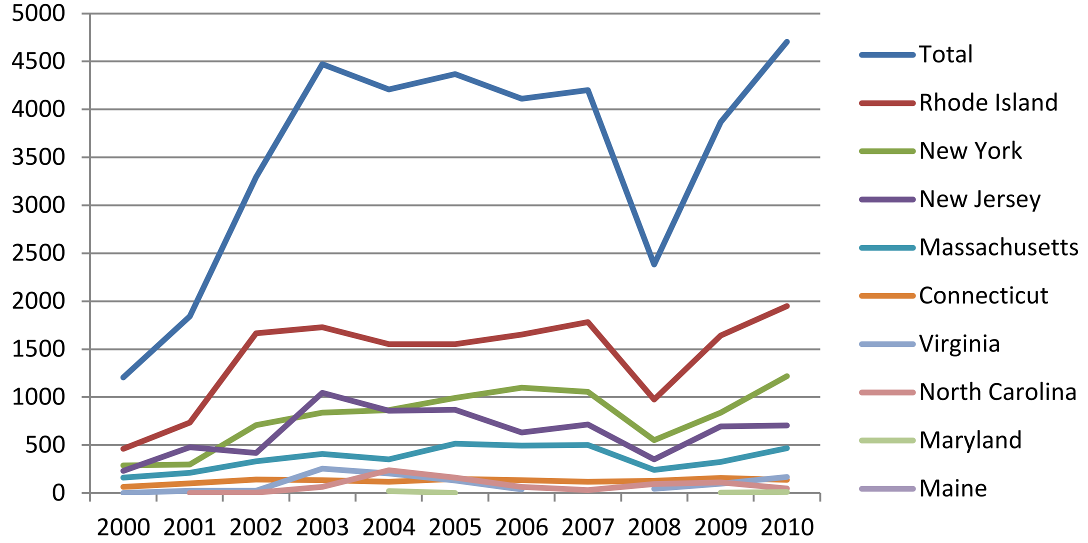


Figure 2.2. Landed Value in Dollars by State 2000-2010.

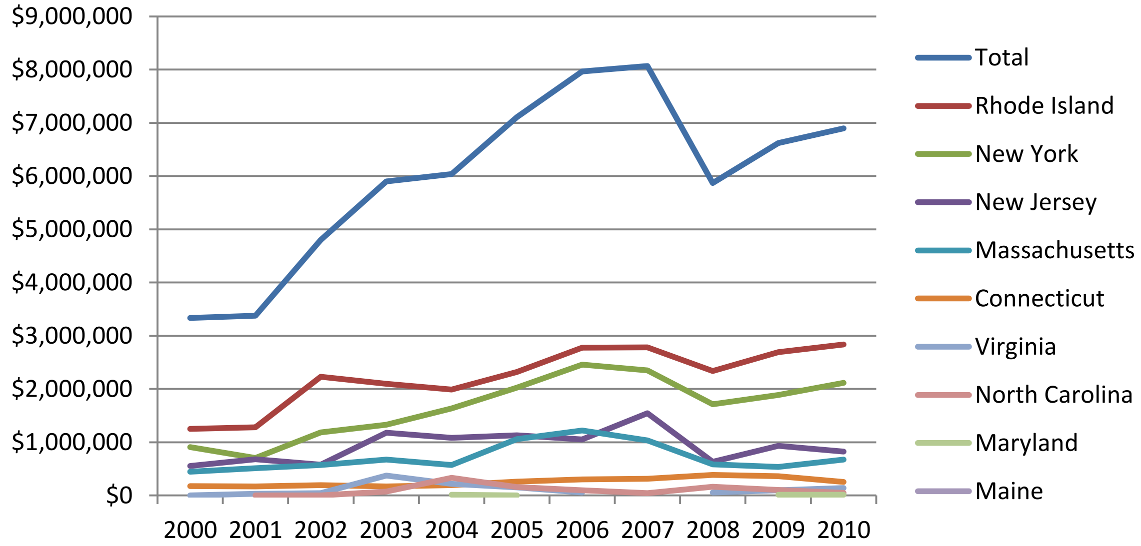


Table 2.2 details gear use in the VTR record between trips in federal waters and trips in state waters across the entire sample. Bottom trawls account for 81.42% of all trips in federal waters followed by pots and traps (12.54%) and gill nets (5.98%). Bottom trawls still make up the majority of trips in state waters (67.56%) but contain more effort by pots and traps (21.29%) and gill nets (11.05%). However, VTRs are not required for boats fishing in state waters without federal permits. While the majority of vessels fishing for scup have federal permits, some state permitted boats catch scup. Confidential state landings data were obtained from the Atlantic Coastal Cooperative Statistical Program (ACCSP) for each state. Unfortunately, the state data cannot separate out landings from state waters from vessels without federal permits. Additionally, the state permit files do not always contain gear type nor do they

contain the vessel characteristics needed to estimate trip costs, such as trip length, needed for the cost model described below. The VTR database that will be used for the remainder of this work therefore is not the universe of all trips landing scup. Instead it is a data set containing all federal waters trips and all state water trips from vessels that hold federal permits.

Table 2.1 Gear Type Use by Season , 2005-2009.

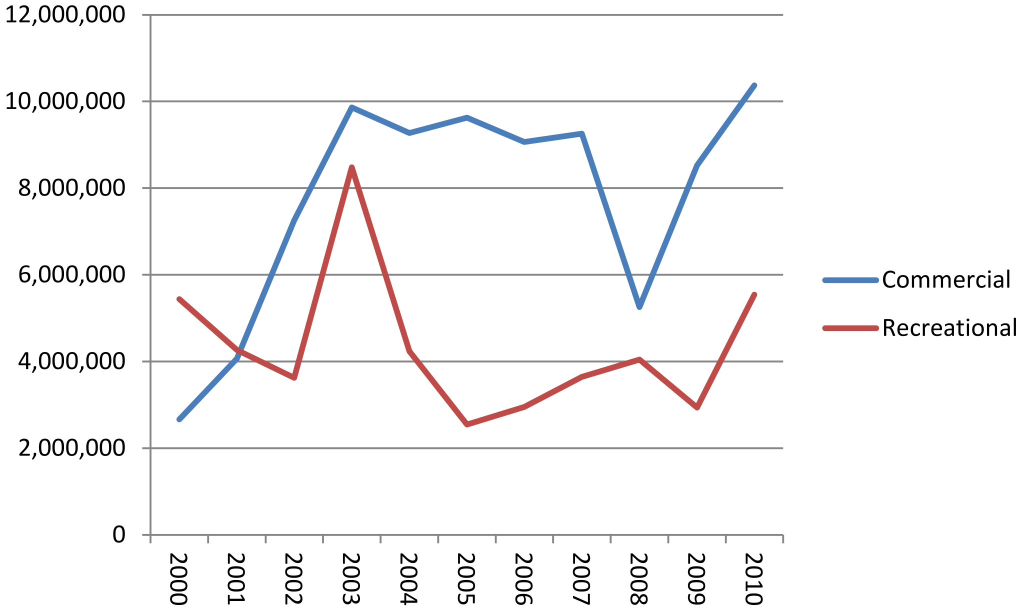
Scup Seaon	Gear Type	COUNT	PERCENT
Summer	BOTTOM TRAWL	14,111	68.98
	GILL NETS	2,049	10.02
	OTHER GEAR	6	0.03
	POTS & TRAPS	4,289	20.97
	SURF CLAM / OCE	1	0.00
Winter I	BOTTOM TRAWL	5,561	96.00
	GILL NETS	174	3.00
	OTHER GEAR	9	0.16
	POTS & TRAPS	49	0.85
Winter II	BOTTOM TRAWL	5,539	93.42
	GILL NETS	64	1.08
	OTHER GEAR	2	0.03
	POTS & TRAPS	322	5.43
	SCALLOP DREDGE	2	0.03

Table 2.2. Gear Type Use by Jurisdiction 2005-2009.

Jurisdiction	Gear Type	COUNT	PERCENT
Federal Waters	BOTTOM TRAWL	20,388	81.42
	GILL NETS	1,498	5.98
	MID-WATER TRAWL	10	0.04
	POTS & TRAPS	3,140	12.54
	SCALLOP DREDGES	2	0.01
State Waters	BOTTOM TRAWL	4,823	67.56
	GILL NETS	789	11.05
	MID-WATER TRAWL	7	0.10
	POTS & TRAPS	1,520	21.29

Finally, Figure 2.3 displays the trend in commercial landings and recreational landings across the entire sample. The figure shows that while recreational scup landings were relatively stable from 2005 through 2009, they increased in 2010. In 2010, the recreational sector exceeded its quota by 91%. While scup stocks are in good shape, recreational anglers now face stringent scup regulations to keep their catch within their allocation. Currently, the commercial allocation has been set at 78% of the harvest limit and the recreational allocation at 22%. Since 1997, the recreational sector has exceeded its allocation in 10 of the 14 years between 1997 and 2010 while the commercial sector has undershot its allocation in seven of those 14 years.

Figure 2.3. Recreational and Commercial Landings 2000-2010 (Pounds).



2.1.2 Recreational Trends

Figure 2.5 details recreational catch as taken from the Marine Recreational Fisheries Statistical Survey (MRFSS) online queries (before the new weighting regime).[4] These estimates include both fish landed and fish released on the trip (type A+B1+B2 catch). Total catch has fluctuated widely over this ten year period although the trend is flat if not slightly downward. In 2006 NMFS split the for-hire mode (listed on the figure as party/charter) into the party boat mode and the charter boat mode, with the party boat mode taking the majority of the for-hire mode catch. Private/rental recreational boats catch the majority of the scup by a wide margin. Shore catch of scup has followed the private boat mode with the second highest total catch up until 2008 when the for-hire mode overtook shore catch.

Figure 2.6 displays scup harvest or those fish retained and observed by the interviewer plus self reported catch that was released dead or otherwise consumed before coming back to the dock (MRFFS catch type A+B1). This graph is by weight rather than numbers of fish. Besides a spike in 2003, catch has remained relatively flat with a sharp increase in 2010. Again, catch by weight is dominated by the private/rental boat mode followed by charter boats, party boats and then shore anglers.

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[4] http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html

Figure 2.5. Recreational Catch (A+B1+B2) by Mode and Year in Numbers of Fish, 2000-2010.

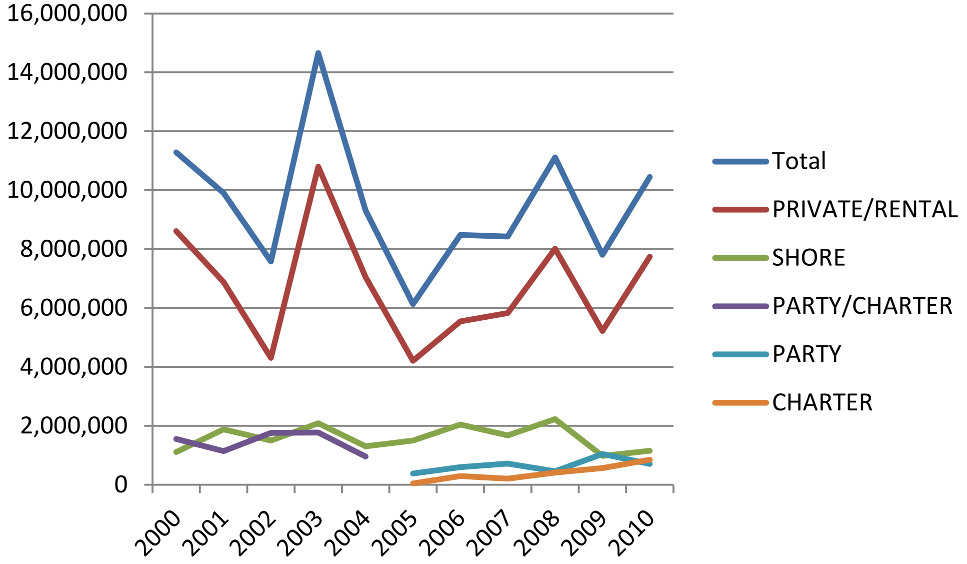


Figure 2.6. Recreational Harvest (A+B1) by Mode and Year in Pounds, 2000-2010.

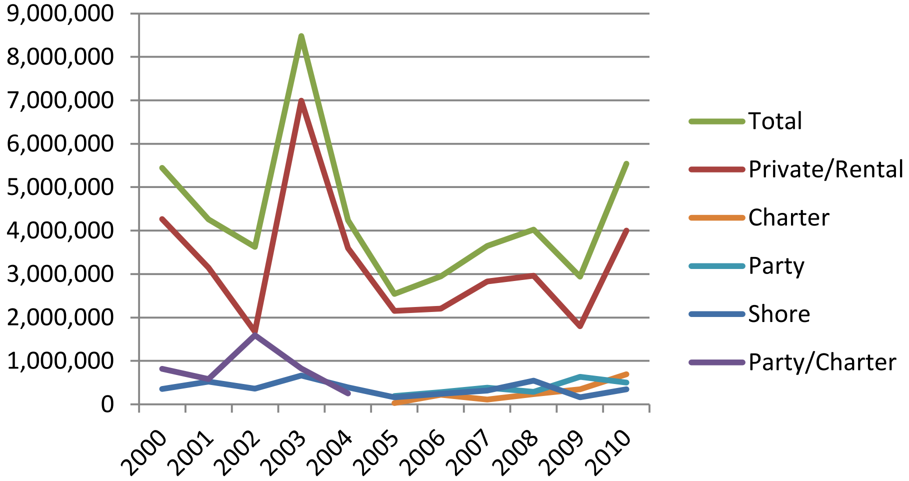
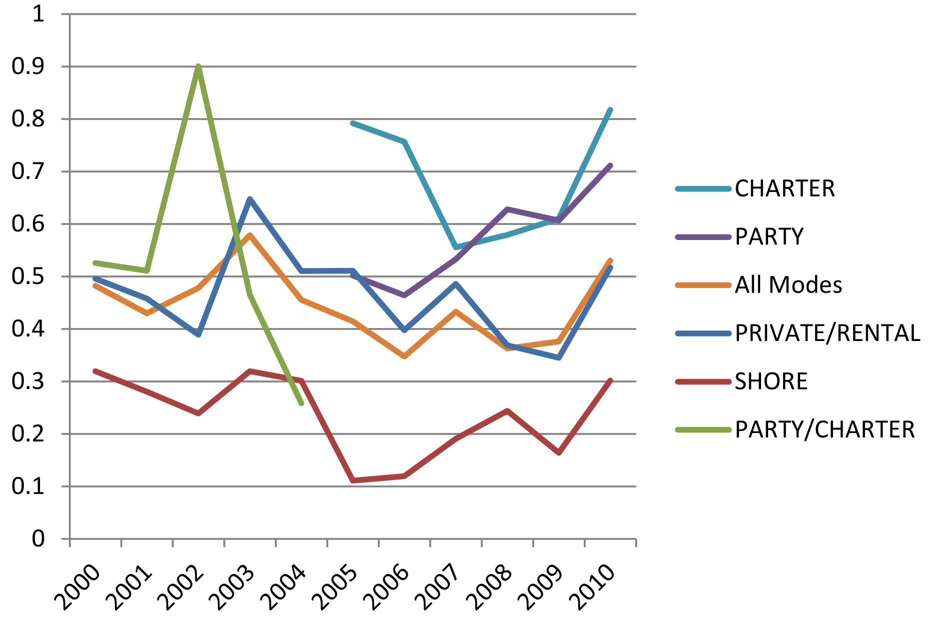


Figure 2.7 displays the average weight per fish in pounds. The trend in weight per fish has been decidedly downward (All Modes) until 2007 when there was a sharp spike upwards followed by a drop again in 2008 and then a steady increase since. In 2010, the weight per fish was higher than any other time in the time series at 0.53 pounds per fish. The charter mode has the highest weight per fish followed by the party boat mode. Shore mode has the lowest weight per fish, as might be expected.

Figure 2.7. Average Recreational Weight per Fish in Pounds Harvested by Mode, 2000-2010.



2.2 Basis for Economic Allocation Analysis

Broadly defined, economists use two different metrics to examine the implications of policy decisions on society: economic value and economic impacts. The first, economic value, also known as economic benefit or welfare, monetizes the value society places on resources or activities. Economic value should be the metric used to decide between one course of action and another (Freeman 1993, Edwards 1990, and others). Economic value, however, is not the only criteria that should be examined when focusing on resource allocation questions. Equity, fairness, distributional concerns, and other social impacts are important (Edwards 1990), but will not be addressed in this report. Plummer et al. (2012) present a basic and in-depth discussion of these principles for the non-economist.

The second, economic impacts, examines the flow of expenditures on fishery resource activities and products as that spending moves through a community. While economic impact measures should not be used to choose a course of action, they can be used to examine the distributional impacts or what particular sectors in the economy are hurt or helped by a particular policy and to what degree. Economic impact analysis examines the distribution of value changes identified when comparing benefits, making both types of analysis complementary.

Edwards (1990) developed a guide for the allocation of fishery resources and this discussion follows his framework. Very few allocation studies have been conducted for saltwater recreational fishing. Kirkley, et al. (2000) conducted a study for striped bass allocation in Virginia examining total value in each sector. Carter et al.(2008) conducted an allocation analysis for the red grouper fishery in the Gulf of Mexico using the equimarginal principle. Gentner et al. (2010) conducted an analysis of the summer flounder allocation for NMFS.

For both the recreational and commercial sectors, total value is the sum of consumer and producer surplus. Producer surplus is measured by examining the supply curves for commercial producers of seafood, including harvesters, processors, wholesalers, and distributors, as well as the supply curves for for-hire recreational service providers. Essentially, producer surplus is the difference between the cost of producing the good and the dollar value generated by the sale of the good. Consumer surplus is measured by examining the demand for goods at the consumer level including the demand for fish at markets and restaurants and the demand for recreational fishing trips. Consumer surplus is the difference between the amount society would be willing to pay for the good in question and what consumers actually paid for the good in the marketplace.

For the recreational sector, total value or net benefits is the sum of the consumer surplus from recreational fishing participants and producer surplus from for-hire charter and head boat operators. For the commercial sector, total value is the sum of consumer surplus from the purchase of seafood products in markets and restaurants and the producer surplus from harvesters, processors, wholesalers, and distributors of those fishery products.

Value is not static across all allocations, and, as any consumer obtains more of a good, the marginal value of obtaining the next unit of that good falls. That is, there are diminishing returns to additional consumption of any good and this is a fundamental tenet of consumer demand, which has important implications for allocation decisions. A similar tenet exists for producers, but does not always hold depending on the character of the industry. As a result, it is important to examine the schedule of these marginal values in each sector. Societal benefits are maximized at the allocation where commercial sector marginal value is equal to the marginal value from the recreational sector. This is known in economics as the equimarginal principle. Using the equimarginal principle is widely recognized as the best way to maximize societal value in an allocation analysis (Freeman 1993, Edwards 1990).

Early in the process, however, the MAFMC in discussions with GCG and the NMFS partners that conducted the recreational demand analysis decided that tracing out the entire benefits schedule for each was not appropriate. Instead, GCG was instructed to focus on total benefits across a narrow range of allocation changes; 6% commercial increase/6% recreational decrease, 3% commercial increase/3% recreational increase, status quo, 3% commercial decrease/3% recreational increase, 6% commercial decrease/6% recreational increase, 9% commercial decrease/9% recreational increase. This decision was made primarily because simulating the recreational model was computationally demanding and the project team felt that forecasting too far away from the current catch rates was also inappropriate.[5] A similar suite of changes (9% increase to 9% decrease) will also be examined across the commercial seasonal allocations.

Estimating producer surplus and the marginal value of a pound of scup harvest for the commercial fleet requires data on the costs and earnings of all the various businesses involved in the production and sale of seafood or recreational services. Very little of this type of information exists, making the calculation of producer surplus difficult at best and impossible at worst. Multi-species fisheries, like the scup otter trawl fishery complicate estimation. For this analysis, data on trip costs from a sample of otter trawl trips will be used to estimate the trip costs for all otter trawl trips taken between 2005 and 2009.

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[5] That said, the final analysis used a total harvest limit more than twice the harvest limits in place when the data for this analysis was collected. As a result, the results presented in this document, even across the limit percent changes agreed upon by the project team, represent a prediction far outside the data used to construct the estimates.

Estimating consumer surplus entails estimating demand curves for both the angling experience and for consumer purchases of seafood. On the recreational side of the equation, estimating consumer surplus involves specialized surveys of anglers. In this particular case, NMFS conducted a stated preference conjoint survey that collected response to a set of hypothetical fishing trips for summer flounder and other bottomfish species including scup. NMFS conducted the recreational demand analysis and estimation of recreational angler marginal value because NMFS viewed this data as proprietary.

On the seafood consumer side, data on the prices and quantities of seafood purchased in markets and restaurants is needed. Unfortunately this type of data rarely exists. Instead there are techniques that utilize landings data to estimate consumer demand functions that can be used to calculate the marginal value of scup consumption at the retail level. Those techniques will be used here.

In summary, the equimarginal principle is the preferred method to examine allocations. Often, it is difficult to develop a complete schedule of marginal values across all possible allocations. This work was not designed to develop the optimal, efficient allocation of scup. Instead, the analysis focuses on a discrete set of allocation levels, but still using the equimarginal principle across the range of changes being examined.

3.0 Commercial Valuation

This chapter estimates commercial harvesters' marginal value for scup. Typically, cost and earnings information for commercial harvesters is sparse or non-existent. In this case, trip cost data was collected from a sample of otter trawl fishermen and those trip costs were used by NMFS in a regression model to estimate trip costs for the entire fleet. Estimated trip costs are then used to model the input compensated supplies for scup and four other species groups harvested by otter trawl fishermen. From these input compensated supply equations, it is possible to estimate the current marginal value for a pound of scup and simulate that marginal value across the entire range of potential allocations.

3.1 Estimation of Commercial Trip Costs and Data Manipulation

This study uses data from 2005 through 2009. Estimation of commercial harvester profits requires data on both harvester revenues and harvester costs. NMFS collects revenue information from a combination of self-reported logbook entries and seafood dealer data. To collect cost information, NMFS uses the observer program to collect very accurate trip cost data across a sample of otter trawl vessels and vessels using other gears. Because the observer program samples commercial trips, NMFS does not have trip costs for all reported trips in the VTR database.

To address the need for trip costs for all trips, NMFS contracted with the Woods Hole Oceanographic Institute to develop the first regression based model to predict trip costs for boats not included in the observer sample. That work is detailed in Jin (2008). His model used trip cost data from the 2006 observer year. Jin's (2008) work estimated regression models for fixed costs, labor costs, and trip costs. This work was repeated by Gentner et al. (2010).

While Jin estimated a number of models, the focus here is on the otter trawl gear type. Jin's otter trawl modeling was performed in two phases. The first phase used a stepwise linear regression to select the relevant variables. This was performed in SAS using the PROC REG procedure, and that procedure adds independent variables to the model one at a time. The decision rule for inclusion is maximizing r-square while retaining only those variables with a significance level of 0.15 or better. This process yielded the following variables; total trip duration, steam time, gross tons, gross tons squared, April monthly dummy, and North Carolina and Rhode Island principle port dummies. While the original regressions included a full suite of port state and monthly dummies because seasonality and port location have the potential to impact trip costs, the stepwise regression eliminated those regressors that did not contribute to model fit.

For this effort, NMFS estimated a model of trip costs following Jin (2008) and Gentner et al. (2010).[6] After merging the permit, VTR and dealer databases, there were 35,910 trips that caught at least some scup. This dataset was used to estimate a heteroscadasticity corrected ordinary least squares model for only those trips using an otter trawl as their principle fishing gear on the trip. Table 3.1 contains the parameter estimates for the trip cost model and Appendix 1 contains the variable definitions. Due to missing value for some variables, costs were predicted for 29,781 trips that harvested scup.

Table 3.1. Trip Cost Model Parameters.

Log of Trip Cost is the Dependent Variable

Parameter	Estimate	Approximate Standard Error	t Value	Approximate Pr > jt|
Constant	3.1124	0.149	20.85	<.0001
multdaytp	1.0065	0.032	31.08	<.0001
lnfp	0.8145	0.024	34.28	<.0001
tripdur	0.0082	0	38.18	<.0001
crew	0.0985	0.01	8.97	<.0001
trip ct	-0.0033	0	-14.06	<.0001
len	0.0395	0.004	9.66	<.0001
farfz	0.2283	0.022	9.553	<.0001
medfz	0.1108	0.022	4.96	<.0001
vessval ths	0.0002	0	7.03	<.0001
lensq	-0.0002	0	-7.05	<.0001
reg ne	0.1421	0.02	7.12	<.0001
tonpft	0.2156	0.026	8.29	<.0001
vhplen	0.0226	0.003	6.25	<.0001
yr09	-0.075	0.016	-4.62	<.0001
div	-0.1289	0.033	-3.88	0.0001
thaul	-0.0037	0	-4.86	<.0001

Number of observations: 5,265. Adjusted R-Squared: 0.93.

Table 3.2 contains the actual and predicted trip costs from this new otter trawl trip cost model. This model has excellent predictive ability. The parameters in Table 3.1 were then used to predict trip costs for all trips in the VTR database.

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[6] Personal communication Chhandita Das, NMFS.

Table 3.2. Trip Cost Model Predictive Success.

Model	Mean	Sum	Maximum	Minimum	Std Dev
Actual Trip Cost	$4,872	$26,672,137	$49,706	$82	6,140
Predicted Trip Cost	$4,757	$25,043,897	$97,680	$95	6,247
Residual (Actual vs. Predicted)	1.14	-	100.88	0.03	1.65

The profit models to be estimated below will be estimated at the trip level given the problems encountered during the summer flounder analysis. In the summer flounder analysis, annual models were attempted however those models had poor model fit (Gentner et al. 2010). As in Gentner et al. (2010), modeling of profits will focus on those trips where 25% or more of the trip revenue was from the sale of scup. Table 3.3 contains the descriptive statistics for the modeling data set. Overall, the entire data set covers 8,604 trips across 1,721 vessels. This data set also covers the majority of scup landings by weight (86.1% in 2009) and by value (83.51% in 2009).

Table 3.3. Trip Data Set Characteristics, 2005 – 2009.

Year	Number of Trips	Number of Vessels	Average Trips per Vessel	Percent of Total VTR Data Trawl Caught Scup	
				Pounds	Value
2005	1,487	204	7.3	83.35%	83.35%
2006	1,829	73	25.1	83.31%	81.97%
2007	1,826	31	58.9	83.76%	85.27%
2008	1,501	35	42.9	83.98%	82.30%
2009	1,961	42	46.7	86.07%	83.51%

Table 3.4 contains mean accounting profit[7] (per trip), total revenue, predicted cost and total landed weight across all species in the modeling data set. Accounting profit has been falling during this time series. Costs have increased slightly, but revenues have dropped more. Total landings have also fallen during this time period.

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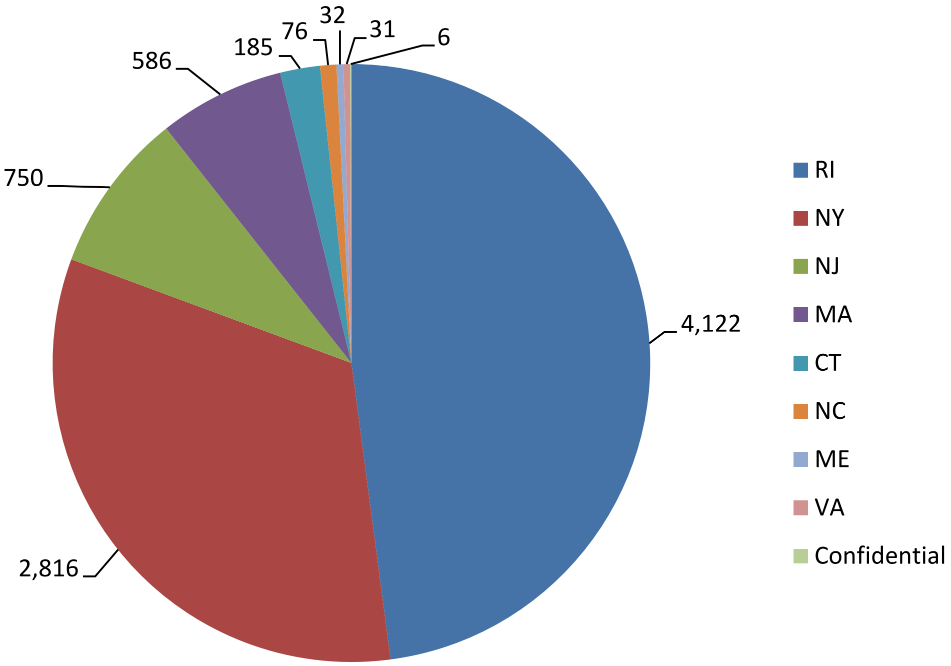
[7] Accounting profit is equal to sales revenues minus all costs except the opportun ity cost of equity capital.

Table3.4. Total Pounds, Value, Costs, and Profit per Trip 2005 – 2009, 2009 Dollars.

Year	Trip Characteristic	Number of Trips	Mean	Standard Error	Lower Bound	Upper Bound
2005	Accounting Profit	1,487	$4,156	$194	$3,776	$4,536
	Total Revenue	1,487	$4,901	$212	$4,486	$5,315
	Predicted Cost	1,487	$744	$32	$681	$807
	Total Landed Weight	1,487	4,403	185	4,040	4,765
2006	Accounting Profit	1,829	$3,449	$142	$3,169	$3,728
	Total Revenue	1,829	$4,519	$161	$4,203	$4,834
	Predicted Cost	1,829	$1,070	$41	$989	$1,151
	Total Landed Weight	1,829	3,961	143	3,680	4,242
2007	Accounting Profit	1,826	$2,270	$114	$2,046	$2,495
	Total Revenue	1,826	$3,270	$128	$3,019	$3,520
	Predicted Cost	1,826	$999	$36	$928	$1,071
	Total Landed Weight	1,826	3,505	139	3,233	3,778
2008	Accounting Profit	1,501	$987	$88	$815	$1,158
	Total Revenue	1,501	$2,570	$91	$2,392	$2,748
	Predicted Cost	1,501	$1,583	$71	$1,445	$1,722
	Total Landed Weight	1,501	3,024	121	2,786	3,261
2009	Accounting Profit	1,961	$2,173	$119	$1,940	$2,406
	Total Revenue	1,961	$3,275	$133	$3,014	$3,535
	Predicted Cost	1,961	$1,102	$42	$1,020	$1,184
	Total Landed Weight	1,961	3,565	139	3,293	3,837

Figure 3.2 displays the number of trips landing in each state over the time series. Rhode Island dominates all the other states with 4,112 trips landing their harvest in Rhode Island. Rhode Island is followed by New York with 2,816 trips followed by New Jersey with 750 trips.

Figure 3.2. Number of Trips Landing in Each State, 2005-2009



Otter trawls catch a variety of species. In this data set there are over 21 species including two miscellaneous categories with an unknown number of species in each. For the profit model, it is necessary to aggregate these species into fewer species groups. For this study, five species groups were developed: scup; bait which includes menhaden, herring, butterfish, mackerel, and skate; other bottomfish which includes summer flounder, black sea bass, monkfish, tilefish, small mesh species, and other flat fish; shellfish which includes shrimp, loligo squid, lobster, scallops, and illex squid; and other species which includes others species, highly migratory species, and bluefish. These species groups were developed based on the work in Gentner et al. (2010) and GCG's knowledge of Mid-Atlantic and New England fisheries.

Table 3.5 details the total landed pounds by each species group across the time series. Scup is landed in every trip and makes up the majority of fish landed, by definition. In 2009, the average trip landed 2,689 pounds of scup. Other bottomfish are the second most landed species group, 660 pounds in 2009, with the remaining three groups are fairly equally distributed.

Table 3.5. Pounds Landed per Trip by Species Group, 2005 – 2009.

Year	Species Group	Number of Trips	Mean	Standard Error	Lower Bound	Upper Bound
2005	Scup	1,487	3,337	156	3,031	3,643
	Other Bottomfish	1,487	692	43	608	777
	Bait	1,487	49	9	32	66
	Shellfish	1,487	178	22	134	222
	Other Finfish	1,487	147	8	130	163
2006	Scup	1,829	2,950	112	2,730	3,169
	Other Bottomfish	1,829	615	41	535	695
	Bait	1,829	131	53	27	236
	Shellfish	1,829	145	15	116	174
	Other Finfish	1,829	120	7	106	134
2007	Scup	1,826	2,655	114	2,430	2,879
	Other Bottomfish	1,826	511	47	418	604
	Bait	1,826	106	27	54	159
	Shellfish	1,826	143	10	124	162
	Other Finfish	1,826	91	5	81	102
2008	Scup	1,501	2,015	89	1,840	2,190
	Other Bottomfish	1,501	738	54	632	845
	Bait	1,501	81	11	60	103
	Shellfish	1,501	129	21	88	169
	Other Finfish	1,501	60	4	52	68
2009	Scup	1,961	2,689	122	2,450	2,927
	Other Bottomfish	1,961	660	37	587	732
	Bait	1,961	33	4	25	40
	Shellfish	1,961	124	17	91	157
	Other Finfish	1,961	60	3	53	67

Table 3.6 details the average price for each species group, per trip, for each year. In all years, other bottomfish obtain the highest prices ranging from $1.77 to $2.76 per pound. Shellfish prices are the second highest ranging from $0.83 to $1.28 per pound. The lowest priced species group in all years is the bait category that ranges from $0.32 to $0.44 per pound. Scup's price has fluctuated from a low of $0.97 to $1.30 per pound.

Table 3.6. Landed Price per Trip by Species Group, 2005 – 2009 (2009 dollars).

Year	Species Group	Number of Trips	Mean	Standard Error	Lower Bound	Upper Bound
2005	Scup	1,487	$1.13	$0.01	$1.11	$1.15
	Other Bottomfish	1,487	$2.43	$0.02	$2.39	$2.48
	Bait	1,487	$0.32	$0.01	$0.30	$0.34
	Shellfish	1,487	$1.28	$0.08	$1.13	$1.43
	Other Finfish	1,487	$0.55	$0.01	$0.52	$0.57
2006	Scup	1,829	$1.30	$0.01	$1.27	$1.32
	Other Bottomfish	1,829	$2.76	$0.02	$2.71	$2.81
	Bait	1,829	$0.41	$0.01	$0.39	$0.42
	Shellfish	1,829	$1.09	$0.02	$1.04	$1.13
	Other Finfish	1,829	$0.60	$0.01	$0.57	$0.62
2007	Scup	1,826	$0.97	$0.01	$0.95	$0.99
	Other Bottomfish	1,826	$2.21	$0.02	$2.16	$2.25
	Bait	1,826	$0.44	$0.01	$0.43	$0.46
	Shellfish	1,826	$0.89	$0.01	$0.86	$0.91
	Other Finfish	1,826	$0.49	$0.01	$0.46	$0.51
2008	Scup	1,501	$0.99	$0.01	$0.97	$1.01
	Other Bottomfish	1,501	$1.77	$0.02	$1.73	$1.81
	Bait	1,501	$0.32	$0.01	$0.31	$0.33
	Shellfish	1,501	$0.83	$0.01	$0.80	$0.86
	Other Finfish	1,501	$0.41	$0.01	$0.39	$0.43
2009	Scup	1,961	$1.04	$0.01	$1.02	$1.06
	Other Bottomfish	1,961	$1.92	$0.02	$1.88	$1.97
	Bait	1,961	$0.33	$0.01	$0.32	$0.34
	Shellfish	1,961	$1.01	$0.02	$0.98	$1.05
	Other Finfish	1,961	$0.51	$0.01	$0.48	$0.53

Table 3.7 details the average landed value by species group and year. Across trips that land 25% or more of their revenue from scup, scup is the highest value landed product. Other bottomfish constitute a significant portion of revenue. Shellfish, bait and other finfish make up very small portions of landed value.

Table 3.7 Landed Value per Trip by Species Group, 2005 – 2009 (2009 Dollars).

Year	Species Group	Number of Trips	Mean	Standard Error	Lower Bound	Upper Bound
2005	Scup	1,487	$3,229	$154	$2,927	$3,532
	Other Bottomfish	1,487	$1,368	$86	$1,199	$1,536
	Bait	1,487	$37	$6	$25	$49
	Shellfish	1,487	$198	$21	$158	$238
	Other Finfish	1,487	$68	$4	$60	$77
2006	Scup	1,829	$3,013	$121	$2,776	$3,250
	Other Bottomfish	1,829	$1,220	$61	$1,100	$1,341
	Bait	1,829	$54	$10	$36	$73
	Shellfish	1,829	$167	$16	$135	$198
	Other Finfish	1,829	$64	$4	$57	$71
2007	Scup	1,826	$2,297	$106	$2,089	$2,506
	Other Bottomfish	1,826	$736	$35	$668	$805
	Bait	1,826	$60	$11	$39	$81
	Shellfish	1,826	$138	$8	$121	$154
	Other Finfish	1,826	$39	$2	$34	$43
2008	Scup	1,501	$1,599	$62	$1,477	$1,722
	Other Bottomfish	1,501	$786	$37	$713	$858
	Bait	1,501	$37	$4	$28	$46
	Shellfish	1,501	$117	$16	$86	$147
	Other Finfish	1,501	$31	$2	$27	$36
2009	Scup	1,961	$2,212	$106	$2,004	$2,419
	Other Bottomfish	1,961	$877	$46	$787	$967
	Bait	1,961	$19	$2	$15	$23
	Shellfish	1,961	$131	$16	$99	$162
	Other Finfish	1,961	$36	$4	$29	$43

As mentioned above, this database does not include trips in state waters taken by boats that do not hold federal permits and only hold state permits. Table 3.8 contains a comparison of state and federal permits. The number of boats with only state permits is very small with as few as 4 boats in 2009 holding only state permits. Those that hold federal permits are included in the VTR database. This count in the state data from ACCSP is before applying any revenue cut off and it is likely that if a 25% revenue cutoff were applied to the state data as it was for the VTR data, this number would fall. While the state databases contain fewer vessel and trip characteristics than the VTR and permit databases, there are a few variables describing the vessels in both data bases. Table 3.9 contains a comparison across these characteristics. From this table the federally permitted boats in the VTR data are, on average, smaller than the state boats. If larger boats have higher costs, they will have lower producer surplus estimates, ceteris paribus (everything else held constant). Therefore, it is likely that inclusion of the small number of state otter trawl boats would lower producer surplus, but only slightly.

Table 3.8. State versus Federal Permit Comparison, 2005-2009.

Year	Count of Federal Permits Landing from State Waters	Count of Federal Permits Landing from State Waters with Otter Trawls (Analysis data set: no zero trip cost, greater than 25% rev/trip)	Count of State Permits Landing from State Waters w/ No Federal Permit
2005	146	28	10
2006	40	16	5
2007	37	13	4
2008	27	7	7
2009	23	11	4

Table 3.9. Vessel Characteristics Across Vessels with Only State Permits and Boats with both Permits Landing from State Waters, 2005-2009..

Vessel Characteristic	**State Permits Only**			**Federal Permits Landing from State Waters**		
	Mean	**Lower Bound**	**Upper Bound**	**Mean**	**Lower Bound**	**Upper Bound**
Length	63.89	59.12	68.65	60.98	60.69	61.28
Horsepower	523.05	457.81	588.29	439.74	435.44	444.04
Gross Tons	104.74	89.86	119.61	78.46	77.45	79.46

This database does not contain other gear types as the most recent NMFS cost and earnings data only covered otter trawl gears. To this author's knowledge, there has never been a scup cost and earnings data collection conducted for pot and trap boats, the second most prevalent gear type in this fishery. As a result, producer surplus will only be calculated for the otter trawl vessels. If costs are higher for the other gears, producer surplus will be less, ceteris paribus. If quality and therefore prices are higher for other gears, producer surplus would be higher for those gears, ceteris paribus. It is expectedthat this will not have a large impact on the allocation results as 69% of Summer landings, 96% of Winter I landings and 93% of Winter II landings are all from the otter trawl gear type. Appendix 2 contains a comparison of trip and vessel characteristics between otter trawls, gillnets and pots and traps; the three most used gears for scup.

3.2 Model

There has been considerable work on multiproduct fisheries models in the literature. Generally, these models use similar specifications and assumptions. In this body of work commercial fishermen are profit maximizers that face a two stage problem (Kirkley and Squires 1991). In the first stage, the fishing trip, the vessel operator chooses the revenue maximizing output bundle subject to fixed inputs, weather, resource quotas, and relative product prices. It is important to note that, for the commercial fisherman, inputs are fixed once they leave the dock. Because of this characteristic, the input bundle can be specified as a single composite input. There have been some detractors of this assumption (McConnell and Price 2006) due to the share system used in fisheries to compensate labor. Under the share system, labor cost is an endogenous function of harvest. Often effort, expressed as days at sea or gross tonnage, is used as the quasi fixed input because trip cost information is typically lacking. In the second stage, firms adjust their levels of effort to minimize production costs by selecting the optimal vessel size or capital stock. This second stage takes place over a 3-14 month horizon (Squires and Kirkley 1991).

Typically, these dual revenue models are estimated using translog or generalized Leontief functional forms, with the generalized Leontief used most frequently (Kirkley and Strand 1988, Squires and Kirkley 1991, Vestergaard 1999, Carter et al. 2008, and others). The generalized Leontief is usually selected because it places few restrictions on the underlying technology. The generalized Leontief also allows the analysis of input separability and non-jointness, but at the cost of imposing linear homogeneity in input prices (Carter et al 2008). Also, the generalized Leontief allows the estimation of output levels directly instead of output shares like the translog making the result more intuitive and improving the ease of estimation of the derived demands.

The generalized Leontief requires a series of sometimes limiting assumptions. First, profit must be non-decreasing in output prices and fixed factors. Profit must also be non-increasing in input prices, linearly homogeneous in prices and convex in prices. It also must be concave in fixed quantities, continuous, and twice differentiable (Carter et al. 2008). Additionally, input and output separability are important testable assumptions regarding the underlying technology. Separability implies that there are no interactions between any one input and any one output. If this assumption holds, it allows the use of composite inputs and composite outputs in the function being estimated.

Jointness in inputs is another testable assumption. Jointness in inputs implies that it takes all inputs to produce all outputs. That is, harvesting processes are interrelated. If jointness is not found, it means that there is a separate production function for each output or groups of outputs. While this assumption does not often hold for other gears, it is suspected that is might for a gear like the otter trawl.

3.2.1 Literature Review

Kirkley and Strand (1988) were one of the first to apply a dual revenue function to look at the Georges Bank multiproduct trawl fishery. The main goal of their work was to test general assumptions about the typical multiproduct specification that requires separability and non-jointness in production. They estimated a revenue function using a generalized Leontief function using the product of days at sea and gross tons as their quasi-fixed input. Their analysis used NMFS data containing 175,000 trips taken on Georges Bank. They used eight species groups including; cod, haddock, yellowtail flounder, pollock, winter flounder, other flounder, miscellaneous, and a catch all group equal to the sum of the seven above minus the total landed pounds. They estimated firm level annual input compensated supply functions using an iterated Zellner approach. Zero outputs by species groups can pose problems for these models. In this case, if there was zero output for one species grouping they left that zero I the data set as less than 11% of the trips contained zero outputs for any one species group. Their analysis showed that the assumptions of separability and non-jointness do not hold, but also felt gross tons and days absent may not have had enough variation or enough systematic variation to use as their quasi fixed input.

Squires and Kirkley (1991) used a dual revenue function to examine quota management in the multiproduct sablefish fishery. They used a generalize Leontief revenue function using total revenue as the dependent variable and output prices, composite input, landing port dummy and quarterly dummies as the independent variables. Similar to this scup analysis, they chose to include only those trips that landed more than 1,000 pounds of sablefish, a threshold established to delineate trips primarily catching sablefish. Instead of allowing zero outputs to remain zero, they replace zero outputs with a trivial value of 0.1. The found the input-output separability was rejected but that jointness overall was a valid assumption.

Squires and Kirkley (1996) used a dual revenue function to estimate the virtual prices in a multi-species fishery for the purpose of analyzing an individual transferable quota. Under the same assumptions as the above work, they used gross tonnage as their single composite input and measure of effort. Again they used a generalized Leontief imposing symmetry, linear homogeneity in prices and assuming input separability. Also, zero outputs were replaced with a small value of 0.1. The focus of that paper was to estimate a firm's input compensated supply equations so that they could derive the virtual price for quota. As will be done below, they horizontally sum the firm inverse derived demands to obtain the market inverse demand. Since the overall quota equals a perfectly inelastic supply of quota they equate the market inverse demand to overall quota and solve for the equilibrium market price for quota. From a static model, this price is equivalent to the price from an open auction. Integrating under these curves estimates producer surplus.

Vestergaard (1999) examined a multiproduct fishery with joint input production. With joint technology, as is the case with the otter trawl fishery, there are spillover effects on other output when one output is controlled through regulation. Allocation changes, which are essentially a change in a sector's harvest limit or quota, is a perfect example of an output control. In this analysis Vestergaard assumes a multiproduct firm faces a perfectly elastic demand for its outputs and input supply curves as assumed perfectly price elastic. The study estimates a profit function to measure the quasi-rent. Quasi-rent is the return to the fixed factors and is more useful than profit functions for obtaining producer's surplus. An important point posited by Vestergaard is that these types of models as short run only and conditional both on the existing biomass and the available biomass. Vestergaard's goal is to estimate producer surplus. To do this, he assumes production is joint in inputs with technology interdependence. He also posits that there may be one output for which zero production is possible, if and only if, no production takes place at all (Just et al. 1982). He calls this the necessary output. Most multispecies fisheries fit this model well with joint production and little ability to adjust output composition, which is certainly the case with otter trawls (Kirkley and Strand 1988, Squires 1987, Squires and Kirkley 1991, 1996).

3.2.2 Theoretical Model Specification

Recently Carter et al. (2008) performed a comprehensive analysis of both recreational consumer surplus and commercial producer surplus in the red grouper fishery in the South Atlantic and Gulf of Mexico. Gentner et al. (2010) also utilized this same formulation. Both analyses follows the above literature closely and that model structure will be used here. Fulginiti and Perrin (1993) describe the linkage between quota constrained quasi-rent and the unconstrained quasi-rent using the concept of a virtual price. Under this structure, the virtual price is the output price that induces the firm to produce at a given quota level. Virtual price is defined as:

$$\frac{\partial \pi}{\partial p_{v_1}} = \overline{q_1} \qquad 3.1)$$

where $\overline{q}_1$ is the quota for output 1, p_{v1} is the virtual price for output 1, and π is profit in this multiproduct fishery. Furthermore:

$$p_{v_1} = (p_1 - \lambda_1) \qquad 3.2)$$

where p_1 is the output price and λ_1 is the rent per unit of quota or the marginal value of output 1. At the virtual price for quota 1, the quota quasi-rent function must equal the quota free quasi-rent function:

$$\pi(p_1, p_h, w; \overline{q_1}, K) = \pi(p_v, p_h, w; K) \qquad 3.3)$$

where p_h is the price vector for all other output prices in this multiproduct fishery, w is a vector of input prices, and K is the quasi fixed input. Quasi rent can be expanded and rewritten as follows for a two output single quasi fixed input case:

$$\pi(p_1, p_h, w; \overline{q_1}, K) = \sum_{i=2}^{n} p_i y_i (p_1 - \lambda_1, p_h, w; K) + \lambda_1 \overline{q_1} - \sum_{j=1}^{m} w_j x_j (p_1 - \lambda_1, p_h, w; K) \qquad 3.4)$$

where x_j is the single quasi fixed input, w_j is the single input price, y_i is a vector of the two output quantities. Using Hotellings lemma:

$$\frac{\partial \pi}{\partial p_i} = y_i (p_1 - \lambda_i, p_h, w; K) \forall i \geq 2 \qquad 3.5)$$

$$\frac{\partial \pi}{\partial w_j} = -x_j (p_1 - \lambda_i, p_h, w; K) \qquad 3.6)$$

Where 5) is the output supply and 6) is the input demand. Inverse derived demand for quota found by differentiating 4) above with respect to quota 1:

$$\frac{\partial \pi}{\partial \overline{q_1}} = \lambda_1(p, w; \overline{q_1}, K) \qquad 3.7)$$

Market output price (landed price) less the virtual price is the marginal quota rent. This expression for the inverse demand captures the optimal adjustment in inputs used and captures optimal adjustments in other outputs (Carter et al 2008). As such, it is the marginal value of the next unit of quota in fishery 1. While it is possible to calculate producer surplus by integrating below the market price and above the output supply, producer surplus can be derived using the input demands as the area under the implicit derived demand for quota measures quasi rent (Carter et al. 2008).

$$PS = \int_0^{\overline{q_1}} \lambda_1(p, w; \overline{q_1}, K) dy_1 = \pi(p, w; \overline{q_1}, K) \qquad 3.8)$$

The total derived demand for the commercial sector is simply the horizontal sum of the individual firm and trip level demands. Therefore, commercial quota rental price for the last unit of quota is found by setting the total demand equal to the perfectly inelastic supply curve for quota, also known as the harvest limit. Quasi rent is estimated by integrating under different levels of the harvest limit at each level of allocation change being considered.

3.2.3 Empirical Model

The general specification of a non-homothetic generalized Leontief quasi-rent function is:

$$\pi(p;K)=\sum_{i=1}^{n}\alpha_i p_i K^2+\sum_{j\neq i}\beta_{ij}\left(p_i p_j\right)^{1/2}K \qquad \text{3.9)}$$

where p_i is output price of species i, and K is the quasi-fixed input. Symmetry is imposed by restricting $\beta_{ij}=\beta_{ji}$ for each i not equal j. Using Hotellings lemma, the input-compensated unconstrained supplies are

$$\frac{\partial\pi}{\partial p_i}=y_i=\alpha_i K^2+\beta_{ii}K+\sum_{j\neq i}\beta_{ij}\left(\frac{p_j}{p_i}\right)^{1/2}K \qquad \text{3.10)}$$

The specification used for estimation is:

$$\pi(p;K)=\sum\alpha_i p_i K^2+\sum_i\sum_j\beta_{ij}\left(p_i p_j\right)^{1/2}K+\sum_i\sum_k\delta_{ik}d_k p_i K+\sum_i\sum_l\varepsilon_{il}e_i p_i K+$$
$$\sum_i\sum_m\phi_{im}f_m p_i K \qquad \text{3.11)}$$

where p_i is the landed price for species i, K is the total estimate trip costs, d is a set of season dummies for the aggregated cost model and a set of monthly dummies used in the seasonal models, e is a set of dummies for the five years in the data, and f is a set of landing port dummies. This study is fairly unique in that the data contains total estimated trip costs. These costs are quasi fixed since once a trip has started, the inputs available, both capital and labor, are fixed. Applying Hotellings lemma the input compensated supplies are:

$$\frac{\partial\pi(p;K)}{\partial p_i}=q_i=\alpha_i K^2+\beta_{ii}K+\sum\beta_{ij}\left(\frac{p_j}{p_i}\right)^{1/2}K+\rho K \qquad \text{3.12)}$$

where

$$\rho=\sum_k\delta_{ik}d_k+\sum_l\varepsilon_{il}e_l+\sum_m\phi_{im}f_m$$

Demand for quota is derived for the unconstrained output supply equations using the virtual prices. Virtual prices relate unconstrained output supply and factor demand functions by substituting the virtual price expression into 12).

$$\lambda_1=p_1-\left(\frac{K\sum_{j\neq 1}\beta_{1j}p_j^{1/2}}{\bar{q}_1-\alpha_1 K^2-\beta_{11}K-\rho K}\right)^2 \qquad \text{3.13)}$$

λ, the input compensated marginal quota rent rises the closer the quota comes to binding. The above expression is the marginal willingness to pay (MWTP) function for additional scup quota (Squires and Kirkley, 1996).

Simulating the quota market involves horizontally summing the individual firm level trip demand functions. The market equilibrium lease price for quota is found by setting market derived demand equal to the harvest limit. The expression for the equilibrium quota market is:

$$\overline{Q_1} = \sum_k \left[\alpha_1 \left(K^k\right)^2 + \beta_{11} K^k + \sum_{j \neq 1} \beta_{1j} \left(\frac{p_j^k}{\left(p_1^k - \lambda_1^k\right)} \right)^{1/2} K + \rho K^k \right] \qquad 3.14)$$

where $\overline{Q_1}$ is the overall quota for scup and *k* is the number of trips in the year.

3.3 Results

Model estimation was handled in SAS using PROC Model (SAS 2003). Each input scaled output supply function, scup, baitfish, shellfish, other bottomfish, and other finfish, was estimated individually and tested for heteroscedasticity using White's test (White 1980). Table 3.10 contains the results of those tests. In each case the null hypothesis of homoscedasticity is rejected in favor of a heteroscedastic error structure. Heteroscedasticity stemming from the square of the quasi fixed input was anticipated (Squires and Kirkley 1991, Carter et al 2008), and it was found with this specification. To remedy the heteroscedasticity, the following systems regression was weighted by the quasi fixed input.

Table 3.10. Results of White's Test for Heteroscedasticity for Individual Equations.

Equation	Statistic	Degrees of Freedom	Pr > ChiSq	Variables
Scup	3,669	230	<.0001	Cross of all variables
Other Bottomfish	4,319	230	<.0001	Cross of all variables
Bait	2,921	230	<.0001	Cross of all variables
Shellfish	740	230	<.0001	Cross of all variables
Other Finfish	852	230	<.0001	Cross of all variables

The full system of input scaled output supply functions were estimated using FIML estimators (SAS 2003). Symmetry was maintained for the regression result reported here. Initially, the Atlantic cyclonic index by month was tried, but for the northern Atlantic, there was not enough variation in the index to provide additional explanatory power.

For this regression, the functional form is assumed exact rather than an approximation (Squires and Kirkley 1996). As such, the errors are then assumed to arise from optimization rather than the approximation. Zero outputs in any species group in the regression create a limited dependent variable problem that introduces bias and non-normality of the regression residuals. As a result, zero outputs were replaced with the value of 0.1. See Squires and Kirkley (1991) and Carter et al. (2008) for a more complete discussion of the impact of this replacement and other potential solutions that weren't possible due to computational feasibility or assumptions that would impact the analysis negatively.

Parameter estimates and regression diagnostics are detailed in Appendix 3. The scup equation (wt_1 and parameters a1-a24) had the second highest adjusted R-squared at 0.3741 and other bottomfish had the highest at 0.5414, which fits with scup being a bycatch species. Also as expected, trip costs, the quasi fixed input, was positive and significant and trip cost squared was negative, small, and significant. Additionally, the prices of the other four species groups were positive and significant. Landings during the late winter (January, February, and March) and fall (October and November) had positive effects in the regression and were significant with the exception of the parameter on November. The spring and summer months had negative and significant impacts on the regression, with the exception of September which was negative, but not significant. There are far too many ports modeled to discuss each individually. Many of the port variables were insignificant. The remaining three equations, bait, shellfish and other finfish had low adjusted R-squared values but their inclusion improve the fit of the overall system.

The technology tests included nonjointness and symmetry and the results are displayed in Table 3.11. Overall non-jointness in inputs was rejected suggesting that all inputs are required to produce all outputs, and, by broader extension, that harvesting processes for each species are connected. Species specific non-jointness tests were also rejected for each species grouping. This suggests that the production of one group relative to the other groups is interrelated to the harvest and relative prices of the other species groups in this joint production function. Separability was also rejected indicating that neither inputs nor outputs can be represented by composite goods. That is, a specific output bundle is required to produce a specific input bundle.

Table 3.11. Technology Test Results

Test	Statistic	Value	Probability > Chi-Square	Conclusion
System Nonjointness	Wald	1,108.75	<0.0001	Reject
Scup Nonjointness	Wald	750.96	<0.0001	Reject
Bottomfish Nonjointness	Wald	3,973.10	<0.0001	Reject
Bait Nonjointness	Wald	199.31	<0.0001	Reject
Shellfish Nonjointness	Wald	395.06	<0.0001	Reject
Other Finfish Nonjointness	Wald	225.33	<0.0001	Reject
Separability	Wald	1,359.10	<0.0001	Reject

In order to estimate the marginal willingness to pay (MWTP) for quota at the predetermined allocation levels, the quota market was simulated. The following simulation assumes that the MWTP for quota values that are generated for the otter trawl fleet are equivalent to the MWTP for quota across other gear types that harvest scup. Across the time series, 78% of the quota was harvested by the otter trawl fleet. In 2009, scup dockside prices averaged across all other gear types were $1.25/pound while scup prices for otter trawl caught fish were $1.04/pound. If the cost structure of the other gears (gillnets and pots and traps primarily) are similar to otter trawls, the MWTP from this simulation will represent lower bounds on the true value. If the cost structure of these other gears are lower than otter trawls the MWTP will be understated even more and if their cost structure is higher, the otter trawl MWTP simulated here may represent these other gears well. Due to the lack of cost information on the other gears, it is impossible to speculate on the cost structures for these other gears.

A total harvest limit of 29.96 million was used for the simulations (based on a three year average of the most recent allocation years 2010-2012 during most recent stock conditions). This is more than two times the 2010 total harvest limit and larger than any other harvest limit in the data time series. The quota market was simulated by randomly sampling additional observations from the otter trawl data set until predicted harvests equaled the total harvest limit (Carter et al. 2008). A full bioeconomic model was not used as there just was not time to combine the commercial model with the recreational bioeconomic model. Equation 3.14 was simulated across the allocation scenarios requested by MAFMC (plus 6% to minus 9% in 3% intervals) using the 29.96 million pound harvest limit. The results of this simulation are contained in Table 3.12. Additionally, only well-behaved observations or those observations that did not violate monotonicity requirements were used in the simulation (Squires and Kirkley 1996, Carter et al 2008). At the 23.37 million pounds status quo level of commercial landings, scup commercial fishermen are willing to pay $0.5082 for an additional pound of scup quota.

Table 3.12. Marginal Willingness-To-Pay for a pound of Scup Quota.[a]

Allocation	**MWTP**	**Pounds of Quota**	**Total Benefits**
6%	$0.4685	25,166,400	$11,791,331.82
3%	$0.4932	24,267,600	$11,968,225.90
Status Quo	$0.5082	23,368,800	$11,875,776.55
-3%	$0.5243	22,470,000	$11,780,652.07
-6%	$0.5388	21,571,200	$11,622,114.06
-9%	$0.5654	20,672,400	$11,687,294.81

[a] All dollar values are in 2010 constant dollars.

3.4 Seasonal Models

In order to examine seasonal allocations, the data set was split into summer and winter season trips and same modeling strategy used above was run on these stratified data sets. Because quota from Winter I is rolled over in to Winter II and because separate models for each season were unreliable these seasons were aggregated into a single winter season. Table 3.13 contains the prices paid for otter trawl caught fish by year. Summer fish obtain a higher price at an average of $1.26 in 2009. Winter prices averaged $0.91 in 2009.

Appendix 4 contains the model results for the combined winter season. Model fit for the scup equation in the winter season was higher (0.3196) than in the aggregated model and for the bottomfish equation fit was much worse (0.1514). As found above, the parameter on cost is positive and the parameter on cost squared is negative in the scup equation. Heteroscedasticity was found and corrected by weighting by the quasi fixed input. Finally the same technology conclusions were reached as in the aggregate model; nonjointness for the whole system and for each equation rejected and separability rejected. Appendix 5 contains the model results for the summer season. Model fit for the scup equation in the summer season was lower (0.2612) than in the aggregated model and for the bottomfish equation fit was much worse (0.1870). As found above, the parameter on cost is positive and the parameter on cost squared is negative in the scup equation. Heteroscedasticity was found and corrected by weighting by the quasi fixed input. Finally the same technology conclusions were reached as in the aggregate model; nonjointness for the whole system and for each equation rejected and separability rejected. Simulations were conducted as above using the total quota. Table 3.14 details the MWTP for each allocation level As expected with similar cost structures and different average prices received at landing, the winter season MWTP is lower than the summer season MWTP across all allocation levels. This results suggests the current allocation is not efficient and efficiency would be increased if allocation was moved to 9% to favor the summer season.

Table 3.13. Scup Prices by Season 2005-2009.

Year	Season	N	Mean	95% Lower Bound	95% Upper Bound
2005	Summer	460	$1.24	$1.20	$1.28
	Winter	691	$0.96	$0.94	$0.98
2006	Summer	620	$1.52	$1.48	$1.56
	Winter	885	$0.98	$0.95	$1.01
2007	Summer	527	$1.03	$1.00	$1.06
	Winter	910	$0.84	$0.82	$0.87
2008	Summer	275	$1.12	$1.07	$1.17
	Winter	1034	$0.93	$0.91	$0.96
2009	Summer	423	$1.26	$1.21	$1.31
	Winter	1235	$0.91	$0.88	$0.94

Table 3.14. Seasonal Marginal Willingness-To-Pay for a pound of Scup Quota.[a]

Allocation	Winter			Summer			Total Benefits (Relative to Summer)
	MWTP	Pounds of Quota	Total Benefits	MWTP	Pounds of Quota	Total Benefits	
9%	$0.4601	20,986,980	$9,656,910	$0.5625	14,365,820	$8,080,576	$17,595,936
6%	$0.4871	20,088,180	$9,784,667	$0.5928	13,467,020	$7,983,760	$17,530,599
3%	$0.5082	19,189,380	$9,752,034	$0.5972	12,568,220	$7,506,214	$17,295,729
0%	$0.5258	18,290,580	$9,618,042	$0.6072	11,669,420	$7,086,111	$16,704,153
-3%	$0.5629	17,391,780	$9,789,516	$0.6497	10,770,620	$6,997,177	$16,749,211
-6%	$0.5788	16,492,980	$9,546,839	$0.6669	9,871,820	$6,583,234	$16,367,901
-9%	$0.6102	15,594,180	$9,515,360	$0.6749	8,973,020	$6,055,544	$15,712,454

[a] All dollar values are in 2009 constant dollars.

4.0 Consumer Valuation

This section provides a broad overview of the estimation of consumer benefits of the sale of scup using compensating variation, derived using landings and dockside prices, as the benefits metric. Through this exercise, price changes stemming from changes in allocations are also estimated. Using the models developed, this section provides estimates of changes in prices, real revenues, and compensating variation corresponding to the scup allocation scenarios developed above (+9% to -6% commercial quota change).

4.1 Methodology

The body of literature describing approaches for estimating both market and non-market values for various goods, services, and states of the environment is rich (see, for example, Freeman, 1989 and Bockstael and McConnell, 2007). Our primary focus here, however, is estimating how changes in commercial landings affect commercial prices, ex-vessel revenues, and compensating variation for consumers. Further attention is focused, then, on estimating market values for scup.

4.1.1 The Synthetic Inverse Demand System

There is an extensive literature of estimating commercial demand functions. This includes literature on functional form specification as well as whether or not fish demand models should be price or quantity dependent. There is no precise answer, but the available literature suggests that the demand for many agricultural and fishery commodities should be expressed as price dependent equations (Barten and Bettendorf, 1989; Barten, 1993; Brown et al., 1995; and Park et al., 2004).

One approach gaining favor by empirical researchers is the synthetic inverse demand system (SIDS). This is a flexible functional form specification of an inverse demand, which facilitates testing various restrictions to determine if other alternative specifications of demand can be used. These alternative specifications include the inverse Rotterdam demand model (IROT), the inverse almost ideal demand system (IAIDS), the inverse Central Bureau of Statistics (ICBS) demand model, and the inverse National Bureau of Research (INBR) demand model.[8] All these models maintain desirable properties of demand theory and facilitate estimation of changes in prices, revenues, and consumer benefits associated with changes in the demand (landings) of agricultural and fishery commodities.

Within the SIDS framework, a system of demand equations can be estimated by seemingly unrelated regression or, if there are cross equation constraints, maximum likelihood estimation techniques. The basic specification used in the analysis contained in this paper follows Park et al. (2004):

$$w_{it}\,\Delta\ln v_{it} = \alpha_i + \sum_{j=1}^{n}\pi_{ij}\,\Delta\ln q_{jt} + \pi_i\,\Delta\ln Q_t - \theta_1 w_{it}\,\Delta\ln Q_t - \theta_2 w_{it}\,\Delta\ln\left(\frac{q_{it}}{Q_t}\right)_{it} + \varepsilon_{it}, \quad 4.1)$$

where $\ln Q_t = \sum_{j=1}^{N} w_{jt}\ln q_{it}$.

In this specification, q_i is the per capita quantity demanded for the ith quantity; v_i is a normalized price for the ith commodity (i.e., $v_i = p_i/m$, where p_i is the price of the ith commodity, and m is the per capita level of total expenditures for all commodities under consideration); α_i, π_i, and π_{ij} are coefficients to be estimated; Δ is a change operator; ε_{it} is the error term, which is assumed to be normally distributed with a mean of zero and constant variance; and θ_1 and θ_2 are estimable parameters. θ_1 and θ_2 are further assessed, via parametric restrictions, to determine if one of the four basic inverse demand models best describe the demand for seafood. If $\theta_1 = \theta_2 = 0$, the model reduces to the inverse Rotterdam model; if $\theta_1 = \theta_2 = 1$, the model becomes the inverse almost ideal demand system (IADS) model; if $\theta_1 = 1$ and $\theta_2 = 0$, the model becomes the ICBS model; and if $\theta_1 = 0$ and $\theta_2 = 1$, the SIDS model becomes the INBR model.[9] The inverse demand system of equations requires several constraints consistent with demand theory: (1) symmetry in which $\pi_{ij} = \pi_{ji}$, (2) adding up in which $\Sigma_i\,\pi_{ij} = 0.0$, (3) homogeneity in which $\Sigma_j\,\pi_{ij} = 0.0$, and (4) $\Sigma_i\,\pi_i = 0.0$.

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[8] Park et al. (2004) provide a comprehensive discussion and illustration of the SIDS model.

[9] See Park et al. (2004) for a detailed discussion of the SIDS and related inverse demand models.

No retail data exists for seafood at the species level. As a result these five groups were constructed using a review of the literature, correlation analysis from landings data, and through discussions with retailers. Scup is a challenging species to model as total scup and porgy landings account for only 0.12% of all US finfish landings. There are only five species of scup and/or porgies caught in the US including scup, jolthead porgy, knobbed porgy, red porgy and whitebone porgy. Additionally, the landing records contain a species group named "scup or porgies" and that group contains 93% of all landings across these six scup categories. These six categories were aggregated into one group that will be used to model scup demand. To develop the other groups, correlation analysis was conducted across all species in the landings record relative to this scup group. Species with a Pearson's correlation coefficient greater than 0.5 were grouped together and correlation analysis was conducted again.[10] This analysis resulted in five groups: scup, other panfish, groundfish/reef fish, shellfish and all other species. This fifth category was discarded. The final group for analysis includes imports. All imports matching other panfish or groundfish/reef fish groups were included in imports. This demand system includes five equations, one each for 1) scup, 2) other panfish, 3) groundfish/reef fish, 4) shellfish and 5) imports.[11]

No models were run examining different aggregations among the flatfish species other than the aggregation detailed above. Also, data on all other protein expenditures, while important in explaining seafood protein expenditures were not included due to data and modeling limitations. It is very time consuming to set up each species group and most modeling programs are limited in the number of simultaneous equations that can be supported. It has been the author's experience that adding additional sectors adds little to change the parameter estimates, after a certain point. Asche et al. (2005), Parks et al. (2004) and others find that focusing on a narrower range of species thought to be substitutes or complements a priori has little effect on overall estimates.

Although most researchers estimate the system of demand equations using iterative Zellner (1962) procedure;Greene (2003) demonstrated that maximum likelihood should be used to estimate the system of equations when cross equation constraints are imposed. Therefore the proc model routine, available in SAS, was used to estimate the system of seemingly unrelated demand equations using maximum likelihood methods. The cross equation constraints used include:

$$\boldsymbol{\sum_i\left(\pi_{ij} - \theta_2\omega_i\delta_{ij} + \theta_2\omega_i\omega_j\right) = \sum_i \pi_{ij} = 0 \; adding\ up}$$

$$\boldsymbol{\sum_i\left(\pi_{ij} - \theta_2\omega_i\right) = 1 \; adding\ up} \qquad 4.2)$$

$$\boldsymbol{\sum_j\left(\pi_{ij} - \theta_2\omega_i\delta_{ij} + \theta_2\omega_i\omega_j\right) = \sum_j \pi_{ij} = 0 \; homogeneity}$$

$$\boldsymbol{\pi_{ij} = \pi_{ji} \; symmetry}$$

The SIDS model is quite convenient because it easily facilitates calculation of various compensated and uncompensated price flexibilities or elasticities and measures of welfare, which include compensated

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[10] The full results of this correlation analysis are not included here but are available from GCG, Inc. upon request.

[11] For details regarding the correlation analysis and species composition of these groups, please contact Gentner Consulting Group, Inc.

and equivalent variation and consumer surplus. Calculations of the elasticities used here are as follows:[12]

$$\begin{aligned}
&\textit{scale elasticity} = f_i = \frac{\pi_i}{w_i} - \theta_1 \\
&\textit{compensated cross quantity elasticity} = f_{ij} = \frac{\pi_{ij}}{w_i} + \theta_2 w_j \qquad\qquad 4.3) \\
&\textit{compensated own quantity elasticity} = f_{ii} = \frac{\pi_{ii}}{w_i} - \theta_2 + \theta_2 w_i
\end{aligned}$$

For this exercise the focus is on compensating variation. Typically, there is little difference between compensating variation, equivalent variation, and consumer surplus. Moreover, Freeman (1979) suggests that the Marshallian consumer surplus measure is without economic foundation, and thus, recommends using compensating variation as the preferred measure of welfare or benefits. Compensating variation is simply the level of compensating payment or offsetting change in income, which is necessary to make an individual indifferent between an original situation and new situation. It may also be interpreted as the maximum amount an individual would be willing to pay for the opportunity to consume the same quantity of goods at a new price, as consumed under the original price.

Park et al. (2004) provide three convenient formulas for calculating all three welfare measures.

$$\textit{compensating variation} = -\Delta q \left\{ v^0 - 0.5 \left[(f_{ii}) \frac{v^0}{q^0} \right] \Delta q \right\} \qquad 4.4)$$

For welfare gains, the estimates of compensating and equivalent variation are negative, and for welfare losses, the estimates are positive. A remaining concern is estimating changes in demand price and corresponding revenues. Park et al. (2004) provide a convenient equation for estimating the demand price corresponding to a change in demand:

$$v^1 = v^0 + \Delta v = v^0[1-(\text{flexibility})\text{x}(\Delta q/q)], \qquad 4.5)$$

where v is the normalized price (price divided by total expenditures for all commodities under consideration); v^1 and v^0 represent normalized prices at time 1 and time 0; flexibility is the compensated quantity elasticity; and $\Delta q = q^1 - q^0$. In this particular situation, q is defined to equal the reported quantity landed divided by the U.S. population.

4.1.2 Statistical Estimates of the SIDS Model

The SIDS model was estimated by the method of maximum likelihood. As shown by Greene (2002), maximum likelihood is the preferred method over iterative seemingly unrelated regression when cross equation restrictions are imposed, and estimation requires dropping one equation from the estimation to avoid singularity. There are five equations: 1) an inverse demand for scup, 2) the inverse demand for other other panfish, 3) the inverse demand for groundfish/reef fish, 4) the inverse demand for shellfish, and 5) the inverse demand for imports. One equation must be omitted to avoid singularity. For the

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[12] The elasticities and respective calculations are further derived in Park et al. (2004). The scale flexibility or elasticity is often equated to the income elasticity in demand. As shown by Park and Thurman (1999), however, they are not equivalent. Scale flexibility is defined to be the proportional change in a normalized price, v_i in our model, resulting from a scalar expansion of all commodities in the consumption bundle (i.e., all q_i in our analysis). The scale flexibility is restricted to a radial expansion from the origin to the indifference curve or utility function.

purpose of estimation, we omit imports from the system of equations. Parameter estimates for imports are directly obtained via restrictions imposed on the system of equations (e.g., homogeneity and adding up constraints).

Data on monthly imports, landings and ex-vessel values were obtained from NOAA Fisheries, electronic databases. Landings data came from the commercial landings data files, and data on imports were derived from NOAA's international fisheries statistics. These data were used to construct prices and expenditures, with the latter equaling the sum of the price times the quantity of each of the species under consideration in the grouping. All landings and expenditure data were converted to per capita statistics by dividing by the resident civilian population, by month. Data covered the period 1990 through 2010. Data for 1990, however, were omitted because it was necessary to take first differences of all variables.

The system of equations contained 24 parameters. The statistical results were mostly significant, and all equations had relatively good fit. Appendix 6 contains the detailed model estimates. Adjusted R-squared values ranged from a low of 0.31 for scup to 0.87 for other panfish. Based on the Durbin-Watson statistics, autocorrelation did not appear to pose a problem. Spurious correlation was also not a problem because all equations were specified as first differences. We accept the original restrictions on the SIDS model regarding symmetry, homogeneity, and adding up.

The best model estimated was the SIDS model with unrestricted θ values, and these results are typical of many SIDS modes where the unrestricted values perform the best (Park et al. 2004). While the mixing parameters, θ_1 and θ_2, are close to the ICBS values of 1 and 0, they are not statistically the same. The IROT model restrictions ($\theta_1 = 0$, $\theta_2 = 0$) yields a Wald of 167.8; the ICBS model restrictions ($\theta_1 = 1$ and $\theta_2 = 0$) yields a Wald of 14.27; the IAIDS model restrictions ($\theta_1 = \theta_2 = 1$) yield a Wald of 13,959.9; and the INBR model restrictions ($\theta_1 = 0$ and $\theta_2 = 1$) yield a Wald of 14,113.4. This suggests that none of the restrictions are appropriate.

Table 4.1 contains the compensated cross and own price flexibilities, the scale elasticities and standard errors (in italics), generated using equation 4.3. Elasticities are presented instead of parameter estimates as the parameter estimates do not have an intuitive explanation. The scale flexibility is defined to be the proportional change in a normalized price, v_i in our model, resulting from a scalar expansion of all commodities in the consumption bundle (i.e., all q_i in our analysis). For homothetic preferences, all scale elasticities would be -1. Estimates of the scale elasticities were similar to those obtained in numerous other studies in which the values are near -1, which simply depict the percentage change in price as the quantity of each good in the system is changed by 1.0%. Many of these are close to this value, but none are statistically equal to -1 and the scup scale elasticity is very different from -1. For example, if the quantity of all species in this model increased by 1%, the price of scup would fall by 0.0998%, other panfish would fall by 1.04%, groundfish/reef fish would increase by 3.29%, shellfish would fall by 1.35% and the price of imports would fall by 1.01% The elasticity for scup is much higher than the elasticity estimated in Park et al. (2004), but it has the correct sign. For example, Park et al. (2004) found that a 1% increase in the porgy quantity reduced its price by 0.073%. In this case a 1% increase in scup quantity reduces its price by 0.34%. Positive cross price elasticities indicate the products are substitutes and negative cross price elasticities suggest the products are complements.

Table 4.1. Model Price Flexibilities and Elasticities.

Species Groups	Scup	Other Panfish	Groundfish/ Reef Fish	Shellfish	Imports	Scale Elasticities
Scup	-0.3397	0.0157	0.2697	-0.1893	-0.6269	-0.0998
	0.0092	*0.0017*	*0.0310*	*0.0425*	*0.1033*	*0.1177*
Other Panfish	0.0157	-0.6238	-0.0180	0.3909	0.1580	-1.0373
	0.0017	*0.0070*	*0.0013*	*0.0078*	*0.0039*	*0.0017*
Groundfish/Reef Fish	0.2697	-0.0180	1.0449	-1.3047	-3.3141	3.2871
	0.0310	*0.0013*	*0.0480*	*0.0501*	*0.1172*	*0.1459*
Shellfish	-0.1893	0.3909	-1.3047	-0.2060	0.4627	-1.3501
	0.0425	*0.0078*	*0.0501*	*0.0021*	*0.0075*	*0.0052*
Imports	-0.6269	-0.6269	-3.3141	0.4627	-0.2382	-1.0134
	0.1033	*0.1033*	*0.1172*	*0.0075*	*0.0042*	*0.0011*

4.2 Prices, Revenues, and Compensating Variation

In this assessment, scup commercial allocation increases of 3% and 6% and decreases of 3% and 6% are considered. Table 4.2 contains the estimates of consumer MWTP calculated using equation 4.4. Table 4.2 also contains estimates of the new dockside prices that would result from allocation changes using equation 4.5. As is suggested by the quantity elasticities, prices are not very sensitive to changes in demand. Consumers would be willing to pay $.06/pound for 6% more scup and ex-vessel price would decrease to $1.02/pound.

Table 4.2. Consumer Marginal Willingness-To-Pay for Scup and Dockside Prices.

Allocation Scenario (Relative to current commercial allocation)	MWTP	New Dockside Price
6%	$0.0155	$1.02
3%	$0.0447	$1.03
0%	$0.0761	$1.04
-3%	$0.1099	$1.05
-6%	$0.1463	$1.06
-9%	$0.1855	$1.07

5.0 For-Hire Producer Surplus

While it was hoped that the data from the recently completed for-hire cost and earnings survey could be used to estimate a for-hire model of production, ultimately estimating a production function proved impossible. Instead, mean economic profit per trip was calculated for both the charter and party boat sectors using the survey data. While this technique has its limitations, detailed below, it does supply a measure of producer surplus per angler trip taken in either for-hire mode. This section details the ideal framework for a for-hire production function and discusses the data limitations that prevented estimation in this case. Next, the producer estimation technique is detailed and estimates presented.

In an exhaustive search of the literature, no one has ever estimated a for-hire fishing production function nor has anyone ever estimated for-hire producer surplus (Abbott and Wilen 2009, Plummer et al. 2012).[13] While it might be technically possible to estimate a multi-output dual approach as specified above in the commercial producer surplus section, there are several data limitations preventing the application of this methodology. First, and specific only to this effort, there is no way to link respondents to the for-hire cost and earnings survey to actual trip records from the VTR data described above, nor can the data be linked to trip records in the for-hire telephone survey. As a result, there is no direct link to catch of scup or any other species per trip. This is due to several survey design issues. Due to budget limitations in the for-hire cost and earnings survey, the sampling unit was the vessel owner and not the individual trip. As a result, only annual total expenditures and annual total revenues could be collected. Also, to insure confidentiality to respondents, no identifying variables, such as permit number, were recorded in the survey data base. Without the permit number, the record could not be linked to the VTR data or the for-hire telephone survey data. Several attempts were made to link the cost and earnings data to the VTR data and those attempts are discussed in detail below.

Second, for-hire fishing is a multiproduct production function producing catch of multiple species and entertainment across non-catch products. This second class of outputs include sightseeing, being with friends and family, and simply enjoyment of the boat ride. It is impossible to price out each of these individual products using any of the currently available data sets as was done in the commercial production modeling. For the commercial model, dockside prices for each species were available and it was assumed that there were no non catch products. To be fair, it may be impossible to tease out for-hire prices per species caught or price per non catch product without detailed survey of the charter patrons. If the for-hire cost and earnings survey could have been linked to the VTR data, the best case scenario would have been a producer surplus value per pound not specific to scup but calculated based on all pounds caught across all species of fish. This value would have been an upper bound as it would have also contained producer surplus stemming from the provision of non catch products.

Additionally, there are theoretical challenges to estimating a production function for for-hire fisheries.[14] Multi-output commercial fishing models are a challenging set of models that contain many limiting assumptions and that have limited applicability. Even if the appropriate data could be obtained that provided pricing for all for-hire products, effort and catch alone do not fully explain the behavior of for-hire captains. For instance, many for-hire captains may not be profit maximizers, but economic satisficers. That is, they operate the boat because they enjoy operating a for-hire vessel and may only work to cover costs and not maximize profits. Box 1 contains selected open-ended responses to a question asking why respondents were in the for-hire business. Also, when trying to specify a production function for trips, trips are typically of a fixed length that is set exogenously, which created problems for certain types of models.

Abbott and Wilen (2009) proposed a for-hire production function. It would involve specifying a seasonal vessel expenditure function instead of cost minimization to capture the choice of vessel inputs. The model would need data on the number of passengers on each trip. In contrast to the dual specification described above in the commercial section, this allows the explicit inclusion of individual inputs instead of the use of a composite input. This framework would also be able to capture input stuffing. This specification would require the following classes of expenditures; trip costs, trip invariant expenditures

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[13] This fact was also verified in personal communications with Jim Wilen (Professor UC Davis), Josh Abbott (Professor Arizona State University), and David Carter (NOAA Fisheries SEFSC). All three have completed extensive work in fisheries production analysis, both commercial and for-hire.

[14] Joshua Abbott, personal communication.

avoidable without exit, and trip invariant costs only avoidable with exit. Without a link to trip characteristics this framework would be impossible to specify.

Given the inability to estimate a production model using the existing data, the focus shifted to estimating economic profit per angler trip. The measure was denominated by angler trips because that is the measure estimated by the MRFSS survey and the measure that will be the output of the recreational model estimated by NMFS and detailed below. While there is no direct link to the VTR data in the for-hire cost and earnings survey, attempts were made to link revenues and costs from the survey to the VTR data. This 2010 quota levels were used to attempt to develop a measure of the producer surplus per pound of all fish caught. However, due to the restrictive assumptions needed to transfer costs and earnings into the VTR data, a realization that the VTR data only records numbers of fish and the discovery of what appears to be significant digit bias in the VTR catch records, this effort was abandoned.[15] Instead, the for-hire cost and earnings survey alone was used to estimate the mean producer surplus (revenue less variable costs) per angler trip. While this is the technical definition of producer surplus, it assumes that all owners face the same opportunity cost of employing themselves and their capital in some other endeavor, which may or may not be a good assumption. Additionally, this measure of producer surplus is only valid for 2010 quota levels and catches and cannot vary for changing allocations. As a result, while accurate for the status quo, it will overestimate producer surplus for increasing allocations and underestimate producer surplus for decreasing allocations. For this analysis, MAFMC has asked that we examine a harvest limit more than twice that in 2010. Finally, this measure represents an upper bound on the producer surplus for scup trips as all trips in the VTR database caught multiple species and provided non catch products.

To estimate producer surplus per trip total variable costs were subtracted from total revenue and then divided by the number of angler trips. Variable costs included; fuel and oil, captain's share, crew share, bait, ice, food and drink, fishing gear and tackle, other supplies, booking agent fees, tow vehicle gas, tow vehicle tolls and launch ramp/parking fees (for trailered boats). These categories represent an over estimate of the trip level variable costs as some fishing gear and tackle expenditures fall into the fixed cost category. However, some tackle and gear is consumable and rightly a variable cost. Because the variable and fixed portions of these costs could not be divorced, all costs were included to err on the side of being conservative. Costs were treated similarly for other supplies, which included cleaning supplies. The last three expenditure items only apply to those charter boats that are stored on trailers and launched from boat ramps for each trip. Table 5.4 displays descriptive statistics from this process and displays the producer surplus per angler trip. Overall, both charter and party boats are earning accounting profits, on average. However, this was after throwing out 25 vessels that took very few trips in 2009 but reported very high fixed costs, suggesting that the business was operating as a tax shelter. Removing these vessels had little impact on the producer surplus per angler trip. The difference between the 231 observations used for the total annual estimates and the per angler trip estimates is due to respondents failing to report t he total number of trips taken in a year and/or the number of passengers taken on each trip. On average, charter boats are generating $76.64 in producer surplus for each angler trip and party boats are generating $23.98 in producer surplus per passenger trip.

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[15] Both John Witzig (NERO) and HanLin Lai (Supervisory Statistician, MRIP) confirmed significant digit bias and potential catch misreporting in the VTR data.

Box 1. Reasons for participating in the for-hire fishery: selected quotes from survey participants.

"Strong desire to make boat pay for itself… realizes not getting enough charters due to not being full time… planning to try harder this year to make a profit."

"Still have a full time job and this helps offset costs. Intend to do it full time soon."

"Slow start up of charter business for retirement income, I run other profitable businesses in construction for income, and not retired yet."

"Side job only, when he has time for it"

"Self gratification and a partial tax break"

"RETIREMENT POTENTIAL BUSINESS; SUPPLEMENTING INCOME IN FUTURE YEARS; ENJOY FISHING AND TAKING PEOPLE OUT IN THE BOAT."

"Retired - enjoy being on the water."

"Offers opportunity to work with son. Helps to reduce cost of operating/maintaining the boat."

"Love to fish."

"It is for fun and I do cover a few expenses."

"In order to kepp the boat and maintain it I need to charter, The bad economy kept my charter numbers down. I hope to use the business for retirement income so I want to keep on trying."

"I just started out and main motivation is to pay for a boat/gear and eventually retirement job, booked less trips"

Table 5.4. 2009 For-Hire Revenue, Trip Costs and Trip Profit by Mode.

Mode	Variable	N	Mean	95% Lower Bound	95% Upper Bound
Charter	Total Annual Income	231	$42,532.12	$25,567.96	$59,496.27
	Total Annual Expenditures	231	$33,903.35	$22,439.43	$45,367.27
	Total Variable Expenditures	231	$17,693.46	$11,135.54	$24,251.38
	Annual Accounting Profit	231	$8,628.77	$280.76	$16,976.78
	Number of Trips Annually	206	50	43	58
	Number of Passenger Trips	206	282	216	348
	Producer Surplus per Passenger Trip	206	$76.64	$54.53	$98.76
Party	Total Annual Income	31	$334,517.52	$194,798.59	$474,236.45
	Total Annual Expenditures	31	$259,793.42	$162,715.85	$356,870.99
	Total Variable Expenditures	31	$163,380.06	$105,106.48	$221,653.65
	Annual Accounting Profit	31	$74,724.10	$16,543.03	$132,905.17
	Number of Trips Annually	31	265	210	320
	Number of Passenger Trips	31	6,637	4,565	8,709
	Producer Surplus per Passenger Trip	31	$23.98	$17.17	$30.79

6.0 Recreational Angler Surplus[16]

6.1 Bioeconomic Recreational Fishing Simulation Model

A bioeconomic simulation model was used to examine the effects of changes in the recreational harvest allocation for scup. The model combines economic information derived from an angler choice experiment (CE) survey, historical data on recreational catchability and targeting, and biological stock information for scup, black sea bass, and summer flounder. Black sea bass and summer flounder are included in the model since these species are regularly caught with scup. The model simulates the effects of proposed changes in the recreational allocation, minimum size limits, and bag limits on angler effort, welfare, catch, and discards in this recreational complex.

6.2 Overview

6.2.1 Measuring Changes in Angler Behavior

Changes in angler fishing preferences from alternative regulations are estimated using data from a choice experiment (CE) survey. The CE survey was administered in conjunction with NMFS' Marine Recreational Fisheries Statistics Survey (MRFSS) in the Northeast Region (ME-NC) during calendar year 2010. Anglers intercepted in the Northeast Region for the MRFSS were asked to participate in a voluntary follow-up mail survey. Anglers were also provided the opportunity to complete the survey online. All anglers that agreed to participate in the follow-up were sent mail questionnaires using a modified Dillman Tailored Design (Dillman, 2000). A total of 10,244 surveys were mailed to anglers that agreed to participate. Anglers participating in the survey returned 3,067 questionnaires by mail or completed the survey online for a total response rate of approximately 30%.

CE surveys are frequently used to estimate the behavioral effects of regulation changes when existing data are inadequate or nonexistent. Surveys of this kind provide information on multiple valuation settings that can be simultaneously compared. For this CE survey, anglers were asked to simultaneously compare features of three different hypothetical fishing trips and then to choose the trip they preferred the most. The features or attributes of the first two hypothetical fishing trips varied and included the number and size of scup, summer flounder, and black sea bass caught and kept, possession and size limits associated with each species, and total trip costs. The third trip option was "Go fishing for striped bass or bluefish." Respondents were also provided the option of not choosing any of the three hypothetical fishing trips and selecting the opt-out option: "I would not go saltwater fishing." The collection of choice responses from the various choice scenarios allowed us to predict tradeoffs and behavioral responses to various biological and regulatory changes.

A Random Utility Model (RUM) was selected as the behavioral model for anglers. In this model, the angler faces a choice among alternative saltwater fishing trips and opting out of saltwater fishing. The utility of all alternatives is known to the angler, but never observed directly. However, some components of utility, including trip costs, kept fish and released fish are observed. The utility function is specified so that regulations affect an angler utility indirectly by altering an angler's expected distribution of kept and released fish. The RUM is estimated using a conditional logit model (Train,

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[16] This section was provided to Gentner Consulting Group, Inc. in its entirety by Scott Steinback and Min-Yang Lee, Northeast Fisheries Science Center.

2003). In this model, the angler is assumed to select option *j* if the utility obtained from option *j* is the highest. Formally, the probability that *j* is selected is a function of the utility of the alternatives and an error term:

$$P_{jn} = P\left[V_n(x_j) + \varepsilon_{jn} > V_n(x_k) + \varepsilon_{kn}\right] \ \forall\, j \neq k \in s,$$

where *V* is the observed component of utility and ε are unobserved components of utility. The general form of the utility function used is (suppressing the *s* subscripts):

$$V_{jn} = a\sqrt{Kept_{jn}} + b\sqrt{Released_{jn}} + \beta_1 Optout_{jn} + \beta_2 SB_{jn} + \beta_3 Price_{jn} + \varepsilon_{jn}$$

Optout is a dummy variable which indicates that the individual stated that no fishing was preferable to any of the fishing alternatives. *SB* is a dummy variable which indicates that the individual preferred to fish for striped bass or bluefish instead. Kept, Released and a and *b* are vectors for expected numbers of each of the three respective species (scup, black sea bass, and summer flounder) .

The Conditional Logit states that:

$$p_{jns} = \frac{exp(V_{jns})}{\sum_{l=1}^{m} exp(V_{lns})}$$

The estimated parameters for the conditional logit are shown in Table 6.1.

Because trips costs (in dollars) also enter the utility function, the marginal willingness to pay for kept or released fish can be derived from the estimated parameters. The effects of changes in kept or released fish on both angler welfare and probability of trip occurrence can be evaluated using simulation methods.

The RUM parameters imply that anglers, on average, only value kept fish and prefer less expensive trips. Anglers have a zero marginal willingness to pay for released scup, summer flounder, and black sea bass. The marginal WTP and total WTP schedules and shown in Figures 6.1 and 6.2, respectively. Summer Flounder is the mostly highly valued of the three species and scup has the least value. The RUM used for this analysis assumes that anglers do not directly place a value on bag limits, minimum size limits, or annual total harvest. That is, anglers do not value these items directly and have no preferences for the mechanism, but only the mechanisms outcome as expressed as harvest changes.

6.2.2 Simulation Overview

The RUM addresses the effect of regulation changes on angler behaviors for individual trips, but provides little information regarding aggregate effort shifts. Additionally, historic data on effort and catch for scup, summer flounder, and black sea bass are generally inadequate for assessing the effects of policy changes on angler behavior. While it has been tried, it has proven impossible to isolate variation in effort and catch attributable to regulations that don't change very frequently or aren't adequately recorded. Therefore, a simulation procedure is employed to quantify the effects of proposed changes in the scup recreational allocation on angler effort, welfare, catch, and discards. In the simulations, adjustments to bag and size limits interact with stock conditions to change an angler's expected number of kept and released fish on a given fishing trip and therefore angler welfare. The underlying simulation procedure was originally developed by Jarvis (2011) to analyze recreational angling in New England groundfish.

Recreational fishing activity is simulated at the trip level and simulated anglers make trip decisions based on the RUM derived from the CE survey results. The size-structure of both biomass and caught fish are incorporated into the simulations. The simulations attempt to replicate actual fishing behavior under different regulatory scenarios.

The simulations begin by generating angler expectations for a prospective trip. First, a prospective trip is randomly assigned the maximum number of scup, black sea bass, and summer flounder which an angler expects to catch. MRFSS data from 2007-2009 are used to generate the probability distribution of expected catch for each species caught per trip. The distributions were calculated from trips that caught scup, black sea bass, or summer flounder, or from trips that indicated scup, black sea bass, or summer flounder was the primary species targeted. Thus, trips that targeted scup, black sea bass, and summer flounder but did not catch either species are also included in the catch distributions.

Given the angler's expectation of catch, the next step in the simulation model is to categorize the expected caught fish as either kept or released. Each fish is randomly assigned a size based on a distribution derived from a combination of the projected biomass age structure, length-age relationship, and historical size selectivity of catch by anglers. Adjusting the biological stock structure by the size selectivity is necessary because anglers may target specific sizes of fish.

The length of each expected scupis compared to the minimum size limit and if the fish is legal it is added to the angler's "expected keep bucket," otherwise it is discarded. This is repeated until the angler reaches the assigned maximum expected caught scup or the bag limit. The process is repeated for black sea bass and summer flounder.

In the model, simulated anglers choose whether or not to take the trip based on the expected total number of fish kept and released on the trip. The probability that the trip will be chosen by the simulated angler is derived from the RUM using the stated preference survey data and the expected keep and release numbers. If the trip is considered acceptable to the simulated angler, the actual catch on the trip is simulated using a process similar to the one used to generate expected catch. Acceptable trips are randomly assigned a maximum actual catch for each species, the size of each fish caught is simulated and checked against the minimum size and bag limits, and the willingness to pay, computed from the estimated RUM parameters, is added to the total welfare measure for the fishery.

For this analysis, baseline management measures (based on the average of the recent regulations in place) for scup consist of a 10.5" minimum size and a 50 fish possession limit. Baseline management measures for black sea bass consist of a 12" minimum size and a 25 fish possession limit. Baseline management measures for summer flounder consist of an 18" minimum size and a 5 fish possession limit. Scup minimum size limits ranging from 9-10.5" and possession limits of 35 and 50 fish are also examined.

6.3 Data Used and Parameterization

This section describes the data used and parameterization of the simulation component of the model.

6.3.1 Stock Sizes and Structure

For simulations in this analysis, the age structure for scup, summer flounder, and black sea bass are initialized to the 2010 stock size. For computation of historical angler catchability, the 2007-2009 stock sizes are used and taken directly from the stock assessment reports. These stock sizes are also used to calibrate the model.

6.3.2 Length at Age Data

The numbers at age of scup, black sea bass, and summer flounder are converted to a length based structure by pooling the 2007-2009 survey data. The empirical age-length distribution is used with the age structure of all three species to produce a length structure. A LOWESS (Local regression) smoother was used to smooth the age-length relationship.

Figures 6.3,6.4, and 6.5 are graphical representations of the probability that an age X fish is Y inches in length for each of the three species. For example, an Age-1 scup has a 23.7% probability of being 5” long (fork length) and a 19.4% probability of being 6” long (Figure 6.3). An Age-5 scup has a 25% probability of being 10” long and a 29% probability of being 11” long. The age-length data are combined with the age-structure to produce a length-structure. Combined with the numbers-at-ages, the length-age relationship produces a length distribution for each stock of fish.

6.3.3 Length-Structure and Recreational Selectivity

To compute length-based recreational selectivity, the 2007-2009 catch data from MRFSS was pooled to create the catch-at-length distribution for each species. This was divided by the pooled length distribution of each stock and then normalized to set the maximum selectivity equal to 1. These are shown in Figures 6.6, 6.7 and 6.8.

6.3.4 Length to Weight Relationship

The length to weight relationship for scup, black sea bass, and summer flounder are given by Mayo *et al* (2009). This length-weight relationship is expressed in metric units (kilograms and centimeters). These are converted into Imperial (pounds and inches) to be consistent with management policy. Scup age-length and length-weight relationships are based on fork length while management policy is based on total length. This has been accounted for; that is, fish are checked against the minimum size limits based on total length but the length-weight and age-length relationships are computed using fork length.

6.3.5 Catch Distributions for Scup, Black Sea Bass, and Summer FLounder

Every trip is assigned a maximum amount of scup, black sea bass, and summer flounder catch based on historical distributions of catch. The 2007-2009 MRFSS data was pooled to compute a frequency distribution of scup, black sea bass, and summer flounder catch-per-trip. During the three years, over 19 million trips harvested or targeted one of these three species. However, catch was zero for one or more of the species fairly frequently (Table 6.2).

Figures 6.9, 6.10, and 6.11 contain the probability distribution functions from which the maximum catch per trip for scup, black sea bass, and summer flounder are drawn, for trips which have at least 1 fish.

For example, a trip has an 11.5% chance of being assigned 1 summer flounder. A trip has a 0.5% chance of being assigned 10 scup. A trip has a 2.9% chance of being assigned 2 black sea bass. The data shows that anglers are catching larger scup and black sea bass than the population of these fish. Anglers are also catching smaller summer flounder than present in the population.

6.4 Model Calibration

The model is calibrated to 2007 through 2009 using just two parameters: the "maximum number of trips" and the probability threshold which defines an "acceptable" expected trip. These two parameters are set so that the realized number of fishing trips under current regulation levels is approximately equal to the effort in 2007-2009. There is substantial variability in the regulations across states. Instead of building models of individual states, a region-wide model is constructed and regulatory parameters which broadly represent the management regulations are used.

The "maximum number of trips" is set at a level larger than the actual number of trips which occurred in any year. This can be interpreted as the number of trips which would occur if every fishing trip was expected to be an acceptable trip. This allows additional effort, beyond the 2007-2009 levels of effort, if regulatory or stock conditions result in better quality trips (higher amounts of expected catch) relative to the 2007-2009 levels.

Tables 6.3 through 6.6 contain some of the model calibration results. The model is quite accurate for "Total Catch (Kept + Discarded)" for all species aggregated over 2007-2009. It is less accurate for individual years. The model also performs reasonably well for kept and released scup and black sea bass. It performs less well for summer flounder; the reasons for this are uncertain at this time. The major source of inaccuracy seems to be in the breakdown of kept and released fish, and not total catch.

While the inaccuracy regarding summer flounder is undesirable, it is likely to have minimal impact on most aspects of scup management measures. Because the model under-predicts kept summer flounder relative to the data, it predicts trips which are less desirable. This is corrected for by adjusting the threshold probability at which a trip will occur. This is equivalent to recalibrating the constant term in the RUM, and is theoretically acceptable (Train, 2003; p37).

However, because trips have lower kept summer flounder, the aggregate welfare measures are downward biased. The model under-predicts kept summer flounder by approximately 1.6 million fish per year. Therefore, total WTP for fishing in this recreational complex may be underestimated by as much as $20-40 million.

The model overestimates the number of trips that keep scup; however, the estimates of trips which kept or discarded scup are reasonably accurate. It is possible that anglers (in real life) are discarding legal size scup when fishing for summer flounder or black sea bass. The simulation model assumes that all legal size fish are retained.

The data to which the model is being calibrated is subject to some uncertainty. Table 6.7 contains the Proportional Standard Errors (PSEs) for kept and released fish for the three species. The pooled PSEs in the entire region (New England, New York, and New Jersey) are lower than the region-specific standard errors, but cannot be computed at this time. However, the PSEs can provide some insight into the uncertainty of the data.

The +3% and +6% commercial allocation scenarios can be examined by this model. A running sum of scup weight is computed during the simulations. When the recreational scup limit is reached, the expected numbers of kept and released scup are set to zero for all subsequent simulated trips. Anglers can continue to target and catch summer flounder and black sea bass, but the model assumes no additional scup catch once the scup harvest limit is reached. The angler, based on the new expected catch numbers, chooses whether or not the trip is acceptable. If the trip is acceptable, catch by species (for summer flounder and black sea bass) is computed as before. This allows for effort to leave the recreational complex and allows targeting of summer flounder and black sea bass to continue if the scup harvest quota is reached.

6.5 Results

Table 6.8 contains model results for scup, under alternative management measures, and are estimated from 2010 stock conditions. Changes in the scup bag limit have minimal, if any, impact on the numbers and weight of retained scup. This is because few anglers catch 35 or more legal-size scup. From the angler's point of view, increasing the scup possession limit from 35 to 50 fish leads to higher expected catch and therefore better trips. However, the number of additional trips predicted to occur is low. Only trips which would catch more than 35 scup would be affected. For example, consider a trip where 40 legal sized scup are caught. This trip is only slightly better under a 50 fish limit than a 35 fish limit. The extra utility gained by anglers is low, because the marginal willingness to pay for additional scup is small when the angler has already caught 35 scup (SeeFigure 6.1).

Changes in the minimum size limit affect whether scup are retained or discarded, but does not substantially impact the total number of scup which are caught. Consider a decrease in the size limit from 10.5" to 10". From the angler's point of view, decreasing the scup minimum size limit leads to higher expected catch and therefore better trips. There are some trips (approximately 31,400) which would not have occurred under the 10.5" minimum size which are predicted to occur under a 10" minimum size. Of these trips, only approximately 5,000 are estimated to actually catch scup (26,400 trips are predicted to catch no scup). The decrease in minimum size increases welfare because of the anglers expect to be able to retain 10-10.5" scup.

Tables 6.9 and 6.10 show the predicted black sea bass and summer flounder catch under the different scup management scenarios. Catches of black sea bass and summer flounder are predicted to increase modestly when scup management measures are liberalized. This occurs because all trips become more desirable under lower scup minimum sizes. Therefore, some additional effort is attracted into the fishery; these additional anglers will also catch black sea bass and summer flounder.

Table 6.11 shows the predicted net benefits, under each of the alternative scup management measures examined in this analysis, to recreational anglers that target or harvest scup, black sea bass, or summer flounder. When the scup harvest limits are reached, every subsequent trip which would have caught scup becomes less desirable. However, the model still allows fishing for the other two species. Total MWP values range from $50.1 million under the most restrictive scup management measures (10.5" minimum size, 35 fish bag limit) to $57.3 million under the least restrictive scup measures (9.0" minimum size, 50 fish bag limit). These values assume that the coast wide management measures analyzed for black sea bass (12.0" minimum size, 25 fish bag limit) and summer flounder (18.0" minimum size, 5 fish bag limit) remain constant.

Table 6.12 contains the commercial-recreational scup allocation scenarios. Relative to the 0% baseline, the increases in recreational quota associated with the -3%, -6%, and -9% scenarios do not increase the overall welfare of recreational anglers. This is because an increase to the baseline recreational quota is not estimated to be binding even when the regulations are relaxed to a 9” minimum size and a 50 fish bag limit. In the model, welfare changes are estimated from changes in the expected number of fish that can be kept. When the quota is not expected to be binding, angler catch expectations remain constant. There may be some level of “nonuse” value anglers obtain from having “extra” quota available, but these effects are not captured in the behavioral model used in this analysis.

Table 6.13 contains the scup model outputs from reducing the recreational quota by 3% and 6%. Relative to the baseline, total trips, trips that keep scup, scup catch, and scup weight decline as expected. Trips thatcatch scup decline by 13% when the recreational quota is reduced by 3% and 27% when the recreational quota declines by 6%. However, total trips targeting any of the three species declinde by less than 1%. In general, a 6% decline in the recreational allocation reduces welfare by approximately 4-6% relative to the baseline, regardless of minimum size and possession limits. This is approximately a $2-3 million decrease in angler welfare.

A 6% decline in the recreational allocation reduces welfare by approximately 8-11% relative to the baseline, regardless of minimum size and possession limits. This is approximately a $3-6 million decrease in angler welfare.

6.6 Discussion

There are number of important assumptions embedded in the bioeconomic model. Historical selectivity is assumed to be similar to future fishing effort. Policy changes are assumed not to produce extreme shifts in behavior or targeting. Anglers are assumed to stop catching a species once the bag limit is reached. Highgrading behavior is precluded. Catch rates for all modes of angling are assumed to be the same and anglers do not discard legal size fish or retain sub-legal size fish.

The ability to analyze welfare benefits of increasing the scup possession limit is hindered by the current regulations and the resultant data. While the possession limit varies across states and seasons, there are very few trips on which more than 35 scup are retained. However, the MWTP for the 36th through 50th scup is relatively small. Changes in possession limits are not likely to affect many anglers; however, these are likely to be the most “die-hard” scup anglers. The RUM provides insight into the marginal value of increasing catch for the average angler. It is likely that the most “die-hard” scup anglers value scup at higher levels; unfortunately, this cannot be quantified at this time.

Finally, because the simulation model under-estimates kept summer flounder, it will also underestimate aggregate WTP. While the changes in WTP resulting from changes in scup regulations are likely to be accurate, the percent changes in WTP are underestimated.

References:

Jarvis, S. L.. 2011. Stated Preference Methods and Models: Analyzing Recreational Angling in New England Groundfisheries. Unpublished Disseration. University of Maryland.

Mayo R.K., Shepherd G., O'Brien L., Col L.A., Traver, M. 2009. The 2008 assessment of the Gulf of Maine Atlantic cod (Gadus morhua) stock. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 09-03; 128 p.

Northeast Fisheries Science Center. 2008. Assessment of 19 Northeast Groundfish Stocks through 2007: Report of the 3rd Groundfish Assessment Review Meeting (GARM III), Northeast Fisheries Science Center, Woods Hole, Massachusetts, August 4-8, 2008. US Dep Commer, NOAA Fisheries, Northeast Fish Sci Cent Ref Doc. 08-15; 884 p + xvii.

Train, K.E. Discrete Choice Methods with Simulation. (New York: Cambridge University Press, 2003).

Table 6.1. Estimated Conditional Logit Parameters.

Parameter	Estimate	Standard Error	t-Value	P-Value
$\sqrt{\text{Scup Kept}}$	0.0636	0.0137	4.63	<0.0001
$\sqrt{\text{Scup Released}}$	-0.000115	0.0102	-0.01	0.9910
$\sqrt{\text{Fluke Kept}}$	0.3083	0.0339	9.08	<0.0001
$\sqrt{\text{Fluke Released}}$	-0.0410	0.0292	-1.40	0.1614
$\sqrt{\text{BSB Kept}}$	0.1630	0.0207	7.86	<0.0001
$\sqrt{\text{BSB Released}}$	-0.00168	0.0163	-0.10	0.9179
Opt Out	-0.8118	.1156	-7.02	<0.0001
SB	1.7654	0.1065	16.57	<0.0001
Price	-0.005901	0.000213	-27.72	<0.0001
McFaddens LRI	0.2435			
N	4,755			

Table 6.2. MRFSS Historical Catch by Species on Trips that Targeted or Harvested At Least One of the Three Species.

Species	No Catch	At least 1 Fish Caught (N=19,131,894)
Scup	81.94%	18.06%
Black Sea Bass	83.13%	16.87%
Summer Flounder	44.98%	55.02%

Table 6.3. Comparison of Model Results and MRFSS Total Catch Estimates.

MRFSS Total Catch Data (Kept + Discards)

Year	Scup Total	BSB Total	SF Total
2007	8,402,164	6,521,249	16,125,089
2008	11,080,471	7,617,677	19,304,466
2009	7,786,687	6,700,182	19,548,725
Aggregate	27,269,321	20,839,108	54,978,280

Model Results

Year	Scup Total	BSB Total	SF Total
2007	9,489,400	6,658,400	19,190,000
2008	9,456,000	6,633,900	19,099,600
2009	9,420,200	6,616,800	19,018,800
Aggregate	28,365,600	19,909,100	57,308,400

Percent Error

Year	Scup Total	BSB Total	SF Total
2007	12.94%	2.10%	19.01%
2008	-14.66%	-12.91%	-1.06%
2009	20.98%	-1.24%	-2.71%
Aggregate	4.02%	-4.46%	4.24%

Table 6.4. Comparison of Model Results and MRFSS Total Harvest Estimates.

Fish Kept

Data

Year	Scup Catch (A+B1)	BSB Catch (A+B1)	SF Catch (A+B1)
2007	3,583,022	1,533,919	2,454,963
2008	3,649,602	971,113	1,890,294
2009	2,764,752	1,406,788	1,438,543
Aggregate	9,997,376	3,911,820	5,783,800

Model Calibration Results

Year	Scup Catch	BSB Catch	SF Catch
2007	3,399,200	1,137,600	323,400
2008	3,311,600	1,023,600	303,800
2009	3,335,200	1,091,200	250,300
Aggregate	10,046,000	3,252,400	877,500

Percent Error

Year	Scup Catch (A+B1)	BSB Catch (A+B1)	SF Catch (A+B1)
2007	-5.13%	-25.84%	-86.83%
2008	-9.26%	5.40%	-83.93%
2009	20.63%	-22.43%	-82.60%
Aggregate	0.49%	-16.86%	-84.83%

Table 6.5. Comparison of Model Results and MRFSS Released Estimates.

	MRFSS Released Fish		
Year	Scup released (B2)	BSB released (B2)	SF released (B2)
2007	4,819,142	4,987,330	13,670,126
2008	7,430,869	6,646,564	17,414,172
2009	5,021,935	5,293,394	18,110,182
Aggregate	17,271,945	16,927,288	49,194,480

	Model Calibration Results		
Year	Scup released	BSB released	SF released
2007	6,090,200	5,520,800	18,866,600
2008	6,144,400	5,610,300	18,795,800
2009	6,085,000	5,525,600	18,768,500
Aggregate	18,319,600	16,656,700	56,430,900

	Percent Error		
Year	Scup released (B2)	BSB released (B2)	SF released (B2)
2007	26.38%	10.70%	38.01%
2008	-17.31%	-15.59%	7.93%
2009	21.17%	4.39%	3.64%
Aggregate	6.07%	-1.60%	14.71%

BSB=black sea bass; SF=summer flounder.

Table 6.6. Comparison of Model Results and MRFSS Estimates of Trips that Caught Scup.

	MRFSS Data		Model	
	Trips which kept Scup	Trips which kept or discarded scup	Trips which kept scup	Trips which kept or discarded scup
2007	592,888	1,109,692	931,700	1,198,200
2008	616,885	1,334,479	922,200	1,193,500
2009	486,486	1,010,503	921,100	1,189,000

Table 6.7. Model Catch Data Uncertainty.

MRFSS Proportional Standard Errors

Scup

	Kept (A+B1)			Released (B2)		
	New England	New York	New Jersey	New England	New York	New Jersey
2007	31.8	26.7	56.9	13.6	18.3	64
2008	17.1	21.3	36.8	15.6	17.8	39.9
2009	16.8	23.3	28.2	13.5	19.1	34.1

Black sea bass

	Kept (A+B1)			Released (B2)		
	New England	New York	New Jersey	New England	New York	New Jersey
2007	23.1	11.8	16.4	21.6	14.5	15
2008	25.4	27.8	29.2	21.9	32.7	18.5
2009	22.7	26.8	17.1	18.7	19.1	16.4

Fluke

	Kept (A+B1)			Released (B2)		
	New England	New York	New Jersey	New England	New York	New Jersey
2007	13.8	12.6	11.5	12.3	10.3	9.7
2008	24.9	13.9	16.1	17.8	11.3	10.2
2009	22	17.7	10.5	17.5	11.5	9.8

Table 6.8. Model Estimated Scup Catch and Effort Under Alternative Management Scenarios.

		Trips (Number)		Scup Catch (Number)			Scup Weight (lbs)		
Scup Minimum Size	Scup Bag Limit	With Scup Catch	Total Trips[a]	Harvest (A + B1)	Released (B2)	Total	Harvest (A + B1)	Released (B2)	Total
10.5	35	1,202,300	6,627,700	3,515,300	6,002,800	9,518,100	4,154,350	2,406,109	6,560,459
10.5	50	1,202,300	6,627,700	3,515,300	6,002,800	9,518,100	4,154,350	2,406,109	6,560,459
10.0	35	1,207,600	6,659,100	4,303,600	5,244,000	9,547,600	4,681,929	1,898,765	6,580,694
10.0	50	1,207,600	6,659,100	4,305,300	5,246,700	9,552,000	4,683,541	1,899,682	6,583,223
9.5	35	1,211,700	6,683,200	4,947,200	4,616,300	9,563,500	5,050,716	1,541,613	6,592,329
9.5	50	1,211,700	6,683,200	4,955,700	4,625,900	9,581,600	5,058,969	1,544,769	6,603,738
9.0	35	1,216,000	6,702,800	5,602,900	3,973,000	9,575,900	5,371,517	1,230,956	6,602,473
9.0	50	1,216,000	6,702,800	5,627,400	3,992,000	9,619,400	5,394,342	1,236,932	6,631,274

[a] Total trips is defined as any angler trip that targeted or caught scup, black sea bass, or summer flounder

Table 6.9. Model Estimated Black Sea Bass Catch Under Alternative Scup Management Scenarios (assumes status quo black sea bass regulations of: 12” minimum size, 25 fish bag limit).

				Black Sea Bass Catch (Number)			Black Sea Bass Weight (lbs)		
Scup Minimum Size	Scup Bag Limit	BSB Minimum Size	BSB Bag Limit	Harvest (A + B1)	Released (B2)	Total	Harvest (A + B1)	Released (B2)	Total
10.5	35	12.0	25	1,233,600	5,447,500	6,681,100	2,229,794	1,610,841	3,840,635
10.5	50	12.0	25	1,233,600	5,447,500	6,681,100	2,229,794	1,610,841	3,840,635
10.0	35	12.0	25	1,239,900	5,474,900	6,714,800	2,240,880	1,619,110	3,859,990
10.0	50	12.0	25	1,239,900	5,474,900	6,714,800	2,240,880	1,619,110	3,859,990
9.5	35	12.0	25	1,244,200	5,491,600	6,735,800	2,249,054	1,623,359	3,872,413
9.5	50	12.0	25	1,244,200	5,491,600	6,735,800	2,249,054	1,623,359	3,872,413
9.0	35	12.0	25	1,250,400	5,517,600	6,768,000	2,259,776	1,630,904	3,890,680
9.0	50	12.0	25	1,250,400	5,517,600	6,768,000	2,259,776	1,630,904	3,890,680

Table 6.10. Model Estimated Summer Flounder Catch Under Alternative Scup Management Scenarios (assumes status quo summer flounder regulations of: 18” minimum size, 5 fish bag limit).

				Summer Flounder Catch (Number)			Summer Flounder Weight (lbs)		
Scup Minimum Size	Scup Bag Limit	Fluke Minimum Size	Fluke Bag Limit	Harvest (A + B1)	Released (B2)	Total	Harvest (A + B1)	Released (B2)	Total
10.5	35	18.0	5	324,000	18,938,000	19,262,000	925,874	13,809,590	14,735,464
10.5	50	18.0	5	324,000	18,938,000	19,262,000	925,874	13,809,590	14,735,464
10.0	35	18.0	5	326,200	19,017,000	19,343,200	932,340	13,869,066	14,801,406
10.0	50	18.0	5	326,200	19,017,000	19,343,200	932,340	13,869,066	14,801,406
9.5	35	18.0	5	327,400	19,093,700	19,421,100	936,133	13,923,259	14,859,392
9.5	50	18.0	5	327,400	19,093,700	19,421,100	936,133	13,923,259	14,859,392
9.0	35	18.0	5	328,400	19,151,300	19,479,700	939,116	13,966,088	14,905,204
9.0	50	18.0	5	328,400	19,151,300	19,479,700	939,116	13,966,088	14,905,204

Table 6.11. Net Benefits: Aggregate Willingness To Pay.

Scup Minimum Size	Scup Bag Limit	BSB Minimum Size	BSB Bag Limit	Fluke Minimum Size	Fluke Bag Limit	Aggregate WTP (2010 $'s)
10.5	35	12.0	25	18.0	5	$50,121,544
10.5	50	12.0	25	18.0	5	$50,121,544
10.0	35	12.0	25	18.0	5	$52,926,304
10.0	50	12.0	25	18.0	5	$52,928,080
9.5	35	12.0	25	18.0	5	$55,161,584
9.5	50	12.0	25	18.0	5	$55,171,980
9.0	35	12.0	25	18.0	5	$57,232,612
9.0	50	12.0	25	18.0	5	$57,265,212

Table 6.12. Commercial-Recreational Scup Allocation Scenarios.

Percent Change in Commercial Quota	Commercial Quota	Recreational Quota
6%	25,166,400	4,793,600
3%	24,267,600	5,692,400
0%	23,368,800	6,591,200
-3%	22,470,000	7,490,000
-6%	21,571,200	8,388,800
-9%	20,672,400	9,287,600

Table 6.13. Scup Model Results from Reducing the Recreational Quota by 3% and 6%.

			Trips (Number)		Scup Catch (Number)			Scup Weight (lbs)			
Recreational Limit Change	Scup Minimum Size	Scup Bag Limit	With Scup Catch	Total Trips	Harvest (A + B1)	Released (B2)	Total	Harvest (A + B1)	Released (B2)	Total	Aggregate WTP
-3%	10.5	50	1,041,000	6,594,800	3,056,000	5,197,100	8,253,100	3,610,654	2,081,456	5,692,110	$47,917,884
-3%	10.5	35	1,041,000	6,594,800	3,056,000	5,197,100	8,253,100	3,610,654	2,081,456	5,692,110	$47,917,884
-3%	10.0	50	1,041,000	6,620,700	3,723,400	4,528,600	8,252,000	4,052,945	1,639,079	5,692,024	$50,285,116
-3%	10.0	35	1,041,400	6,620,700	3,722,800	4,527,000	8,249,800	4,052,538	1,638,550	5,691,088	$50,284,860
-3%	9.5	50	1,040,400	6,640,700	4,268,300	3,984,100	8,252,400	4,361,587	1,330,742	5,692,329	$52,180,468
-3%	9.5	35	1,043,800	6,641,300	4,268,200	3,983,700	8,251,900	4,361,417	1,330,578	5,691,995	$52,209,404
-3%	9.0	50	1,039,400	6,655,800	4,825,300	3,424,900	8,250,200	4,630,311	1,061,614	5,691,925	$53,885,412
-3%	9.0	35	1,045,000	6,657,400	4,825,400	3,422,100	8,247,500	4,630,787	1,060,608	5,691,395	$53,958,584
-6%	10.5	50	868,100	6,565,200	2,574,700	4,367,500	6,942,200	3,044,064	1,749,172	4,793,236	$45,751,520
-6%	10.5	35	868,100	6,565,200	2,574,700	4,367,500	6,942,200	3,044,064	1,749,172	4,793,236	$45,751,520
-6%	10.0	50	867,500	6,587,100	3,137,400	3,804,800	6,942,200	3,417,034	1,376,368	4,793,402	$47,720,480
-6%	10.0	35	867,900	6,587,400	3,137,300	3,803,700	6,941,000	3,417,297	1,376,072	4,793,369	$47,732,796
-6%	9.5	50	868,300	6,604,100	3,595,200	3,347,000	6,942,200	3,675,765	1,117,471	4,793,236	$49,313,812
-6%	9.5	35	869,100	6,604,100	3,595,400	3,346,500	6,941,900	3,675,986	1,117,270	4,793,256	$49,315,092
-6%	9.0	50	867,700	6,616,600	4,058,800	2,877,200	6,936,000	3,898,970	891,451	4,790,421	$50,748,620
-6%	9.0	35	871,500	6,617,700	4,061,400	2,877,500	6,938,900	3,901,023	891,583	4,792,606	$50,799,280

Figure 6.1. Marginal Value of Kept Fish Per Trip, by Species.

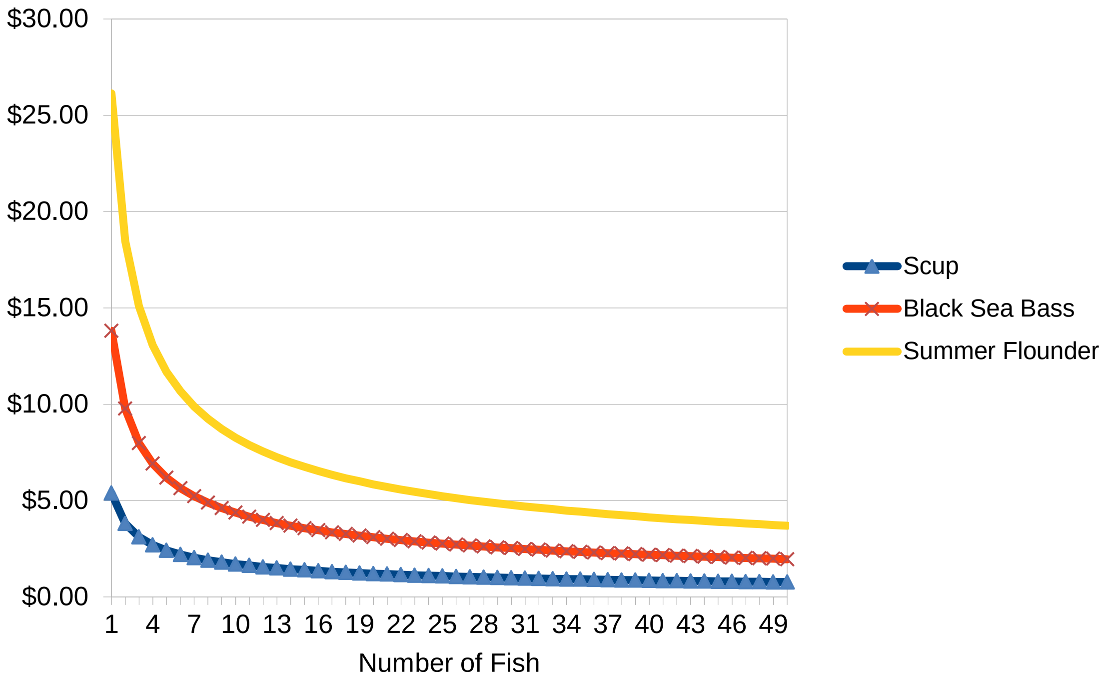


Figure 6.2. Total Value of Kept Fish Per Trip, by Species.

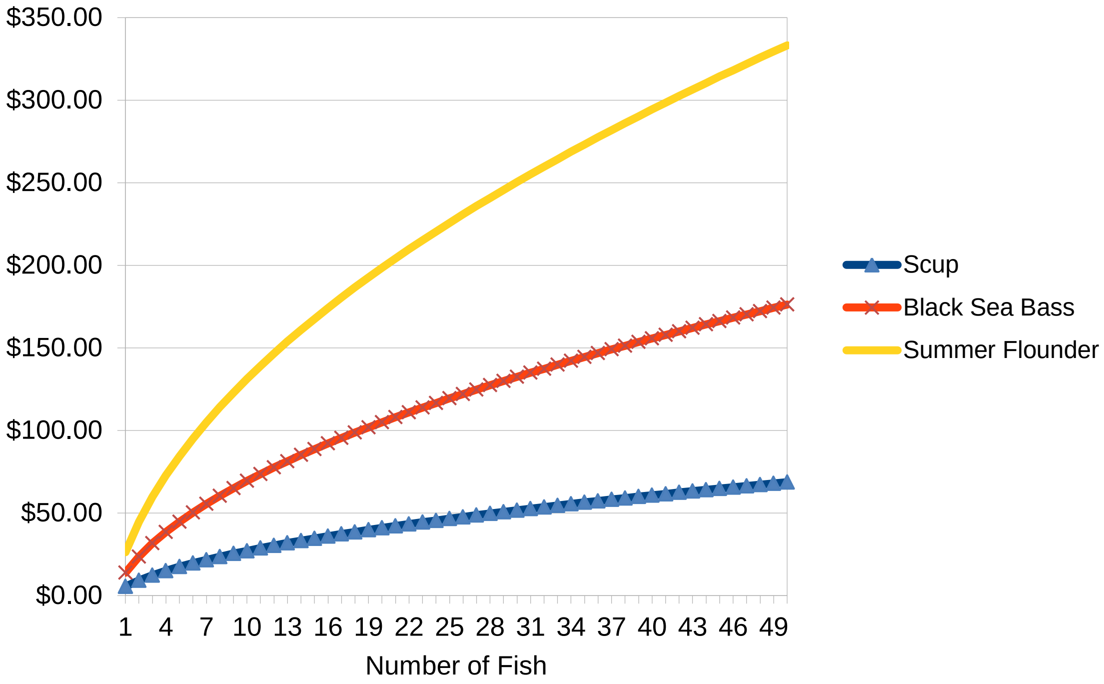


Figure 6.3. Probability Distributions of Scup Length at Age.

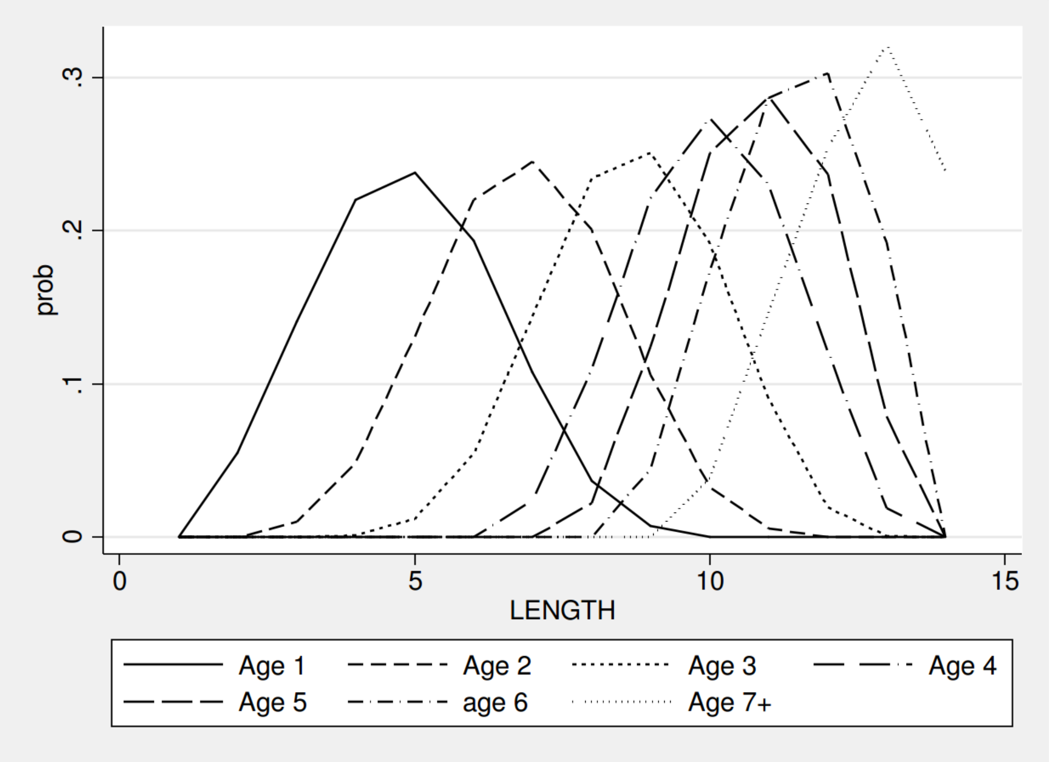


Figure 6.4. Probability Distributions of Black Sea Bass Length at Age.

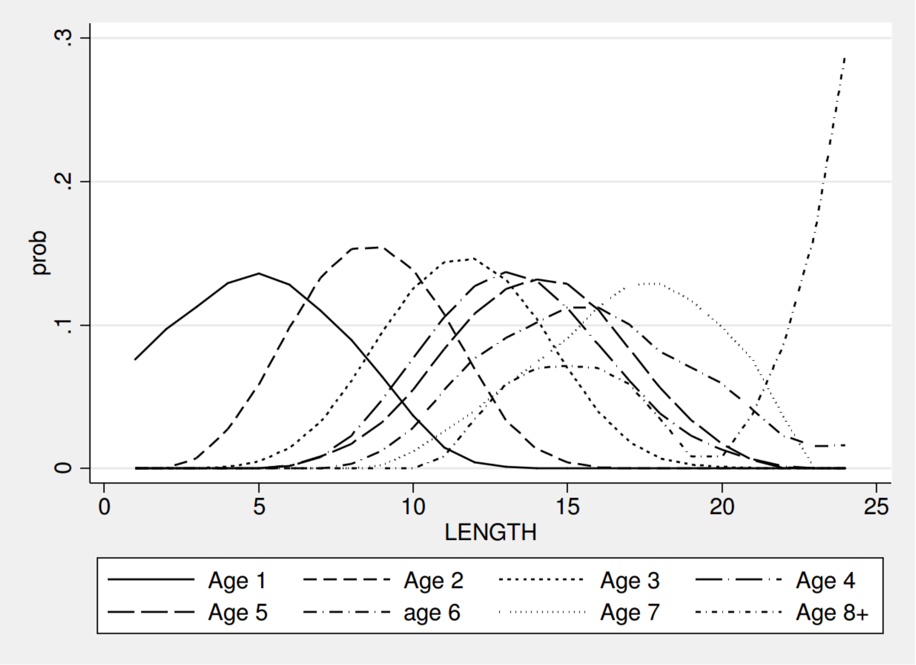


Figure 6.5. Probability Distributions of Summer Flounder Length at Age.

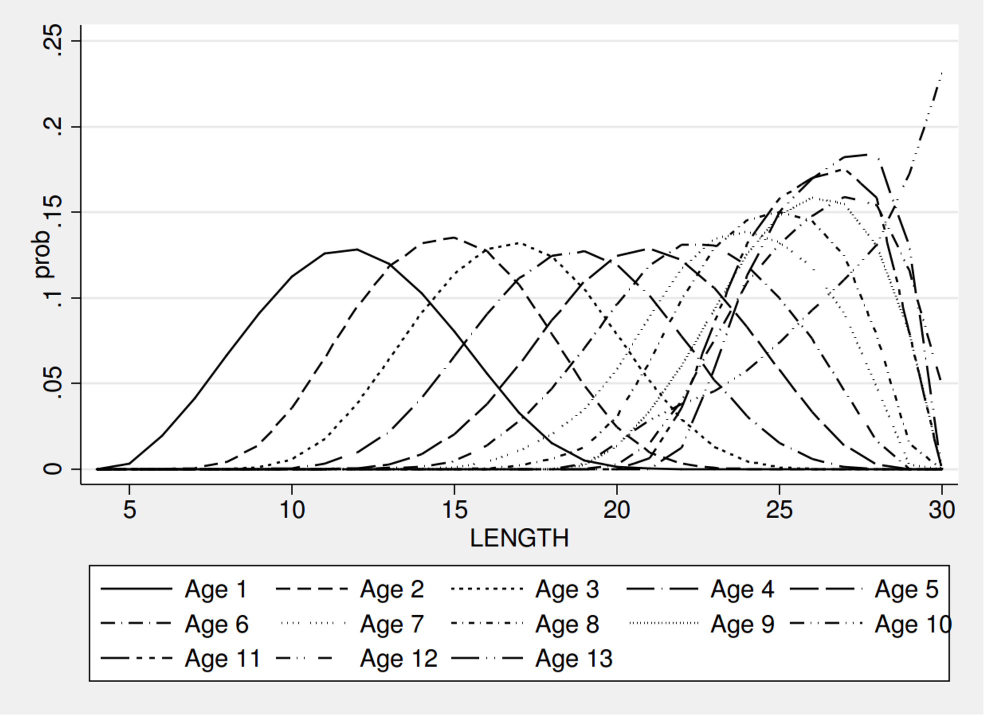


Figure 6.6. Scup Length-Based Stock Distribution versus Length-Based Recreational Selectivity.

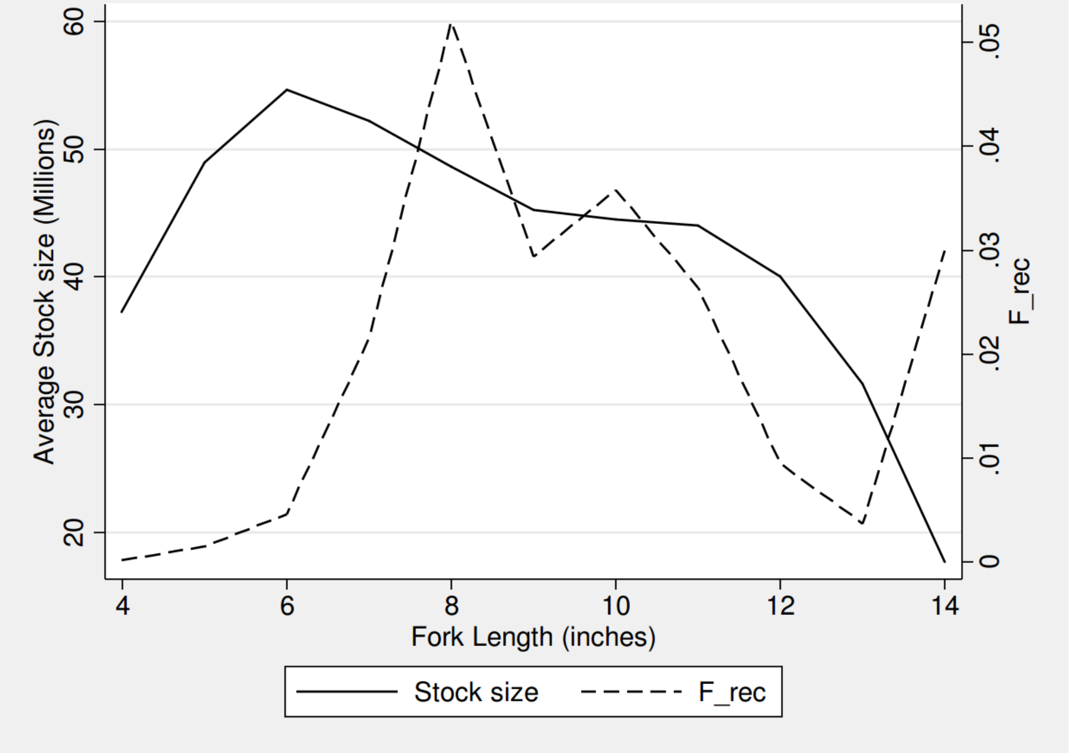


Figure 6.7. Black Sea Bass Length-Based Stock Distribution versus Length-Based Recreational Selectivity

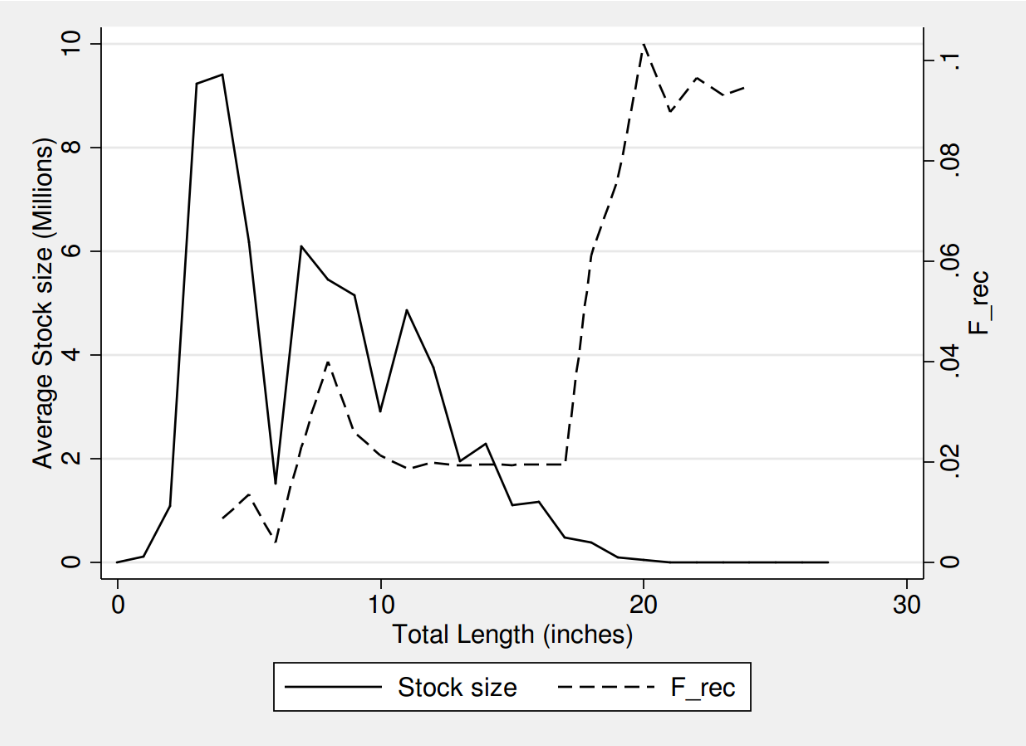


Figure 6.8. Summer Flounder Length-Based Stock Distribution versus Length-Based Recreational Selectivity.

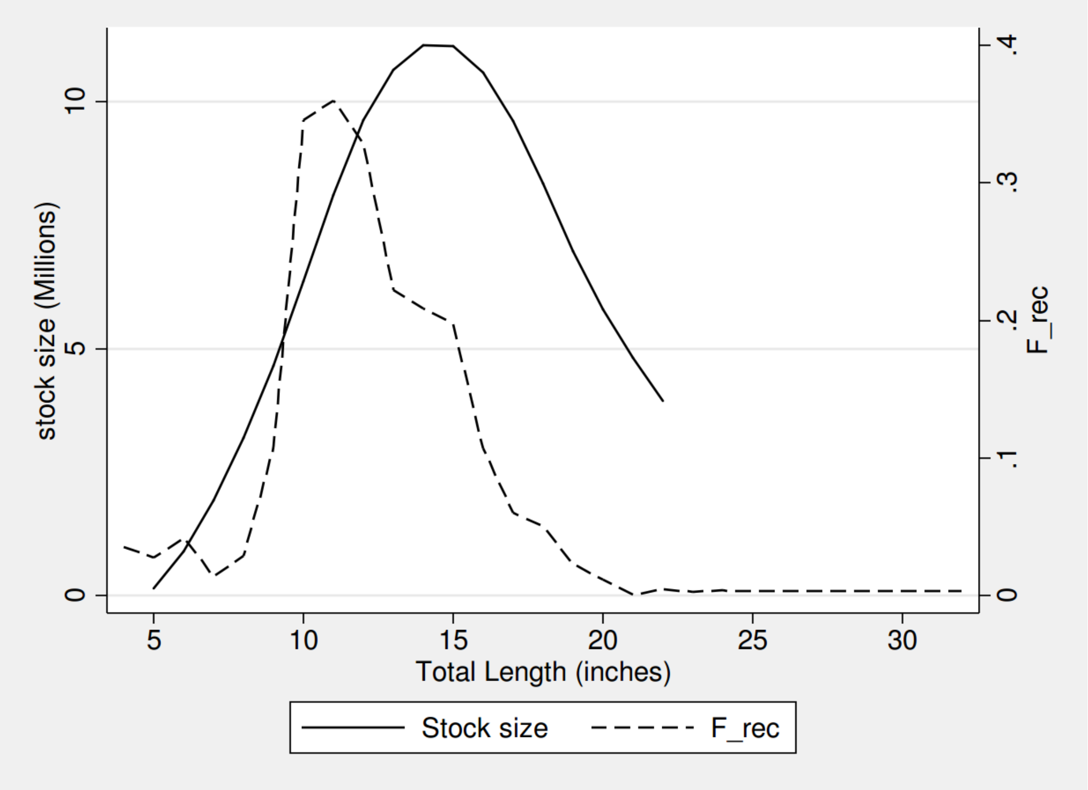


Figure 6.9. Frequency Distribution of Scup Catch Per Trip on Trips that Caught At Least One Fish.

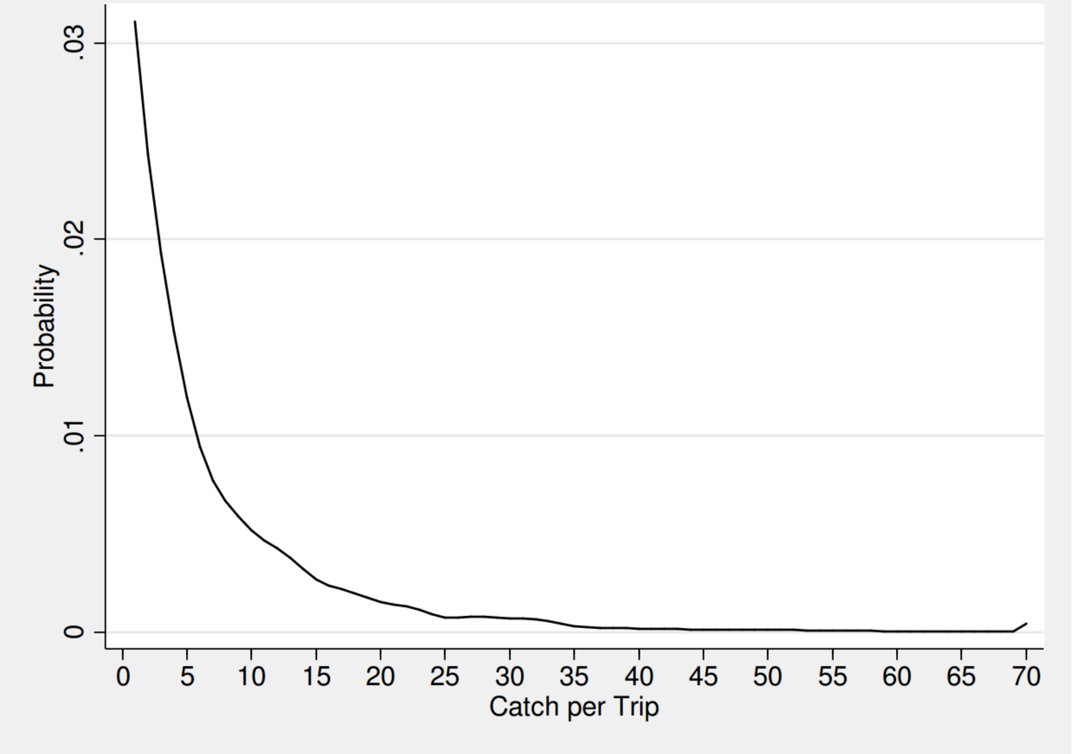


Figure 6.10. Frequency Distribution of Black Sea Bass Catch Per Trip on Trips that Caught At Least One Fish.

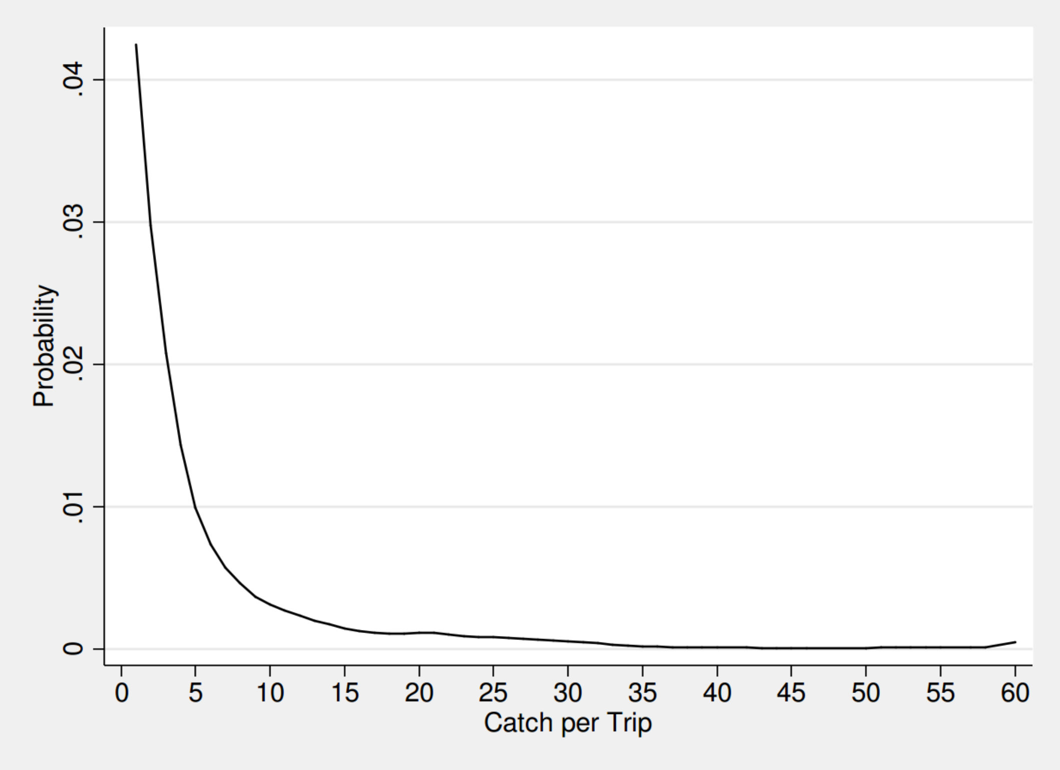
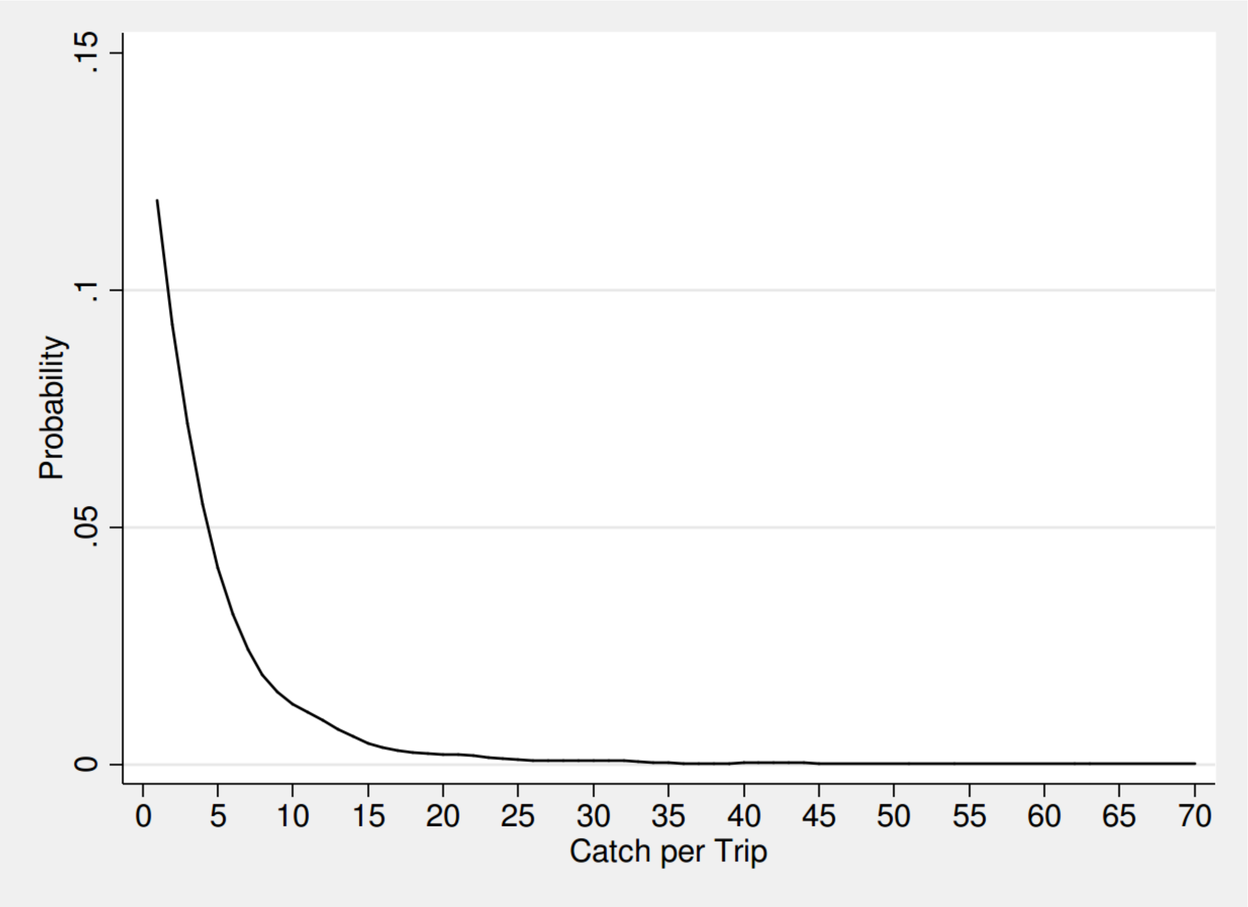


Figure 6.11. Frequency Distribution of Summer Flounder Catch Per Trip on Trips that Caught At Least One Fish.



7.0 Allocation Analysis Summary

This section discusses the results of the various analyses conducted for each sector. All of the estimates generated above for producer and consumer surplus were combined into a model hosted on a password protected portion of the Gentner Consulting Group, Inc. web page (http://www.gentnergroup.com/Scup/Scup.htm) . This model will allow the user to input the percent change in allocation to be examined and the model will produce estimates of total benefits and the economic impact of the allocation shift. Table 7.1 summarizes this output across the range of allocation changes examined for this analysis.

Table7.1. Total Surplus Across a Range of Allocation Options.

Allocation Change Relative to Commercial Quota	Commercial Net Benefit	Consumer Net Benefit	Angler Net Benefit	For-Hire Sector Net Benefit	Total Net Benefits
6%	$11,791,332	$390,590	$45,751,520	$35,684,725	$93,618,167
3%	$11,968,226	$1,085,154	$47,917,884	$35,845,614	$96,816,878
0%	$11,875,777	$1,778,309	$50,121,544	$36,024,440	$99,800,069
-3%	$11,780,652	$2,468,717	$52,926,304	$36,195,113	$103,370,786
-6%	$11,622,114	$3,154,871	$55,171,980	$36,326,107	$106,275,072
-9%	$11,687,295	$3,835,066	$57,265,212	$36,432,641	$109,220,215

Table 7.1 shows that total net benefits are maximized by increasing allocations for the recreational sector, if those changes also involve relaxing recreational regulations. There are numerous caveats to this conclusion. First, and foremost, all models are being used to estimate the value of allocation changes far outside the data used to estimate the models. Table 7.2 contains a comparison of commercial versus recreational quotas and harvests since 1997. The recreational data used to calibrate and estimate the model was from 2010 when the total harvest limit was 13.7 million pounds. During the 2010 season the recreational sector exceeded their catch limit by 91%. The commercial model used data from 2005-2009 when the total harvest limit averaged 12.2 million pounds and the commercial fleet exceeded their harvest limit three out of those five years for an average overage of 8.2%. Looking at these numbers, one can see why the MAFMC decided to explore scup allocations as both sectors were exceeding their allocation. However, since beginning this analysis, the MAFMC has decided to increase the total harvest limit in the scup fishery to 26.1 million pounds, more than doubling the 2010 harvest limit.

As a result, NMFS could not get simulated recreational catch high enough to bind recreational anglers and therefore the NMFS bioeconomic model could not estimate any positive marginal WTP for additional harvest of scup. Likewise, commercial simulations were conducted using harvest levels far above any level seen in recent history. While GCG was able to force the commercial sector to “catch” these new, higher quotas, caution is warranted in the use of the commercial estimates. Looking at the year 2011 in Table 7.2, the 26.1 million pound harvest limit, lower than the 29.96 million pound harvest limit used for simulations in this analysis, was not binding on either sector. The commercial sector was only able to catch 74% of their allocation and the recreational sector was only able to catch 64% of their allocation. Because scup is caught commercially in a multi-species fishery which has been characterized as a bycatch fishery, at least in the otter trawl gear type, it may be that scup landings cannot be increased without increases across other groundfish target species. In this case, the commercial harvest limit could also be non-binding because harvest limits in other fisheries might prevent catching new harvest limits. Or it could be that seasonal market gluts and low prices make landing scup unprofitable. If the commercial model had been included in the recreational bioeconomic model, it is likely that commercial catch would not bind and the commercial MWTP for quota increase would also be zero at the 29.96 million pound harvest limit used here. As a result, the commercial net benefits presented here are likely overestimates in the face of doubling harvest limits.

Table 7.2. Comparison of Quota and Landings for Each Sector and in Total, 1997-2010 (millions of pounds).

Year	Adjusted Total Harvest Limits	Commercial			Recreational			Total	
		Quota	Landings	Percent Over/ Under	Quota	Landings	Percent Over/ Under	Landings	Percent Over/ Under
1997	7.95	6.00	4.82	-20%	1.95	1.20	-38%	6.02	-24%
1998	6.12	4.57	4.18	-9%	1.55	0.88	-43%	5.06	-17%
1999	3.77	2.53	3.32	**31%**	1.24	1.89	**52%**	5.21	**38%**
2000	2.99	1.75	2.66	**52%**	1.24	5.44	**339%**	8.10	**171%**
2001	5.30	3.53	4.07	**15%**	1.77	4.26	**141%**	8.33	**57%**
2002	9.96	7.25	7.28	0%	2.71	3.62	**34%**	10.90	**9%**
2003	16.11	12.10	9.89	-18%	4.01	8.48	**111%**	18.37	**14%**
2004	16.35	12.34	9.32	-24%	4.01	4.24	**6%**	13.56	-17%
2005	16.19	12.23	8.18	-33%	3.96	2.54	-36%	10.72	-34%
2006	16.08	11.93	8.96	-25%	4.15	2.93	-29%	11.89	-26%
2007	11.64	8.90	9.25	**4%**	2.74	3.65	**33%**	12.90	**11%**
2008	6.50	4.67	5.19	**11%**	1.83	4.04	**121%**	9.23	**42%**
2009	10.63	8.04	8.20	**2%**	2.59	2.94	**14%**	11.14	**5%**
2010	13.69	10.68	10.70	0%	3.01	5.74	**91%**	16.44	**20%**
2011	26.10	21.44	15.03	-26%	5.74	3.66	-36%	18.22	-31%

While aggregate benefits indicate that increasing recreational allocation would increase total benefits, the conclusion reached comparing marginal values presented above using the equimarginal principle would suggests staying at status quo allocations. The NMFS report, included above, states that there is no positive MWTP for allocation increases because the recreational sector cannot catch the new, doubled quota in the simulation model. Because this new catch limit is non-binding, anglers demand for more fish could be met within this doubled harvest quota. However, aggregate benefits increase if increased allocations allow current regulations to be relaxed. For example, if regulations are not relaxed, the aggregate net benefit for 3%, 6% and 9% recreational allocation increases would be the same as displayed for the status quo in Table 7.1; $50.1 million for anglers plus $36.0 million for the for-hire businesses for a total of $86.1 million.

However, if recreational allocation increases allow the loosening of regulations, aggregate benefits will increase. That is, aggregate benefits equal the number of trip multiplied by the value per trip. While the value per trip does not increase, the number of trips taken with relaxed regulations does, driving up aggregate value. In Table 7.1, the 3% recreational increase scenario is based on relaxing regulations to a

50 fish bag limit and a 10” minimum size, the aggregate benefit of a 6% recreational increase is based on a 50 fish bag limit and a 9.5” minimum size and the aggregate benefit of a 9% increase is based on a 50 fish bag limit and a 9” minimum size. It is worth pointing out however, that recreational regulations could be relaxed to a 50 fish bag and a 10” minimum size limit without changing allocations. By increasing the allocation to 6.63 million pounds (48,000 pounds or less than 1% more than the status quo allocation) regulations could be relaxed to a 50 fish bag limit and a 9” minimum size. The staff of the MAFMC feels that 9” is the smallest sized scup regulations should allow to avoid growth overfishing. This shows that to increase net benefits of scup management, the recreational regulations should be relaxed and that could potentially require a small increase in recreational allocations.

As another caveat, recreational net benefits are calculated for the scup/black seabass/summer flounder species complex, not just for scup, as are directed effort estimates used for the economic impact calculations below. NMFS chose to examine the net benefits of scup allocations jointly with other species because anglers expect to catch summer flounder and black seabass when targeting scup and vice versa. While the commercial estimates also took into account this “jointness” of production, the commercial analysis was able to single out a marginal value for scup alone.

Additionally, the recreational model does not allow for changing catch rates that would result from increasing allocations that were not completely harvested in each year. That is, if recreational allocations increased but did not bind, those additional fish that were not harvested would grow another year and spawn one more time contributing to a thicker stock. Research has shown in other fisheries that recreational anglers have a positive WTP for a thicker stock and higher catch rates even when fish are not going to be harvested because for some anglers utility is maximized by maximizing the number of encounters rather than harvest (Holland and Ditton 1992, Fedler and Ditton 1994, Kirkegaard and Gartside 1998, and Fenichel et al. 2008). As a result, this analysis is underestimating recreational marginal and aggregate benefits.

Also, a full for-hire production model could not be estimated. While GCG believes the for-hire surplus estimates are conservative, eliminating them from the calculation in Table 7.1 does not change the conclusion as value is primarily driven by the private recreational sector.

Finally, the net benefits presented in Table 7.1 do not include any non-use benefits of scup. Non-anglers and consumers that do not purchase scup may value a thicker scup stock, which would be available in the ecosystem if more scup were allocated to recreational sector and not harvested. Additionally, a thicker stock has value as prey in the production of other popular commercial and recreational species. The ecosystem value of scup in the production of other important species has not been included in this analysis.

The policy model available at http://www.gentnergroup.com/Scup/Scup.htm includes the economic impacts of these proposed allocation changes as per the request of the MAFMC. Economic impacts, while not appropriate for judging the efficiency of allocations, can shed light on the distributional effects of allocations changes. Commercial impacts were calculated using the economic impact model from Fisheries Economics of the United States (FEUS) (NMFS 2010). Commercial impacts were calculated by taking the new harvest levels and new prices to generate total revenue and total revenue was used in the FEUS impact model. Commercial landings at the status quo allocation generate $240.6 million in total sales and support 3,480 jobs from the harvester all the way through the retail sector. Recreational impacts were calculated using the same methodology as Gentner and Steinback (2008) except the estimates were stratified by trips catching or targeting scup, black seabass and summer flounder. The 2006 data was inflated to 2010 dollars using the consumer price index. Using these species specific expenditure estimates, the current recreational effort at the status quo allocation generates $901.7 million in total sales and supports 7,782 jobs. Economic impact results are not detailed here, but included in the password protected online policy tool. All economic impact results available online are expressed as changes from the status quo.

The MAFMC requested the examination seasonal allocations within the commercial fishery. Table 3.14 details the results of that examination. That table shows that the current allocation is inefficient and that more allocation should be shifted to the summer season. The same caveats apply in this comparison. This model is forecasting well outside the data and the model itself lacked stability at the seasonal level. In fact, separate seasonal models (Summer, Winter I and Winter II) could not be estimated reliably. Winter I and Winter II were combined because of this lack of reliability and because all uncaught Winter I quota rolls over into Winter II.

Finally, in light of the fact that the current harvest limit will be more than twice the 2010 harvest level, it is important to be cautious in applying these results. The strongest conclusion to be made is that reducing recreational allocations would reduce marginal recreational WTP more than consumer plus commercial marginal WTP would increase and aggregate value across all sectors would be less than the value at status quo. The evidence is less clear for increasing recreational allocations. Because the harvest limit will increase to levels never seen before, the recreational model could not get any allocation level to bind without relaxing regulations right to their biological limit. Because the new higher harvest levels did not bind recreational catch in the NMFS bioeconomic there is no positive marginal WTP for increases in scup allocations. There is however positive WTP in the aggregate for relaxing the scup regulations and relaxing those regulations may require additional recreational quota. With a 50 fish bag limit and a 9" minimum size limit, the recreational sector would harvest only 48,000 pounds more than the status quo allocation. This result recommends allocating more fish to the recreational sector to allow relaxing regulations, but this recommendation cannot be made strongly.

8.0 References

Abbott, J.K. and J.E. Wilen. 2009. Rent Dissipation and Efficient Rationalization in For-Hire Recreational Fishing. Journal of Environmental Economics and Management. 58(2009):300-314.

Asche, F., T Bjorndal, and D. V. Gordon. 2005. Demand Structure for Fish. SNF Working Paper No. 37/05. Institute for Research in Economics and Business. pp.44.

Barten, A.P. 1993. "Consumer Allocation Models: Choice of Functional Form." *Empirical Economics* 18L 129-158.

Bockstael, N. and K.E. McConnell. 2007. *Environmental and Resource Valuation with Revealed Preferences: A Theoretical Guide to Empirical Models*. The Netherlands: Springer.

Bierlaire, M., D. Bolduc, and D. McFadden. 2007. "The estimation of Generalized Extreme Value models from choice-based samples." Transportation Research: Part B. In Press.

Breiman, L., J.H. Friedman, R.A. Olshen, and C.J. Stone. 1984. Classification and Regression Trees Belmont, CA: Wadsworth International Group.

Brown, M.G., J.Y. Lee, and J.L. Seale. 1995. "A Family of Inverse Demand Systems and Choice of Functional Forms." *Empirical. Econ*. 20 (1995):519-530.

Cameron, A.C. and P.K. Trivedi. 1998. Regression Analysis of Count Data. New York, Cambridge University Press

Campbell, H., and R. Nicholl. 1994. Can purse seiners target yellowfin tuna? Land Economics 70, 345-354.

Carter, D.W. and C. Liese. 2010. Hedonic Valuation of Sportfishing Harvest. Marine Resource Economics. V. 25. Pp. 391-407.

Carter, D.W., J.J. Agar, and J.R. Waters. 2008. Economic Framework for Fishery Allocation Decisions with an Application to Gulf of Mexico Red Grouper. NOAA Technical Memorandum NMFS-SEFSC-576.pp100.

Center for Independent Experts. 27 November 2006 *Review of Recreational Economic Data at the National Marine Fisheries Service.* Kenneth McConnell (chair).

Cohen, J. (1988) Statistical Power Analysis for the Behavioral Sciences. Academic Press, New York, 2nd ed.

Cosslett, S. 1981a. “Maximum Likelihood Estimator for Choice-based Samples.” Econometrica. 49(5): 1289-1316.

Cosslett, S. 1981b. “Efficient Estimation of Discrete-Choice Models.” In Structural Analysis of Discrete Data, C.R. Manski and D. McFadden (eds) Cambridge, Massachusetts: MIT Press. 1981.

Dehejia, R. and S. Wahba. 2002. “Propensity Score Matching Methods for Nonexperimental Causal Studies.” Review of Economics and Statistics. 84(1): 151-161.

Edwards, S.F. 1990. An Economic Guide to Allocation of Fish Stocks between Commercial and Recreational Fisheries. NOAA Technical Report NMFS 94. US Department of Commerce.

Englin, J. and J. Shonkwiler. 1995. “Estimating Social Welfare using Count Data Models: An Application to Long-run Recreation Demand under Conditions of Endogenous Stratification and Truncation.” The Review of Economics and Statistics. 77: 104-112.

Fedler, A.J. & Ditton, R.B. (1994) Understanding Angler Motivations in Fisheries Management. Fisheries, 19, 6-13.

Fenichel, E.P., Tsao, J.I., Jones, M.L. & Hickling, G. (2008) Real options for precautionary fisheries management. Fish and Fisheries, 9, 121-137.

Freeman, A.M. *The Benefits of Environmental Improvement*. 1979. Baltimore MD: John Hopkins University Press.

Friedman, J.H. 2001. “Greedy Function Approximation: A Gradient Boosting Machine.” Annals of Statistics. 29: 1189-1232.

Friedman, J.H. 2002. "Stochastic Gradient Boosting." Computational Statistics and Data Analysis. 38: 367-378.

Friedman, J.H., T. Hastie, and R. Tibshirani. 2000. "Additive logistic regression: A statistical view of boosting." Annals of Statistics. 28: 337-374.

Fulginiti, L. and R. Perrin, 1993. The theory and measurement of producer response under quotas. Review of Economics and Statistics. Vol. 75, pp. 97-105.

Gentner, B, J. Kirkley, P.R. Hindsley, and Scott Steinback. 2010. Summer Flounder Allocation Analysis. U.S. Dep. Commerce, NOAA Tech. Memo. NMFSF/SPO-111, 93 p. http://spo.nwr.noaa.gov/tm/TMSPO111.pdf

Gentner, Brad and Scott Steinback (2008). The Economic Contribution of Marine Angler Expenditures in the United States, 2006. U.S. Department of Commerce, NOAA Tech. Memo. NMFS F/SPO-94, 301p.http://www.st.nmfs.noaa.gov/st5/publication/AnglerExpenditureReport/AnglerExpendituresReport_ALL.pdf

Gentner, Brad. (2007). Sensitivity of angler benefit estimates from a model of recreational demand to the definition of the substitute sites considered by the angler. Fishery Bulletin. 105:161-167.

Greene, W.H. *Econometric Analysis*. 2003. Upper Saddle River NJ: Prentice Hall.

Haab, T., Hicks, R., Schnier, K., and Whitehead, J. 2008. Angler Heterogeneity and the Species-Specific Demand for Recreational Fishing in the Southeast United States. Final Report Marine Fisheries Initiative (MARFIN) Grant #NA06NMF4330055. December 29, 2008.

Haab, T. and K. McConnell. 2003. Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation. New Horizons in Environmental Economics. Edwing Elgar. Northampton, MA. pp. 326.

Haab, T., Whitehead, J. and T. McConnell. 2000. *The economic value of marine recreational fishing in the Southeast United States: 1997 Southeast economic data analysis*. Final Report for NMFS Contract No. 40WCNF802079.

Hicks, R., S. Steinback, A. Gautam, and E. Thunberg. (1999). Volume II: The Economic Value of New England and Mid-Atlantic Sportfishing in 1994. NOAA Technical Memorandum NMFS-F/SPO-38. pp.45.

Hindsley, PR, C Landry, and B Gentner. 2008. "Addressing Onsite Sampling in Recreation Site Choice Models." Working Paper, Department of Economics. East Carolina University.

Hirano, K. and G. Imbens. 2001. "Estimation of causal effects using propensity score weighting: An application to data on right heart catheterization." Health Services and Outcomes Research Methodology. 2: 259-278.

Hirano, K, G. Imbens, and G. Ridder. 2003. "Efficient estimation of average treatment effects using the estimated propensity score." Econometrica. 71: 1161-1189.

Holland, S.M. & Ditton, R.B. (1992) Fishering trip satisfaction: a typology of anglers. North American Journal of Fisheries Management, 12, 28-33.

Hsieh D.A., C. Manski, and D. McFadden. 1985. "Estimation of Response Probabilities From Augmented Retrospective Observations." Journal of the American Statistical Association. 80(391): 651-662.

Imbens, G.W. 1992. "An Efficient Method of Moment Estimator for Discrete Choice Models with Choice Based Sampling," Econometrica. 60: 1187-1214.

Kirkegaard, I.R. & Gartside, D.F. (1998) Performance indicators for management of marine recreational fisheries. Marine Policy, 22, 413-422.

Kirkley, J.E., K.E. McConnell, and W. Ryan. 2000. Economic Aspects of Allocating Striped Bass Among Competing User Groups in Virginia. Virginia Marine Resources Report No. 2000-05. 79p.

Kirkley, J.E. and I. Strand, Jr. 1988. The technology and management of multispecies fisheries, Applied Economics. Vol. 20, pp.1279-1292.

Krinsky, I., and A. L. Robb. 1986. On approximating the statistical properties of elasticities. Rev. Econ. Stats. 68:715−719.

Jin, D. 2008. Development of Commercial Fishing Vessel Cost Models. Project Report Cooperative Institute on Climate and Ocean Recsearch, Award Number NA17RJ1223. pp45.

Just, R., D.L. Hueth, and A. Schmitz. 1982. Applied Welfare Economics and Public Policy. New York: Prentice-Hall.

Manski, C. and S. Lerman (1977), 'The Estimation of Choice Probabilities from Choice Based Samples', Econometrica 45, 1977–1988.

Manski C.F. and D. McFadden. 1981. "Alternative Estimators and Sample Designs for Discrete Choice Analysis." ." In Structural Analysis of Discrete Data, C.R. Manski and D. McFadden (eds) Cambridge, Massachusetts: MIT Press. 1981.

McCaffrey, D., G. Ridgeway, and A. Morral 2004. "Propensity score estimation with boosted regression for evaluating adolescent substance abuse treatment." Psychological Methods. 9(4): 403-425.

McConnell, K.E. and M. Price. 2006. The lay system in commercial fisheries: Origin and implications. Journal of Environmental Economics and Management. 51(2006): 295-307.

McFadden, D. (1974), 'Conditional Logit Analysis of Qualitative Choice Behavior' in P. Zarembka, ed., Frontiers of Econometrics. Academic Press.

McFadden, D. 1999. Econometrics 240B Reader. Unpublished manuscript. UC Berkeley.

Millimet, D. and R. Tchernis. 2008. "On the Specification of Propensity Scores: with Applications to the Analysis of Trade Policies." Journal of Business and Economics Statistics Forthcoming.

National Marine Fisheries Service. 2010. Fisheries Economics of the United States, 2009. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-F/SPO-118, 172p. Available at: https://www.st.nmfs.noaa.gov/st5/publication/index.html.

National Marine Fisheries Service. 2008. Online data queries. http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html. Last accessed November 3, 2008.

National Marine Fisheries Service. 2008a. Length/weight/age calculator. http://www.nefsc.noaa.gov/cgi-bin/jhauser/conv/conv.pl. Last accessed November 3, 2008.

Nevo, A. 2003. "Using weights to adjust for sample selection when auxiliary information is available." Journal of Business and Economics Statistics. 21(1): 43-52.

Patil, G.P. and C.R. Rao. 1978. "Weighted Distributions and Size-Biased Sampling with Applications to Wildlife Populations and Human Families." Biometrics. 34: 179-189.

Park., J. and W.N. Thurman. 1999. "On Interpreting Inverse Demand Systems: A Primal Comparison of Scale Flexibilities and Income Elasticities." *American Journal of Agricultural Economics* 81:950-958.

Park, H., W.N. Thurman, and J.E. Easley, Jr. 2004. Modeling Inverse Demands for Fish: Empirical Welfare Measurement in Gulf and South Atlantic Fisheries. Marine Resource Economics. 19:333-351.

Plummer, M., W. Morrison and E. Steiner. 2012 Allocation of Fishery Harvests under the Magnuson-Stevens Fishery Conservation and Management Act: Principles and Practice. NOAA Technical Memorandum NMFS-NWFSC-115. February 2012. 99pp.

Ridgeway, G. 2006. "Assessing the effect of race bias in post-traffic stop outcomes using propensity scores." Journal of Quantitative Criminology. 22(1): 1-29.

Ridgeway, G. 2007. "Generalized Boosted Models: A guide to the gbm package." http://cran.r-project.org/src/contrib/Descriptions/gbm.html

Ridgeway, G. 2007. gbm: Generalized booseted Regression models Version 1.6-3. http://cran.r-project.org/doc/vignettes/gbm/gbm.pdf

Ridgeway, G., D McCaffrey, and A. Morral. 2006. twang: Toolkit for Weighting and Analysis of Nonequivalent Groups Version 1.0-1. http://cran.r-project.org/src/contrib/Descriptions/twang.html

Ridgeway, G., D McCaffrey, and A. Morral. 2006. "Toolkit for Weighting and Analysis of Nonequivalent Groups: A tutorial for the twang package." http://cran.r-project.org/bin/windows/contrib/r-release/twang_1.0-1.zip

Rosenbaum, P. and D.B. Rubin. 1983. “The central role of the propensity score in observational studies for causal effects. Biometrika. 70: 41-55.

SAS. (2003). SAS OnlineDoc®, Version 9. SAS Institute Inc.

Shaw, D. 1988. “On-Site Samples’ Regression: Problems of Non-negative Integers, Truncation, and Endogenous Stratification.” Journal of Econometrics. 37: 211-223.

Squires, D. 1987. Public regulation and the structure of production in multiproduct industries. Rand Journal of Economics 18, 232-247.

Squires, D. and Kirkley, J., 1991. Production quota in multiproduct Pacific fisheries. Journal of Environmental and Economic Management. Vol. 21, pp. 109-126.

Squires, D. and Kirkley, J. 1996. Individual transferable quotas in a multiproduct common property industry. Canadian Journal of Economics. Vol. 29, No. 2, pp. 318-42.

Steinback, S. and B. Gentner. 2001. *Marine angler expenditures in the Northeast Region, 1998*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/SPO-47.

Thompson, C. 1991. “Effects of Avidity Bias on Survey Estimates of Fishing Effort an Economic Value, in *Creel and Angler Surveys in Fisheries Management.* American Fisheries Society Symposium. 12: 356-66.

Train, K. (2003), Discrete Choice Methods with Simulation. Cambridge, UK: Cambridge University Press.

U.S. Census Bureau, Census 2000 Summary File 3, Detailed Tables, Prepared by the U.S. Census Bureau, 2002.

Vestergaard, N., 1999. Measures of welfare effects in multiproduct industries: the case of multispecies individual quotas. Canadian Journal of Economics. Vol. 32, No. 3, pp. 729-743.

White, Halbert 1980. A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity. Econometrica 48: 817-838.

Wooldridge, J. 2002. “Inverse probability weighted M-estimators for sample selection, attrition, and stratification.” Portuguese Economic Journal. 1: 117-139.

Zellner, A. 1962. “An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests of Aggregation Bias.” *Journal of the American Statistical Association* 57:500-509.

Appendix 1: Variables Used in Cost Estimation.

Variable	Description	Database
	Trip Level Variables	
Tripcost	Sum of trip cost elements	Observer
crew	Number of Crew	VTR
div	diversity of species - sum of squared share landings	
farfz	Calculated Fishery Zone is more than 12 miles	VTR
medfz	Calculated Fishery Zone is between 3 and 12 miles	VTR
medfz	Calculated Fishery Zone is less than 3 miles	VTR
lnfp	log of Fuel Price	Observer
mobile_tp	mobile principle gear by trip	
other_pgp	static principle gear by trip	
static_tp	Others principle gear type by trip	
M1-M12	Dummies for Month of landing	VTR
trip_lbs	total landing pounds by trip	
tripval_ths	total landing value by trip in thousands	VTR/Dealer
tripdur	Trip duration (dateland - datesail)	VTR
thaul	Total Number of hauls by trip	VTR
valshare	share of trip landing of the total vessel landing	VTR/Dealer
multdaytp	1 if trip is more than 24 hours and 0 otherwise	VTR
yr09	Dummies for years (1=2009,=0 otherwise)	VTR
	Vessel Level Variables	
age	vessel age (current year-year built)	Permit
gtons	Gross Tons	Permit
hold	Hold capacity of the vessel in pounds	Permit
len	Length in feet	Permit
lensq	Square of length variable	Permit
vhp	Vessel Horse Power	Permit
vhplen	VHP/LEN	VTR
mobile	mobile principle gear by vessel	
static	static principle gear by vessel	
others_gg	Others principle gear type by vessel	
reg_ma	Region Mid-Atlantic based on Principle Port State of the vessel	Dealer
reg_ne	Region New-England based on Principle Port State of the vessel	Dealer
tonpft	Ton per foot (GTONS/LEN)	Permit
trip_ct	trip frequency per vessel	
vess_lbs	total landing lb by vessel	VTR
vessval_ths	total landing value by vessel in thousands	VTR/Dealer

Appendix 2. Vessel and Trip Characteristics by Gear Type.

Trip Characteristic	Otter Trawl				Gill Nets				Pots and Traps			
	Number of Trips	Mean	Lower Bound	Upper Bound	Number of Trips	Mean	Lower Bound	Upper Bound	Number of Trips	Mean	Lower Bound	Upper Bound
Days Absent	7060	1.15	1.12	1.19	400	0.25	0.20	0.30	1062	0.30	0.27	0.33
Number of Crew		2.59	2.57	2.61		2.17	2.09	2.24		2.72	2.50	2.93
Trips in Federal Waters		0.88	0.88	0.89		0.80	0.76	0.84		0.63	0.60	0.66
Scup Weight		3149.16	3027.30	3271.02		231.21	185.10	277.31		944.85	742.39	1147.31
Other Bottomfish Weight		759.99	713.19	806.78		100.81	83.14	118.47		64.51	58.60	70.43
Bait Weight		97.29	66.39	128.19		2.36	-0.23	4.94		5.26	2.68	7.84
Shellfish Weight		166.60	148.86	184.34		0.19	0.06	0.31		46.12	25.06	67.18
Other Fish Weight		366.37	329.65	403.09		166.58	134.98	198.18		69.52	47.45	91.59
Scup Value		$2,810.01	$2,695.20	$2,924.82		$278.51	$230.10	$326.91		$1,059.95	$843.98	$1,275.91
Other Bottomfish Value		$1,163.60	$1,105.84	$1,221.35		$151.02	$130.92	$171.12		$199.39	$180.05	$218.73
Bait Value		$49.87	$41.84	$57.90		$0.54	$0.06	$1.02		$4.09	$1.95	$6.22
Shellfish Value		$171.96	$155.79	$188.13		$0.04	-$0.01	$0.09		$62.06	$37.35	$86.78
Other Value		$48.03	$44.68	$51.38		$79.28	$66.19	$92.37		$33.57	$24.71	$42.43
All Other Fish Value		$269.85	$250.67	$289.03		$79.86	$66.78	$92.93		$99.72	$72.62	$126.83
Vessel Length		60.98	60.69	61.28		37.29	36.95	37.62		37.23	36.69	37.78
Gross Tons		78.46	77.45	79.46		18.31	17.78	18.83		15.54	14.94	16.15
Vessel Horespower		439.74	435.44	444.04		320.33	313.09	327.57		286.95	282.06	291.85
Hold Capacity		90,102	88,414	91,790		14,609	12,832	16,387		7,180	6,436	7,924
Total Landed Weight		4,275.49	4,127.11	4,423.87		498.56	433.08	564.05		1,078.81	869.70	1,287.92
Total Revenue		$4,079.37	$3,938.93	$4,219.80		$507.77	$443.02	$572.53		$1,335.96	$1,112.35	$1,559.58
Scup Price		$1.03	$1.02	$1.04		$1.41	$1.36	$1.47		$1.33	$1.30	$1.35
Other Bottomfish Price		$2.14	$2.12	$2.17		$2.21	$2.10	$2.32		$2.76	$2.70	$2.81
Bait Price		$0.51	$0.50	$0.52		$0.34	$0.32	$0.37		$0.45	$0.43	$0.48
Shellfish Price		$1.07	$1.04	$1.11		$0.52	$0.51	$0.54		$0.87	$0.80	$0.94
Other Finfish Price		$0.94	$0.90	$0.97		$0.77	$0.72	$0.82		$1.28	$1.21	$1.34

Appendix 3: Commercial Cost Model

The MODEL Procedure

Nonlinear FIML Summary of Residual Errors

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square	Adj R-Sq	Label
wt_1	22	6684	1.791E14	2.68E10	163701	0.3761	0.3741	scup
wt_2	22	6684	1.687E13	2.5234E9	50233.8	0.5429	0.5414	bottom
wt_3	22	6684	3.806E13	5.6945E9	75461.8	0.0488	0.0458	bait
wt_4	22	6684	4.425E12	6.6209E8	25731.2	0.0849	0.0820	shell
wt_5	22	6684	3.069E11	45921826	6776.6	0.0654	0.0624	other

Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|	Label
a1	2.671389	0.1178	22.67	<.0001	Trip Cost
a2	-0.00061	0.000021	-28.77	<.0001	Trip Cost^2
a3	0.072732	0.0139	5.23	<.0001	Pr2/pr1
a4	0.365125	0.0158	23.10	<.0001	Pr3/pr1
a5	0.102078	0.0102	10.03	<.0001	Pr4/pr1
a6	-0.00306	0.00180	-1.70	0.0890	Pr5/pr1
a7	-0.60662	0.1662	-3.65	0.0003	Summer
a8	1.956391	0.0591	33.11	<.0001	Winter I
a9	1.905935	0.0447	42.64	<.0001	2005
a10	0.576214	0.0387	14.87	<.0001	2006
a11	0.41168	0.0376	10.94	<.0001	2007
a12	-1.07754	0.0480	-22.43	<.0001	2008
a13	-0.74517	4.6320	-0.16	0.8722	Port19
a14	-0.82597	0.1081	-7.64	<.0001	Port34

Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
a15	-0.79949	0.1586	-5.04	<.0001	Port35
a16	1.373429	0.0599	22.91	<.0001	Port36
a17	-1.12806	0.1549	-7.28	<.0001	Port38
a18	-0.2981	0.1545	-1.93	0.0537	Port40
a19	-0.8251	0.0982	-8.41	<.0001	Port41
a20	-0.36834	0.1186	-3.11	0.0019	Port42
a21	-0.46959	0.0969	-4.85	<.0001	Port44
a22	-1.18383	0.0797	-14.85	<.0001	Port45
a23	-0.54792	0.0721	-7.60	<.0001	Port46
a24	-0.6656	0.0566	-11.76	<.0001	Port47
b1	0.882313	0.0398	22.18	<.0001	Trip Cost
b2	-0.00012	8.043E-6	-15.28	<.0001	Trip Cost^2
b3	0.133795	0.0132	10.13	<.0001	Pr1/pr2
b4	0.365125	0.0158	23.10	<.0001	Pr3/pr2
b5	-0.08473	0.00636	-13.33	<.0001	Pr4/pr2
b6	0.001164	0.00123	0.95	0.3433	Pr5/pr2
b7	-0.24704	0.0694	-3.56	0.0004	Summer
b8	0.131606	0.0195	6.74	<.0001	Winter I
b9	0.250401	0.0163	15.34	<.0001	2005
b10	0.069239	0.0161	4.31	<.0001	2006
b11	-0.00722	0.0203	-0.36	0.7224	2007
b12	0.044124	0.0154	2.86	0.0042	2008
b13	13.90514	0.2892	48.08	<.0001	Port19

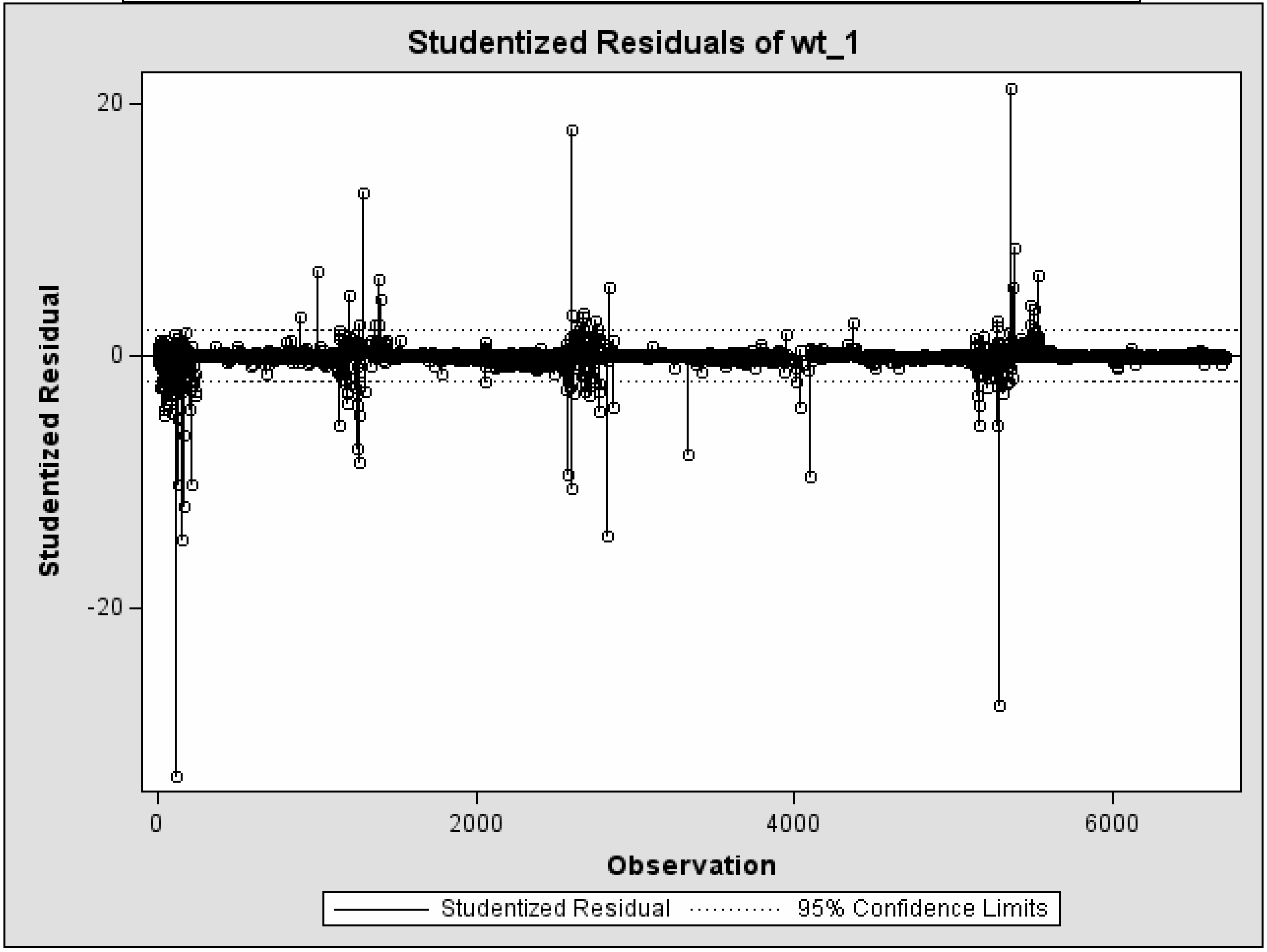
Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
b14	-0.13237	0.0162	-8.18	<.0001	Port34
b15	-0.40235	0.0908	-4.43	<.0001	Port35
b16	-0.55693	0.0259	-21.53	<.0001	Port36
b17	-0.60654	0.0913	-6.64	<.0001	Port38
b18	-0.16337	0.0261	-6.27	<.0001	Port40
b19	-0.56438	0.0941	-6.00	<.0001	Port41
b20	-0.61029	0.0678	-9.00	<.0001	Port42
b21	-0.66804	0.0365	-18.29	<.0001	Port44
b22	-0.59789	0.0333	-17.94	<.0001	Port45
b23	-0.45414	0.0217	-20.93	<.0001	Port46
b24	-0.45324	0.0143	-31.79	<.0001	Port47
c1	-0.58601	0.1329	-4.41	<.0001	Trip Cost
c2	-0.00001	0.000015	-0.73	0.4632	Trip Cost^2
c3	0.133795	0.0132	10.13	<.0001	Pr1/pr3
c4	0.072732	0.0139	5.23	<.0001	Pr2/pr3
c5	0.019793	0.0130	1.53	0.1269	Pr4/pr3
c6	-0.00322	0.00230	-1.40	0.1604	Pr5/pr3
c7	0.085669	0.1166	0.73	0.4626	Summer
c8	0.212786	0.0507	4.20	<.0001	Winter I
c9	-0.0076	0.0700	-0.11	0.9135	2005
c10	0.304711	0.0466	6.53	<.0001	2006
c11	0.219923	0.0524	4.20	<.0001	2007
c12	0.094665	0.0567	1.67	0.0953	2008

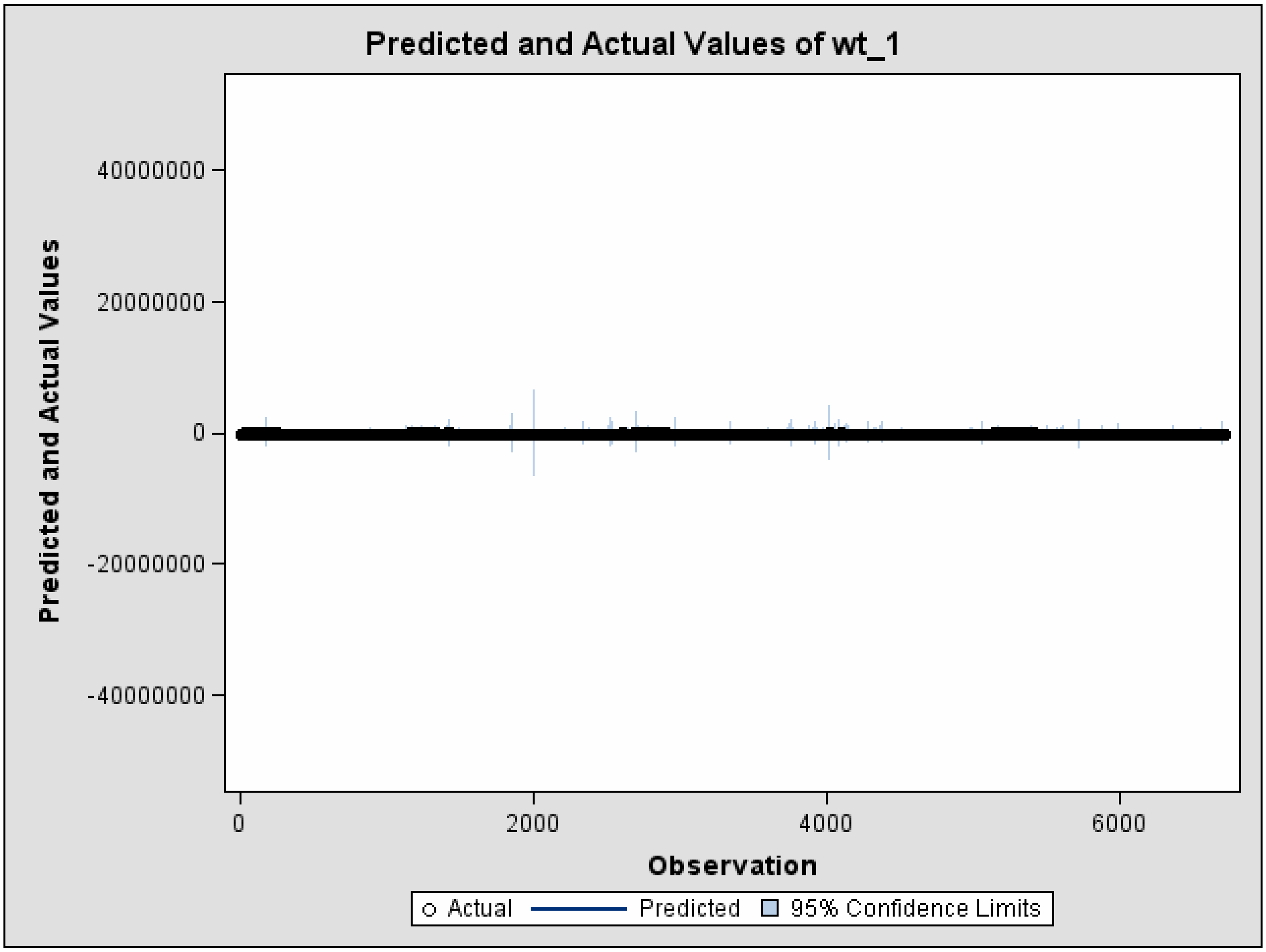
Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
c13	0.191036	6.8941	0.03	0.9779	Port19
c14	0.125281	0.1123	1.12	0.2646	Port34
c15	-0.0607	0.4830	-0.13	0.9000	Port35
c16	0.390995	0.0947	4.13	<.0001	Port36
c17	0.03166	0.3283	0.10	0.9232	Port38
c18	0.054824	0.2000	0.27	0.7841	Port40
c19	0.900398	0.1002	8.99	<.0001	Port41
c20	-0.01027	0.2051	-0.05	0.9601	Port42
c21	-0.06876	0.2122	-0.32	0.7459	Port44
c22	0.018177	0.1382	0.13	0.8954	Port45
c23	0.000705	0.1269	0.01	0.9956	Port46
c24	0.038827	0.1017	0.38	0.7026	Port47
d1	0.125389	0.0358	3.50	0.0005	Trip Cost
d2	-0.00003	4.781E-6	-5.90	<.0001	Trip Cost^2
d3	0.019793	0.0130	1.53	0.1269	Pr1/pr4
d4	-0.08473	0.00636	-13.33	<.0001	Pr2/pr4
d5	0.102078	0.0102	10.03	<.0001	Pr3/pr4
d6	-0.01719	0.00215	-8.01	<.0001	Pr5/pr4
d7	-0.00068	0.0249	-0.03	0.9782	Summer
d8	0.039574	0.00989	4.00	<.0001	Winter I
d9	0.163288	0.00759	21.50	<.0001	2005
d10	0.033213	0.00870	3.82	0.0001	2006
d11	-0.02029	0.0127	-1.60	0.1091	2007

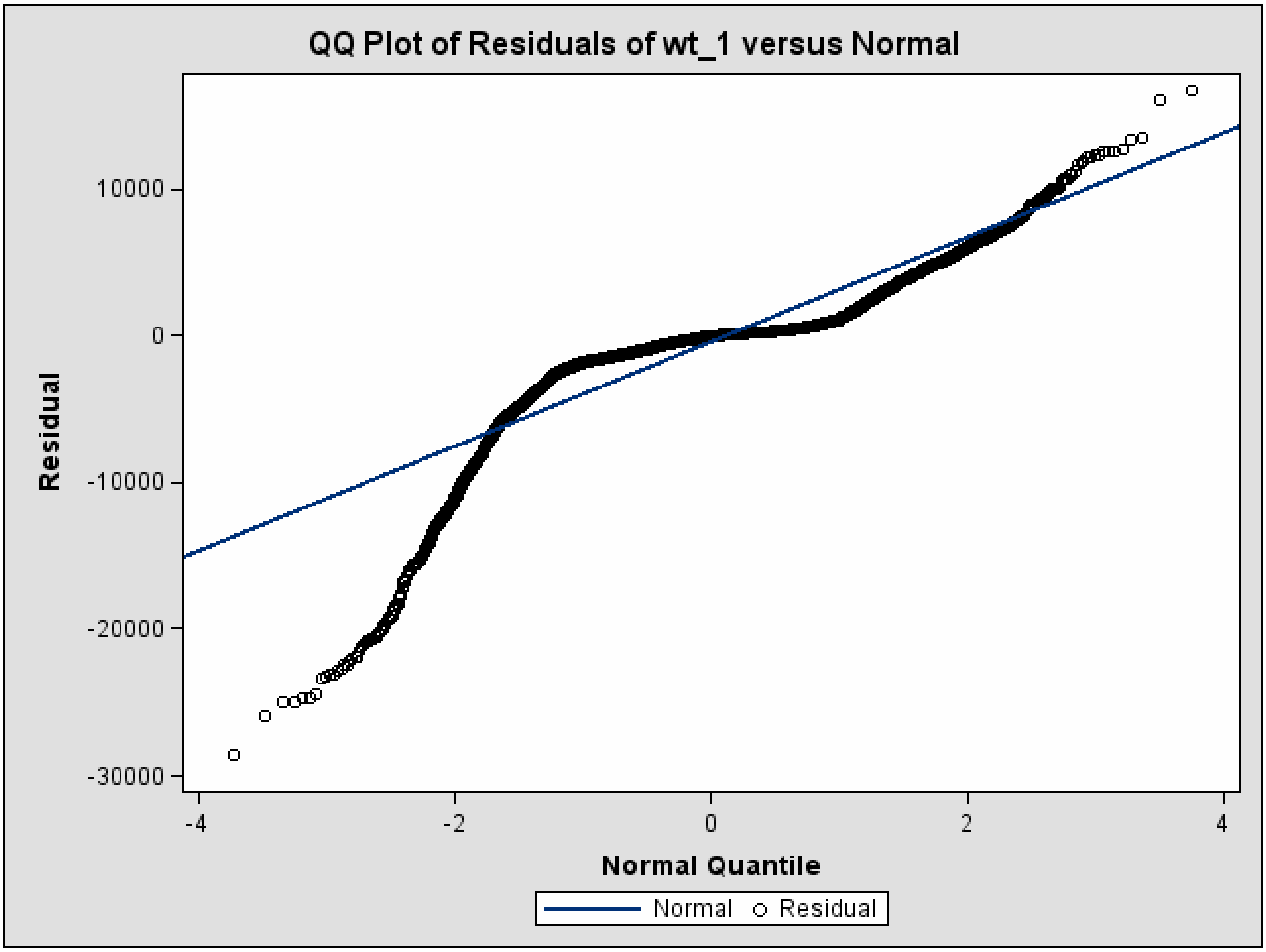
Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
d12	-0.02816	0.00905	-3.11	0.0019	2008
d13	-0.11383	1.5190	-0.07	0.9403	Port19
d14	0.262104	0.0254	10.33	<.0001	Port34
d15	0.003273	0.1626	0.02	0.9839	Port35
d16	0.089295	0.0239	3.74	0.0002	Port36
d17	0.06686	0.0380	1.76	0.0785	Port38
d18	0.169174	0.0297	5.70	<.0001	Port40
d19	0.048592	0.0360	1.35	0.1767	Port41
d20	0.03424	0.0525	0.65	0.5144	Port42
d21	-0.00721	0.0338	-0.21	0.8313	Port44
d22	0.163809	0.0252	6.50	<.0001	Port45
d23	0.07214	0.0258	2.80	0.0051	Port46
d24	0.046444	0.0236	1.97	0.0487	Port47
e1	0.161677	0.00725	22.31	<.0001	Trip Cost
e2	-0.00002	1.186E-6	-15.32	<.0001	Trip Cost^2
e3	-0.00322	0.00230	-1.40	0.1604	Pr1/pr5
e4	0.001164	0.00123	0.95	0.3433	Pr2/pr5
e5	-0.01719	0.00215	-8.01	<.0001	Pr3/pr5
e6	-0.00306	0.00180	-1.70	0.0890	Pr4/pr5
e7	-0.03649	0.00505	-7.23	<.0001	Summer
e8	-0.04713	0.00301	-15.68	<.0001	Winter I
e9	0.041637	0.00376	11.08	<.0001	2005
e10	0.017752	0.00338	5.25	<.0001	2006

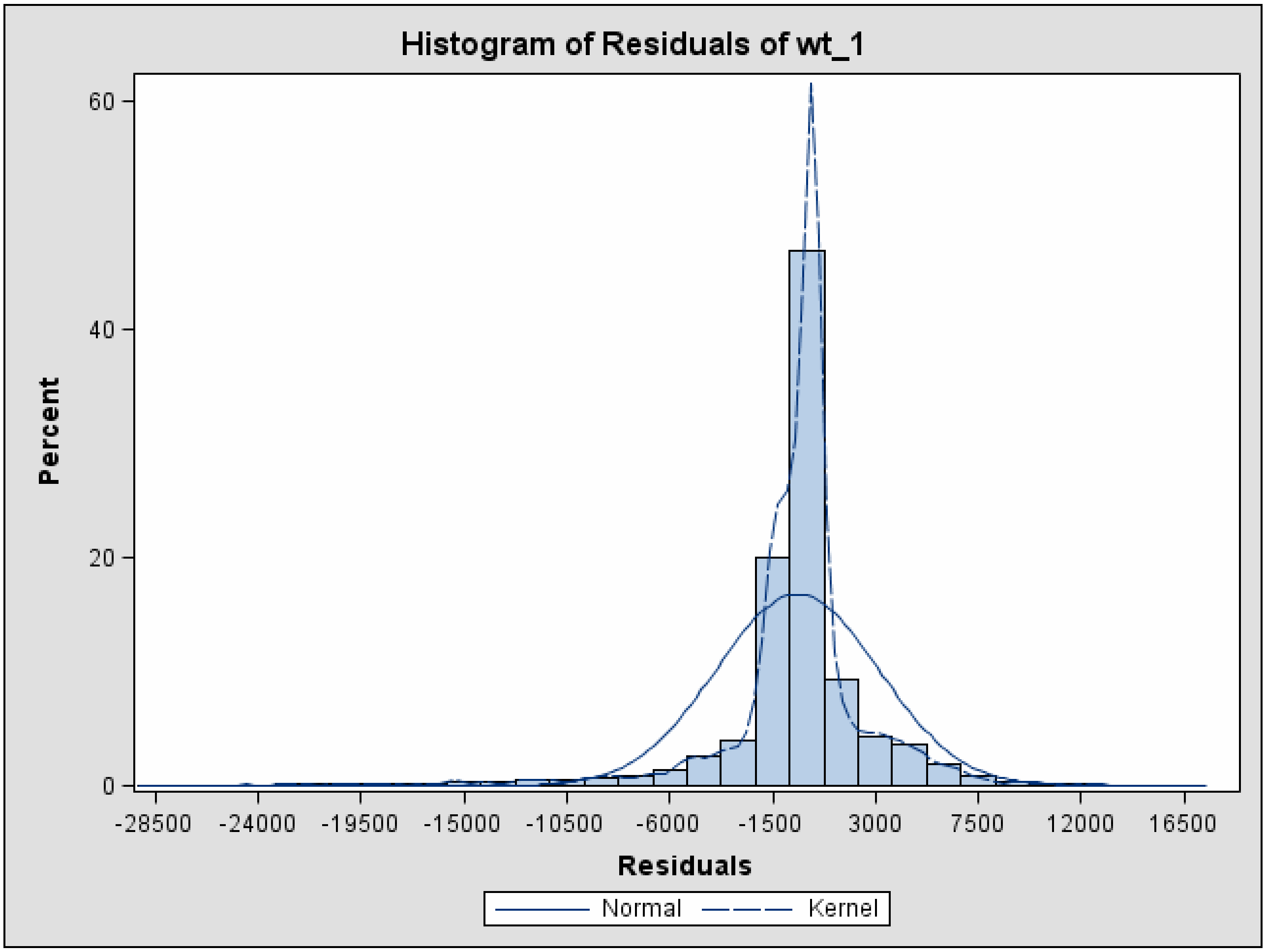
Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
e11	0.009476	0.00392	2.42	0.0157	2007
e12	0.019216	0.00330	5.82	<.0001	2008
e13	-0.09736	0.3167	-0.31	0.7585	Port19
e14	-0.02051	0.00754	-2.72	0.0066	Port34
e15	-0.02916	0.0224	-1.30	0.1925	Port35
e16	-0.00197	0.00415	-0.47	0.6359	Port36
e17	0.012326	0.00836	1.47	0.1406	Port38
e18	-0.03181	0.0172	-1.85	0.0637	Port40
e19	0.0046	0.00529	0.87	0.3846	Port41
e20	0.001274	0.00861	0.15	0.8824	Port42
e21	-0.03629	0.00936	-3.88	0.0001	Port44
e22	-0.01736	0.00493	-3.52	0.0004	Port45
e23	-0.017	0.00536	-3.17	0.0015	Port46
e24	-0.01888	0.00410	-4.61	<.0001	Port47
Restrict0	-105.119	35.4898	-2.96	0.0031	a3 = c4
Restrict1	-36.3366	20.3175	-1.79	0.0737	a4 = b4
Restrict2	-96.9106	33.4861	-2.89	0.0038	a5 = d5
Restrict3	-78.9767	18.6392	-4.24	<.0001	a6 = e6
Restrict4	-101.545	26.9826	-3.76	0.0002	b3 = c3
Restrict5	-254.007	59.4224	-4.27	<.0001	b5 = d4
Restrict6	65.09334	45.7657	1.42	0.1549	b6 = e4
Restrict7	16.77203	34.7845	0.48	0.6297	c5 = d3
Restrict8	-44.9407	19.1272	-2.35	0.0188	c6 = e3

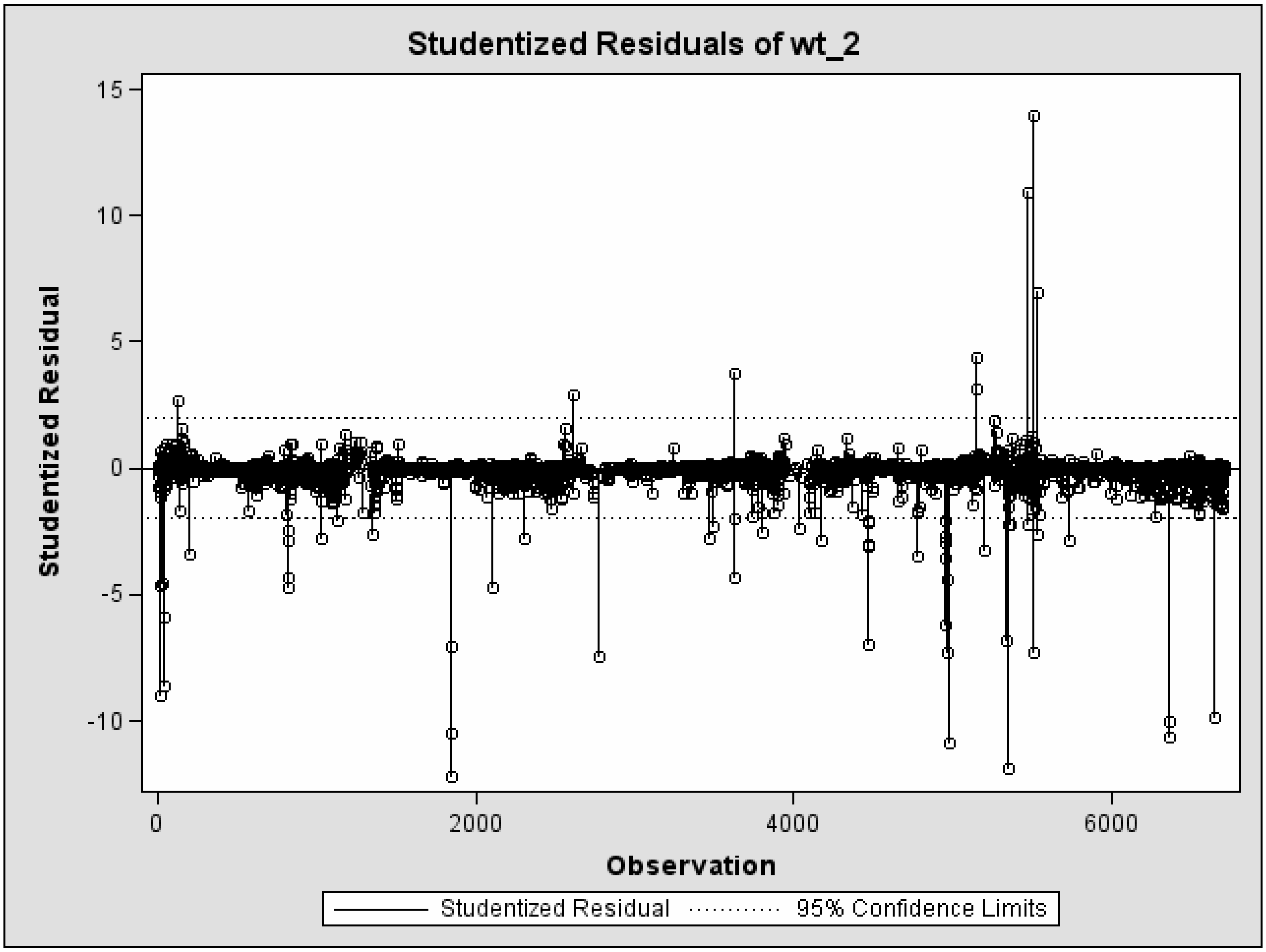
Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
Restrict9	32.59617	51.2866	0.64	0.5251	d6 = e5

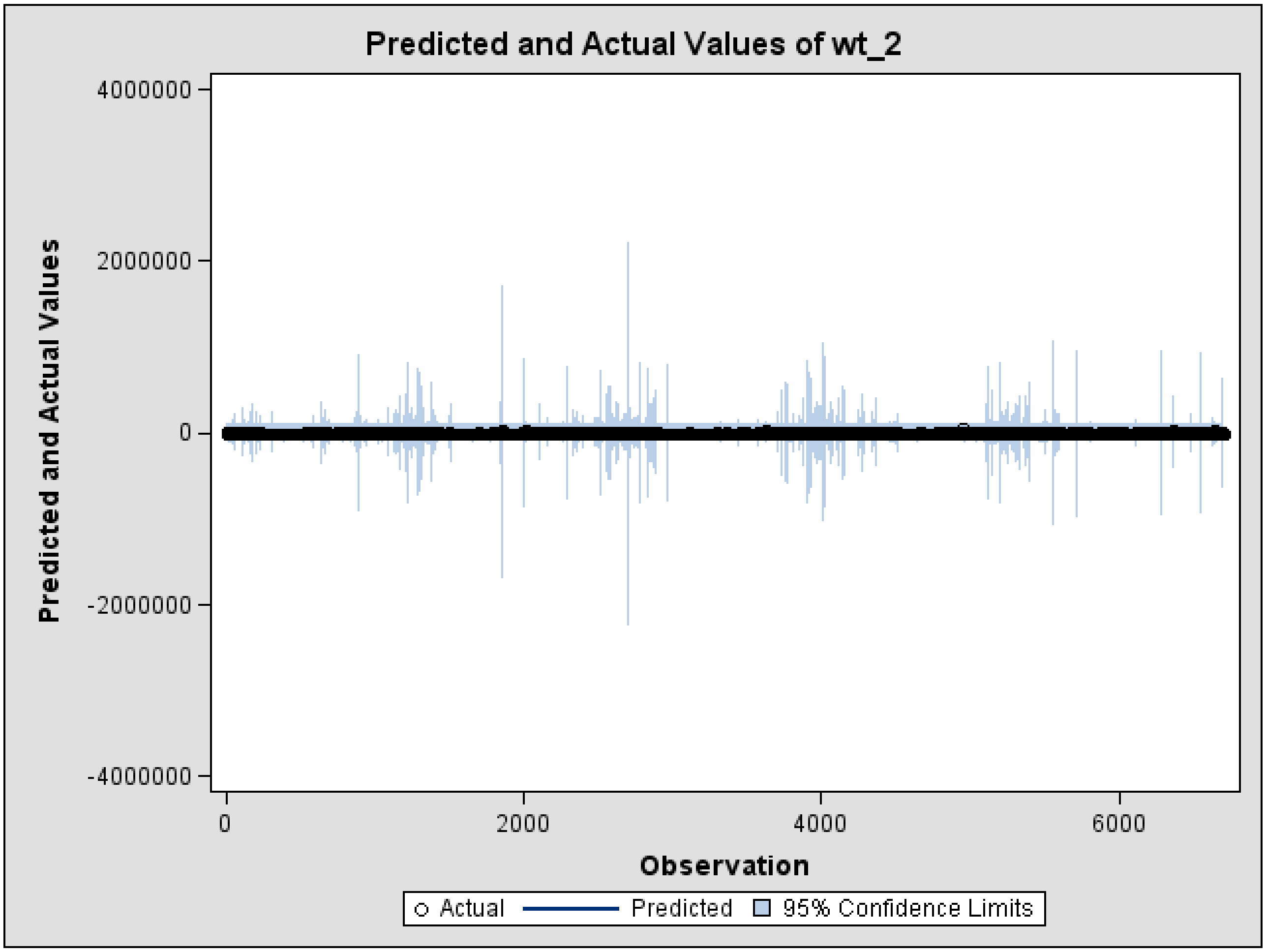


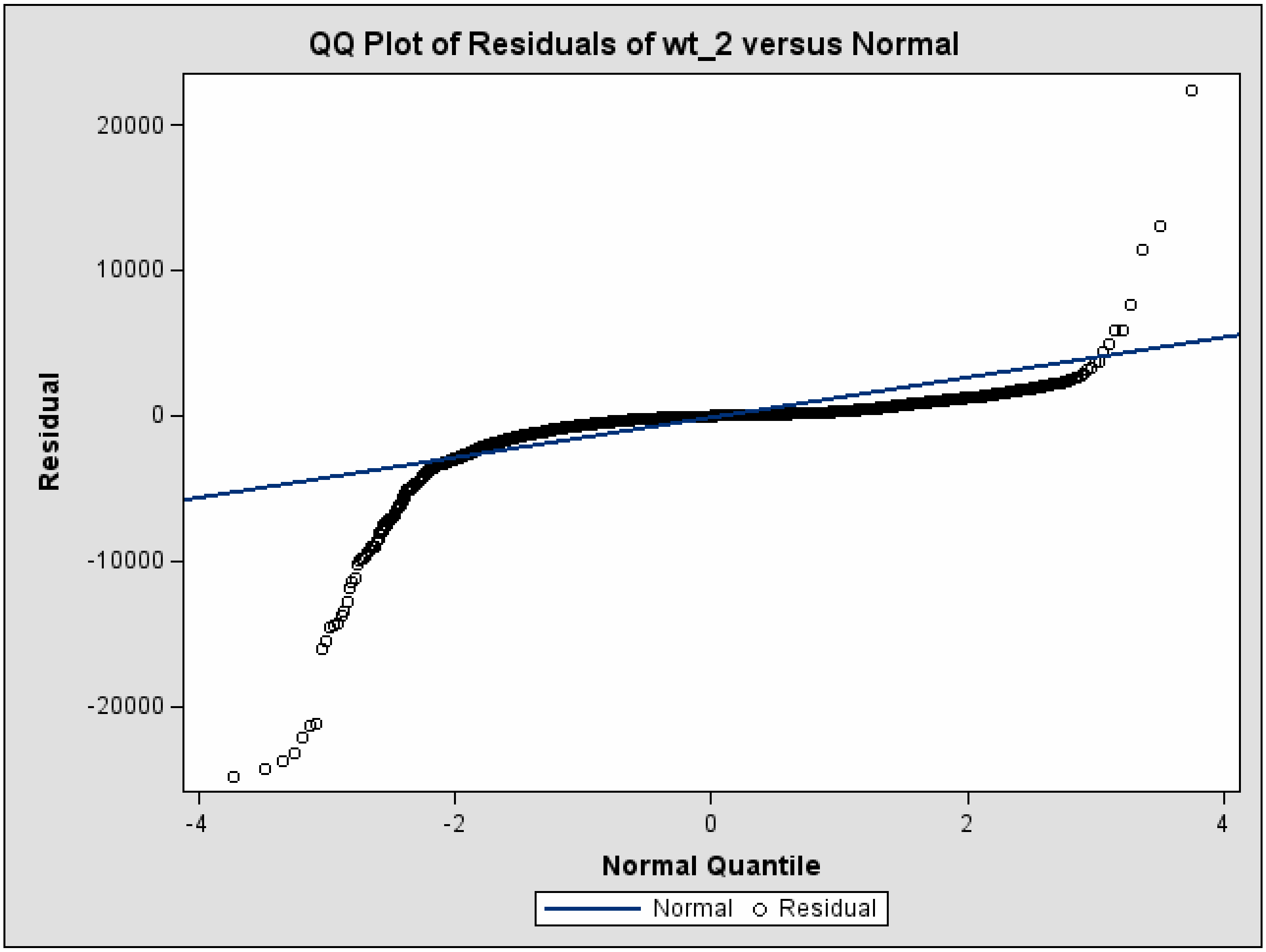

Predicted and Actual Values of wt_1
Predicted and Actual Values
40000000
20000000
0
-20000000
-40000000
0
2000
4000
6000
Observation
○ Actual
Predicted
95% Confidence Limits

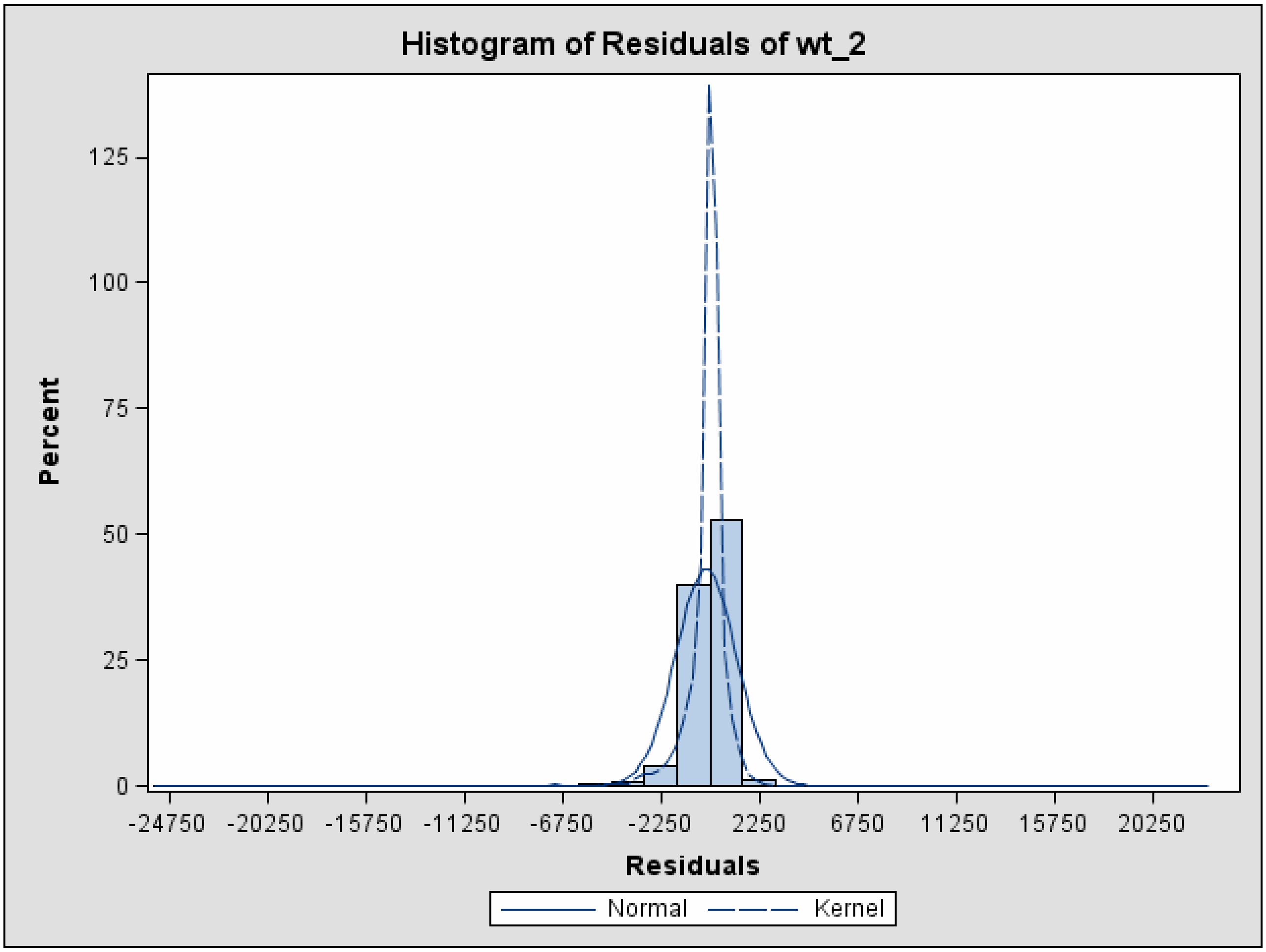

QQ Plot of Residuals of wt_1 versus Normal
Residual
10000
0
-10000
-20000
-30000
-4
-2
0
2
4
Normal Quantile
Normal
○ Residual

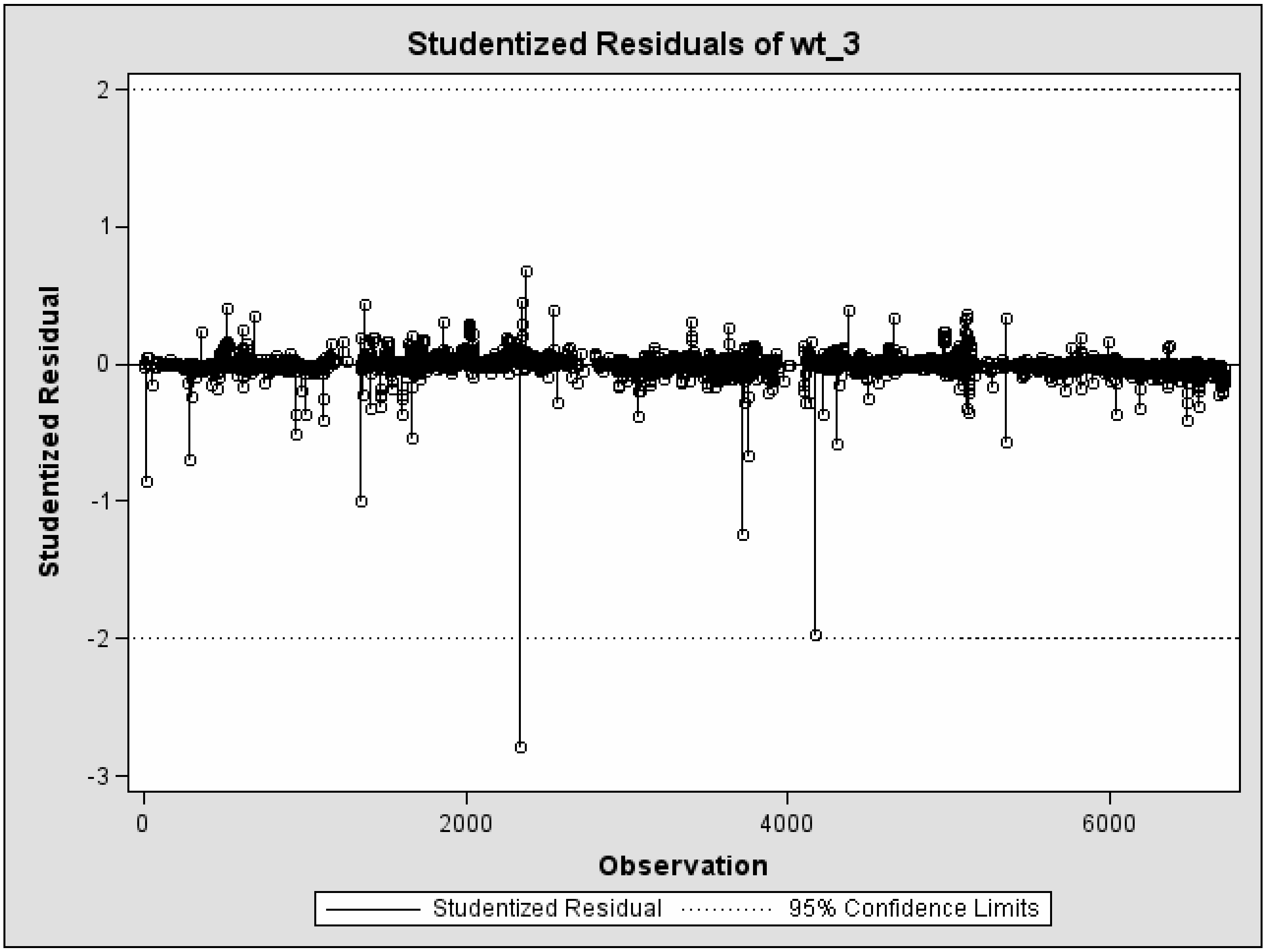

Histogram of Residuals of wt_1
Percent
0
20
40
60
-28500
-24000
-19500
-15000
-10500
-6000
-1500
3000
7500
12000
16500
Residuals
Normal
Kernel

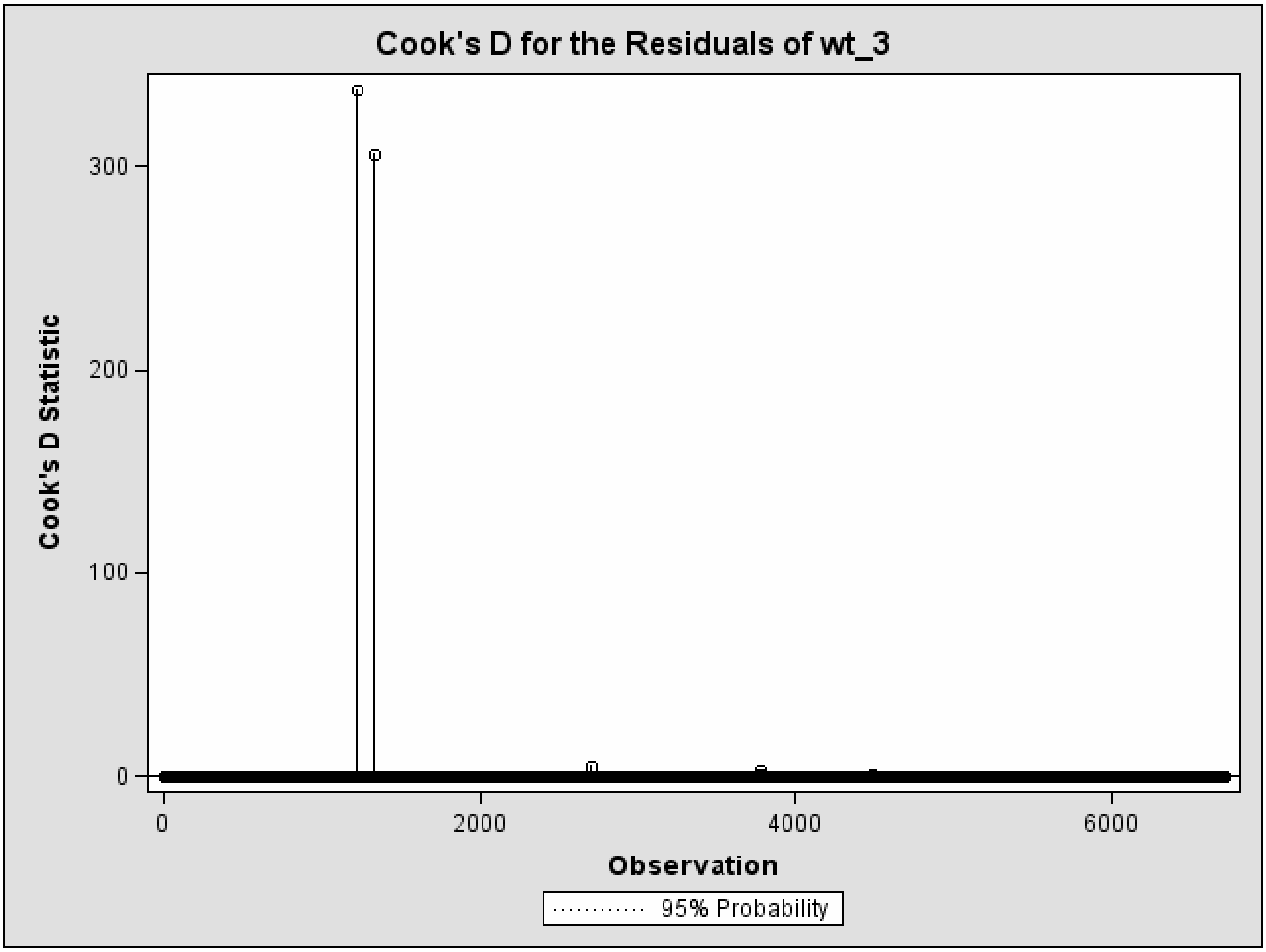

Studentized Residuals of wt_2
Studentized Residual
15
10
5
0
-5
-10
0
2000
4000
6000
Observation
Studentized Residual
95% Confidence Limits

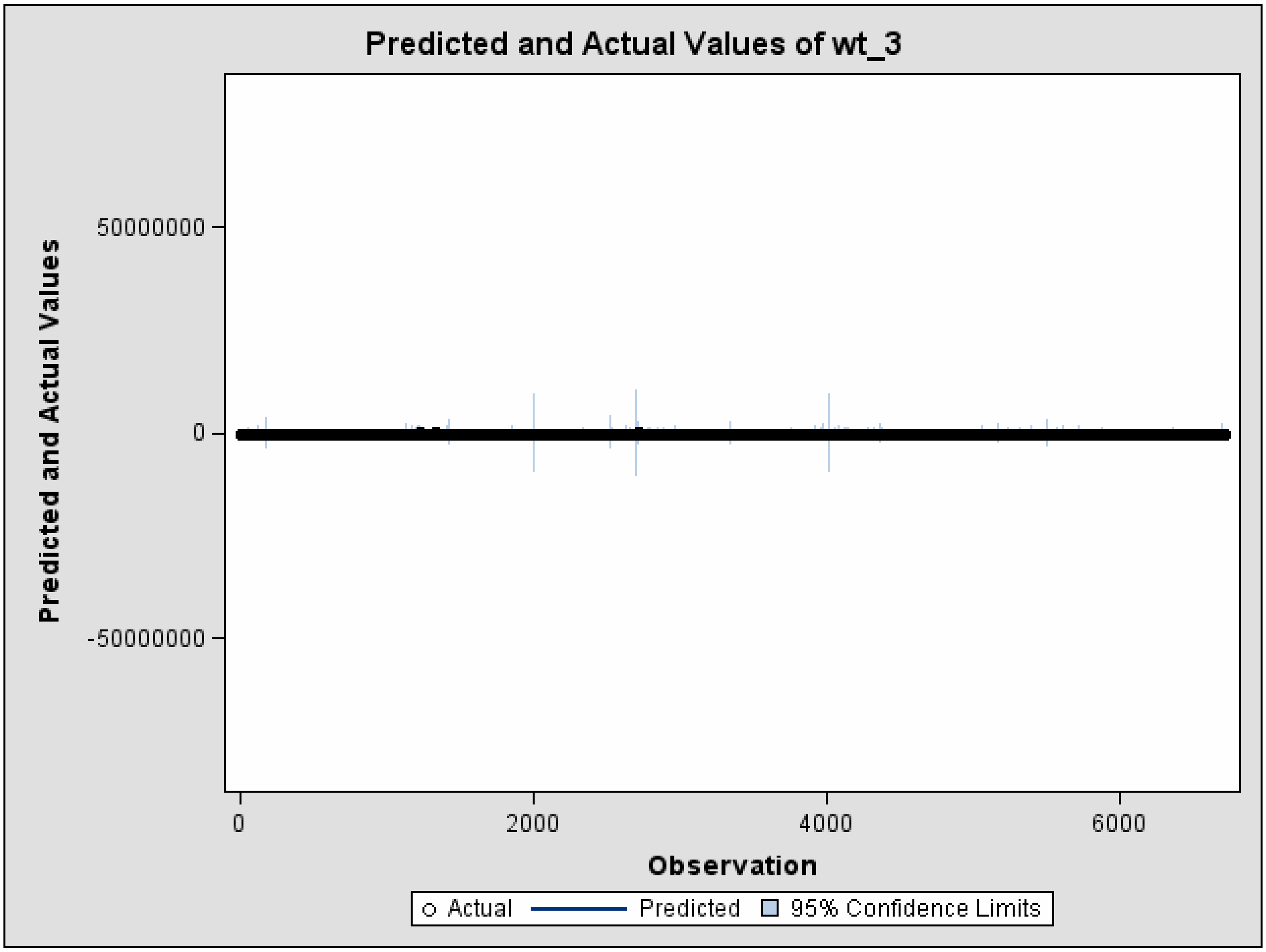

Predicted and Actual Values of wt_2
4000000
2000000
0
-2000000
-4000000
Predicted and Actual Values
0
2000
4000
6000
Observation
○ Actual
Predicted
95% Confidence Limits

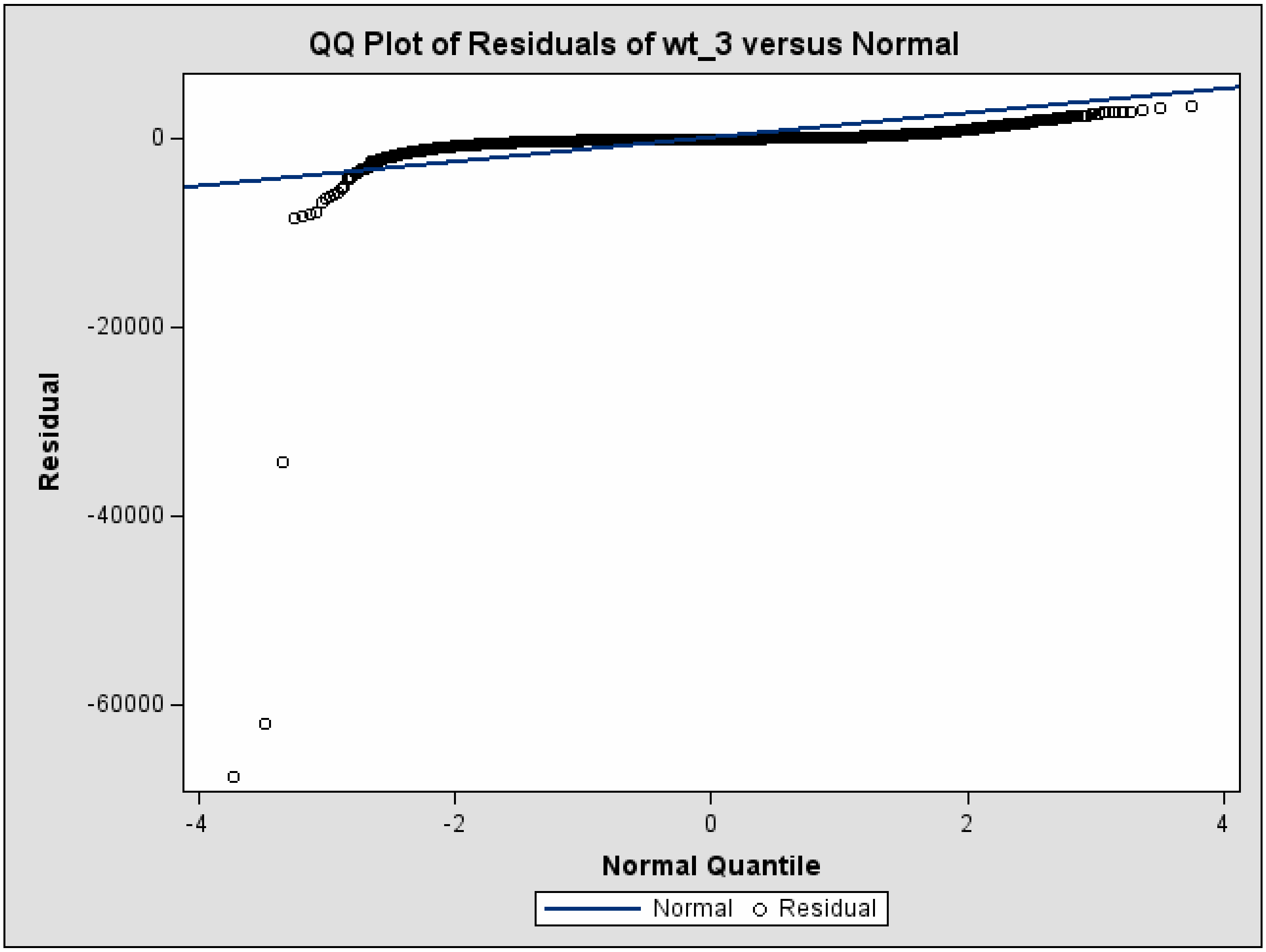

QQ Plot of Residuals of wt_2 versus Normal
Residual
20000
10000
0
-10000
-20000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

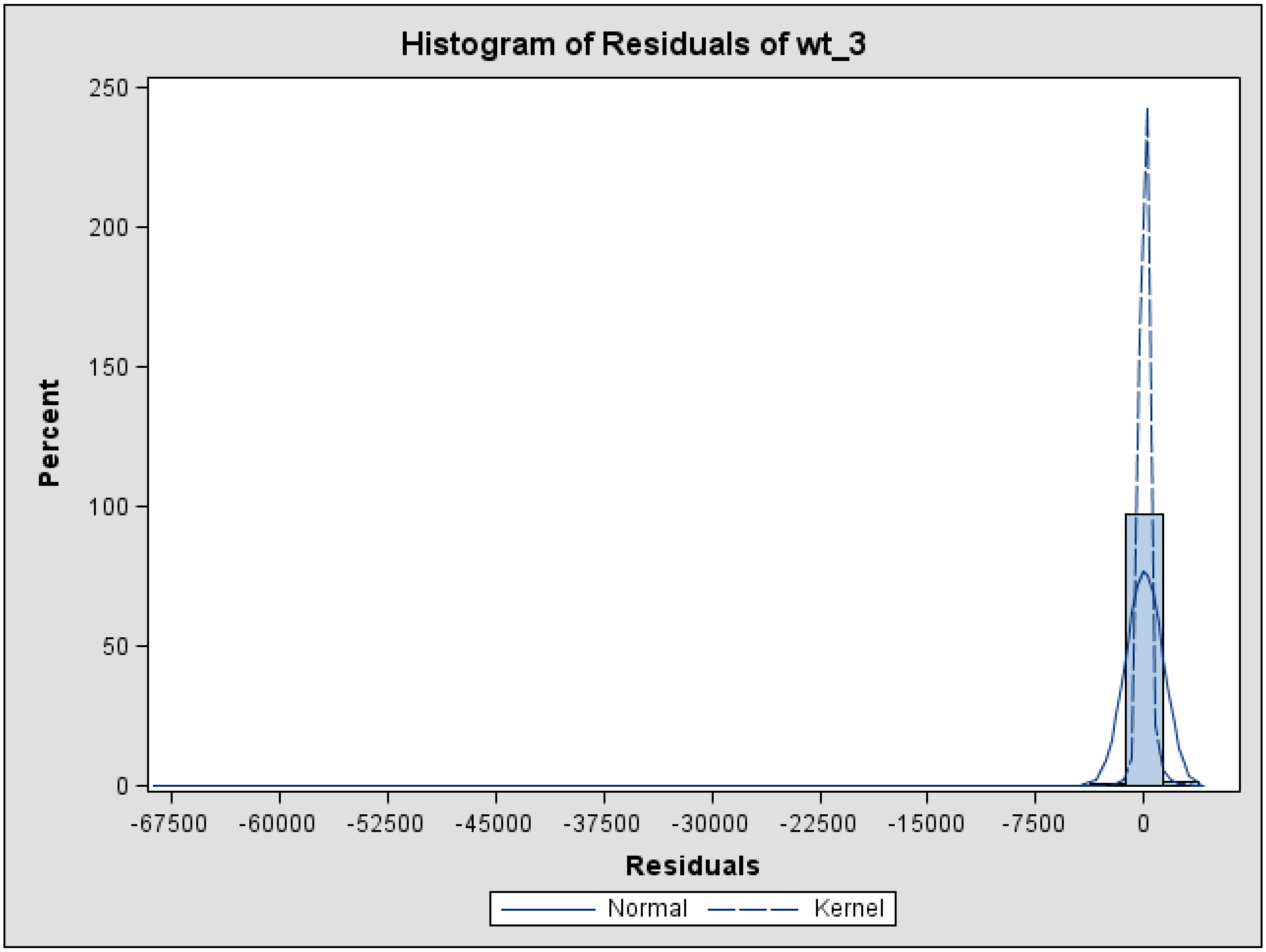

Histogram of Residuals of wt_2
Percent
125
100
75
50
25
0
-24750
-20250
-15750
-11250
-6750
-2250
2250
6750
11250
15750
20250
Residuals
Normal
Kernel

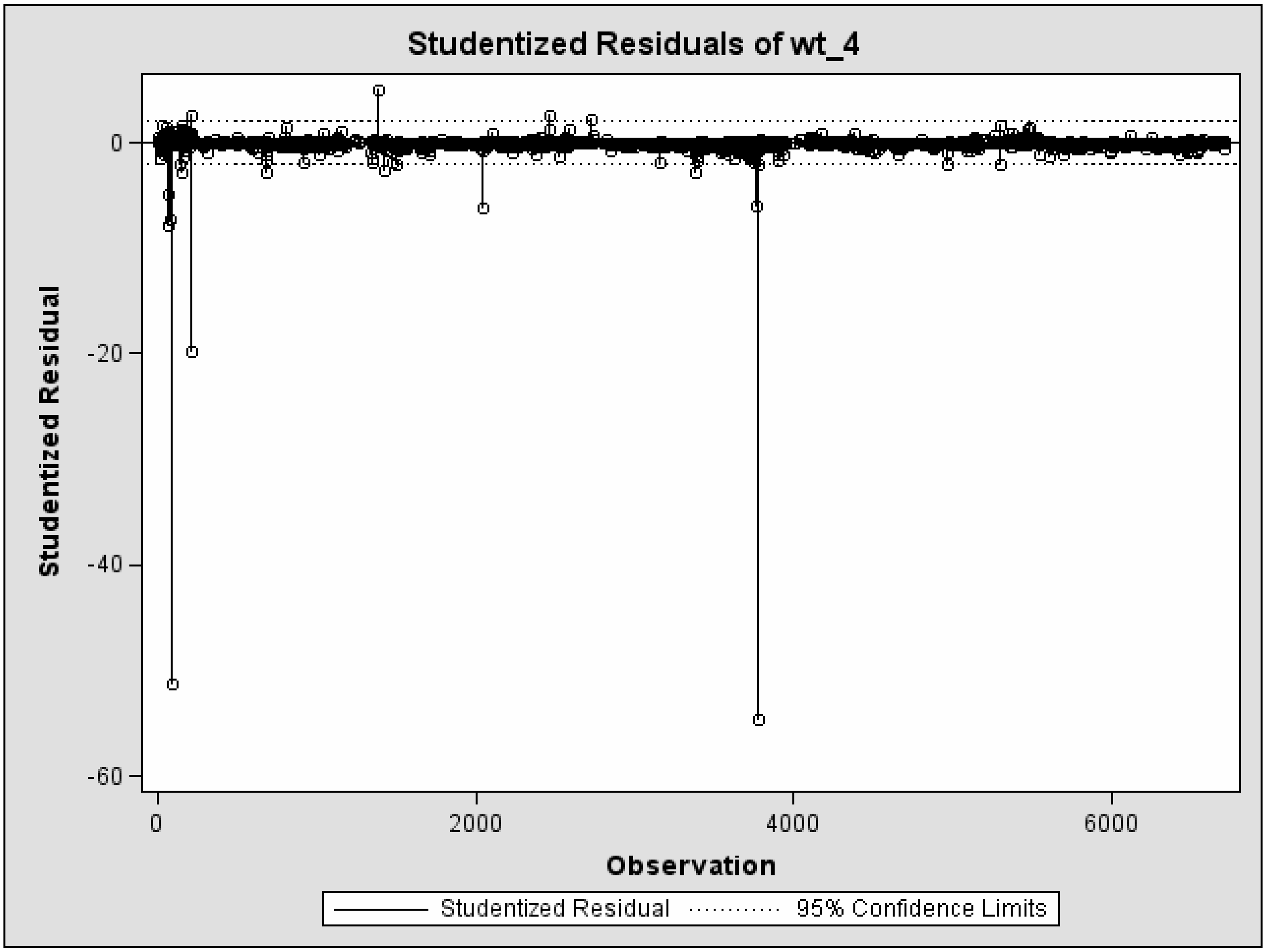

Studentized Residuals of wt_3
Studentized Residual
2
1
0
-1
-2
-3
0
2000
4000
6000
Observation
Studentized Residual
95% Confidence Limits

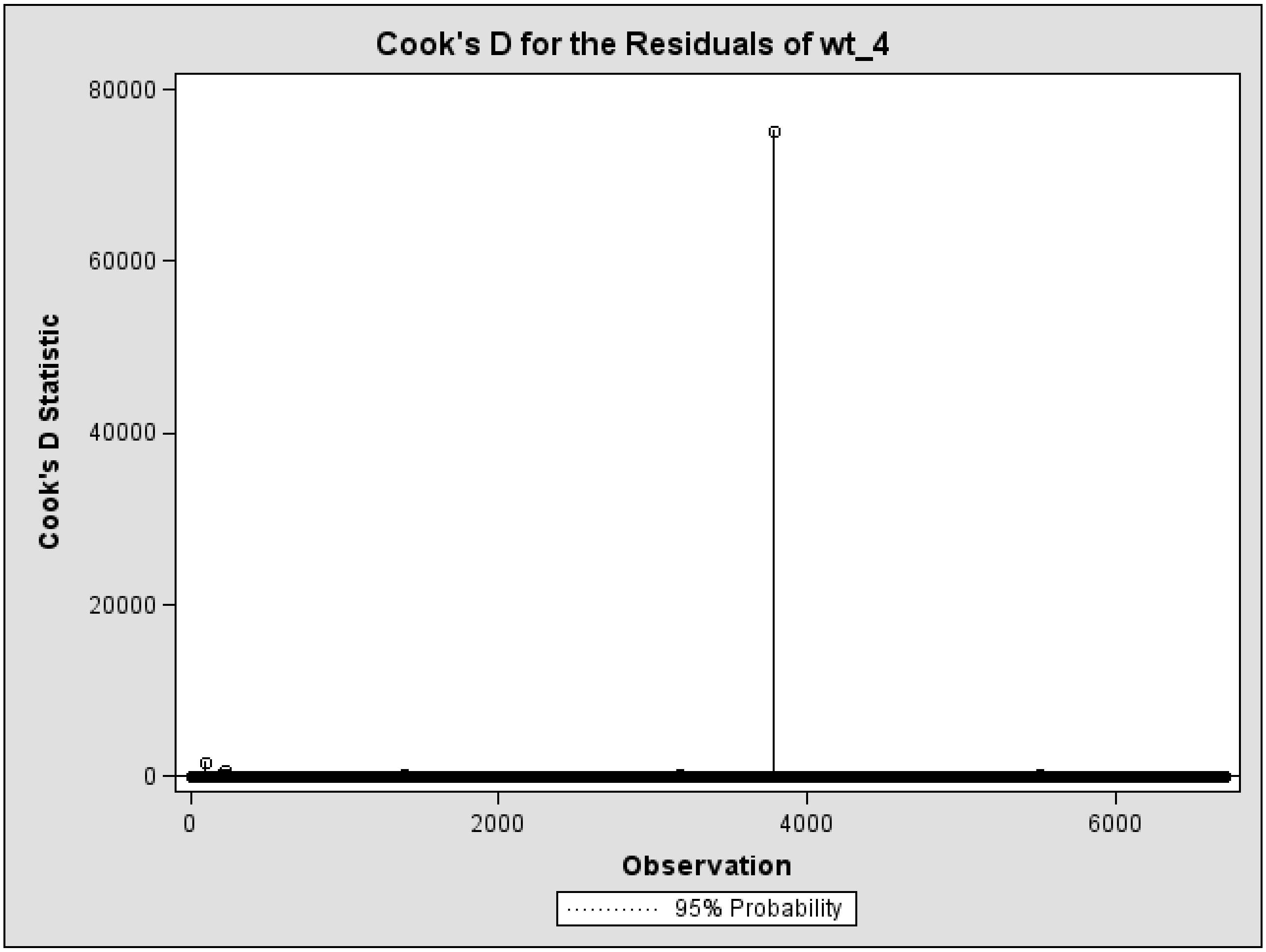

Cook's D for the Residuals of wt_3
Cook's D Statistic
300
200
100
0
0
2000
4000
6000
Observation
95% Probability

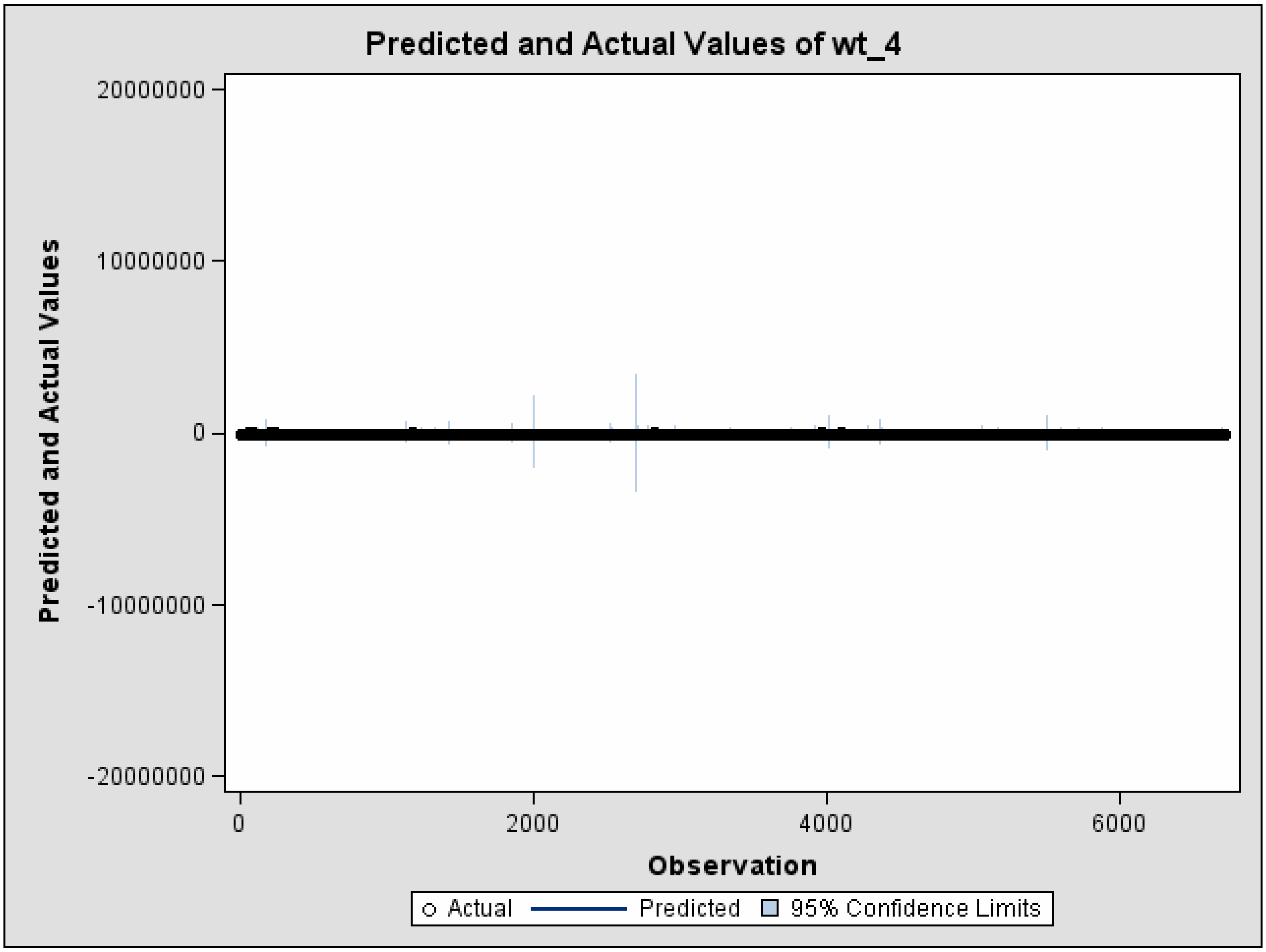

Predicted and Actual Values of wt_3
Predicted and Actual Values
50000000
0
-50000000
0
2000
4000
6000
Observation
○ Actual
Predicted
95% Confidence Limits

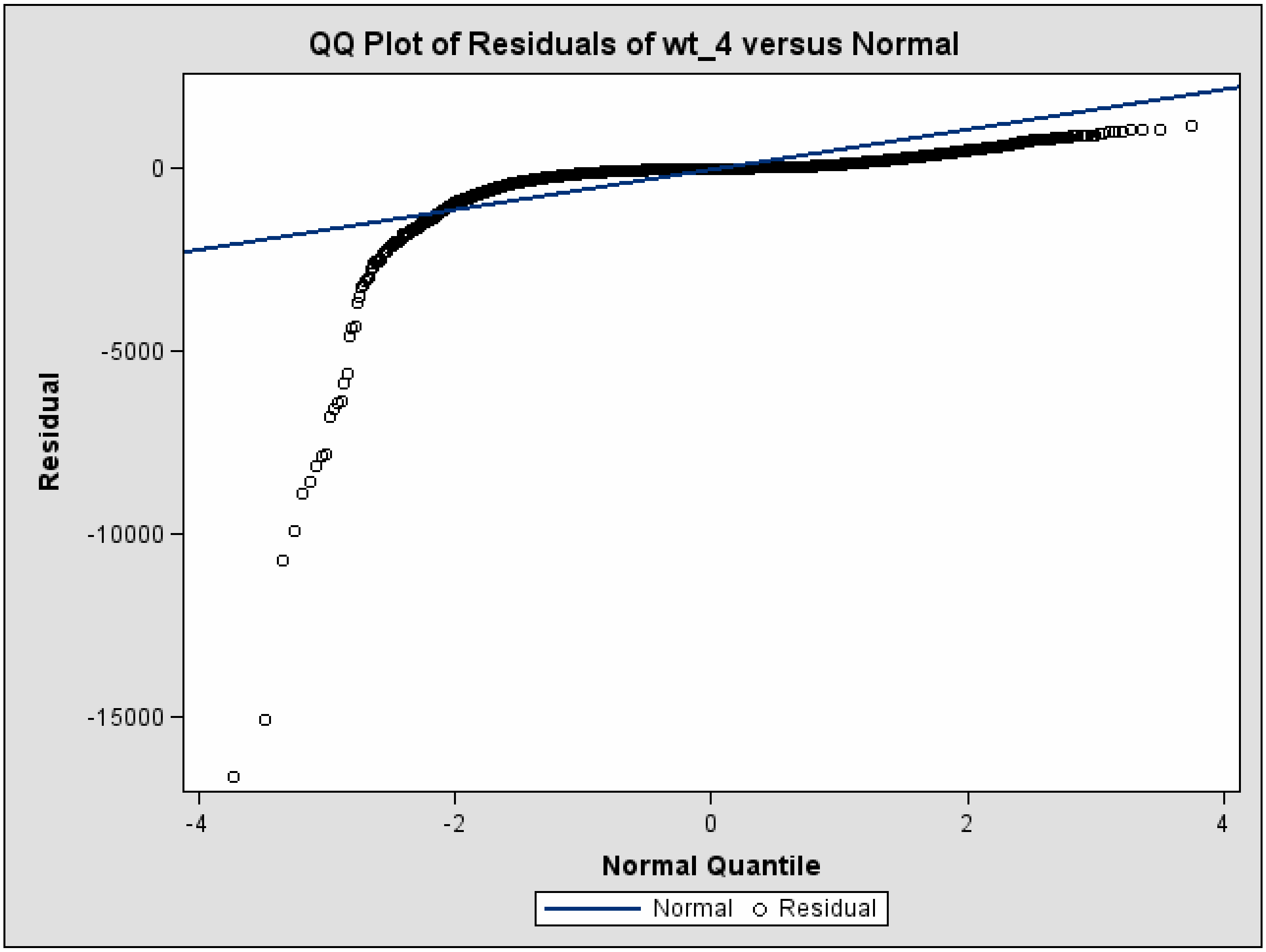

QQ Plot of Residuals of wt_3 versus Normal
Residual
0
-20000
-40000
-60000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

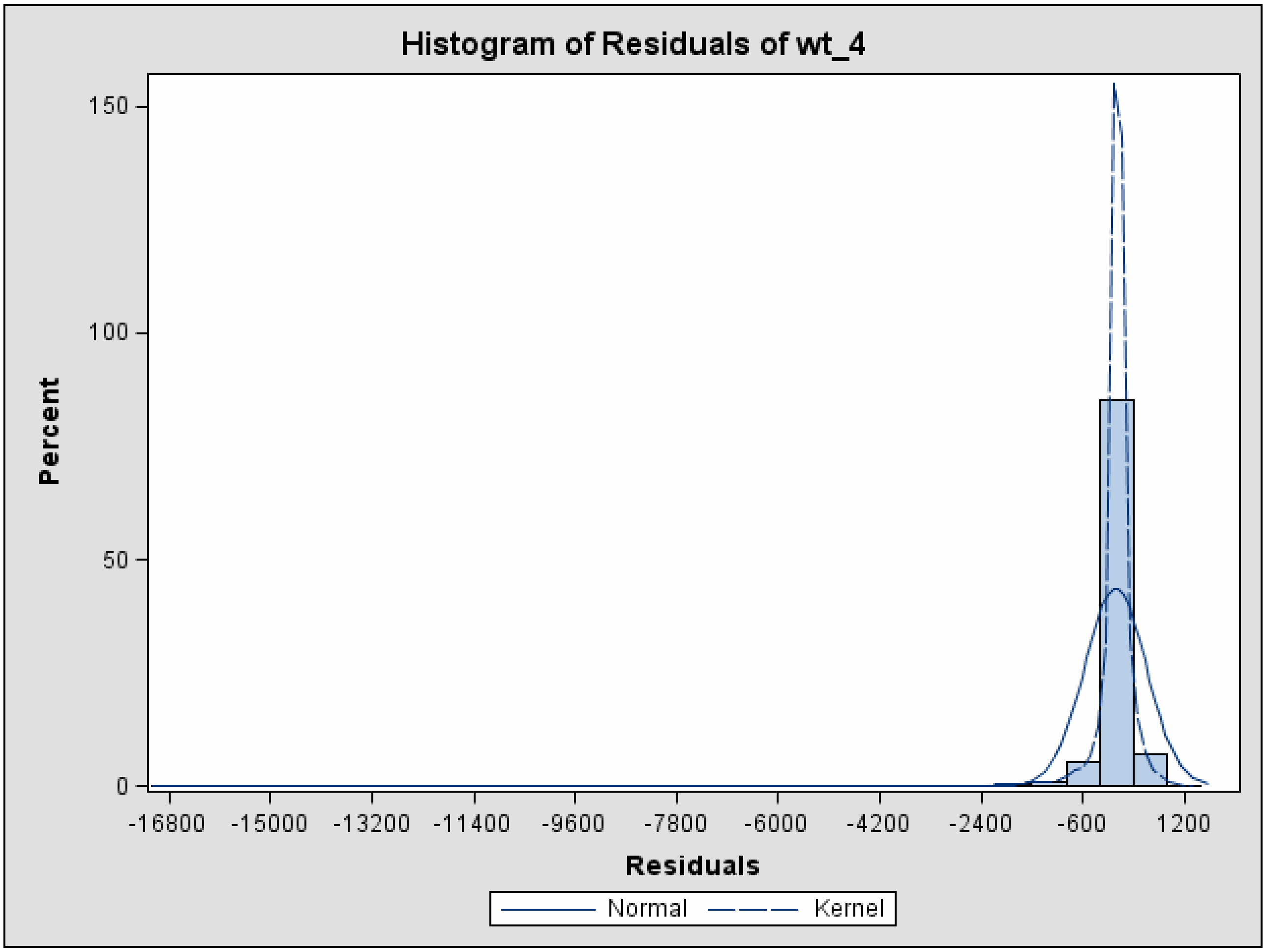

Histogram of Residuals of wt_3
Percent
250
200
150
100
50
0
-67500
-60000
-52500
-45000
-37500
-30000
-22500
-15000
-7500
0
Residuals
Normal
Kernel

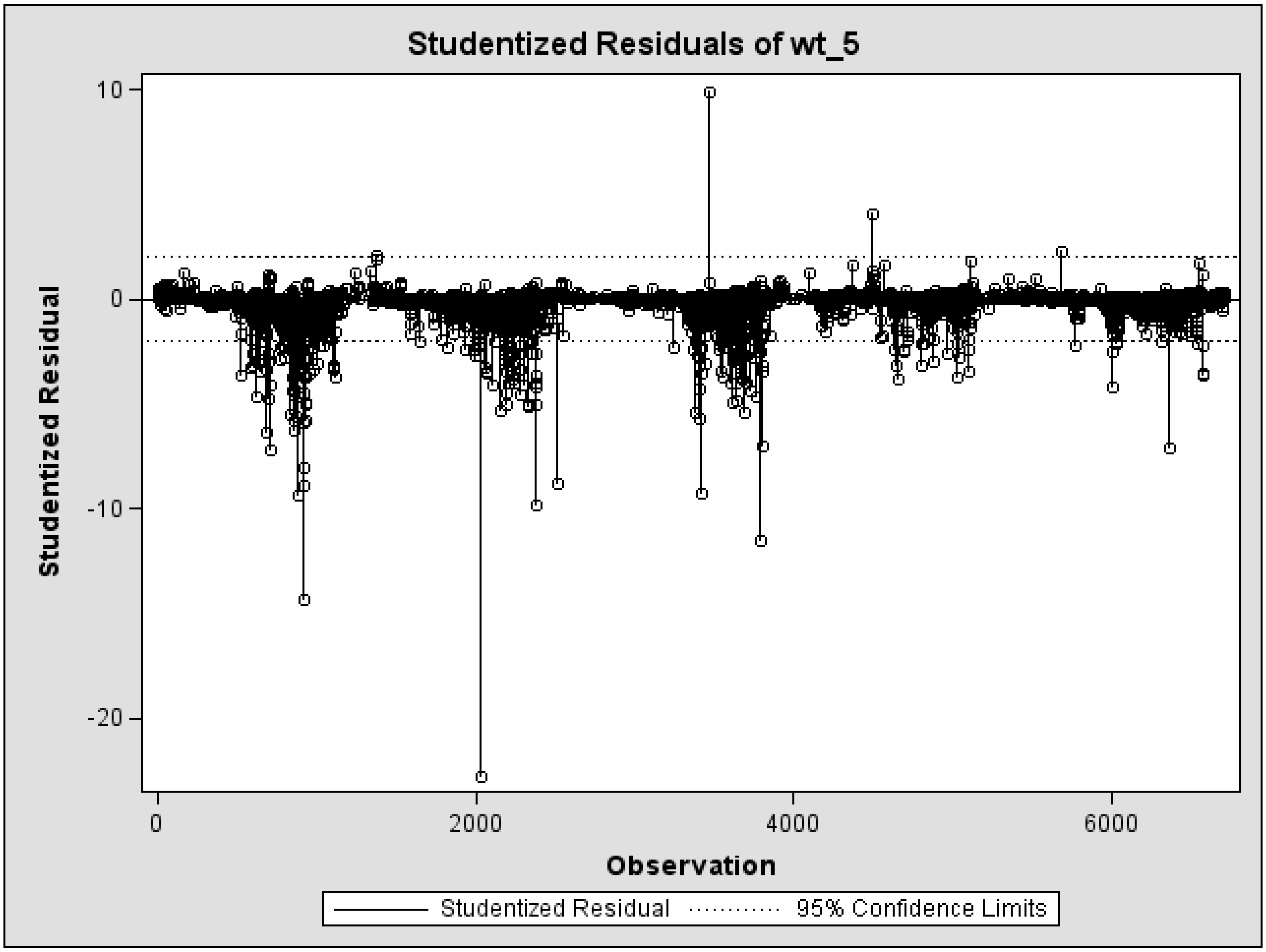

Studentized Residuals of wt_4
Studentized Residual
0
-20
-40
-60
0
2000
4000
6000
Observation
Studentized Residual
95% Confidence Limits

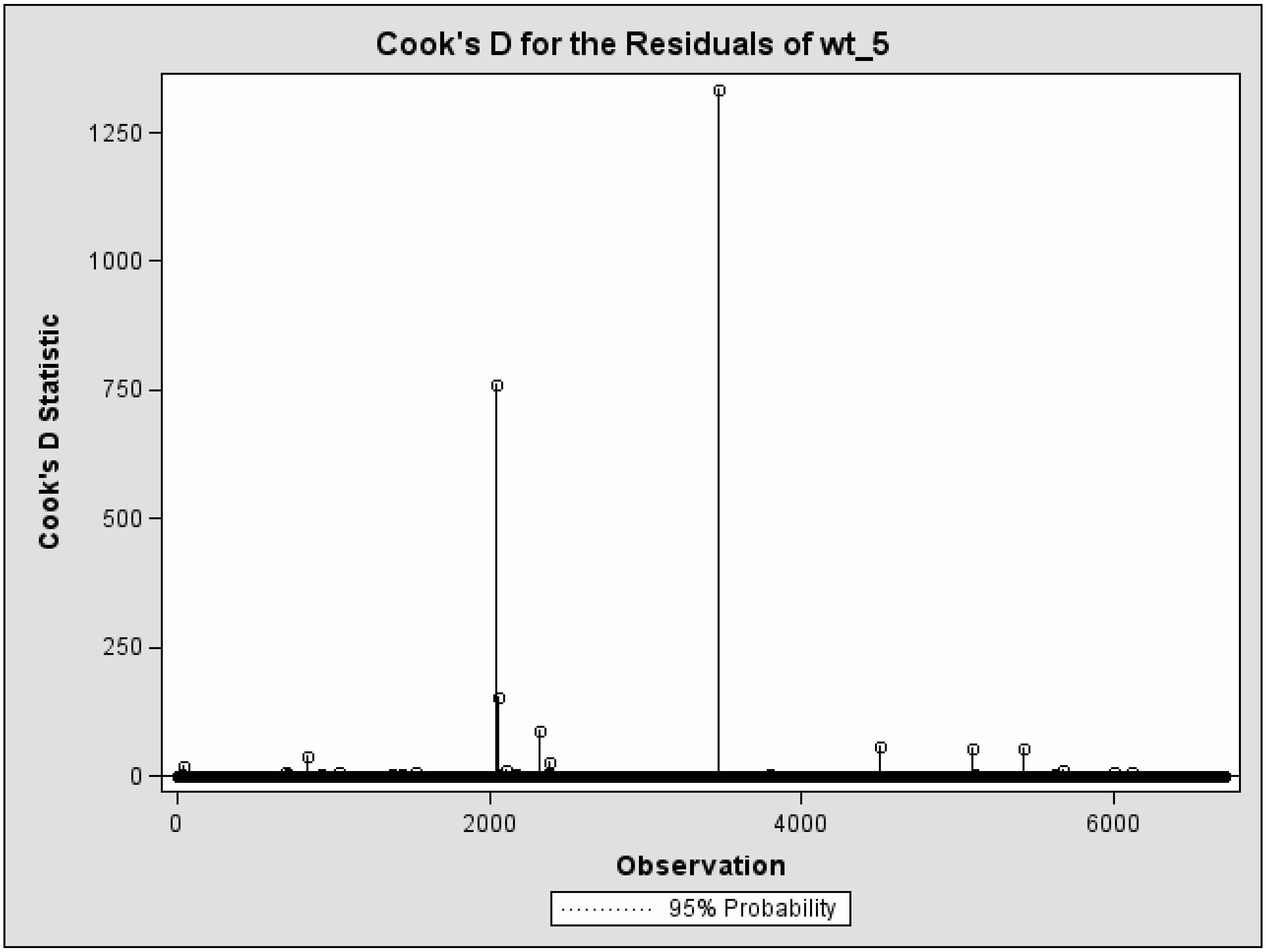

Cook's D for the Residuals of wt_4
Cook's D Statistic
80000
60000
40000
20000
0
Observation
0
2000
4000
6000
95% Probability

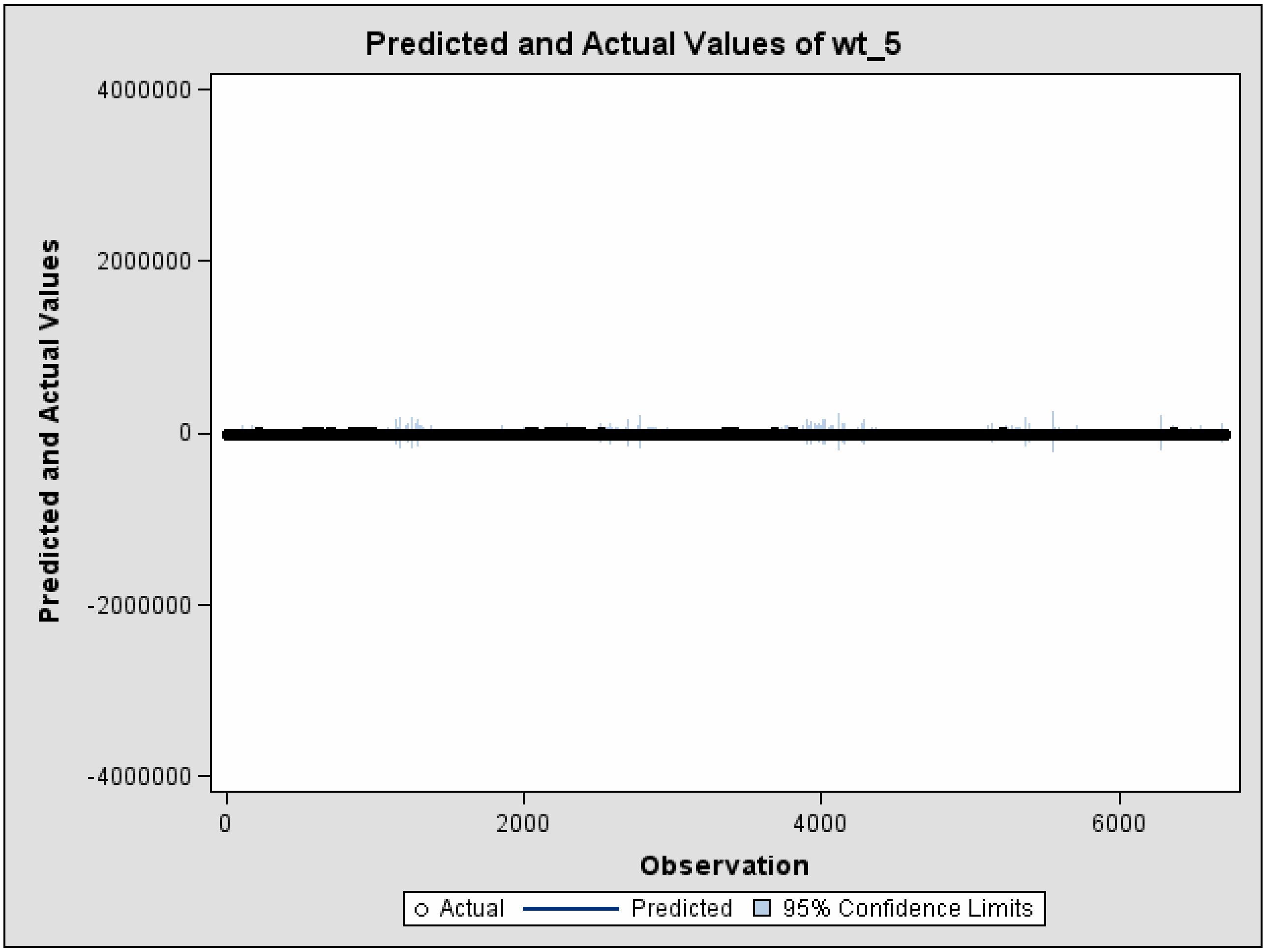

Predicted and Actual Values of wt_4
Predicted and Actual Values
20000000
10000000
0
-10000000
-20000000
0
2000
4000
6000
Observation
○ Actual
Predicted
95% Confidence Limits

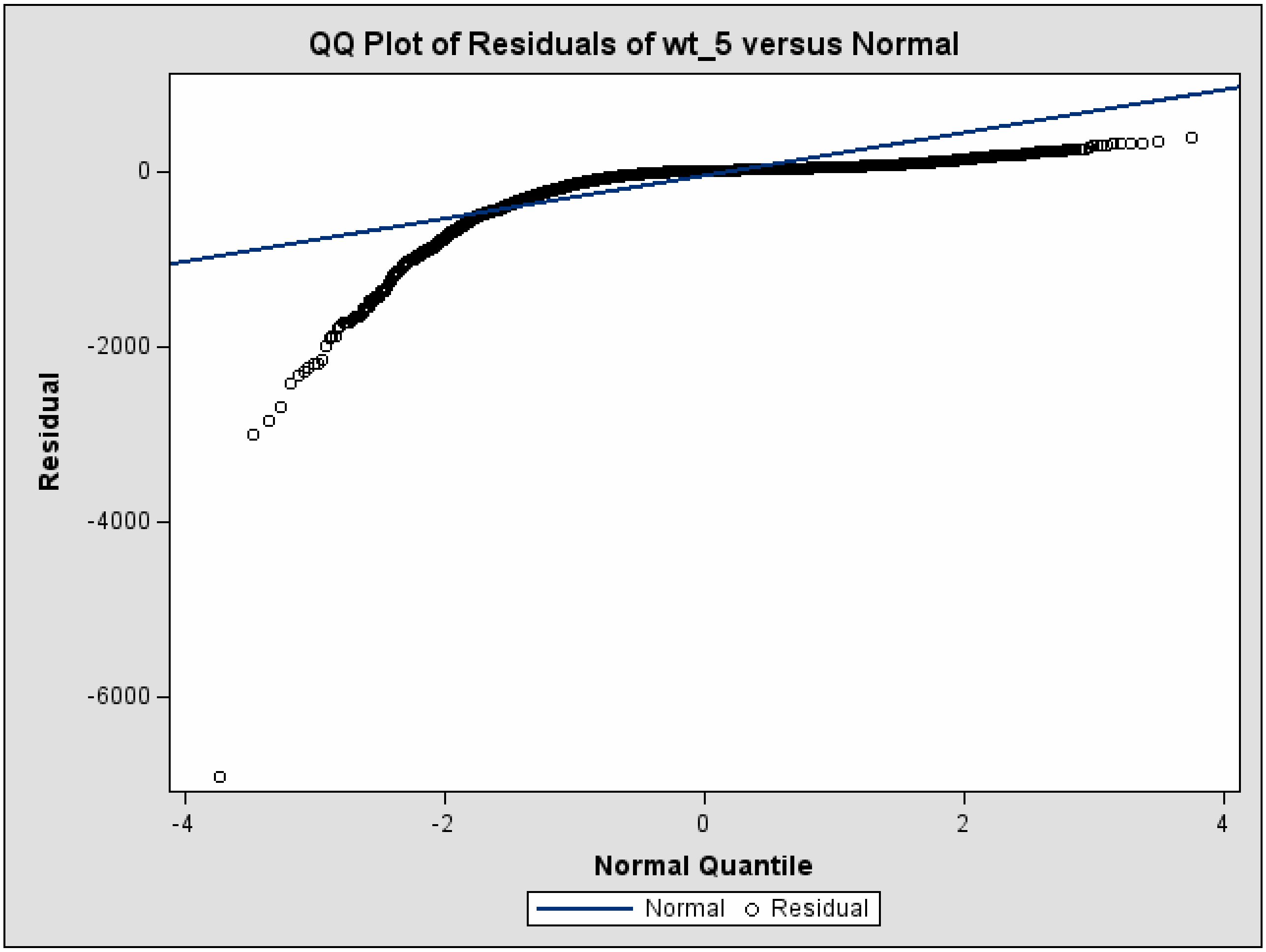

QQ Plot of Residuals of wt_4 versus Normal
Residual
0
-5000
-10000
-15000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

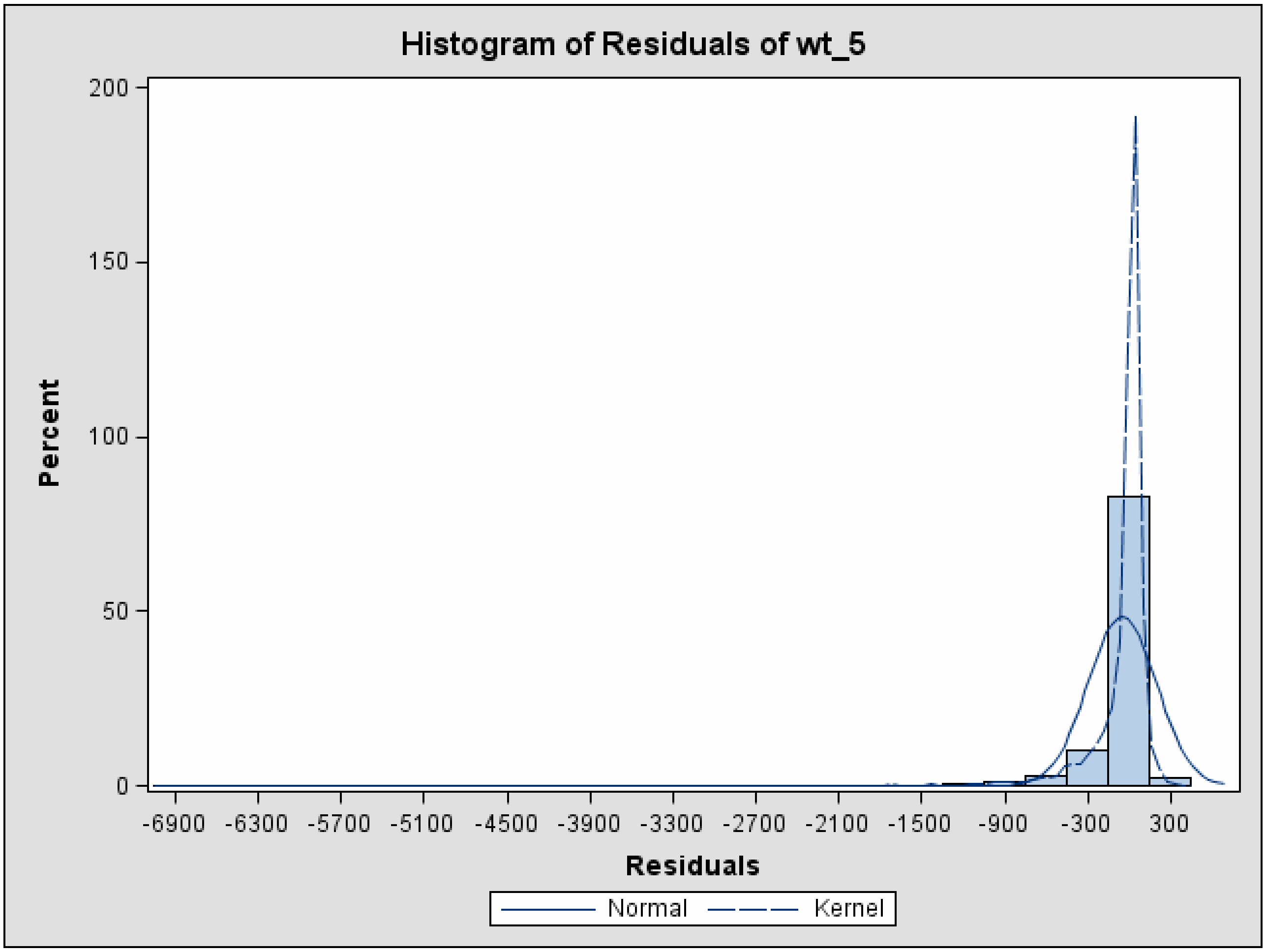

Histogram of Residuals of wt_4
Percent
150
100
50
0
-16800
-15000
-13200
-11400
-9600
-7800
-6000
-4200
-2400
-600
1200
Residuals
Normal
Kernel


Studentized Residuals of wt_5
10
0
-10
-20
Studentized Residual
0
2000
4000
6000
Observation
Studentized Residual
95% Confidence Limits


Cook's D for the Residuals of wt_5
Cook's D Statistic
1250
1000
750
500
250
0
0
2000
4000
6000
Observation
95% Probability


Predicted and Actual Values of wt_5
Predicted and Actual Values
4000000
2000000
0
-2000000
-4000000
0
2000
4000
6000
Observation
Actual
Predicted
95% Confidence Limits


QQ Plot of Residuals of wt_5 versus Normal
Residual
0
-2000
-4000
-6000
-4
-2
0
2
4
Normal Quantile
Normal
Residual


Histogram of Residuals of wt_5
Percent
200
150
100
50
0
-6900
-6300
-5700
-5100
-4500
-3900
-3300
-2700
-2100
-1500
-900
-300
300
Residuals
Normal
Kernel

Appendix 4: Winter Model Results

The MODEL Procedure

Nonlinear FIML Summary of Residual Errors								
Equation	**DF Model**	**DF Error**	**SSE**	**MSE**	**Root MSE**	**R-Square**	**Adj R-Sq**	**Label**
wt_1	24	4493	2.123E14	4.725E10	217369	0.3230	0.3196	scup
wt_2	24	4493	3.227E13	7.1829E9	84751.8	0.1557	0.1514	bottom
wt_3	24	4493	3.847E13	8.5629E9	92535.8	0.0358	0.0308	bait
wt_4	24	4493	8.89E12	1.9787E9	44482.6	0.0436	0.0387	shell
wt_5	24	4493	2.458E11	54704371	7396.2	0.1176	0.1131	other

Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
a1	3.602062	0.1023	35.21	<.0001	Trip Cost
a2	-0.00054	0.000020	-26.37	<.0001	Trip Cost^2
a3	0.055771	0.0226	2.47	0.0137	Pr2/pr1
a4	0.592271	0.0328	18.05	<.0001	Pr3/pr1
a5	0.03519	0.0191	1.84	0.0661	Pr4/pr1
a6	-0.00323	0.00162	-2.00	0.0460	Pr5/pr1
a7	-1.3321	0.1496	-8.90	<.0001	November
a8	-1.57648	0.1574	-10.02	<.0001	December
a9	0.489695	0.0538	9.10	<.0001	January
a10	0.663675	0.0617	10.76	<.0001	February
a11	0.57478	0.0554	10.37	<.0001	March
a12	1.006991	0.0630	15.99	<.0001	2005
a13	0.021447	0.0610	0.35	0.7250	2006
a14	-0.08551	0.0582	-1.47	0.1418	2007

Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|	Label
a15	-1.39845	0.0648	-21.57	<.0001	2008
a16	0.237941	3.055E13	0.00	1.0000	Port14
a17	-0.16302	119.7	-0.00	0.9989	Port18
a18	0.736591	0.4742	1.55	0.1204	Port20
a19	-0.38076	0.3857	-0.99	0.3236	Port31
a20	0.000216	0.1329	0.00	0.9987	Port34
a21	1.753801	0.0729	24.05	<.0001	Port36
a22	0.110039	0.1081	1.02	0.3088	Port41
a23	0.075224	0.1492	0.50	0.6141	Port42
a24	0.200608	0.1287	1.56	0.1192	Port44
a25	0.130101	0.0716	1.82	0.0693	Port46
a26	0.021075	0.0602	0.35	0.7263	Port47
b1	0.529648	0.0713	7.43	<.0001	Trip Cost
b2	-0.00007	0.000010	-6.48	<.0001	Trip Cost^2
b3	0.118087	0.0263	4.48	<.0001	Pr1/pr2
b4	0.592271	0.0328	18.05	<.0001	Pr3/pr2
b5	-0.03856	0.0139	-2.77	0.0057	Pr4/pr2
b6	0.001682	0.00149	1.13	0.2599	Pr5/pr2
b7	0.027002	0.0478	0.56	0.5725	November
b8	-0.16592	0.0589	-2.82	0.0048	December
b9	-0.08443	0.0335	-2.52	0.0117	January
b10	-0.01927	0.0401	-0.48	0.6305	February
b11	-0.00356	0.0351	-0.10	0.9190	March

Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
b12	0.089209	0.0516	1.73	0.0839	2005
b13	0.005143	0.0362	0.14	0.8871	2006
b14	-0.03837	0.0385	-1.00	0.3192	2007
b15	-0.0995	0.0334	-2.98	0.0029	2008
b16	2.722252	8.525E13	0.00	1.0000	Port14
b17	0.508733	37.0892	0.01	0.9891	Port18
b18	0.827324	0.0574	14.42	<.0001	Port20
b19	-0.5579	0.4313	-1.29	0.1959	Port31
b20	0.116776	0.0383	3.05	0.0023	Port34
b21	-0.27396	0.0356	-7.69	<.0001	Port36
b22	-0.26944	0.0675	-3.99	<.0001	Port41
b23	-0.59173	0.1056	-5.61	<.0001	Port42
b24	-0.33493	0.0895	-3.74	0.0002	Port44
b25	-0.19091	0.0350	-5.46	<.0001	Port46
b26	-0.2722	0.0314	-8.68	<.0001	Port47
c1	-0.18811	0.1808	-1.04	0.2981	Trip Cost
c2	-0.00004	0.000027	-1.51	0.1307	Trip Cost^2
c3	0.118087	0.0263	4.48	<.0001	Pr2/pr3
c4	0.055771	0.0226	2.47	0.0137	Pr1/pr3
c5	-0.01309	0.0247	-0.53	0.5957	Pr4/pr3
c6	0.001683	0.00277	0.61	0.5429	Pr5/pr3
c7	-0.11038	0.1217	-0.91	0.3646	November
c8	-0.15769	0.1227	-1.29	0.1988	December

Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|	Label
c9	0.00037	0.0907	0.00	0.9967	January
c10	0.121996	0.0689	1.77	0.0765	February
c11	0.051357	0.0677	0.76	0.4482	March
c12	0.051083	0.1191	0.43	0.6681	2005
c13	0.22354	0.0732	3.05	0.0023	2006
c14	0.188476	0.0876	2.15	0.0315	2007
c15	0.091429	0.0772	1.18	0.2362	2008
c16	0.034773	2.039E14	0.00	1.0000	Port14
c17	-0.1573	476.1	-0.00	0.9997	Port18
c18	-0.02735	0.5258	-0.05	0.9585	Port20
c19	0.065188	1.2312	0.05	0.9578	Port31
c20	0.134653	0.1277	1.05	0.2916	Port34
c21	0.266347	0.1028	2.59	0.0096	Port36
c22	0.430207	0.1070	4.02	<.0001	Port41
c23	0.07085	0.3538	0.20	0.8413	Port42
c24	-0.10728	0.2448	-0.44	0.6613	Port44
c25	0.005167	0.1265	0.04	0.9674	Port46
c26	0.031906	0.1024	0.31	0.7554	Port47
d1	0.247195	0.0457	5.41	<.0001	Trip Cost
d2	-0.00001	6.257E-6	-1.70	0.0899	Trip Cost^2
d3	-0.01309	0.0247	-0.53	0.5957	Pr2/pr4
d4	-0.03856	0.0139	-2.77	0.0057	Pr3/pr4
d5	0.03519	0.0191	1.84	0.0661	Pr1/pr4

Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|	Label
d6	-0.01562	0.00236	-6.63	<.0001	Pr5/pr4
d7	-0.03732	0.0376	-0.99	0.3210	November
d8	-0.00695	0.0374	-0.19	0.8525	December
d9	0.048968	0.0221	2.22	0.0267	January
d10	0.047586	0.0253	1.88	0.0598	February
d11	0.085114	0.0236	3.61	0.0003	March
d12	0.032466	0.0187	1.74	0.0827	2005
d13	-0.04776	0.0175	-2.72	0.0065	2006
d14	-0.0616	0.0226	-2.72	0.0065	2007
d15	-0.09024	0.0206	-4.38	<.0001	2008
d16	-0.20129	4.343E13	-0.00	1.0000	Port14
d17	-0.08476	133.3	-0.00	0.9995	Port18
d18	-0.09554	0.1321	-0.72	0.4696	Port20
d19	-0.11953	0.5053	-0.24	0.8130	Port31
d20	0.164619	0.0264	6.24	<.0001	Port34
d21	-0.07706	0.0303	-2.54	0.0110	Port36
d22	-0.04235	0.0345	-1.23	0.2198	Port41
d23	-0.07691	0.1412	-0.54	0.5861	Port42
d24	-0.10578	0.0720	-1.47	0.1419	Port44
d25	-0.06103	0.0241	-2.53	0.0113	Port46
d26	-0.01939	0.0189	-1.03	0.3052	Port47
e1	0.056385	0.00707	7.98	<.0001	Trip Cost
e2	-8.09E-6	1.052E-6	-7.69	<.0001	Trip Cost^2

Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
e3	0.001683	0.00277	0.61	0.5429	Pr2/pr5
e4	0.001682	0.00149	1.13	0.2599	Pr3/pr5
e5	-0.01562	0.00236	-6.63	<.0001	Pr4/pr5
e6	-0.00323	0.00162	-2.00	0.0460	Pr1/pr5
e7	0.079782	0.00492	16.21	<.0001	November
e8	0.008288	0.00781	1.06	0.2890	December
e9	0.018587	0.00500	3.72	0.0002	January
e10	0.005014	0.00578	0.87	0.3855	February
e11	0.007112	0.00507	1.40	0.1610	March
e12	0.030877	0.00344	8.98	<.0001	2005
e13	0.015558	0.00294	5.29	<.0001	2006
e14	0.006555	0.00420	1.56	0.1184	2007
e15	0.006847	0.00383	1.79	0.0739	2008
e16	0.002352	9.617E12	0.00	1.0000	Port14
e17	0.016155	1.5111	0.01	0.9915	Port18
e18	-0.00551	0.0203	-0.27	0.7859	Port20
e19	-0.00424	0.0559	-0.08	0.9396	Port31
e20	-0.01269	0.00940	-1.35	0.1773	Port34
e21	0.00063	0.00435	0.14	0.8849	Port36
e22	0.004912	0.00514	0.96	0.3392	Port41
e23	-0.00414	0.0142	-0.29	0.7709	Port42
e24	-0.01775	0.0105	-1.69	0.0920	Port44
e25	-0.00376	0.00459	-0.82	0.4129	Port46

Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|	Label
e26	-0.00672	0.00315	-2.13	0.0330	Port47
Restrict0	-27.4475	22.7322	-1.21	0.2273	a3 = c4
Restrict1	15.75608	13.5917	1.16	0.2464	a4 = b4
Restrict2	-79.6807	20.2917	-3.93	<.0001	a5 = d5
Restrict3	-34.3434	12.9688	-2.65	0.0081	a6 = e6
Restrict4	-54.6679	16.6769	-3.28	0.0010	b3 = c3
Restrict5	-134.704	24.4791	-5.50	<.0001	b5 = d4
Restrict6	73.09492	20.9393	3.49	0.0005	b6 = e4
Restrict7	-46.6814	20.6116	-2.26	0.0235	c5 = d3
Restrict8	-34.3936	12.9718	-2.65	0.0080	c6 = e3
Restrict9	111.9711	23.7578	4.71	<.0001	d6 = e5

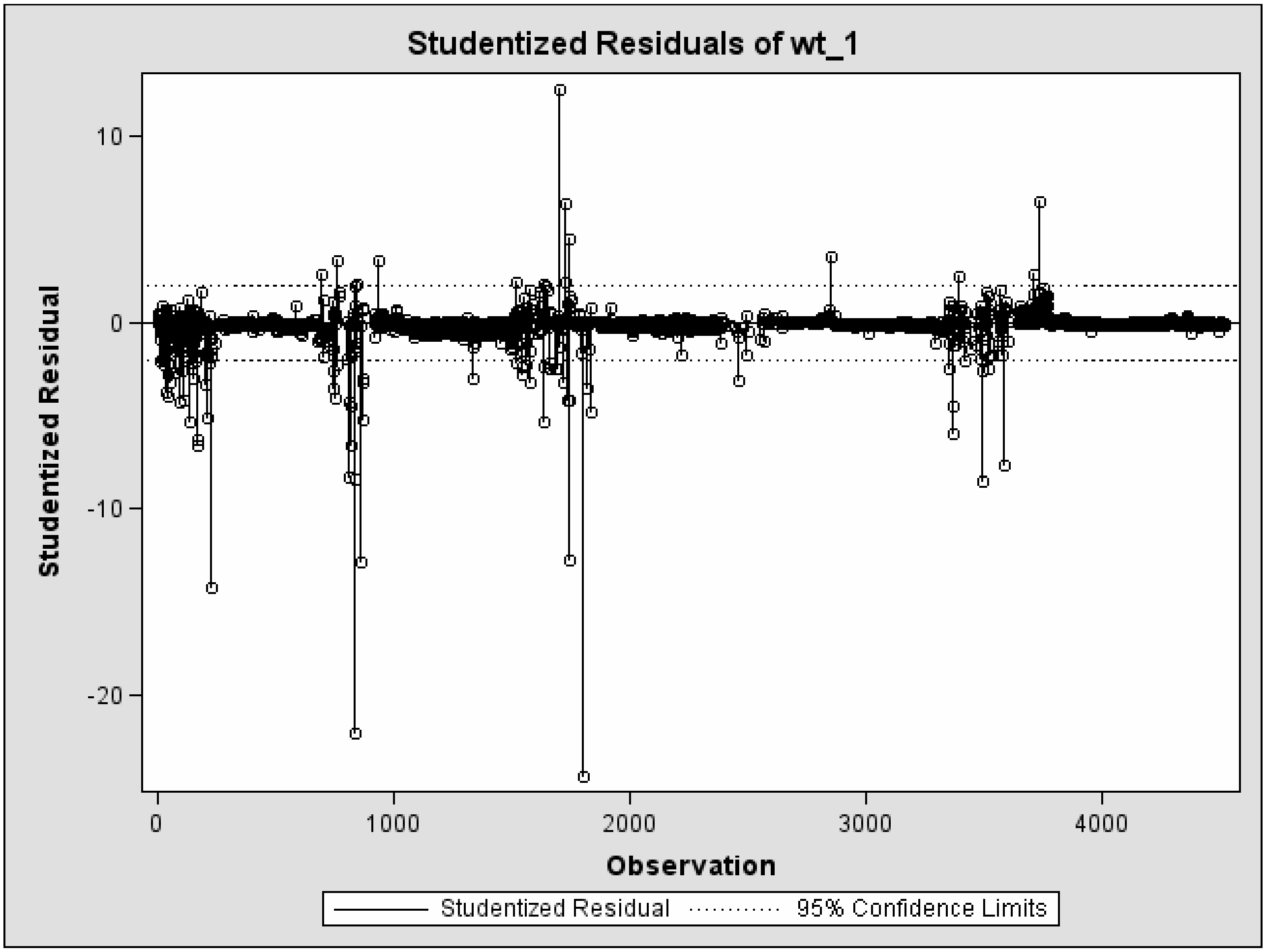
Test Results

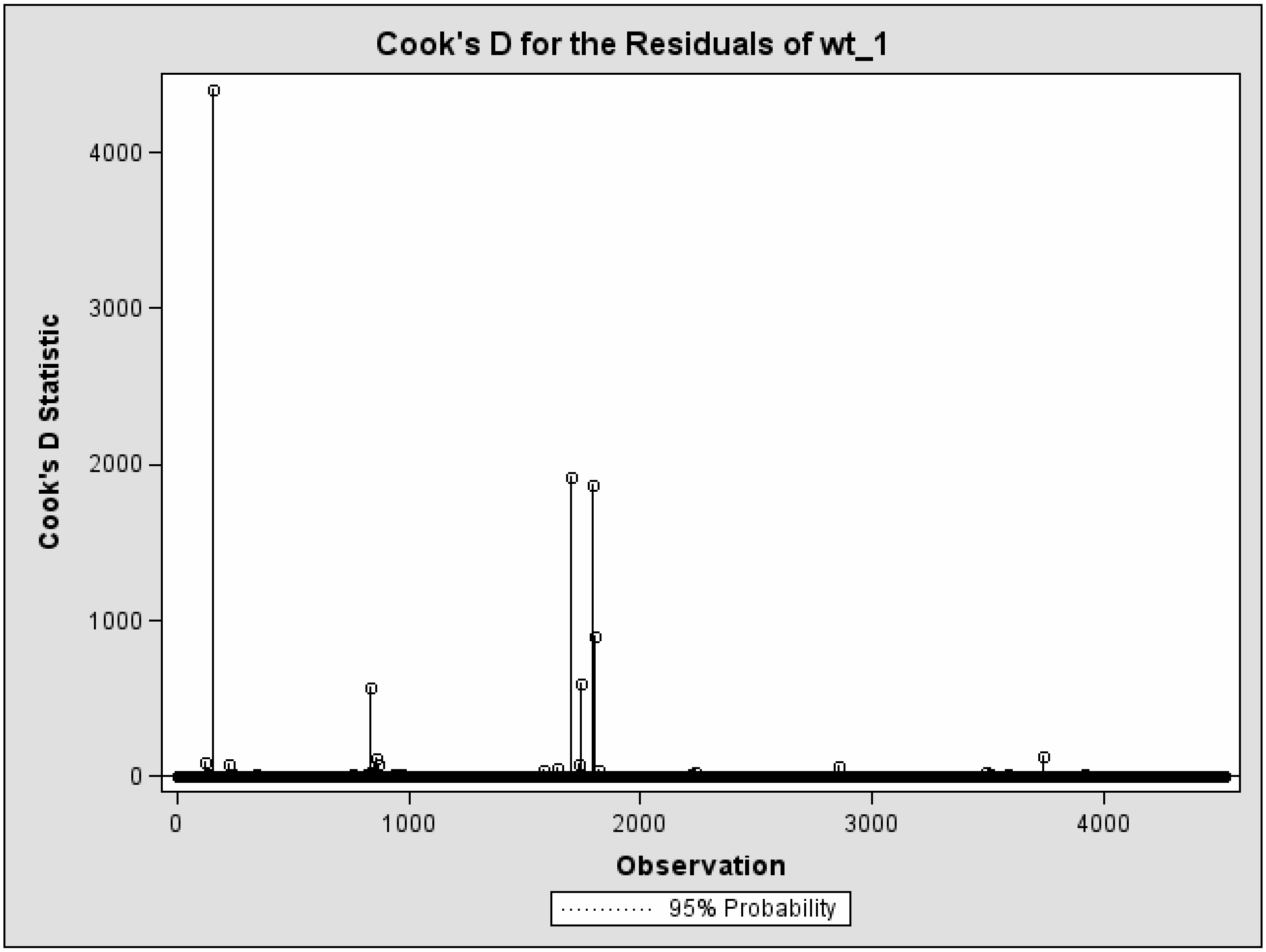
Test	Type	Statistic	Pr > ChiSq	Label
nj	Wald	764.07	<.0001	a3, a4, a5, a6, b3, b4, b5, b6, c3, c4,
fluke nj	Wald	374.42	<.0001	a3 , a4 , a5 , a6
bait nj	Wald	2602.0	<.0001	b3 , b4 , b5 , b6
shell nj	Wald	37.58	<.0001	c3 , c4 , c5 , c6
bottom nj	Wald	55.97	<.0001	d3 , d4 , d5 , d6
other nj	Wald	73.67	<.0001	e3 , e4 , e5 , e6
separability	Wald	1452.8	<.0001	a1 , b1 , c1 , d1 , e1

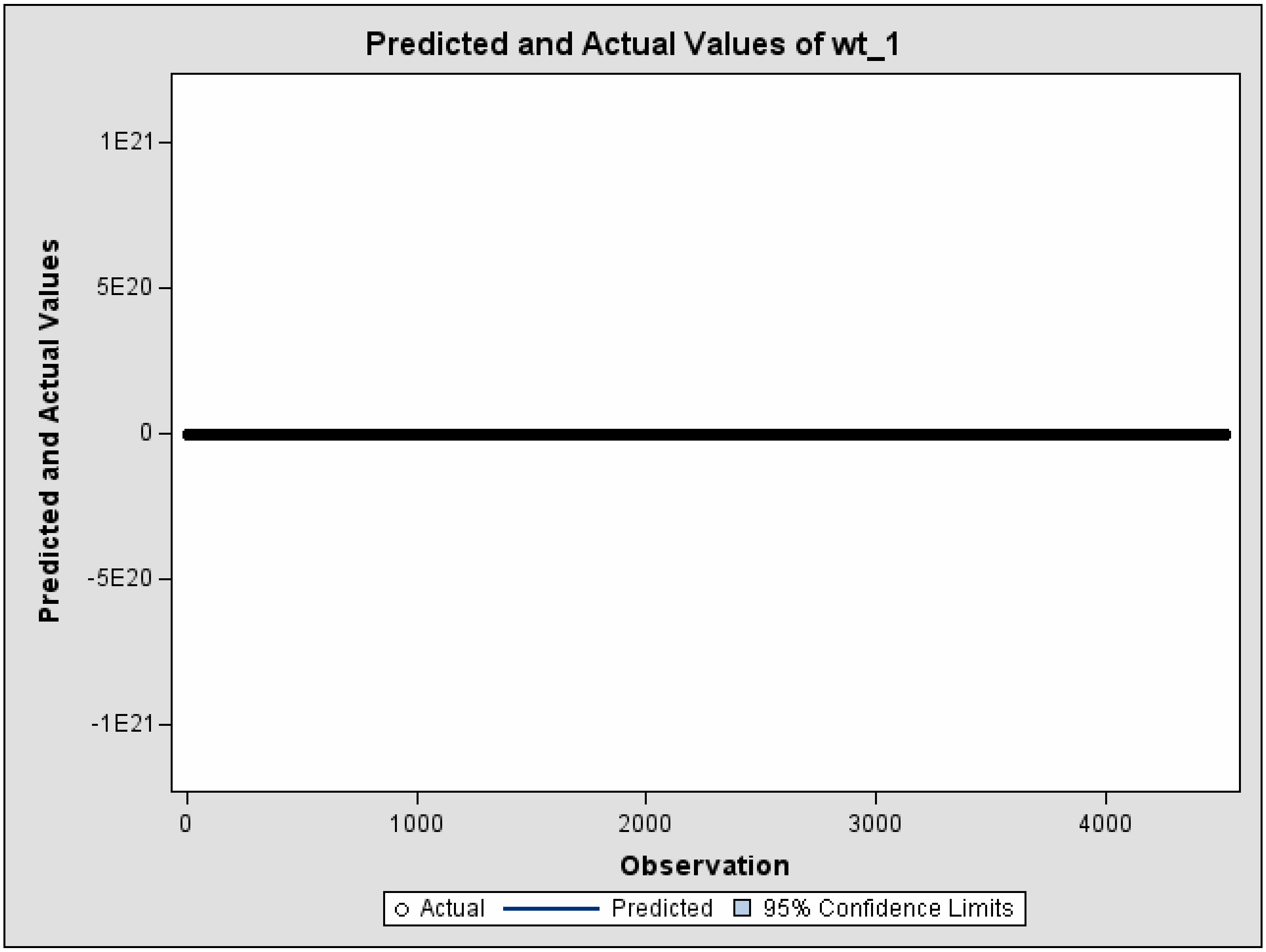
Number of Observations		Statistics for System	
Used	4517	**Log Likelihood**	-203185

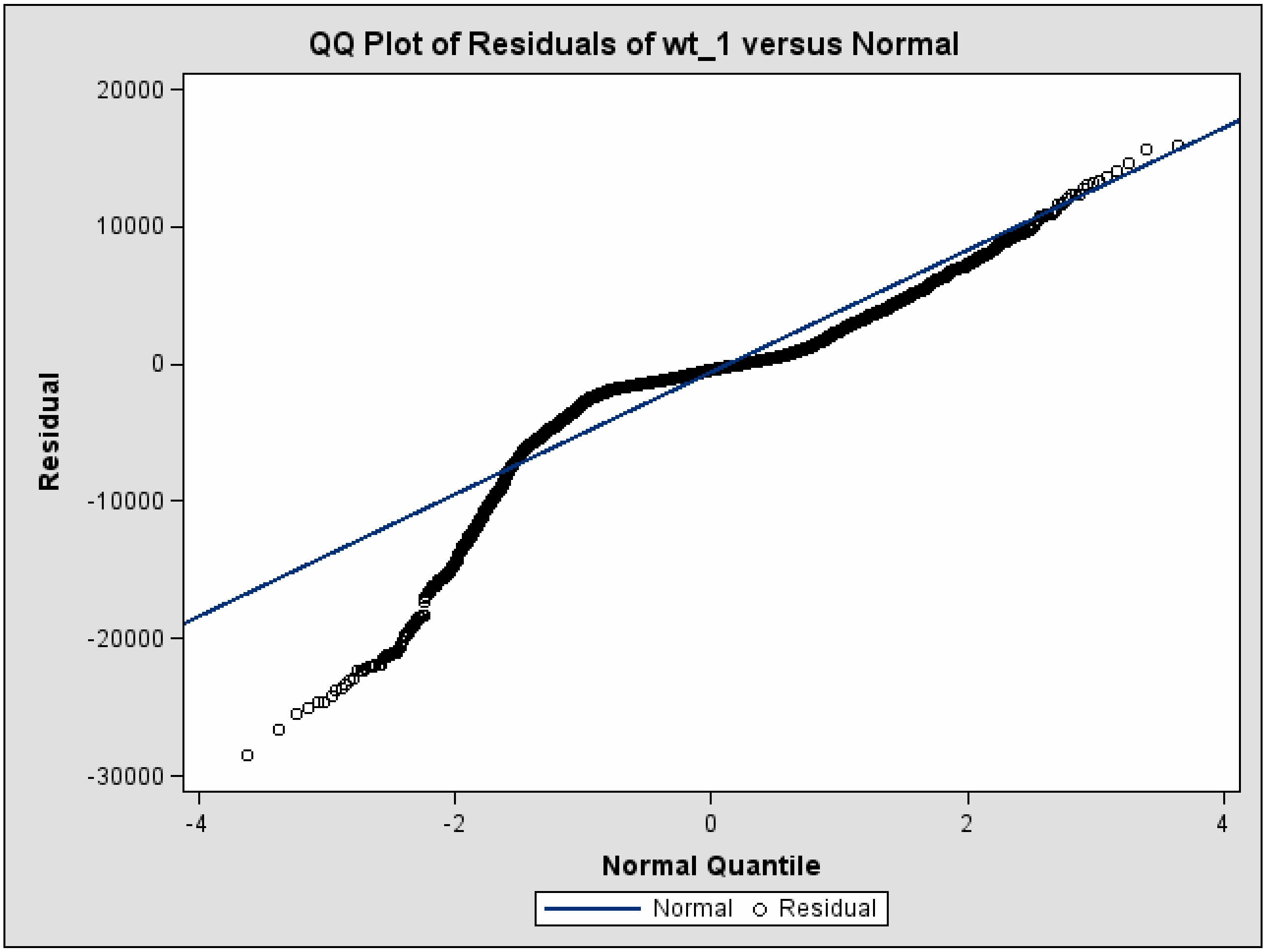
Number of Observations		Statistics for System	
Missing	0		
Sum of Weights	5813200		

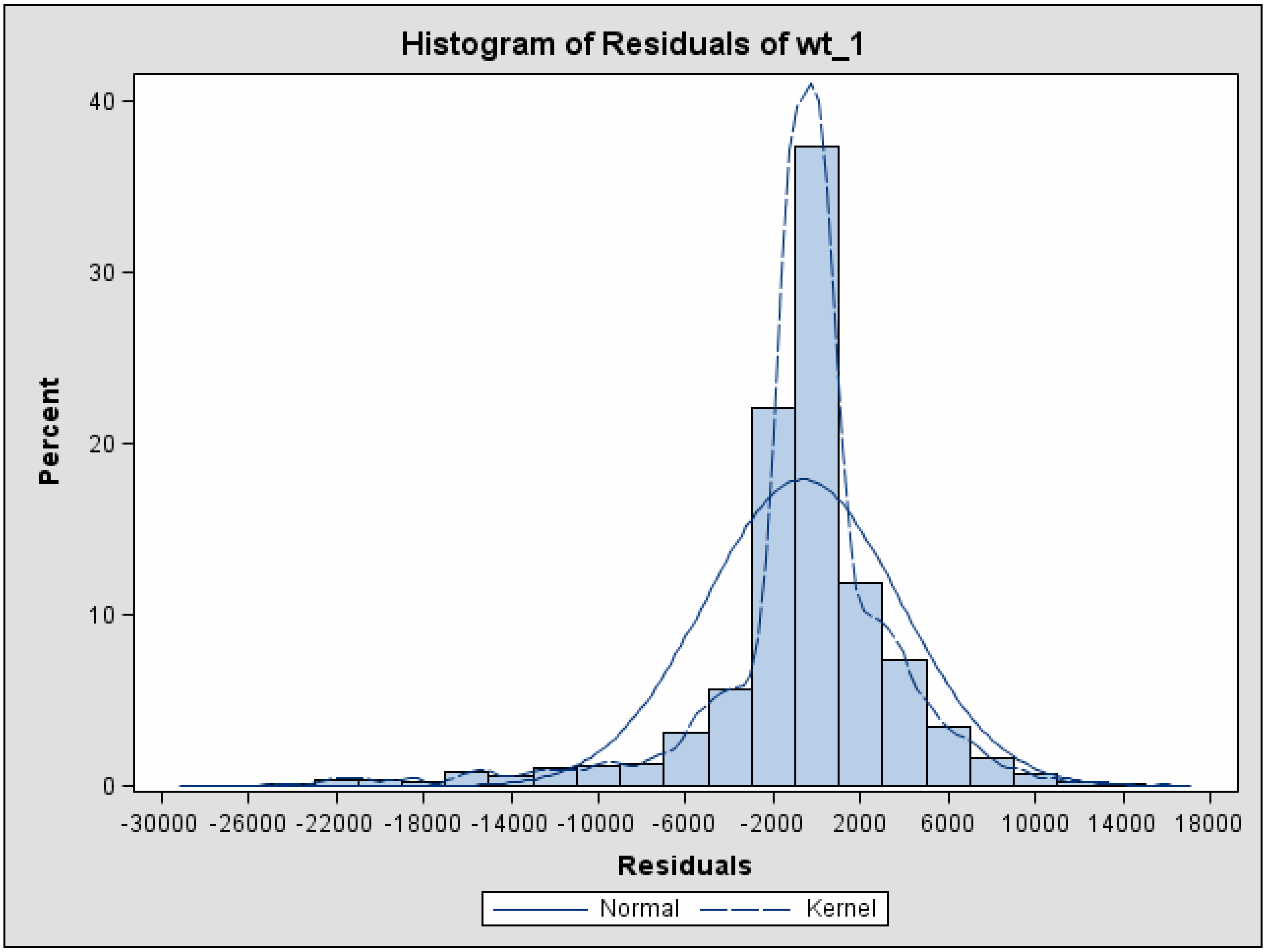
Heteroscedasticity Test					
Equation	Test	Statistic	DF	Pr > ChiSq	Variables
wt_1	White's Test	2453	248	<.0001	Cross of all vars
wt_2	White's Test	2233	248	<.0001	Cross of all vars
wt_3	White's Test	1822	248	<.0001	Cross of all vars
wt_4	White's Test	2654	248	<.0001	Cross of all vars
wt_5	White's Test	1099	248	<.0001	Cross of all vars

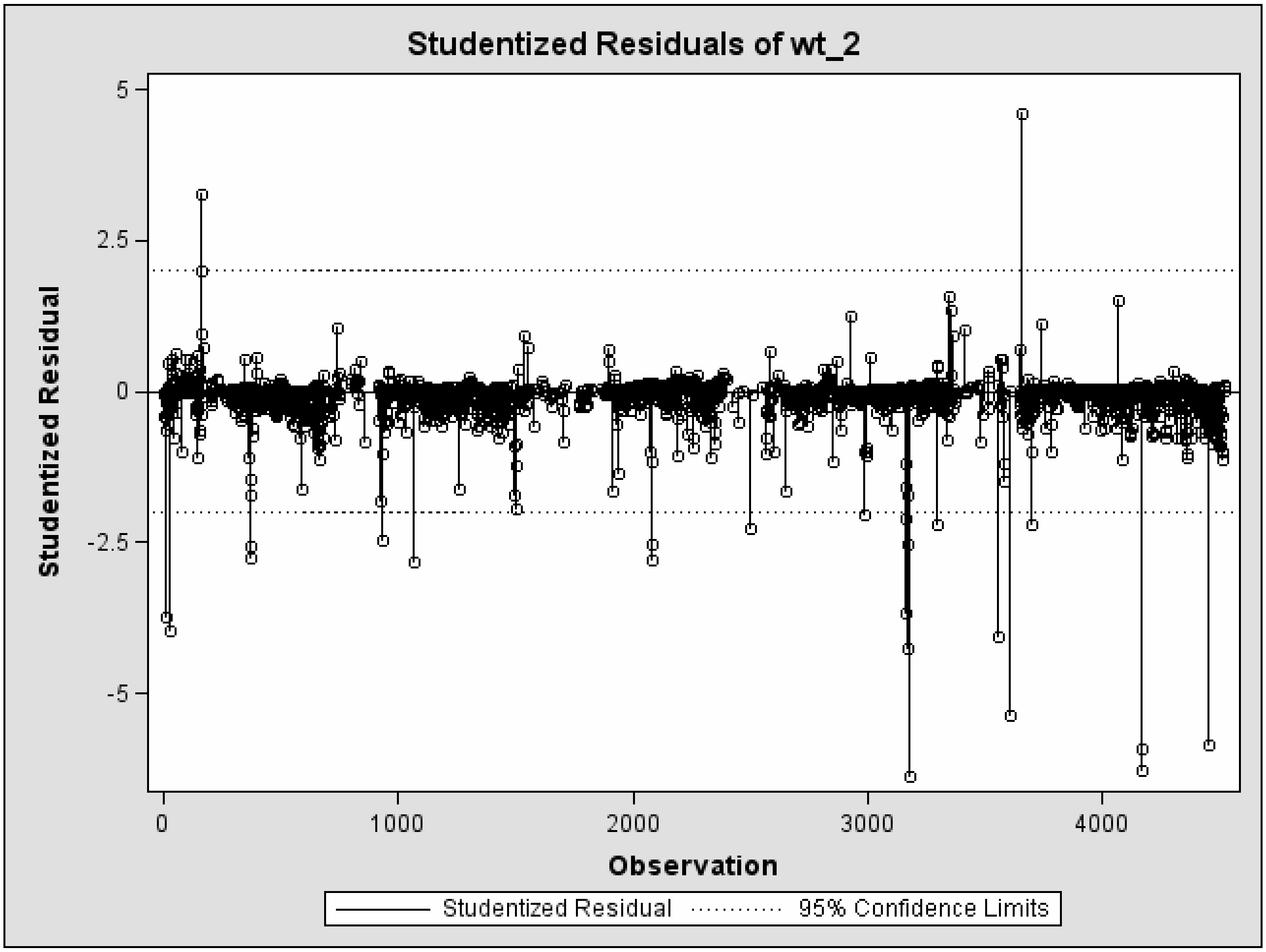


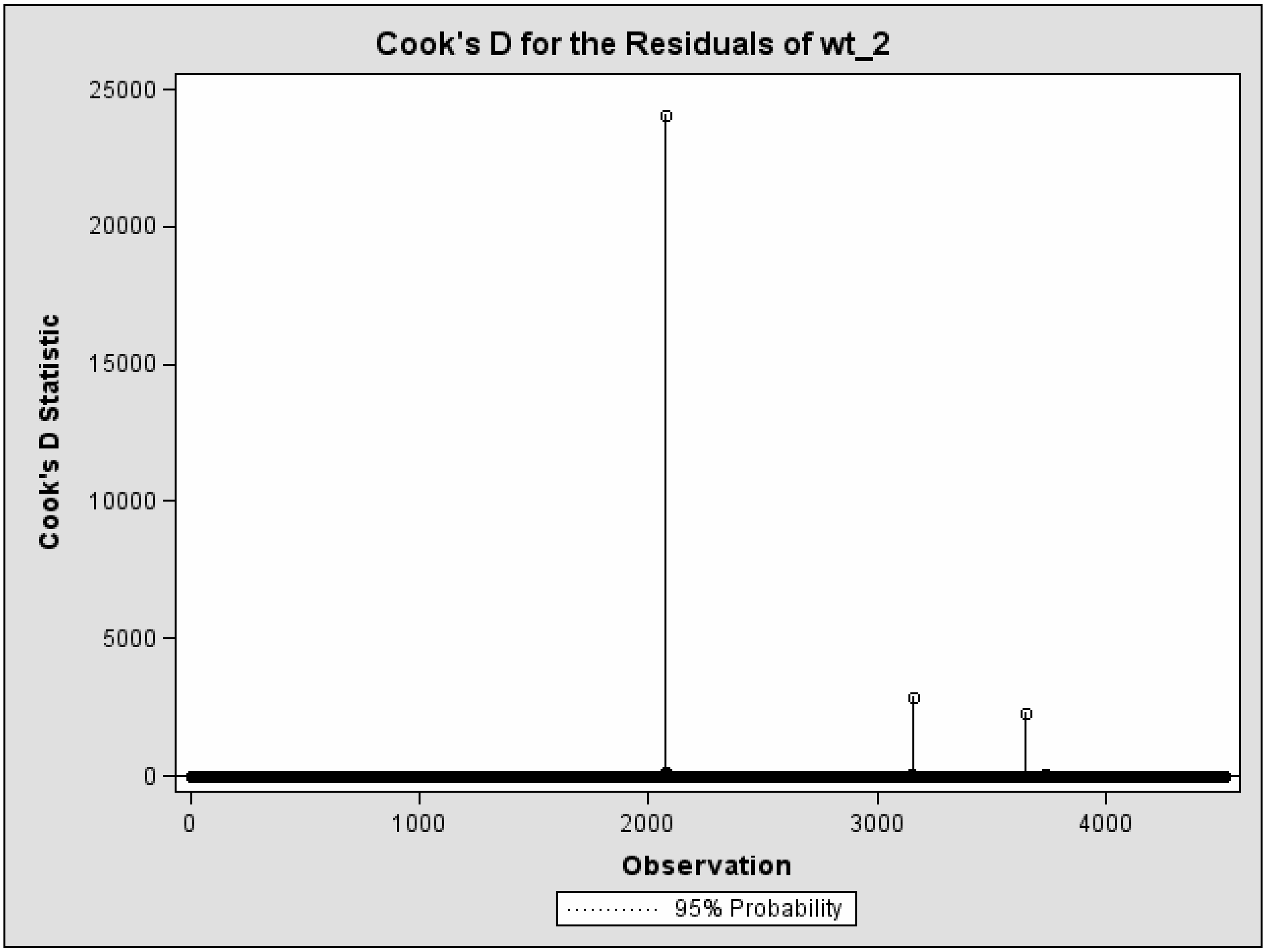

Cook's D for the Residuals of wt_1
Cook's D Statistic
4000
3000
2000
1000
0
0
1000
2000
3000
4000
Observation
95% Probability

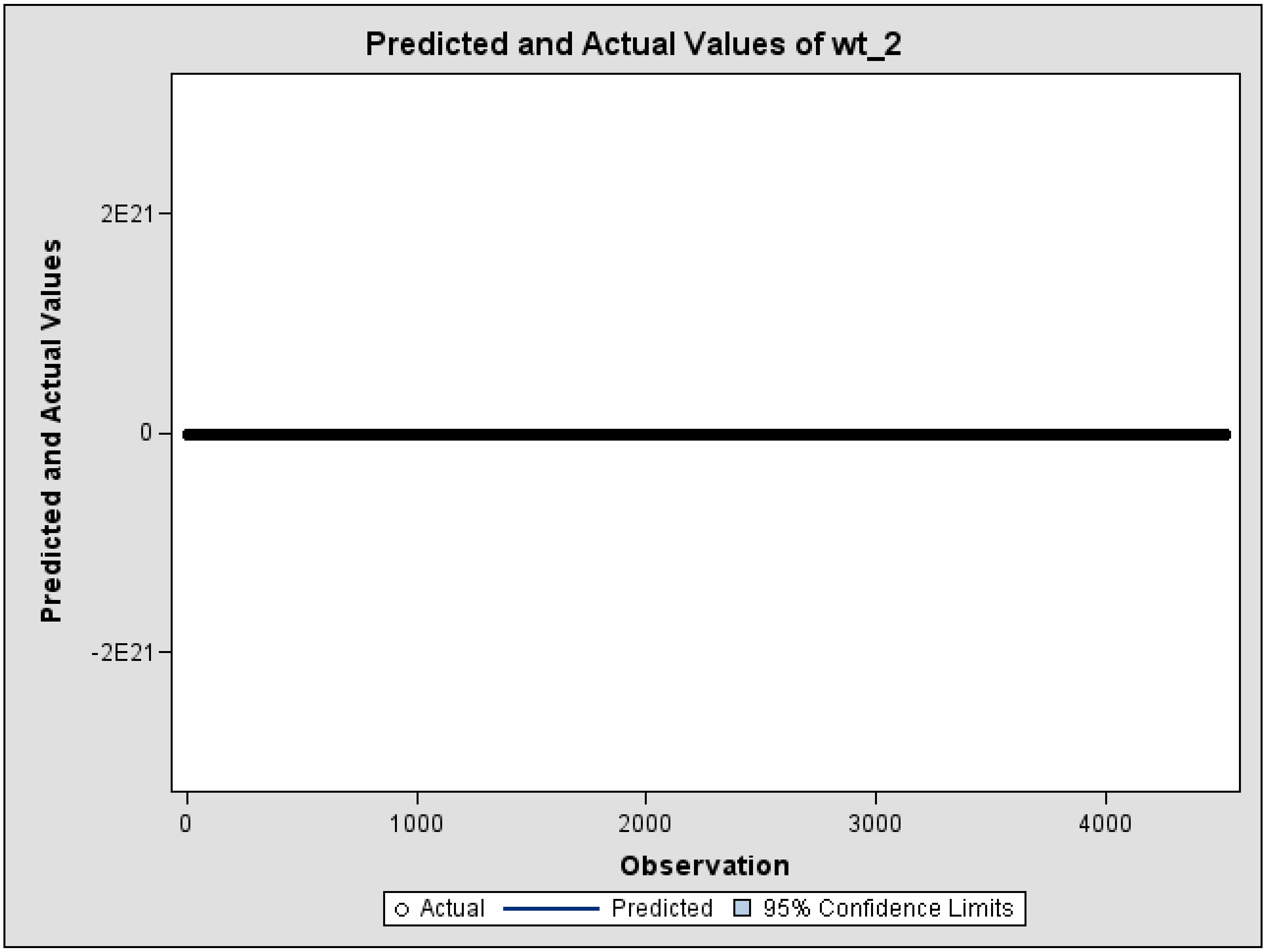

Predicted and Actual Values of wt_1
Predicted and Actual Values
1E21
5E20
0
-5E20
-1E21
0
1000
2000
3000
4000
Observation
○ Actual
Predicted
95% Confidence Limits

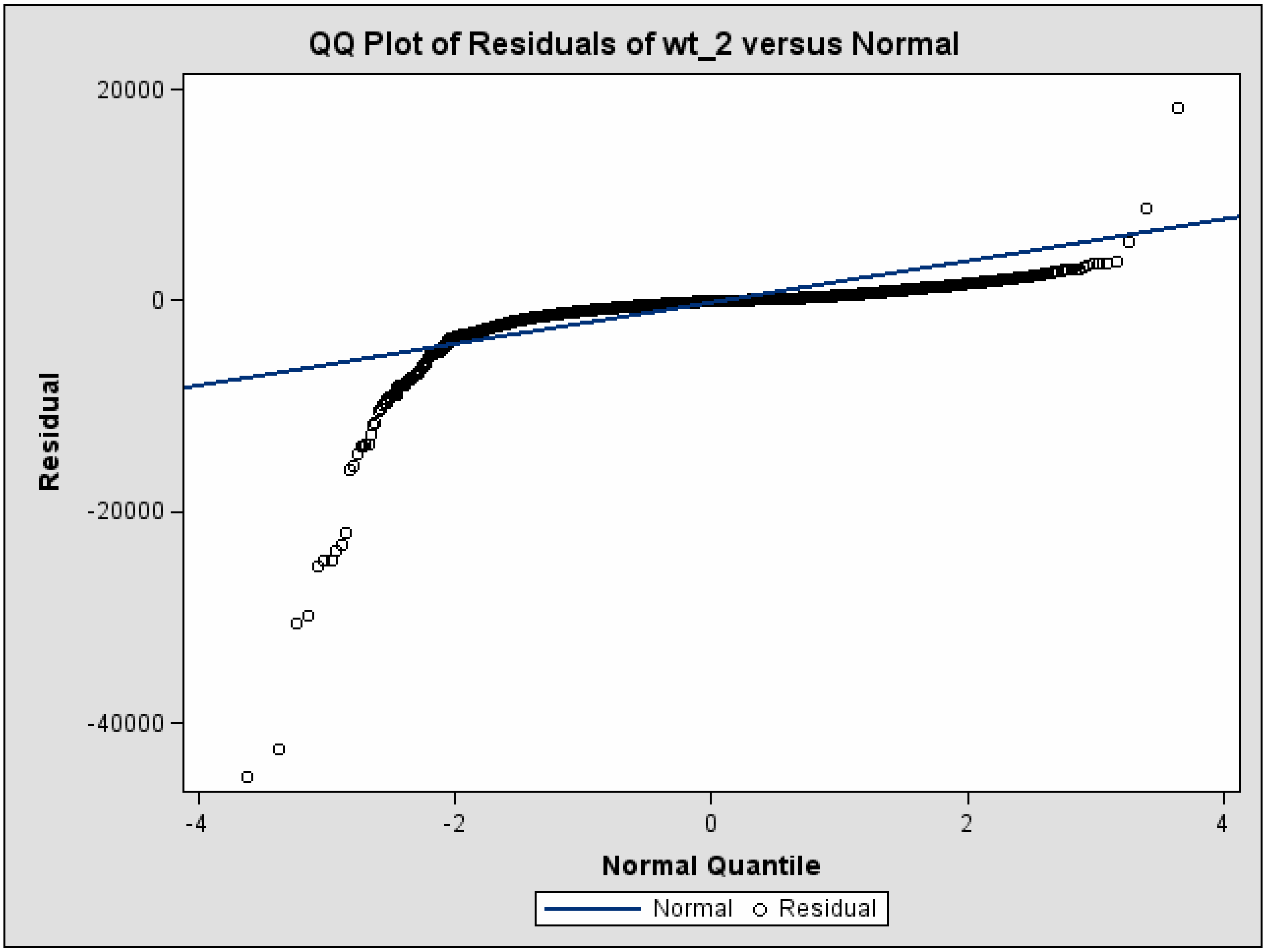

QQ Plot of Residuals of wt_1 versus Normal
Residual
20000
10000
0
-10000
-20000
-30000
-4
-2
0
2
4
Normal Quantile
Normal
○ Residual

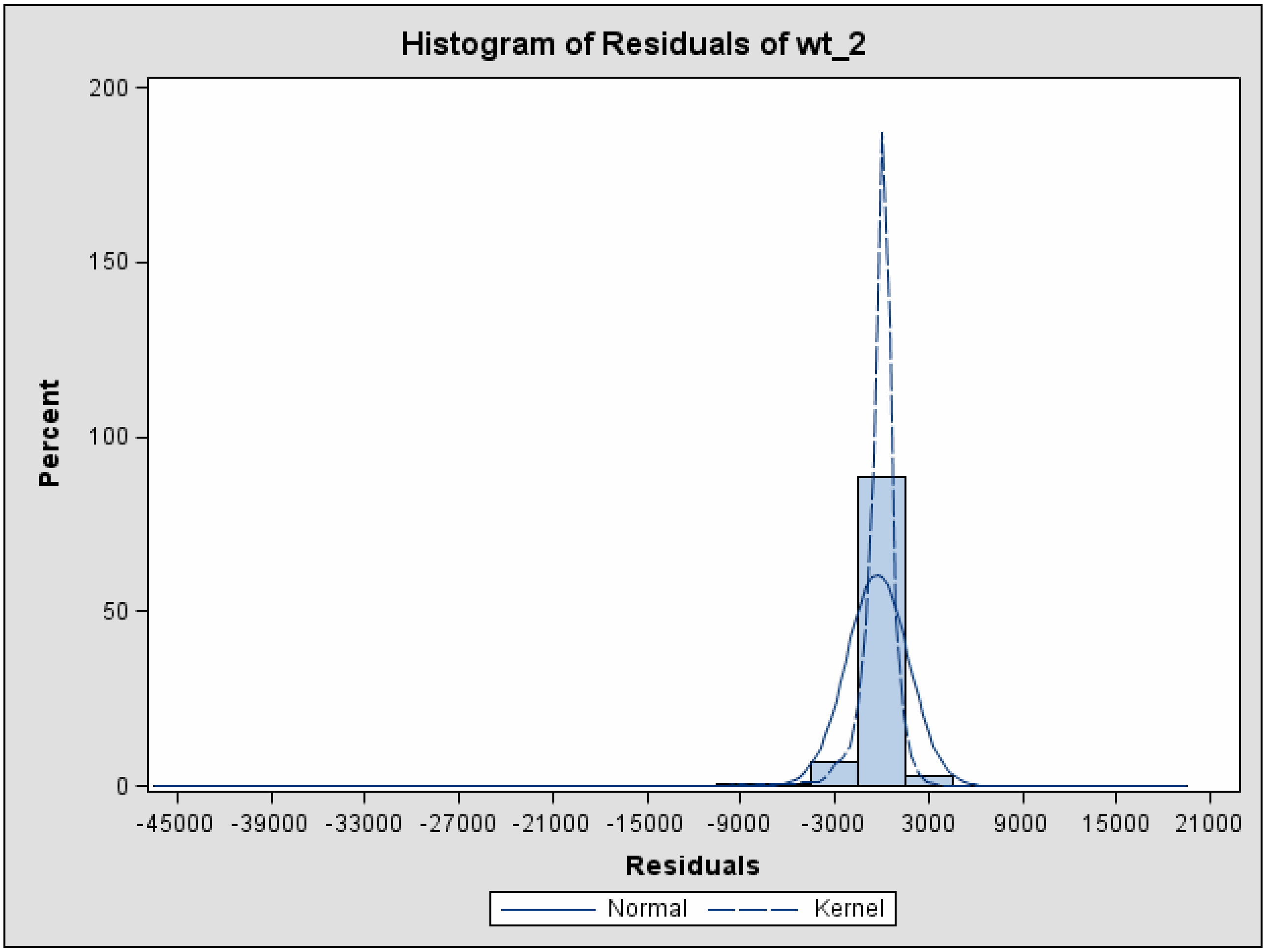

Histogram of Residuals of wt_1
Percent
40
30
20
10
0
-30000
-26000
-22000
-18000
-14000
-10000
-6000
-2000
2000
6000
10000
14000
18000
Residuals
Normal
Kernel

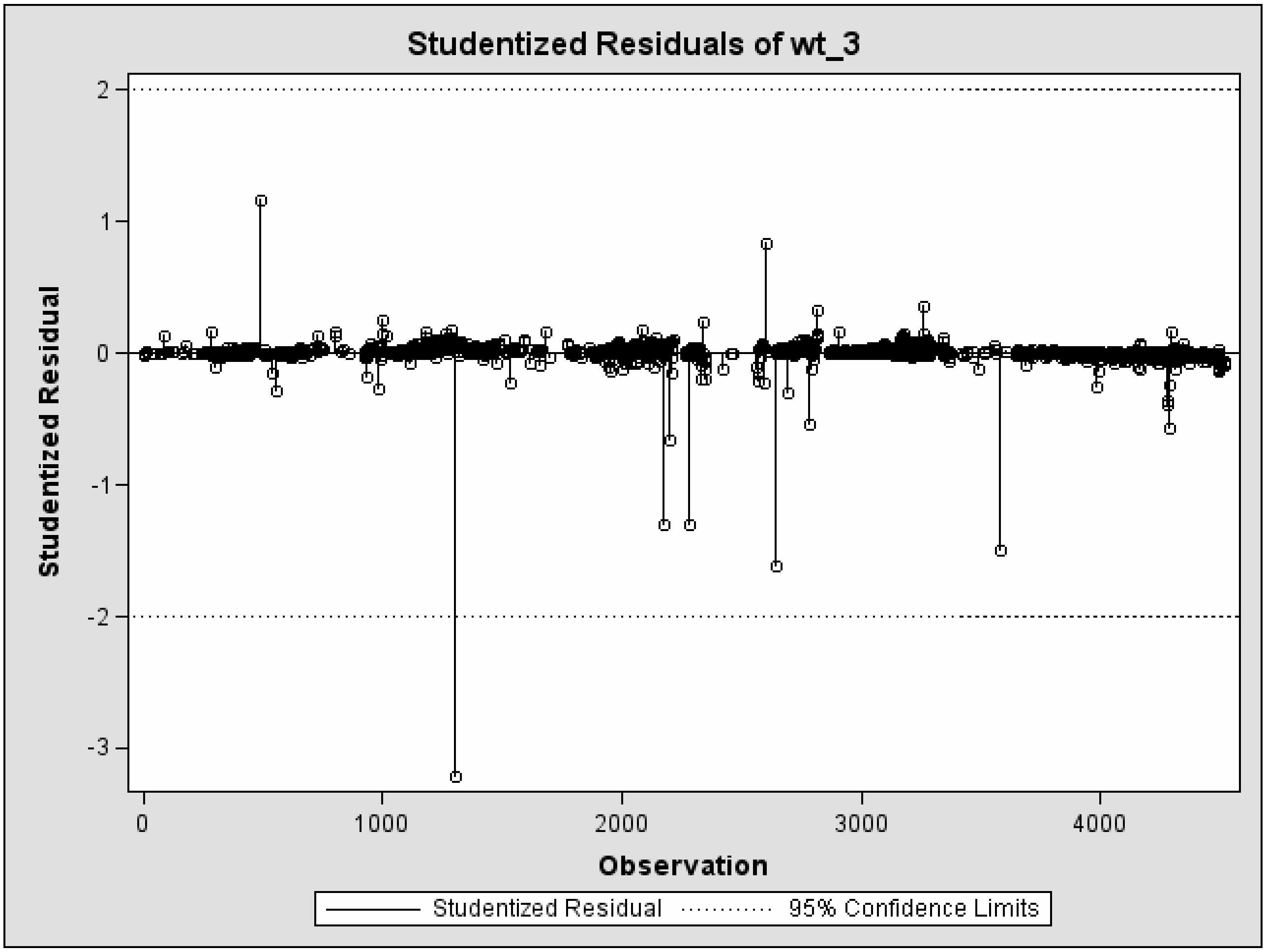

Studentized Residuals of wt_2
Studentized Residual
5
2.5
0
-2.5
-5
0
1000
2000
3000
4000
Observation
Studentized Residual
95% Confidence Limits

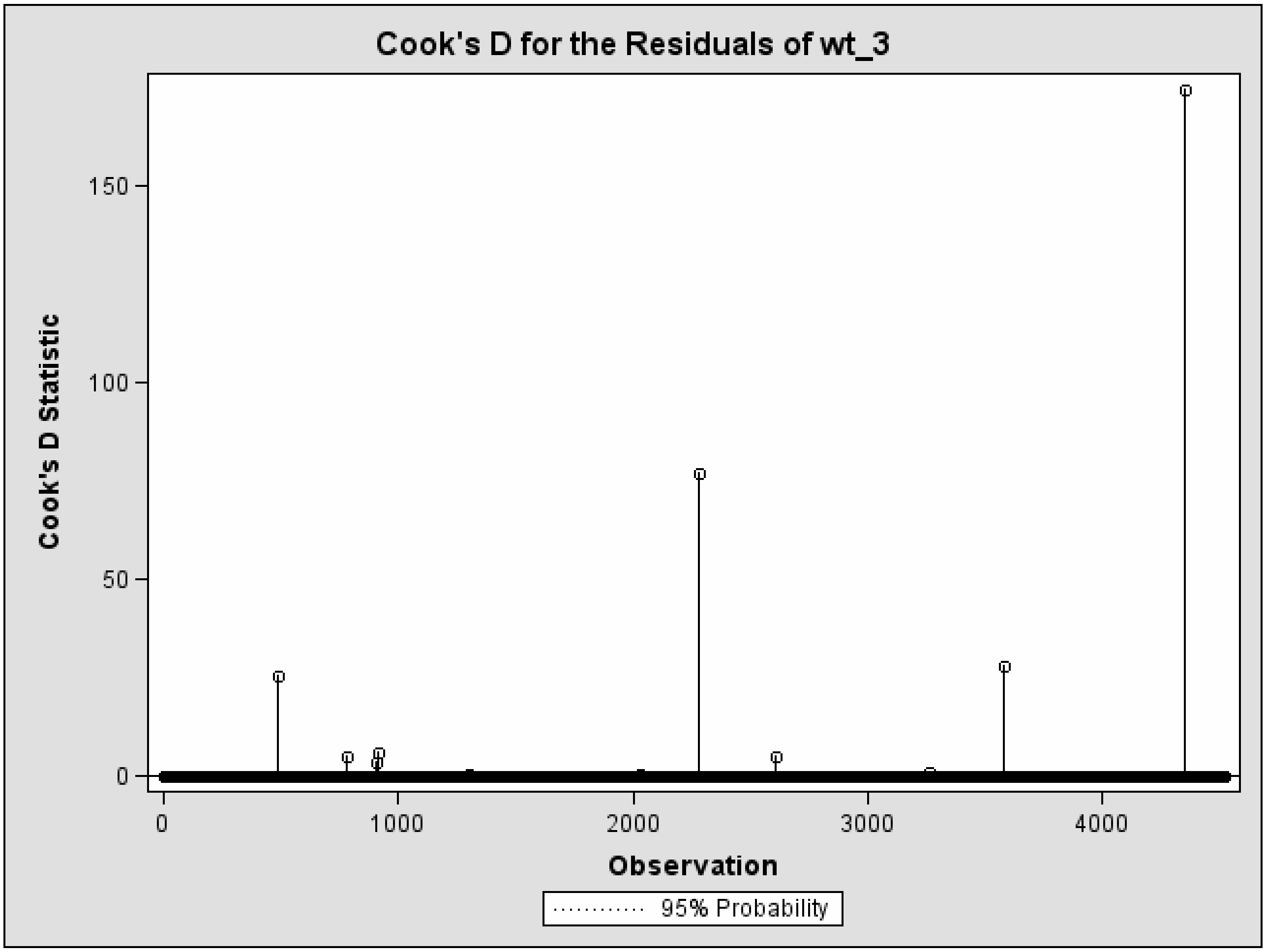

Cook's D for the Residuals of wt_2
Cook's D Statistic
25000
20000
15000
10000
5000
0
Observation
0
1000
2000
3000
4000
95% Probability

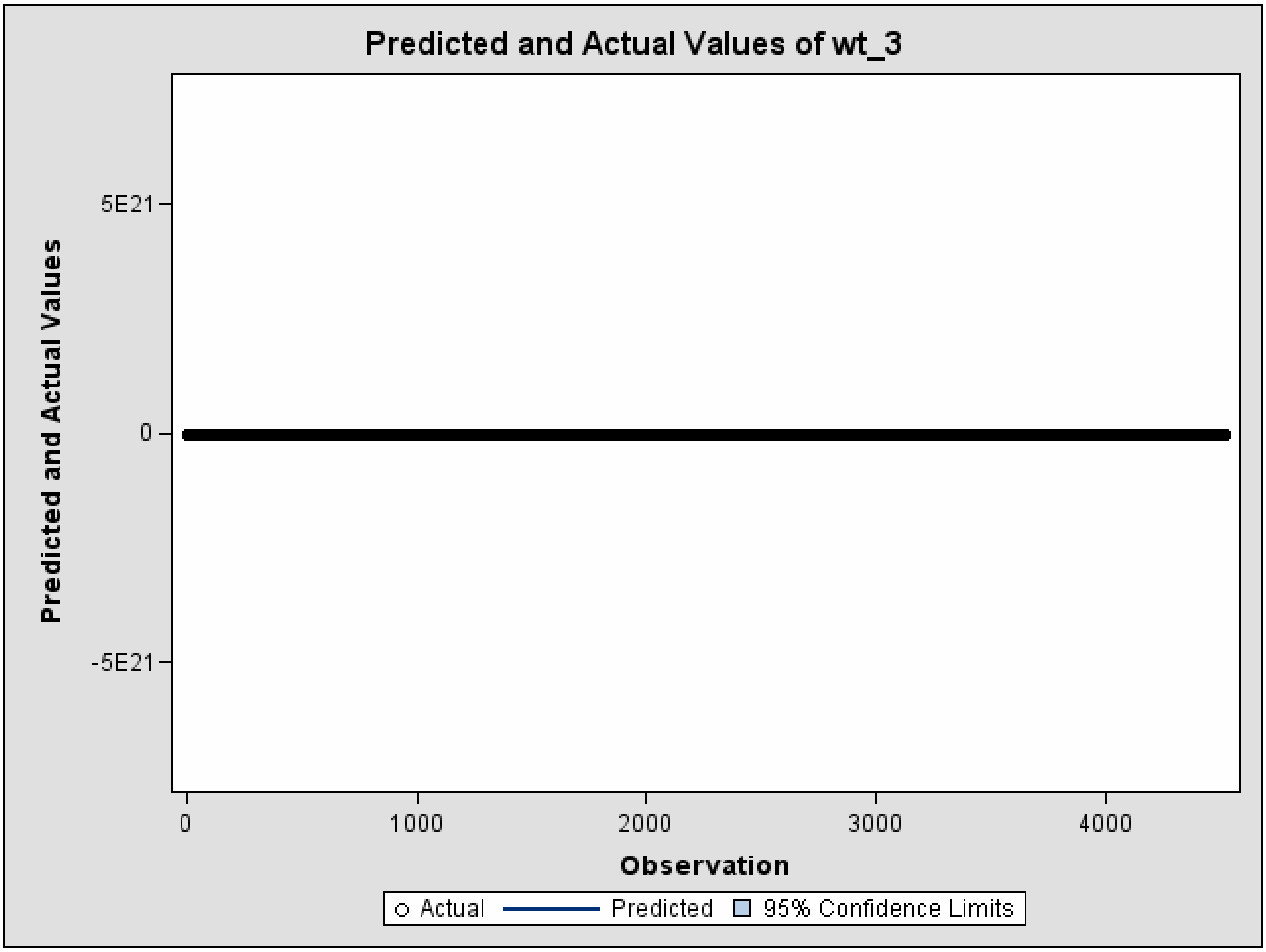

Predicted and Actual Values of wt_2
Predicted and Actual Values
2E21
0
-2E21
0
1000
2000
3000
4000
Observation
○ Actual
Predicted
95% Confidence Limits

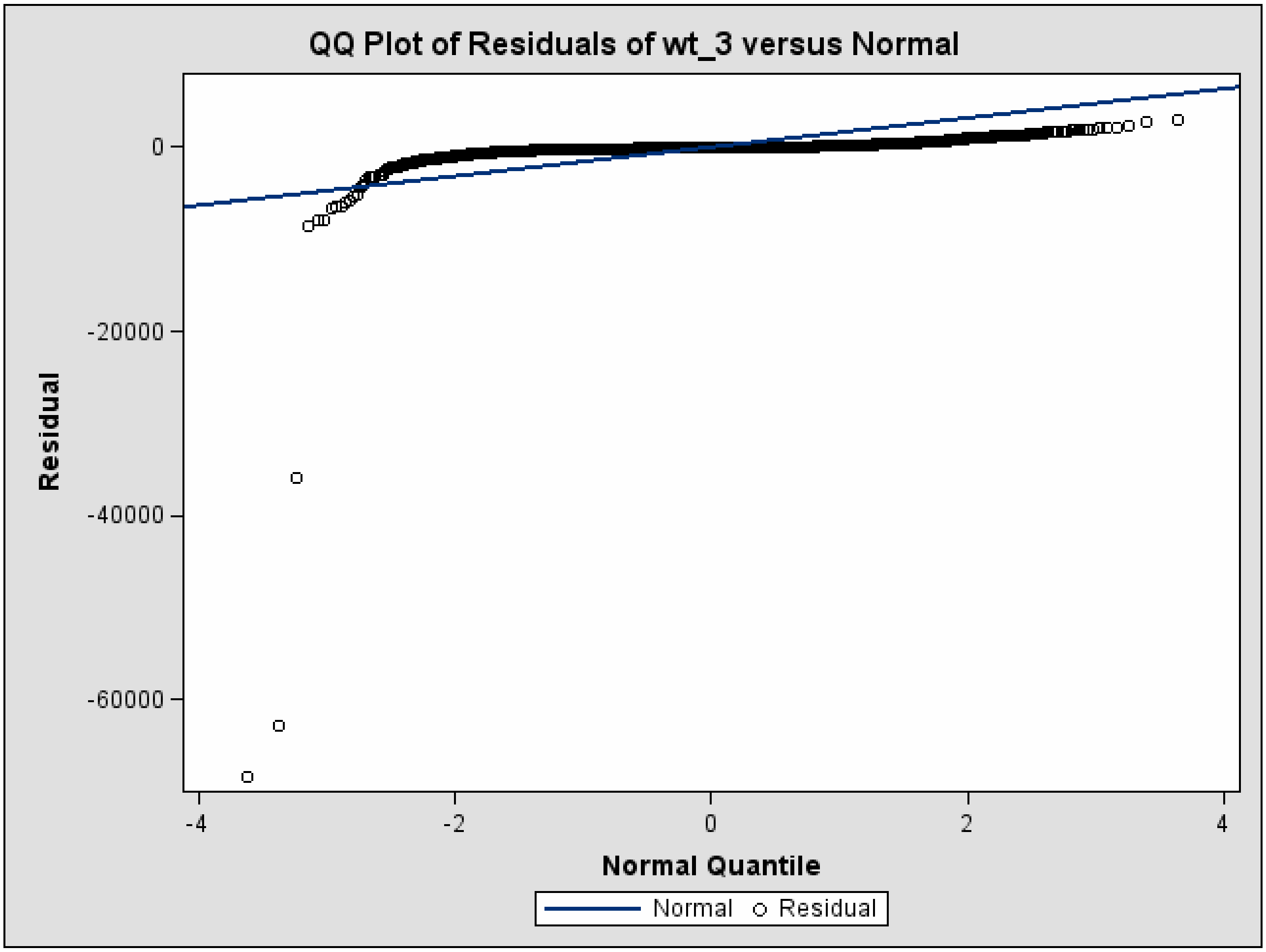

QQ Plot of Residuals of wt_2 versus Normal
Residual
20000
0
-20000
-40000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

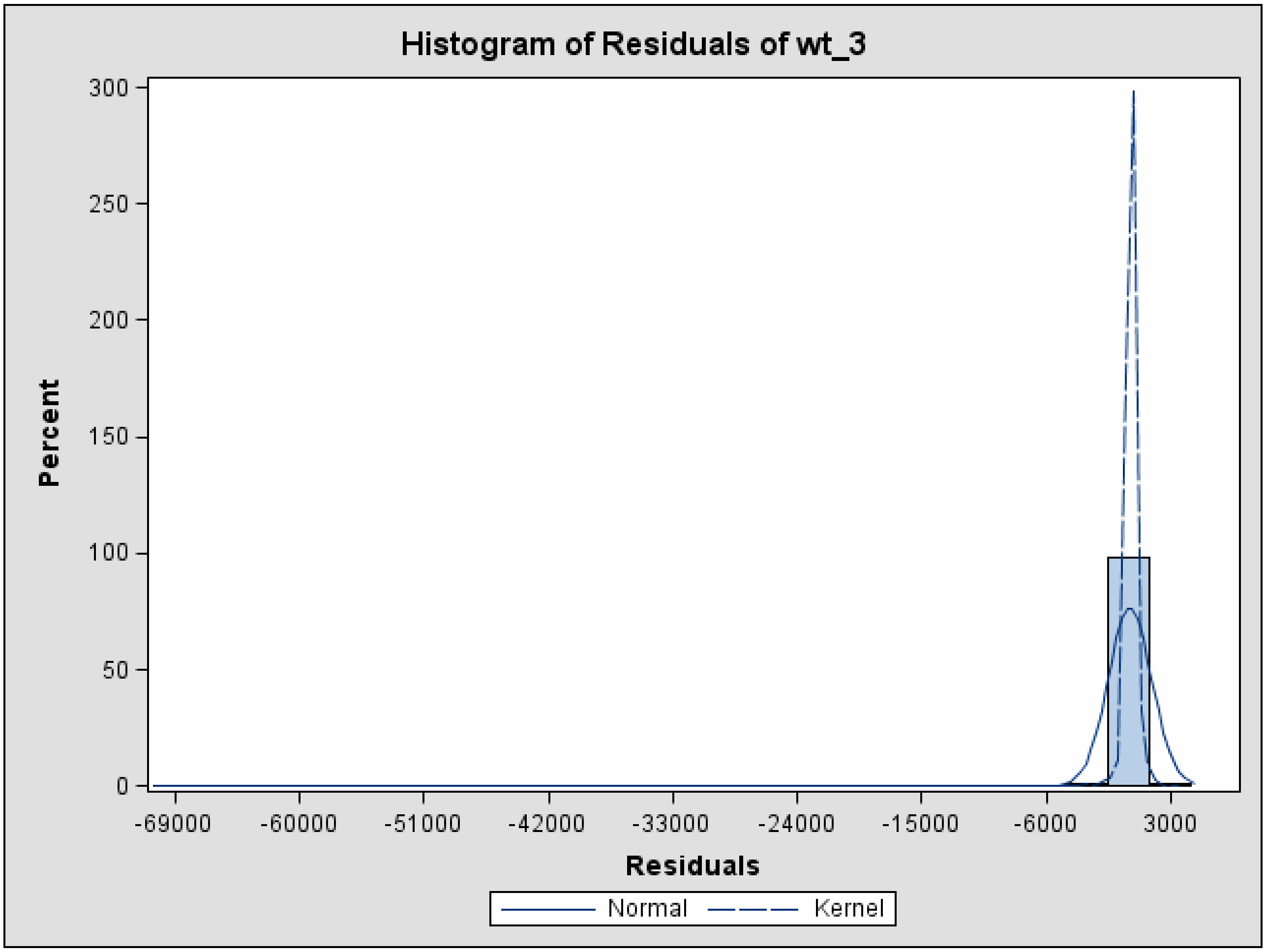

Histogram of Residuals of wt_2
Percent
200
150
100
50
0
-45000
-39000
-33000
-27000
-21000
-15000
-9000
-3000
3000
9000
15000
21000
Residuals
Normal
Kernel

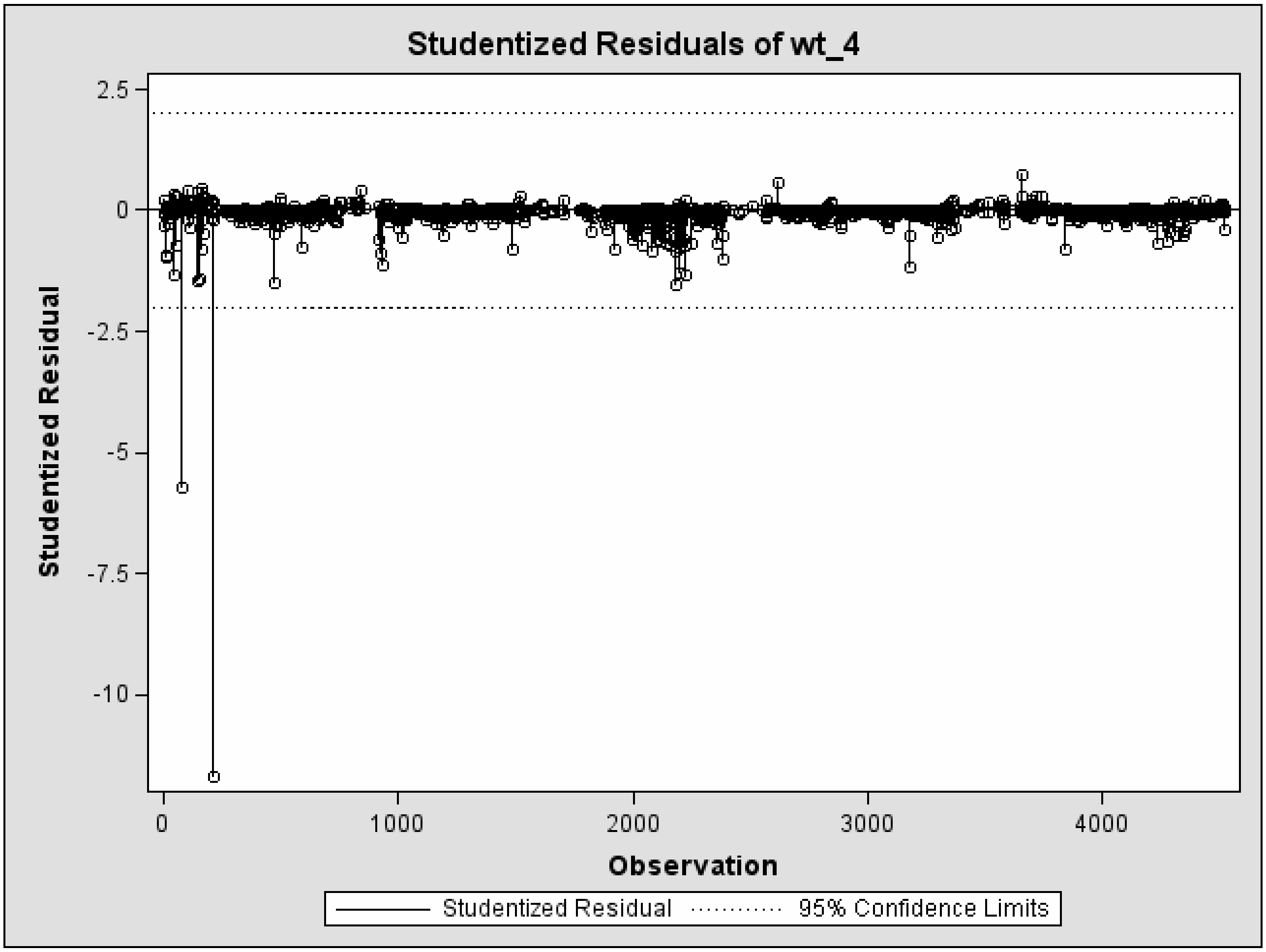

Studentized Residuals of wt_3
Studentized Residual
2
1
0
-1
-2
-3
0
1000
2000
3000
4000
Observation
Studentized Residual
95% Confidence Limits

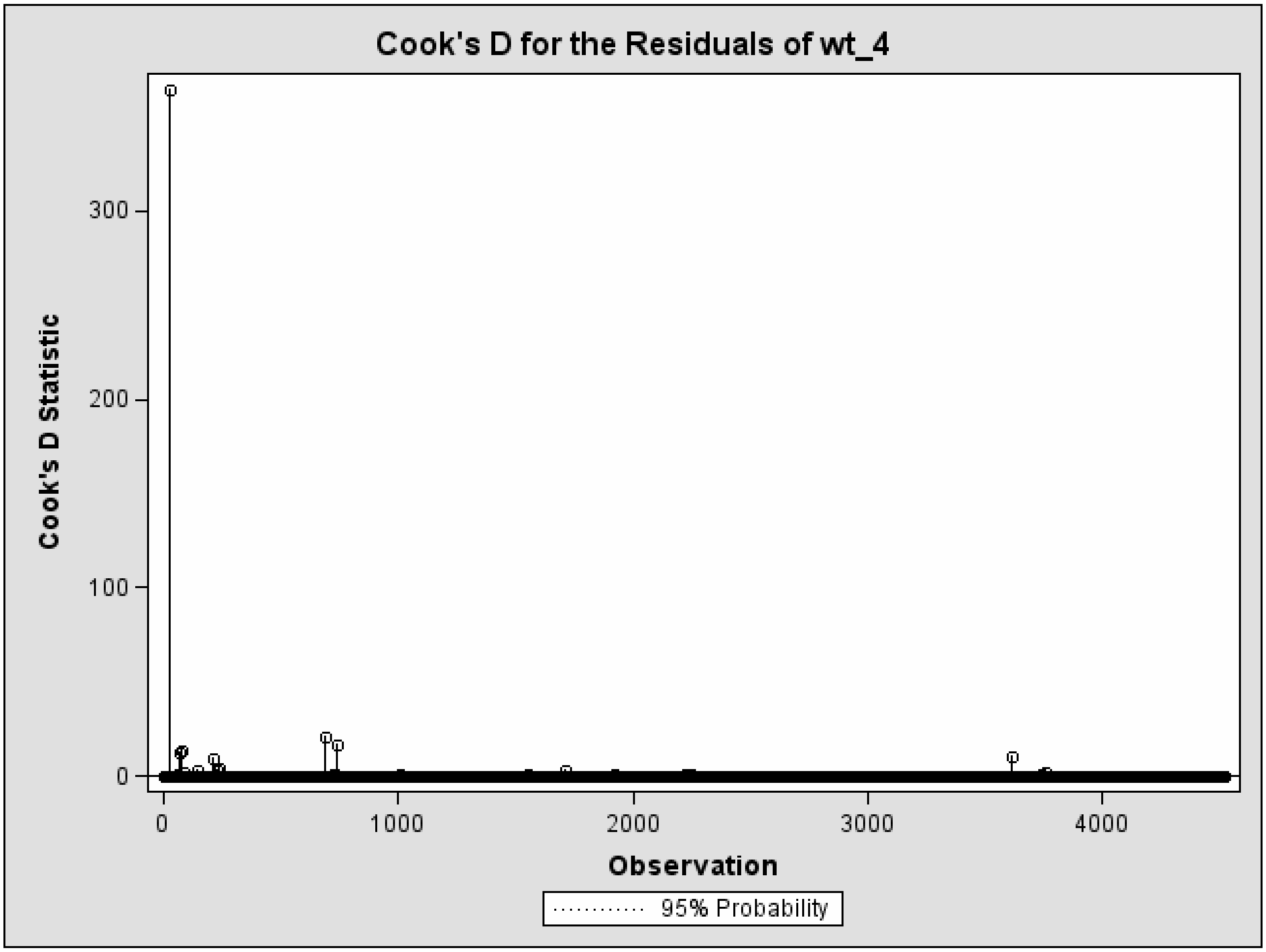

Cook's D for the Residuals of wt_3
Cook's D Statistic
150
100
50
0
0
1000
2000
3000
4000
Observation
95% Probability

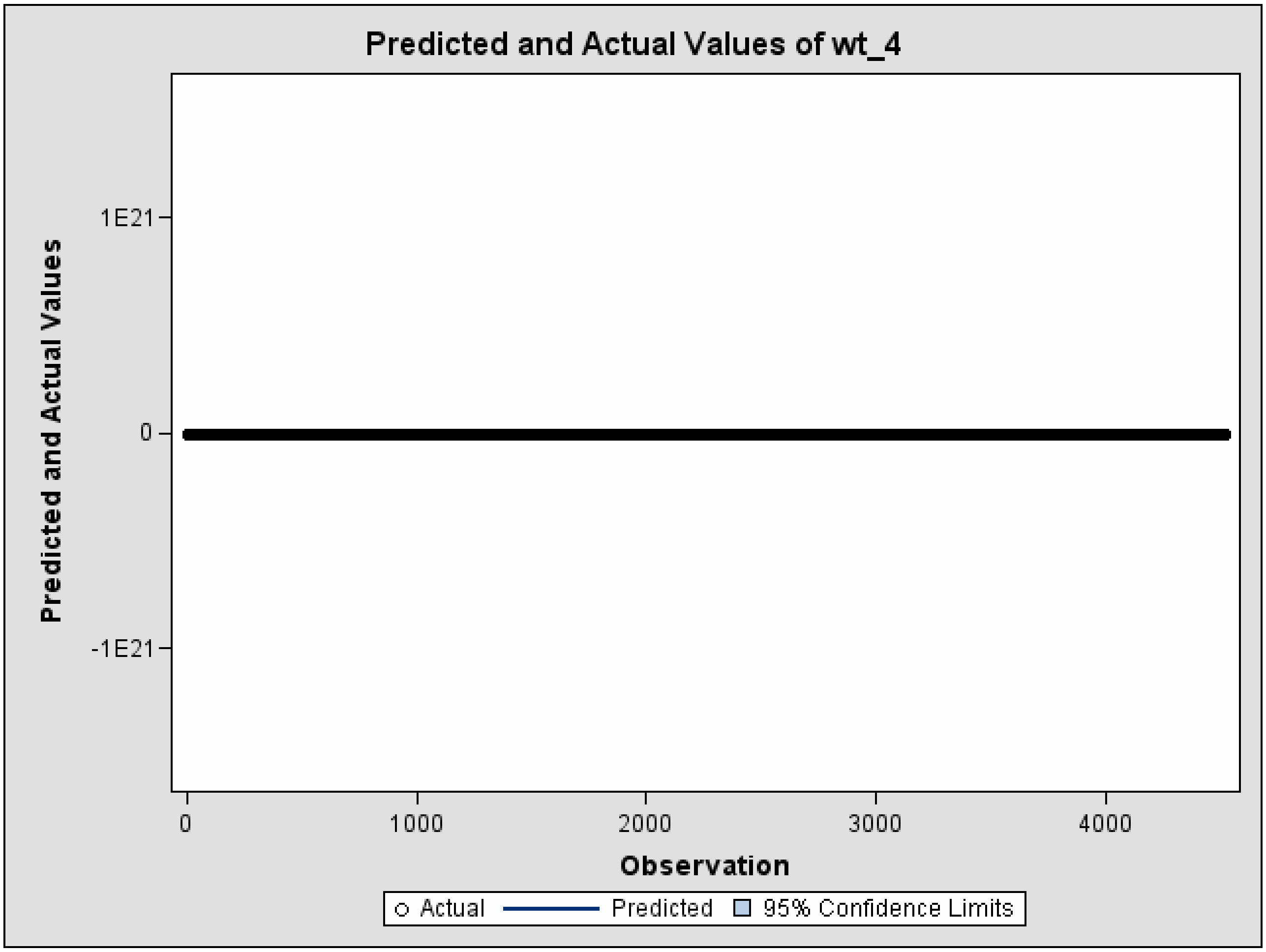

Predicted and Actual Values of wt_3
Predicted and Actual Values
5E21
0
-5E21
0
1000
2000
3000
4000
Observation
○ Actual
Predicted
▢ 95% Confidence Limits

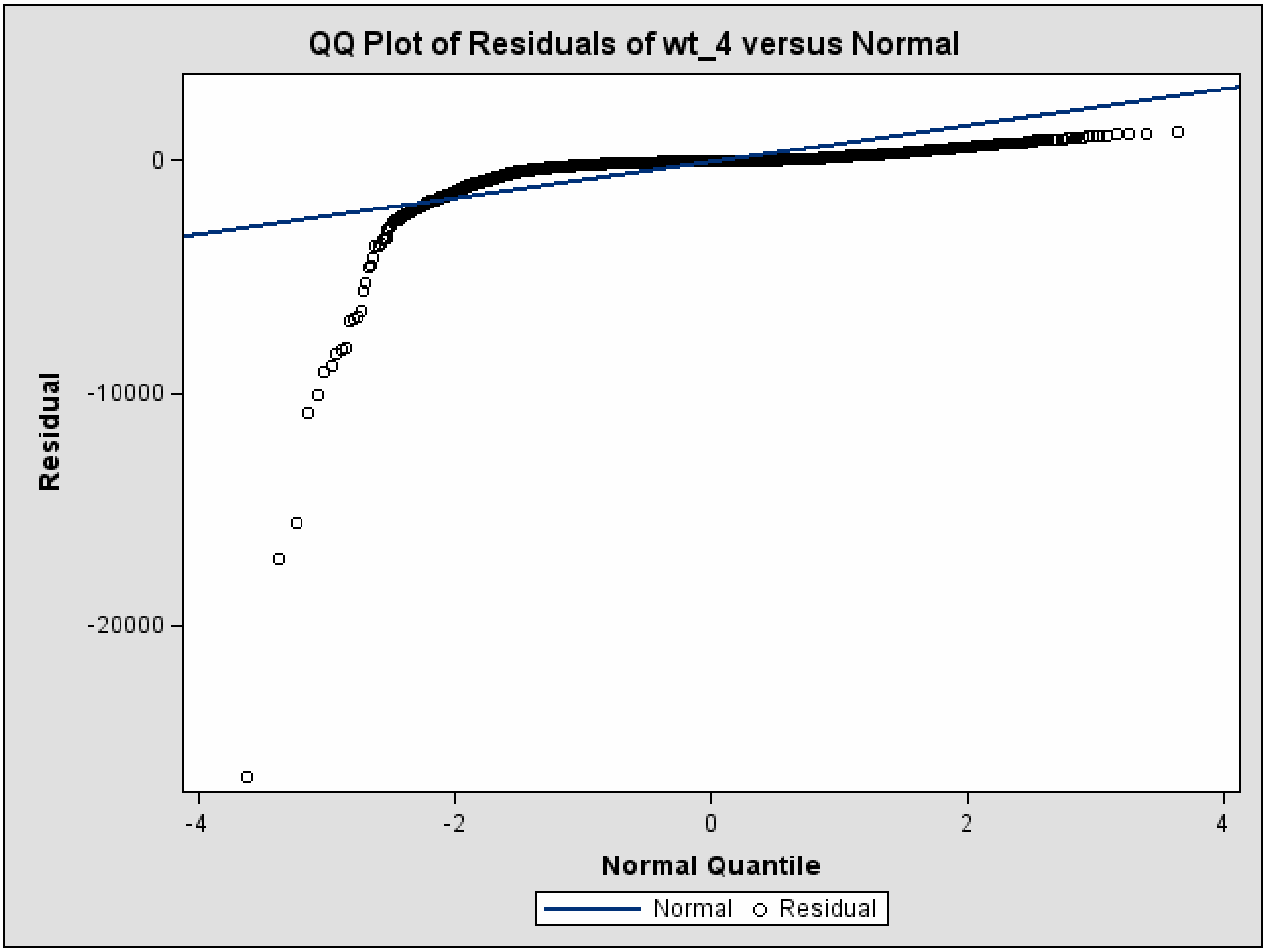

QQ Plot of Residuals of wt_3 versus Normal
Residual
0
-20000
-40000
-60000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

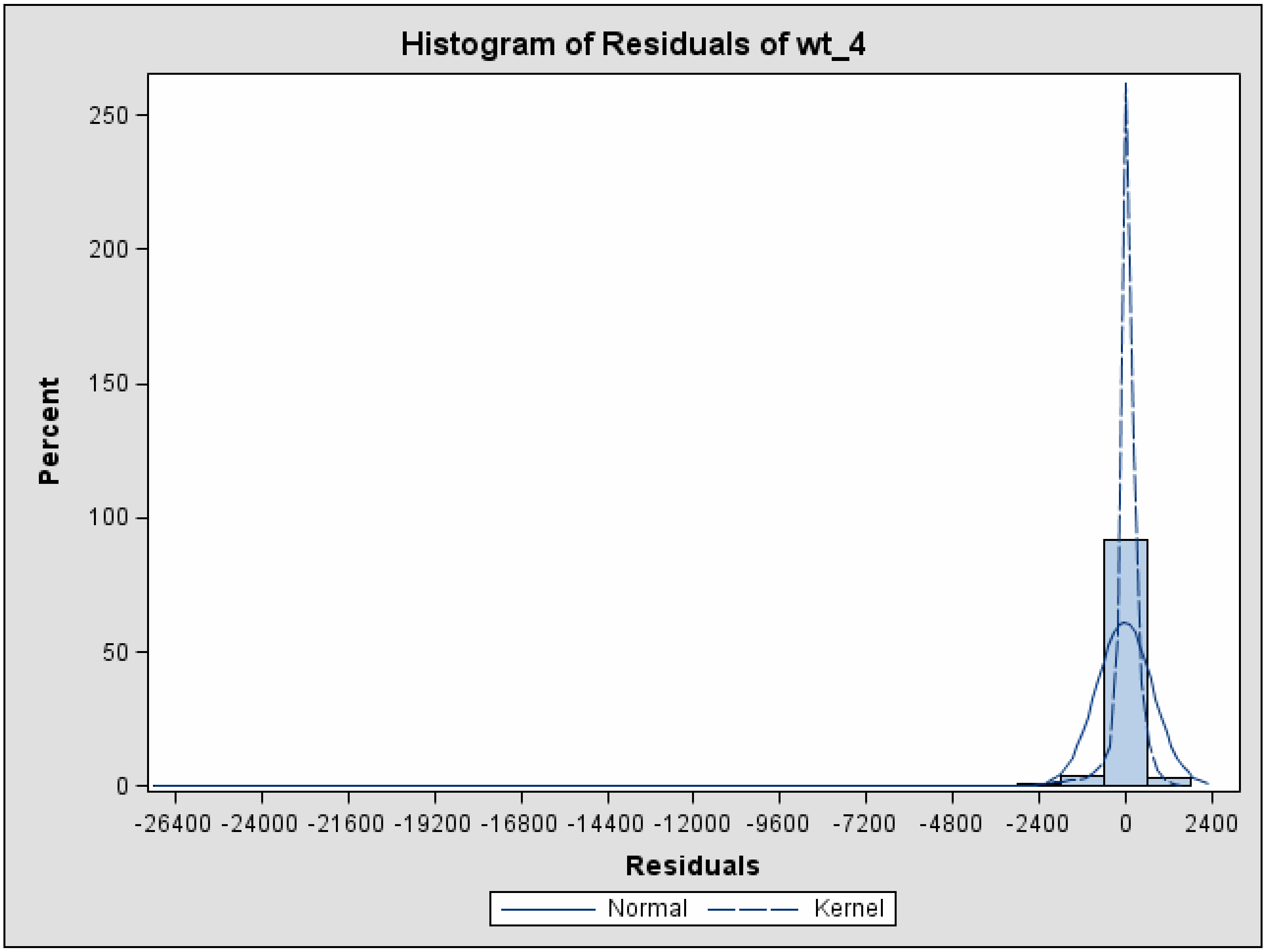

Histogram of Residuals of wt_3
Percent
300
250
200
150
100
50
0
-69000
-60000
-51000
-42000
-33000
-24000
-15000
-6000
3000
Residuals
Normal
Kernel

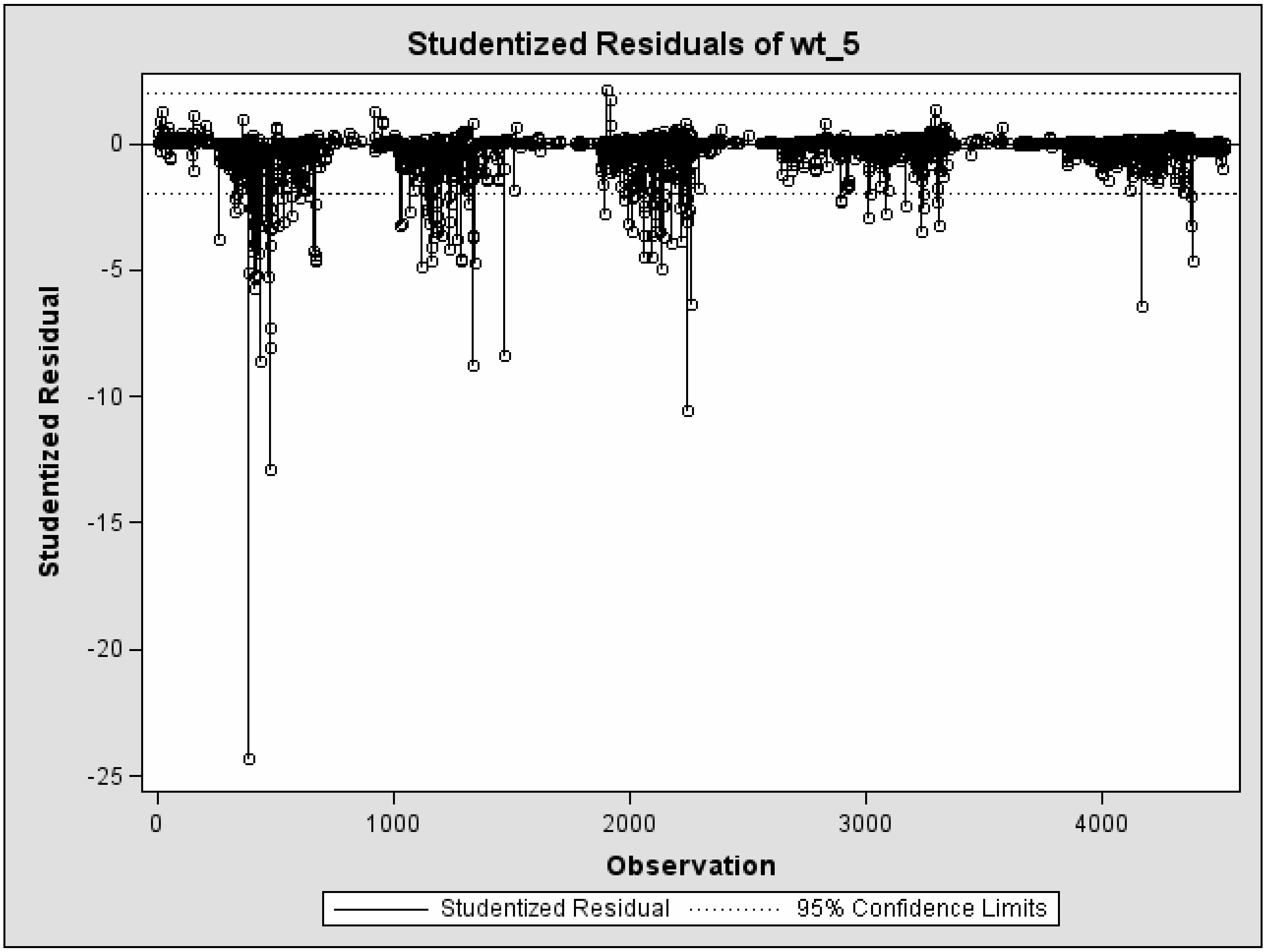

Studentized Residuals of wt_4
Studentized Residual
2.5
0
-2.5
-5
-7.5
-10
0
1000
2000
3000
4000
Observation
Studentized Residual
95% Confidence Limits

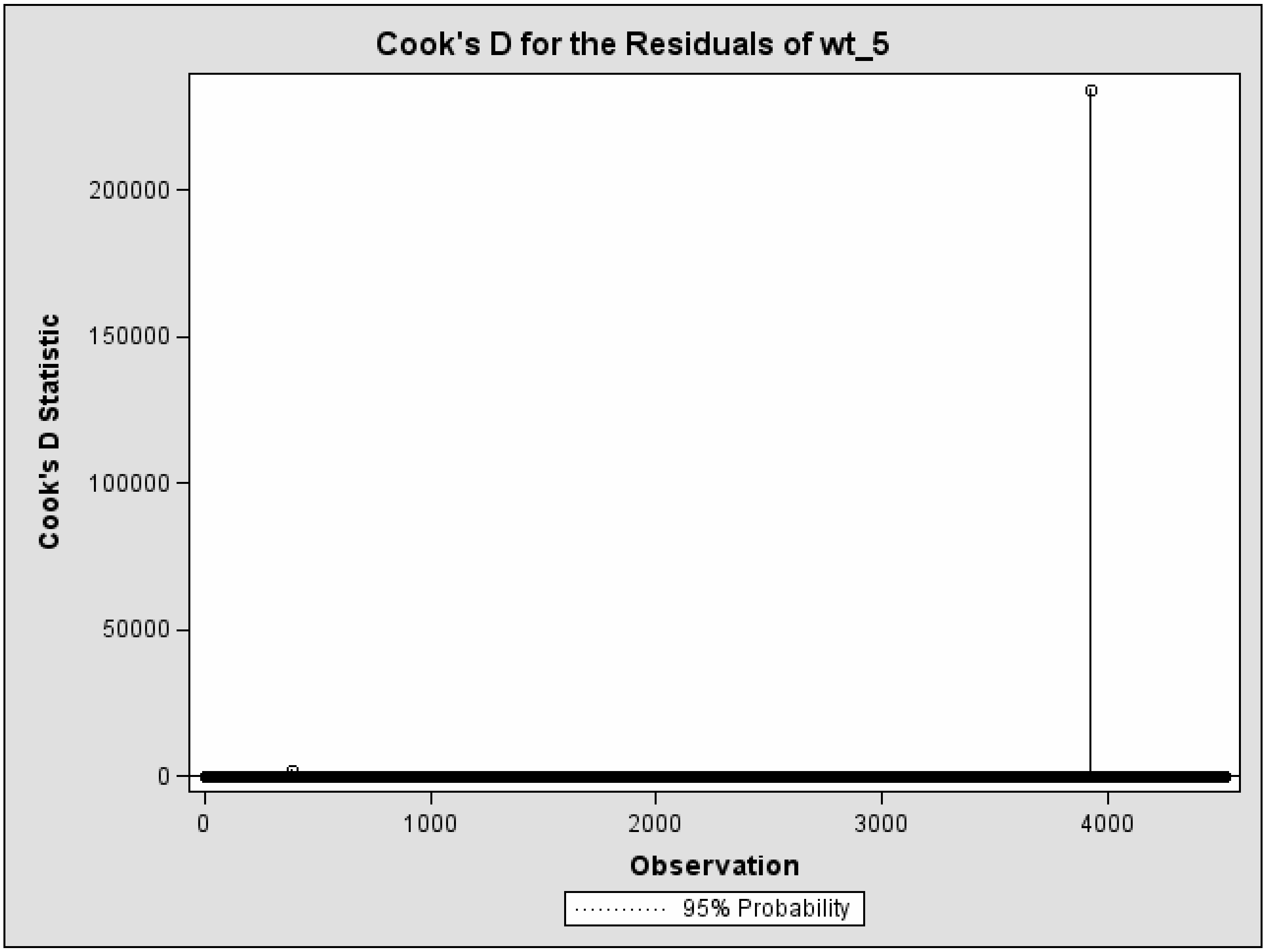

Cook's D for the Residuals of wt_4
Cook's D Statistic
300
200
100
0
0
1000
2000
3000
4000
Observation
95% Probability

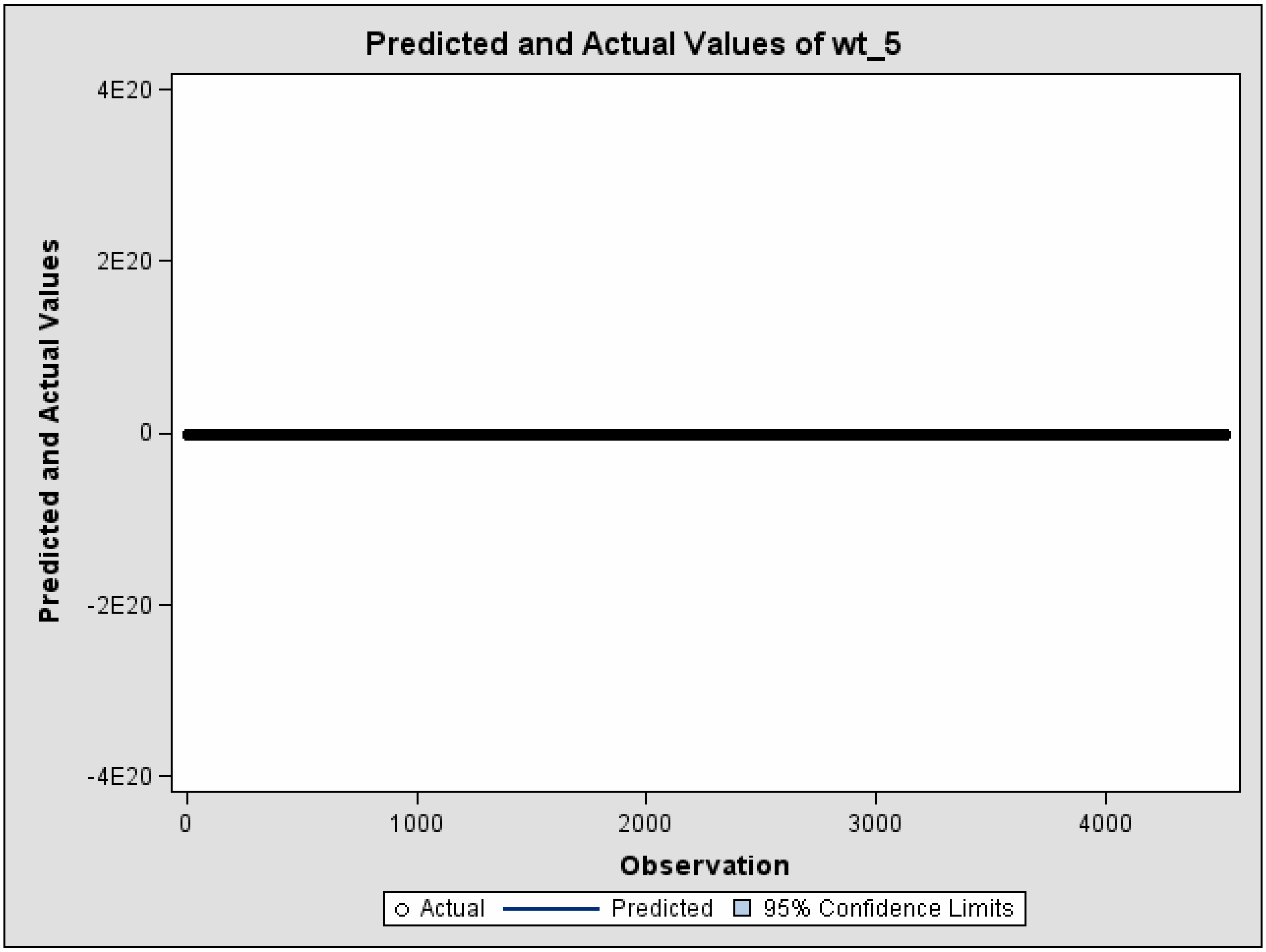

Predicted and Actual Values of wt_4
Predicted and Actual Values
1E21
0
-1E21
0
1000
2000
3000
4000
Observation
○ Actual
Predicted
▨ 95% Confidence Limits

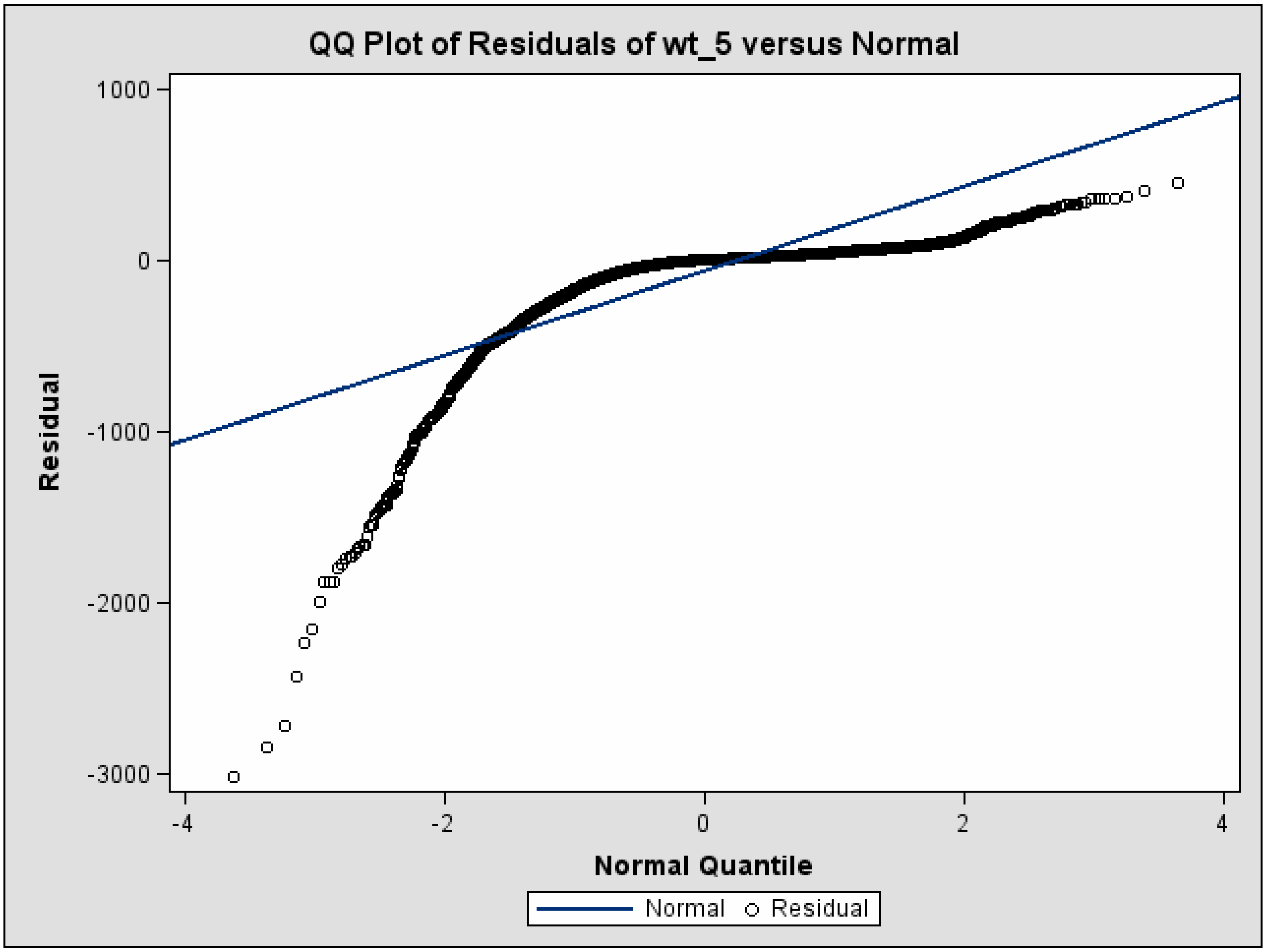

QQ Plot of Residuals of wt_4 versus Normal
Residual
0
-10000
-20000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

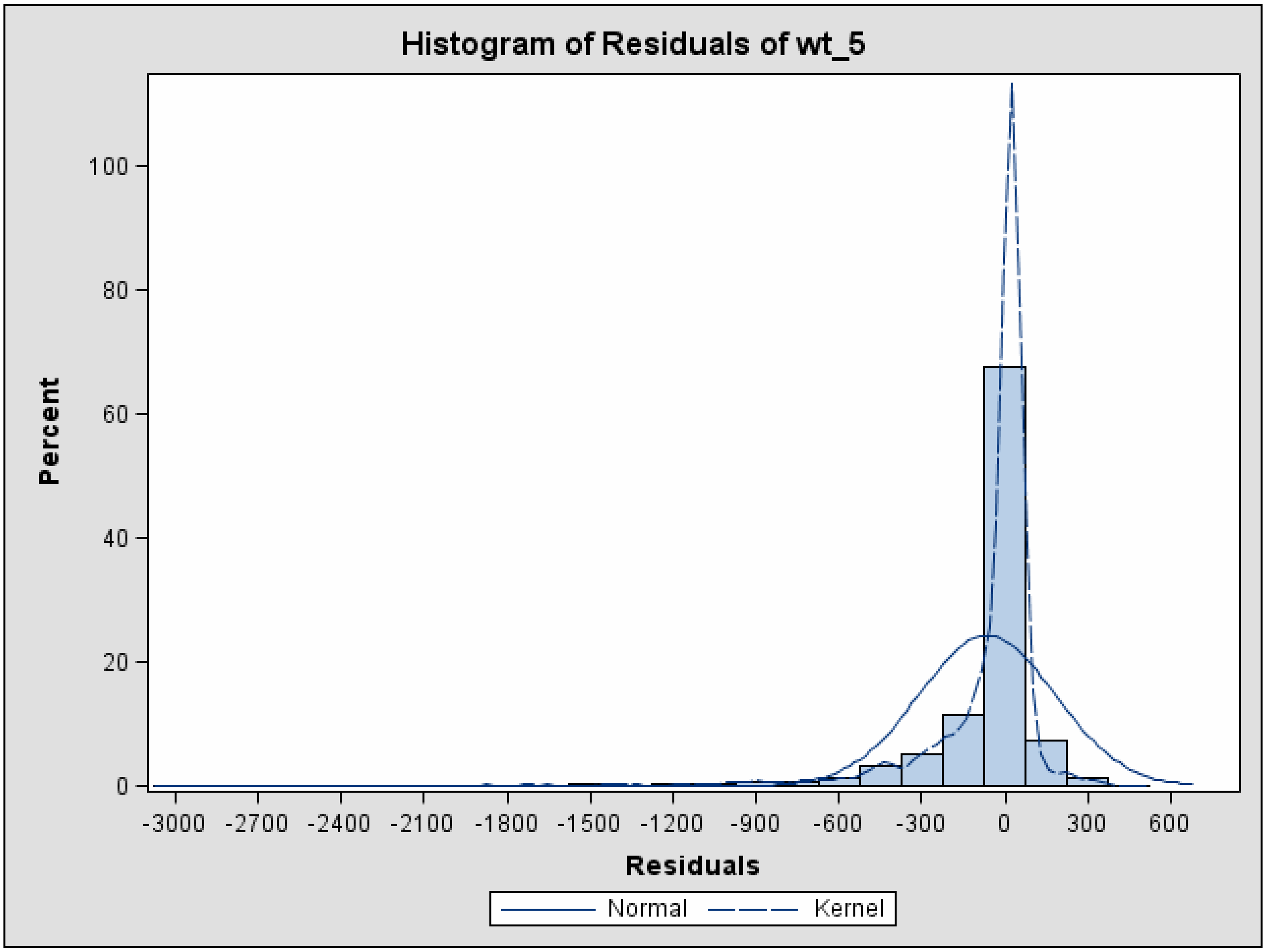

Histogram of Residuals of wt_4
Percent
250
200
150
100
50
0
-26400
-24000
-21600
-19200
-16800
-14400
-12000
-9600
-7200
-4800
-2400
0
2400
Residuals
Normal
Kernel


Studentized Residuals of wt_5
Studentized Residual
0
-5
-10
-15
-20
-25
0
1000
2000
3000
4000
Observation
Studentized Residual
95% Confidence Limits


Cook's D for the Residuals of wt_5
Cook's D Statistic
200000
150000
100000
50000
0
0
1000
2000
3000
4000
Observation
95% Probability


Predicted and Actual Values of wt_5
Predicted and Actual Values
4E20
2E20
0
-2E20
-4E20
0
1000
2000
3000
4000
Observation
Actual
Predicted
95% Confidence Limits


QQ Plot of Residuals of wt_5 versus Normal
Residual
1000
0
-1000
-2000
-3000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

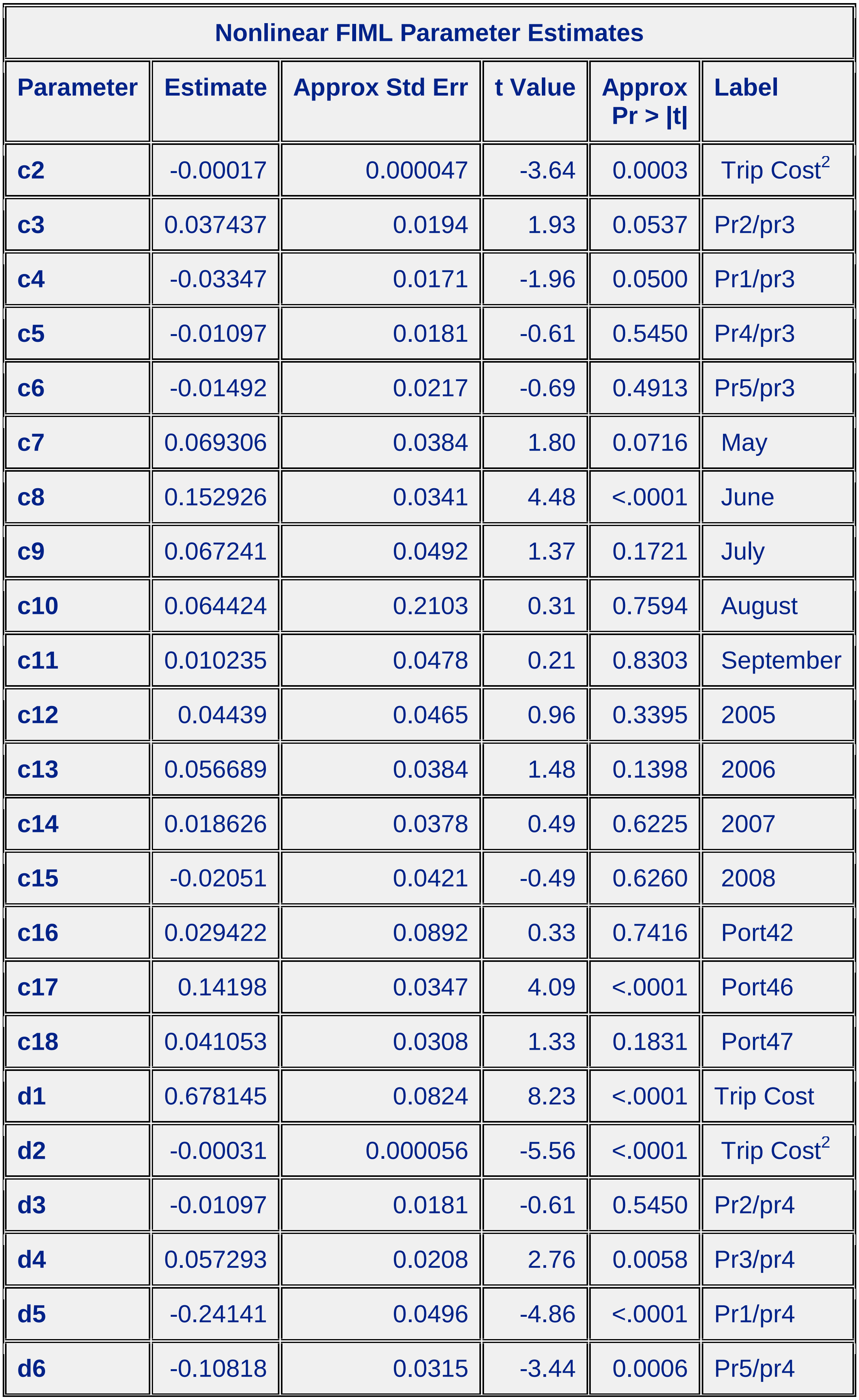

Histogram of Residuals of wt_5
Percent
0
20
40
60
80
100
-3000
-2700
-2400
-2100
-1800
-1500
-1200
-900
-600
-300
0
300
600
Residuals
Normal
Kernel

Appendix 5: Summer Model Results

Nonlinear FIML Summary of Residual Errors								
Equation	**DF Model**	**DF Error**	**SSE**	**MSE**	**Root MSE**	**R-Square**	**Adj R-Sq**	**Label**
wt_1	16	2173	6.711E11	3.0884E8	17573.7	0.2663	0.2612	scup
wt_2	16	2173	7.158E11	3.2939E8	18149.1	0.1926	0.1870	bottom
wt_3	16	2173	1.219E10	5609883	2368.5	0.0410	0.0344	bait
wt_4	16	2173	3.824E10	17598548	4195.1	0.0579	0.0514	shell
wt_5	16	2173	4.472E10	20580281	4536.5	0.1440	0.1381	other

Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
a1	2.027789	0.2122	9.56	<.0001	Trip Cost
a2	-0.00184	0.000197	-9.32	<.0001	Trip Cost^2
a3	-0.03347	0.0171	-1.96	0.0500	Pr2/pr1
a4	2.253801	0.1122	20.09	<.0001	Pr3/pr1
a5	-0.24141	0.0496	-4.86	<.0001	Pr4/pr1
a6	0.031366	0.0320	0.98	0.3266	Pr5/pr1
a7	-1.86821	0.1577	-11.85	<.0001	May
a8	-1.81136	0.2520	-7.19	<.0001	June
a9	-1.49568	0.2314	-6.46	<.0001	July
a10	-2.01662	0.4762	-4.23	<.0001	August
a11	-0.55369	0.1099	-5.04	<.0001	September
a12	0.699827	0.1457	4.80	<.0001	2005
a13	-0.03675	0.1483	-0.25	0.8043	2006
a14	0.204815	0.1597	1.28	0.1998	2007

Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
a15	0.65386	0.1708	3.83	0.0001	2008
a16	2.181993	0.1616	13.50	<.0001	Port42
a17	0.614309	0.1629	3.77	0.0002	Port46
a18	0.756413	0.1483	5.10	<.0001	Port47
b1	-0.02675	0.3755	-0.07	0.9432	Trip Cost
b2	-0.00073	0.000285	-2.55	0.0108	Trip Cost^2
b3	0.037437	0.0194	1.93	0.0537	Pr1/pr2
b4	2.253801	0.1122	20.09	<.0001	Pr3/pr2
b5	0.057293	0.0208	2.76	0.0058	Pr4/pr2
b6	0.009841	0.0211	0.47	0.6402	Pr5/pr2
b7	0.077498	0.2439	0.32	0.7507	May
b8	-0.18465	0.4323	-0.43	0.6693	June
b9	-0.09373	0.6219	-0.15	0.8802	July
b10	-0.66771	1.2086	-0.55	0.5807	August
b11	0.928864	0.2082	4.46	<.0001	September
b12	-0.52905	0.2659	-1.99	0.0467	2005
b13	-0.10586	0.2049	-0.52	0.6054	2006
b14	-0.61886	0.3149	-1.97	0.0495	2007
b15	-0.09648	0.1726	-0.56	0.5763	2008
b16	1.048119	0.2510	4.18	<.0001	Port42
b17	0.546353	0.2772	1.97	0.0489	Port46
b18	-0.07764	0.2162	-0.36	0.7196	Port47
c1	0.113529	0.0593	1.91	0.0558	Trip Cost



Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|	Label
c2	-0.00017	0.000047	-3.64	0.0003	Trip Cost^2
c3	0.037437	0.0194	1.93	0.0537	Pr2/pr3
c4	-0.03347	0.0171	-1.96	0.0500	Pr1/pr3
c5	-0.01097	0.0181	-0.61	0.5450	Pr4/pr3
c6	-0.01492	0.0217	-0.69	0.4913	Pr5/pr3
c7	0.069306	0.0384	1.80	0.0716	May
c8	0.152926	0.0341	4.48	<.0001	June
c9	0.067241	0.0492	1.37	0.1721	July
c10	0.064424	0.2103	0.31	0.7594	August
c11	0.010235	0.0478	0.21	0.8303	September
c12	0.04439	0.0465	0.96	0.3395	2005
c13	0.056689	0.0384	1.48	0.1398	2006
c14	0.018626	0.0378	0.49	0.6225	2007
c15	-0.02051	0.0421	-0.49	0.6260	2008
c16	0.029422	0.0892	0.33	0.7416	Port42
c17	0.14198	0.0347	4.09	<.0001	Port46
c18	0.041053	0.0308	1.33	0.1831	Port47
d1	0.678145	0.0824	8.23	<.0001	Trip Cost
d2	-0.00031	0.000056	-5.56	<.0001	Trip Cost^2
d3	-0.01097	0.0181	-0.61	0.5450	Pr2/pr4
d4	0.057293	0.0208	2.76	0.0058	Pr3/pr4
d5	-0.24141	0.0496	-4.86	<.0001	Pr1/pr4
d6	-0.10818	0.0315	-3.44	0.0006	Pr5/pr4

Nonlinear FIML Parameter Estimates					
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**	**Label**
d7	-0.01103	0.0357	-0.31	0.7577	May
d8	-0.00896	0.0400	-0.22	0.8227	June
d9	-0.05835	0.0816	-0.71	0.4749	July
d10	0.102663	0.1503	0.68	0.4947	August
d11	-0.15337	0.0618	-2.48	0.0131	September
d12	-0.06436	0.0582	-1.10	0.2693	2005
d13	-0.06625	0.0445	-1.49	0.1366	2006
d14	-0.00148	0.0473	-0.03	0.9750	2007
d15	-0.0466	0.0465	-1.00	0.3168	2008
d16	-0.06303	0.0602	-1.05	0.2952	Port42
d17	-0.03999	0.0472	-0.85	0.3973	Port46
d18	0.010793	0.0305	0.35	0.7234	Port47
e1	0.603535	0.1020	5.92	<.0001	Trip Cost
e2	-0.00024	0.000058	-4.16	<.0001	Trip Cost^2
e3	-0.01492	0.0217	-0.69	0.4913	Pr2/pr5
e4	0.009841	0.0211	0.47	0.6402	Pr3/pr5
e5	-0.10818	0.0315	-3.44	0.0006	Pr4/pr5
e6	0.031366	0.0320	0.98	0.3266	Pr1/pr5
e7	-0.44437	0.0710	-6.26	<.0001	May
e8	-0.41798	0.1014	-4.12	<.0001	June
e9	-0.46649	0.1606	-2.90	0.0037	July
e10	-0.30557	0.2192	-1.39	0.1634	August
e11	-0.21716	0.0502	-4.32	<.0001	September

Nonlinear FIML Parameter Estimates

Parameter	Estimate	Approx Std Err	t Value	Approx Pr > |t|	Label
e12	0.006497	0.0691	0.09	0.9251	2005
e13	0.049296	0.0661	0.75	0.4556	2006
e14	0.072271	0.0659	1.10	0.2728	2007
e15	0.064913	0.0732	0.89	0.3750	2008
e16	-0.05137	0.0645	-0.80	0.4259	Port42
e17	0.25069	0.0592	4.23	<.0001	Port46
e18	0.061963	0.0504	1.23	0.2191	Port47
Restrict0	-14.9329	9.5504	-1.56	0.1179	a3 = c4
Restrict1	39.36206	4.7243	8.33	<.0001	a4 = b4
Restrict2	-9.17453	5.1387	-1.79	0.0742	a5 = d5
Restrict3	-1.93204	6.1138	-0.32	0.7521	a6 = e6
Restrict4	-190.586	9.7496	-19.55	<.0001	b3 = c3
Restrict5	-147.11	10.5196	-13.98	<.0001	b5 = d4
Restrict6	-103.592	5.5405	-18.70	<.0001	b6 = e4
Restrict7	-76.9045	15.3770	-5.00	<.0001	c5 = d3
Restrict8	56.23444	18.8499	2.98	0.0028	c6 = e3
Restrict9	46.29978	14.4115	3.21	0.0013	d6 = e5

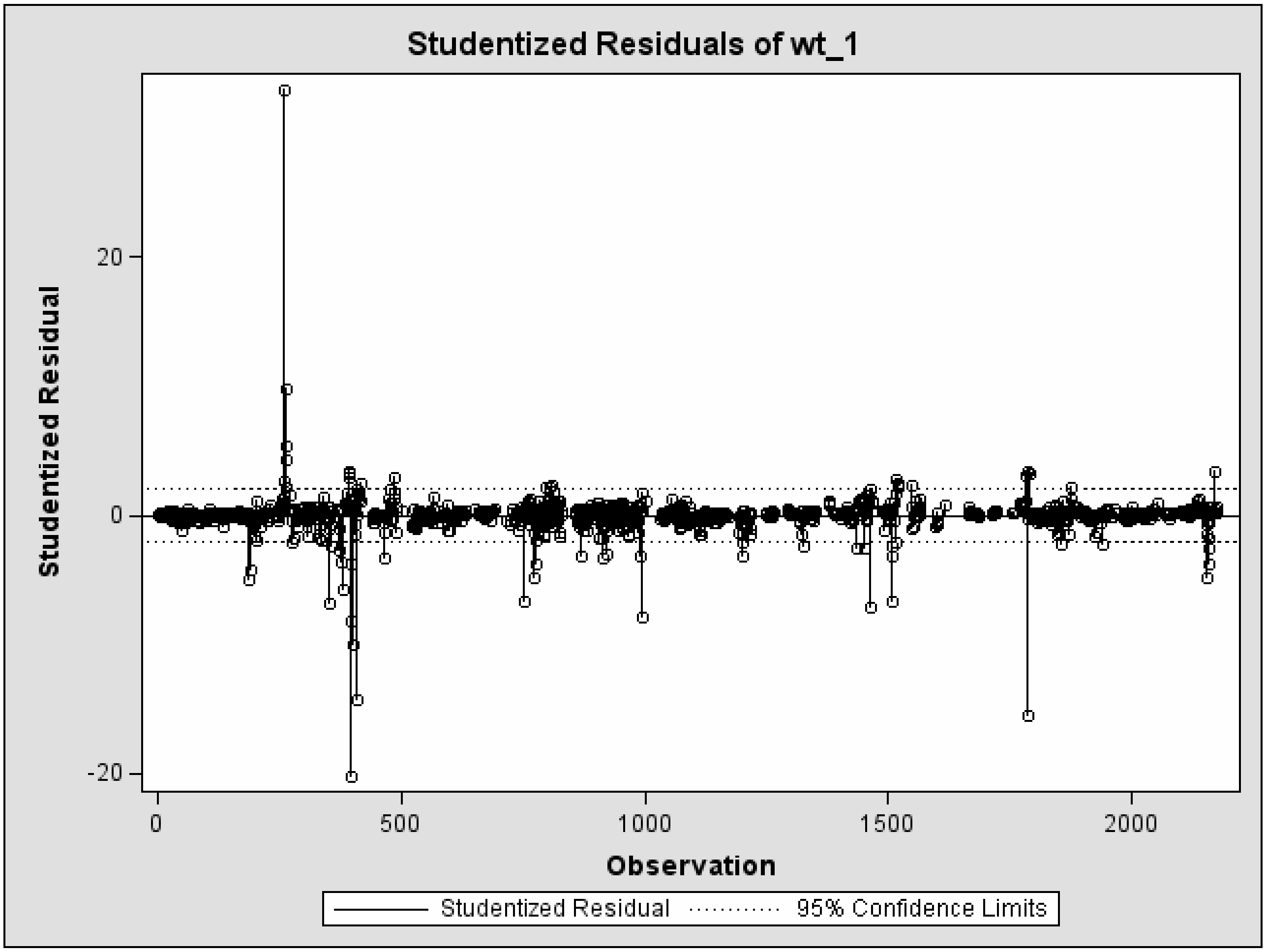
Test Results

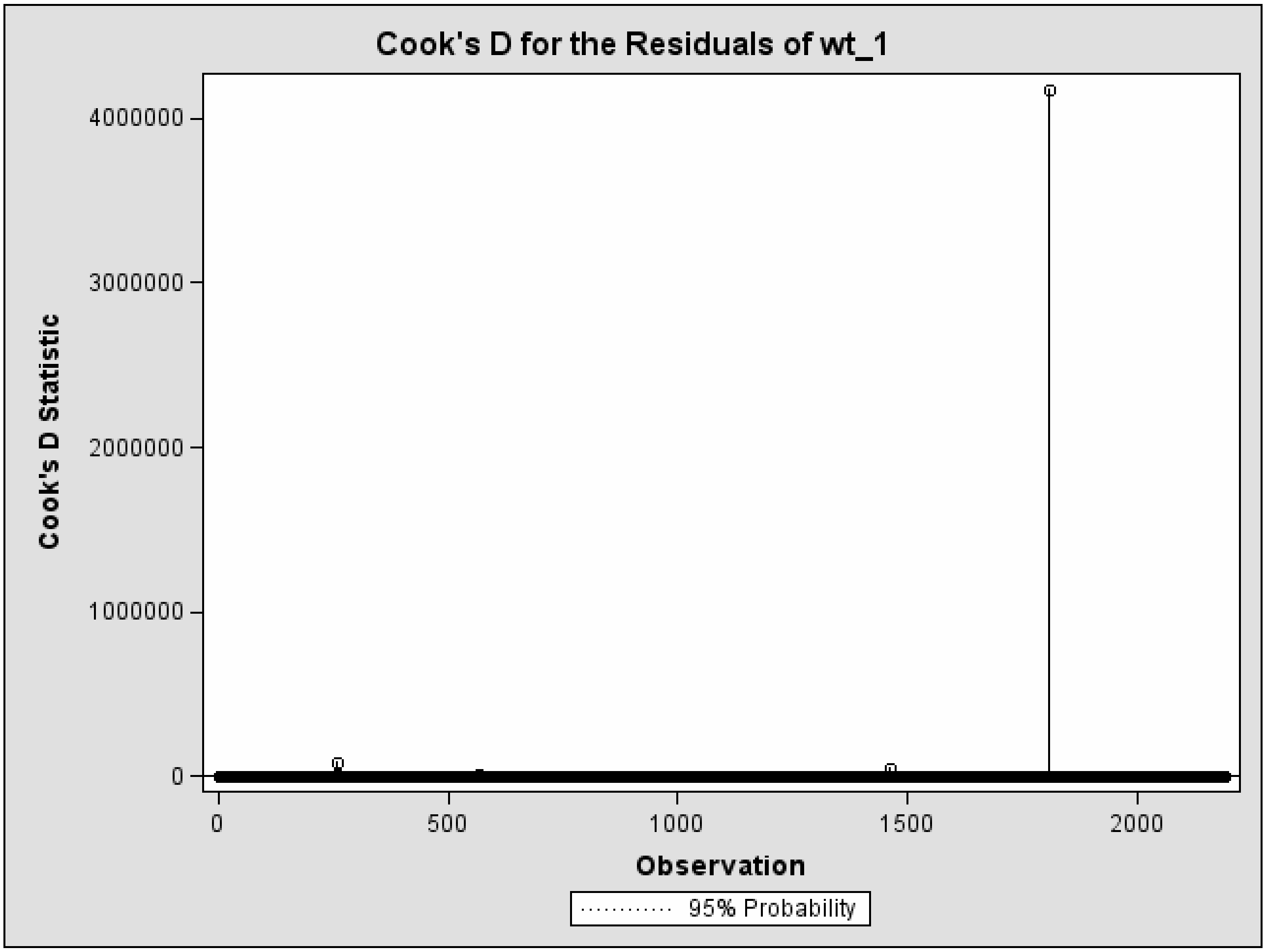
Test	Type	Statistic	Pr > ChiSq	Label
nj	Wald	207.10.	<.0001	a3, a4, a5, a6, b3, b4, b5, b6, c3, c4,
fluke nj	Wald	487.32	<.0001	a3 , a4 , a5 , a6
bait nj	Wald	473.43	<.0001	b3 , b4 , b5 , b6

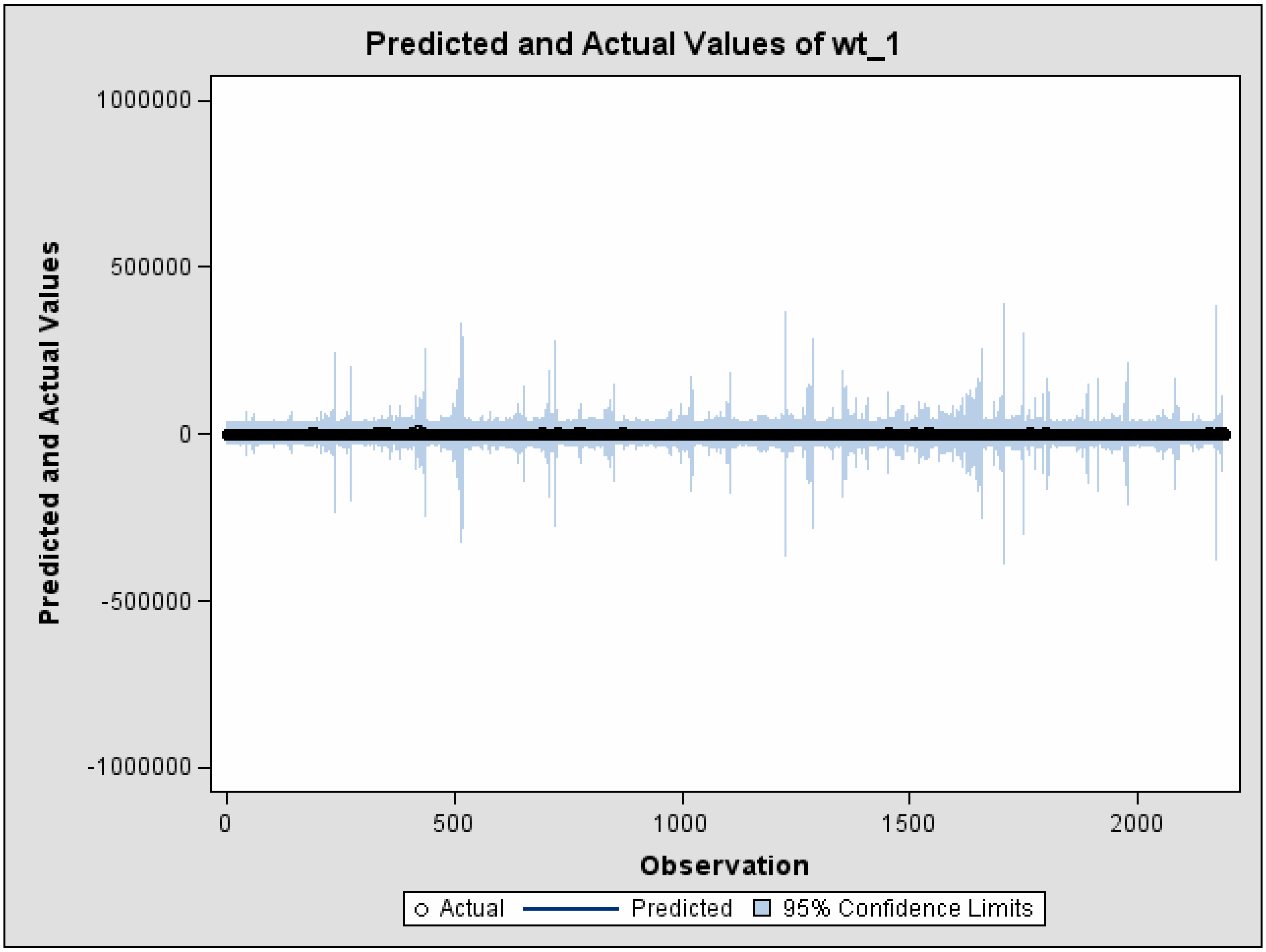
Test Results				
Test	**Type**	**Statistic**	**Pr > ChiSq**	**Label**
shell nj	Wald	15.32	0.0041	c3 , c4 , c5 , c6
bottom nj	Wald	45.88	<.0001	d3 , d4 , d5 , d6
other nj	Wald	13.56	0.0089	e3 , e4 , e5 , e6
separability	Wald	156.97	<.0001	a1 , b1 , c1 , d1 , e1

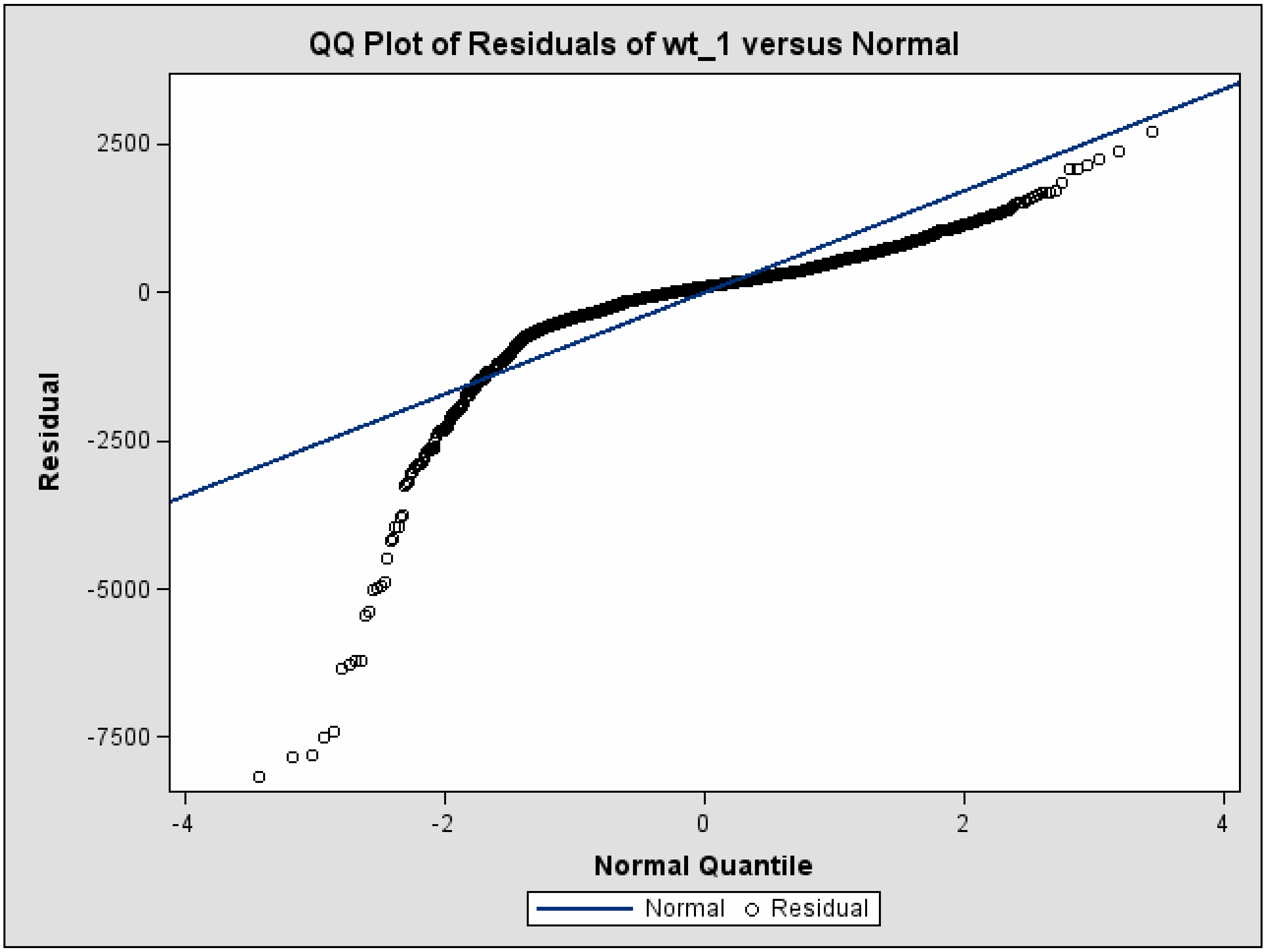
Number of Observations		Statistics for System	
Used	2189	**Log Likelihood**	-81362
Missing	0		
Sum of Weights	664670		

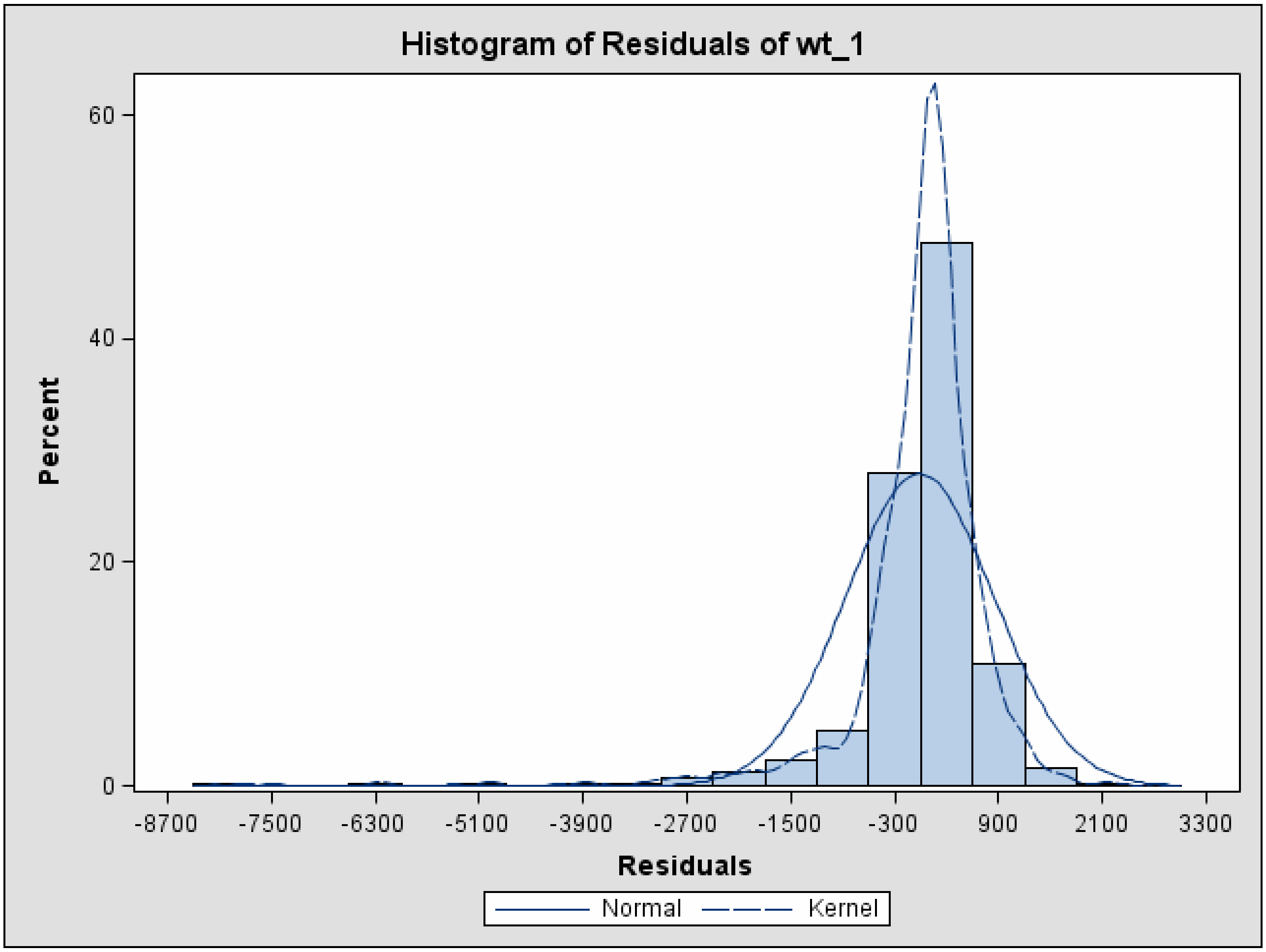
Heteroscedasticity Test					
Equation	**Test**	**Statistic**	**DF**	**Pr > ChiSq**	**Variables**
wt_1	White's Test	828.3	153	<.0001	Cross of all vars
wt_2	White's Test	2126	153	<.0001	Cross of all vars
wt_3	White's Test	126.8	153	0.9403	Cross of all vars
wt_4	White's Test	274.4	153	<.0001	Cross of all vars
wt_5	White's Test	190.7	153	0.0208	Cross of all vars

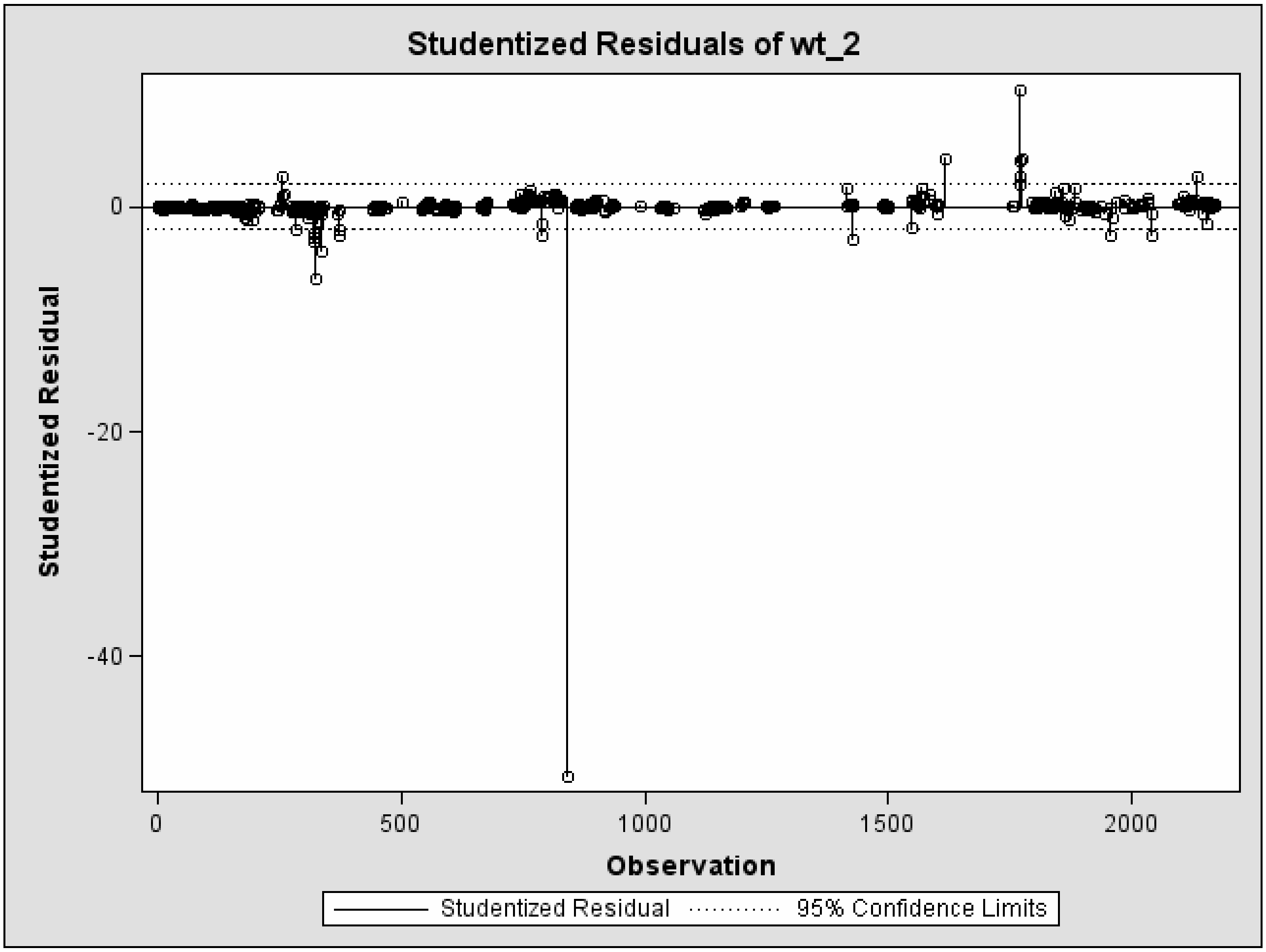

Studentized Residuals of wt_1
Studentized Residual
20
0
-20
0
500
1000
1500
2000
Observation
Studentized Residual
95% Confidence Limits

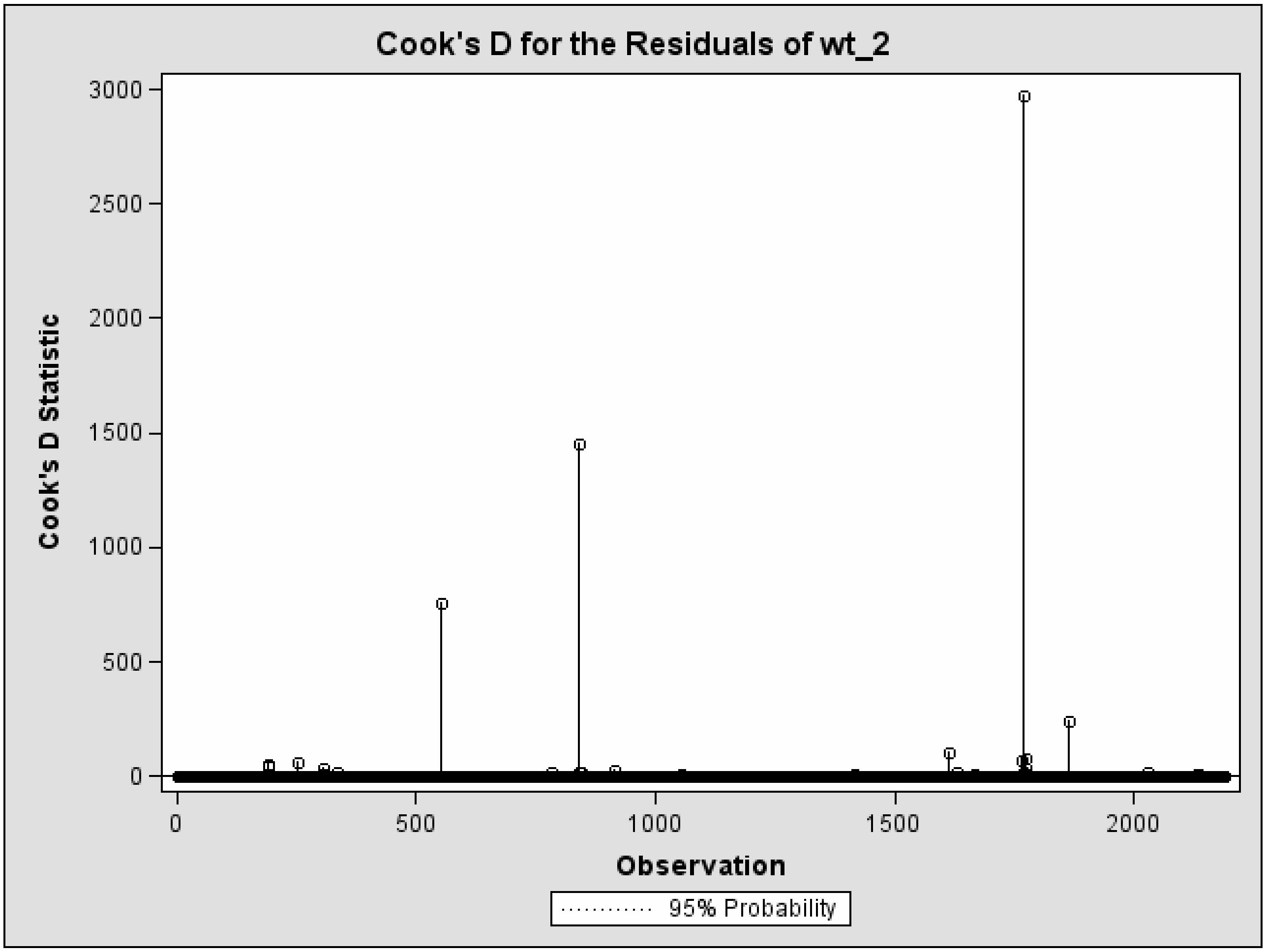

Cook's D for the Residuals of wt_1
Cook's D Statistic
4000000
3000000
2000000
1000000
0
0
500
1000
1500
2000
Observation
95% Probability

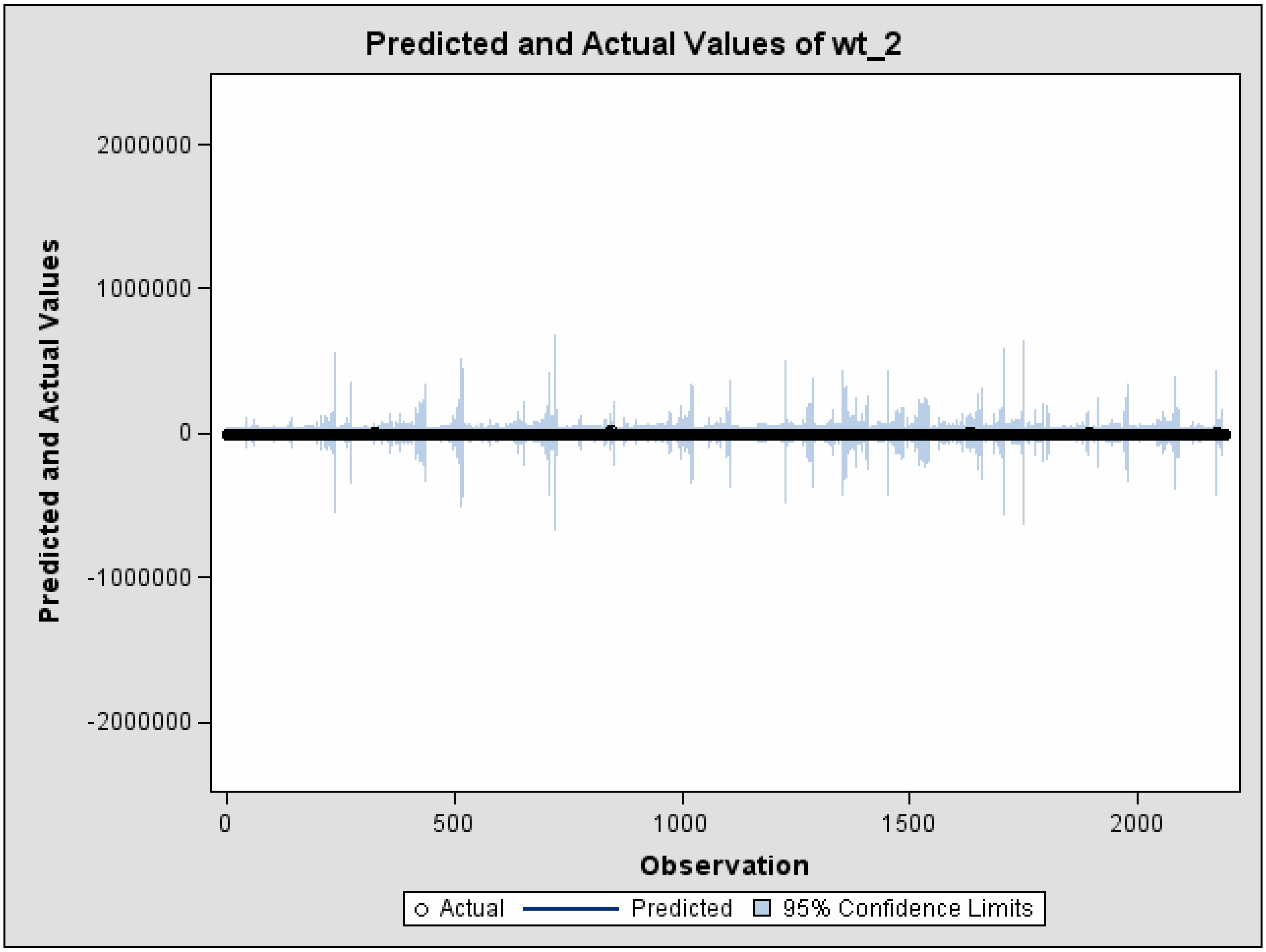

Predicted and Actual Values of wt_1
Predicted and Actual Values
1000000
500000
0
-500000
-1000000
0
500
1000
1500
2000
Observation
Actual
Predicted
95% Confidence Limits

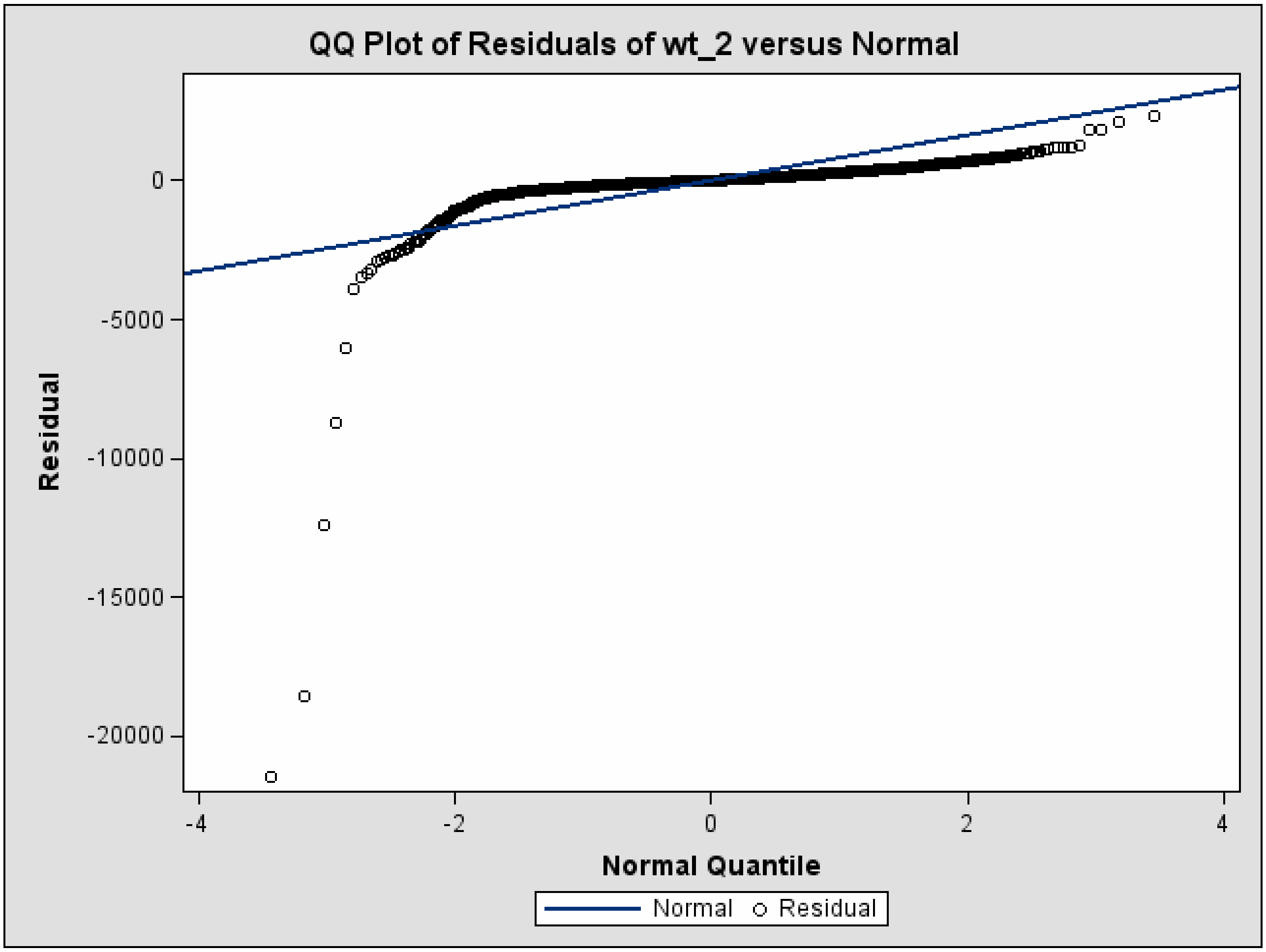

QQ Plot of Residuals of wt_1 versus Normal
Residual
2500
0
-2500
-5000
-7500
-4
-2
0
2
4
Normal Quantile
Normal
Residual

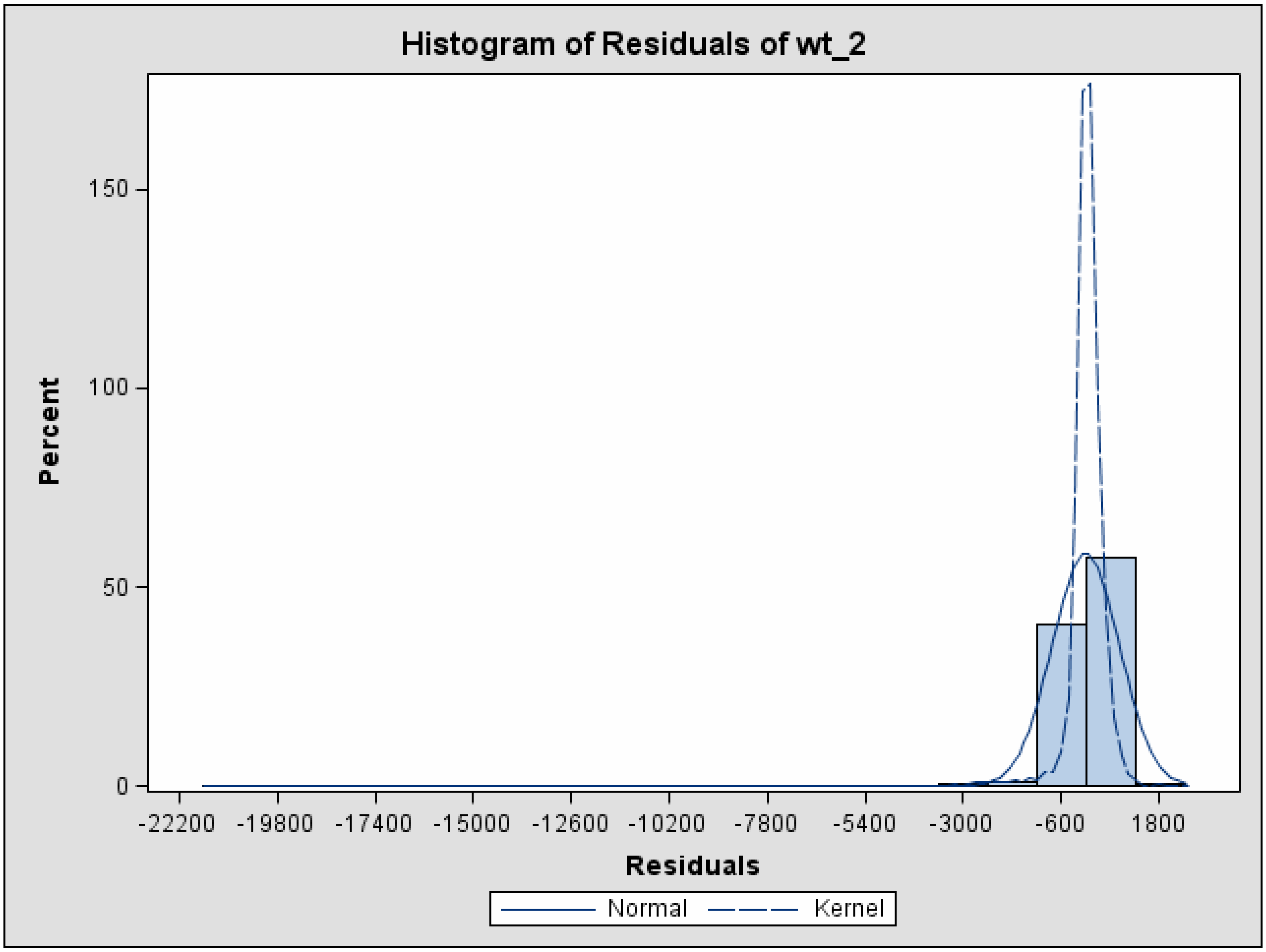

Histogram of Residuals of wt_1
Percent
60
40
20
0
-8700
-7500
-6300
-5100
-3900
-2700
-1500
-300
900
2100
3300
Residuals
Normal
Kernel

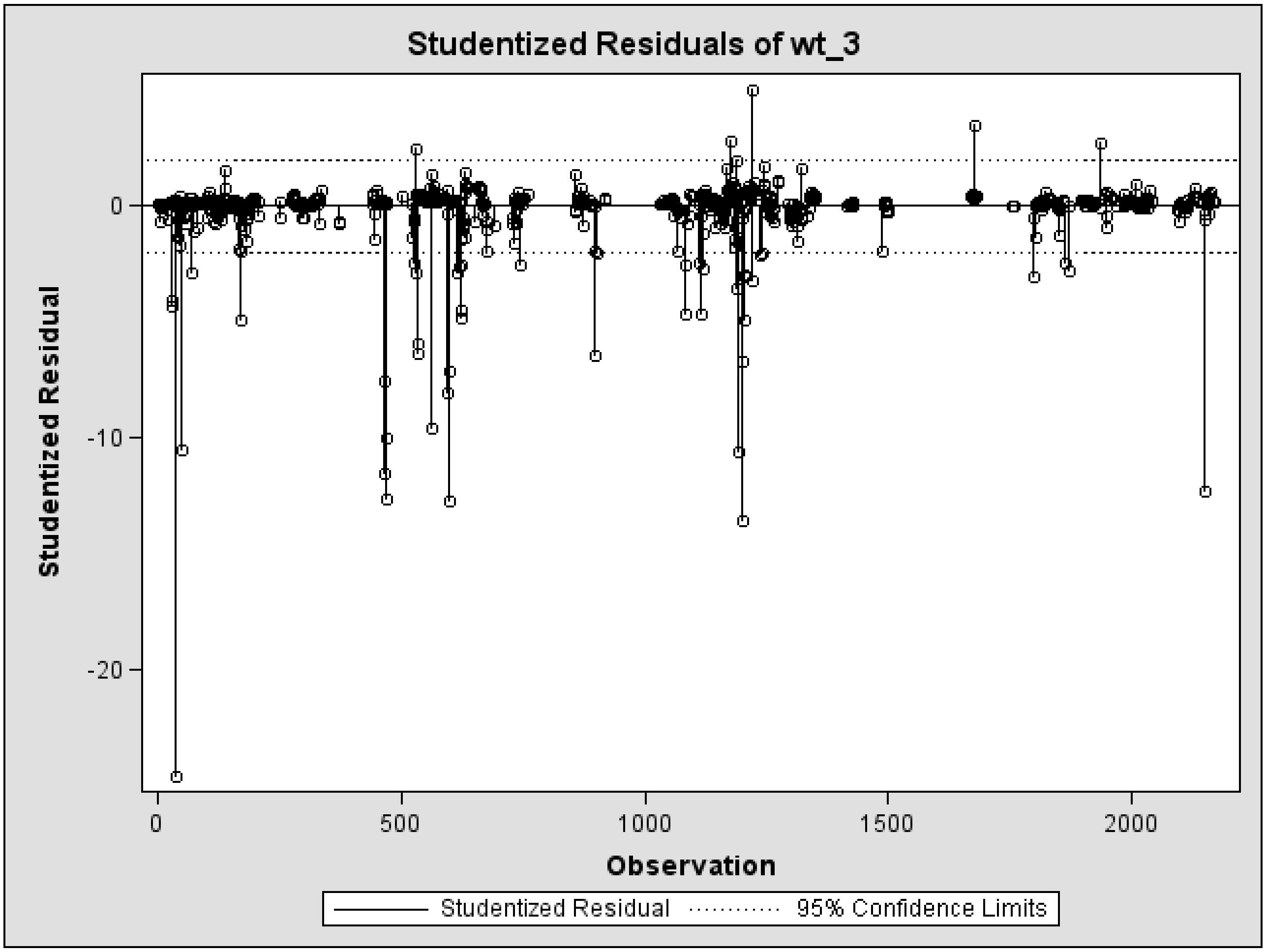

Studentized Residuals of wt_2
Studentized Residual
0
-20
-40
0
500
1000
1500
2000
Observation
Studentized Residual
95% Confidence Limits

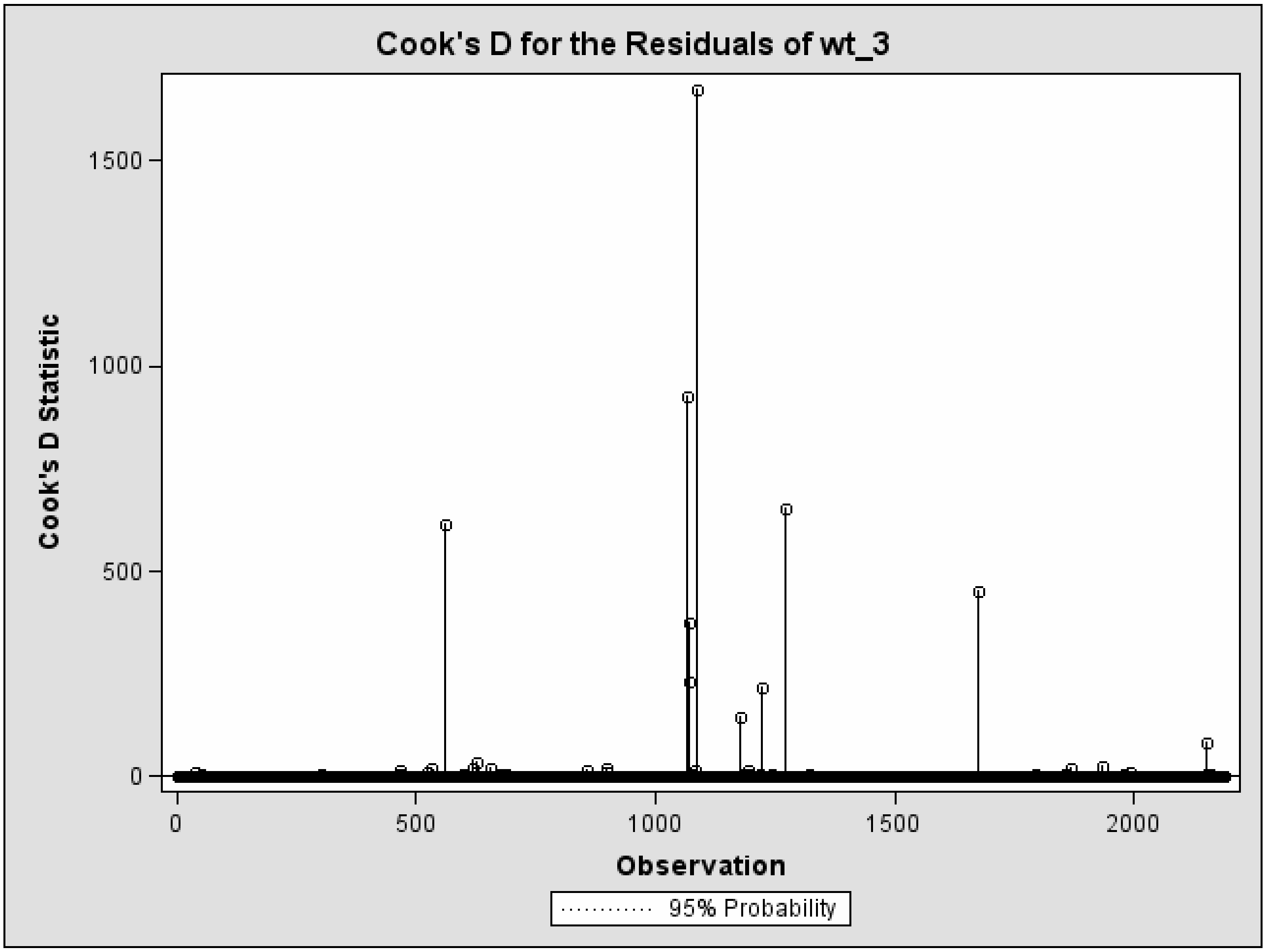

Cook's D for the Residuals of wt_2
Cook's D Statistic
3000
2500
2000
1500
1000
500
0
0
500
1000
1500
2000
Observation
95% Probability

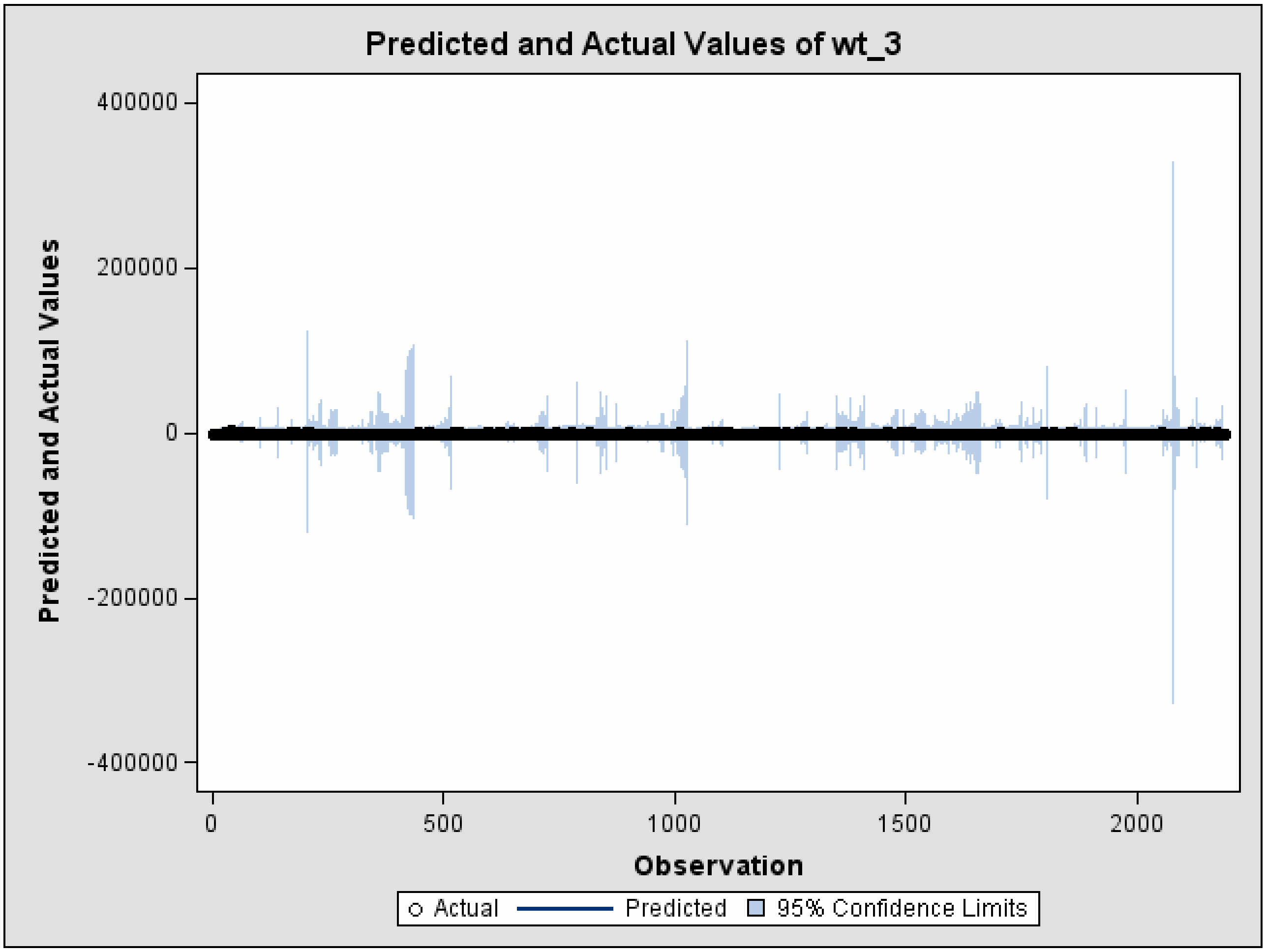

Predicted and Actual Values of wt_2
Predicted and Actual Values
2000000
1000000
0
-1000000
-2000000
0
500
1000
1500
2000
Observation
○ Actual
Predicted
95% Confidence Limits

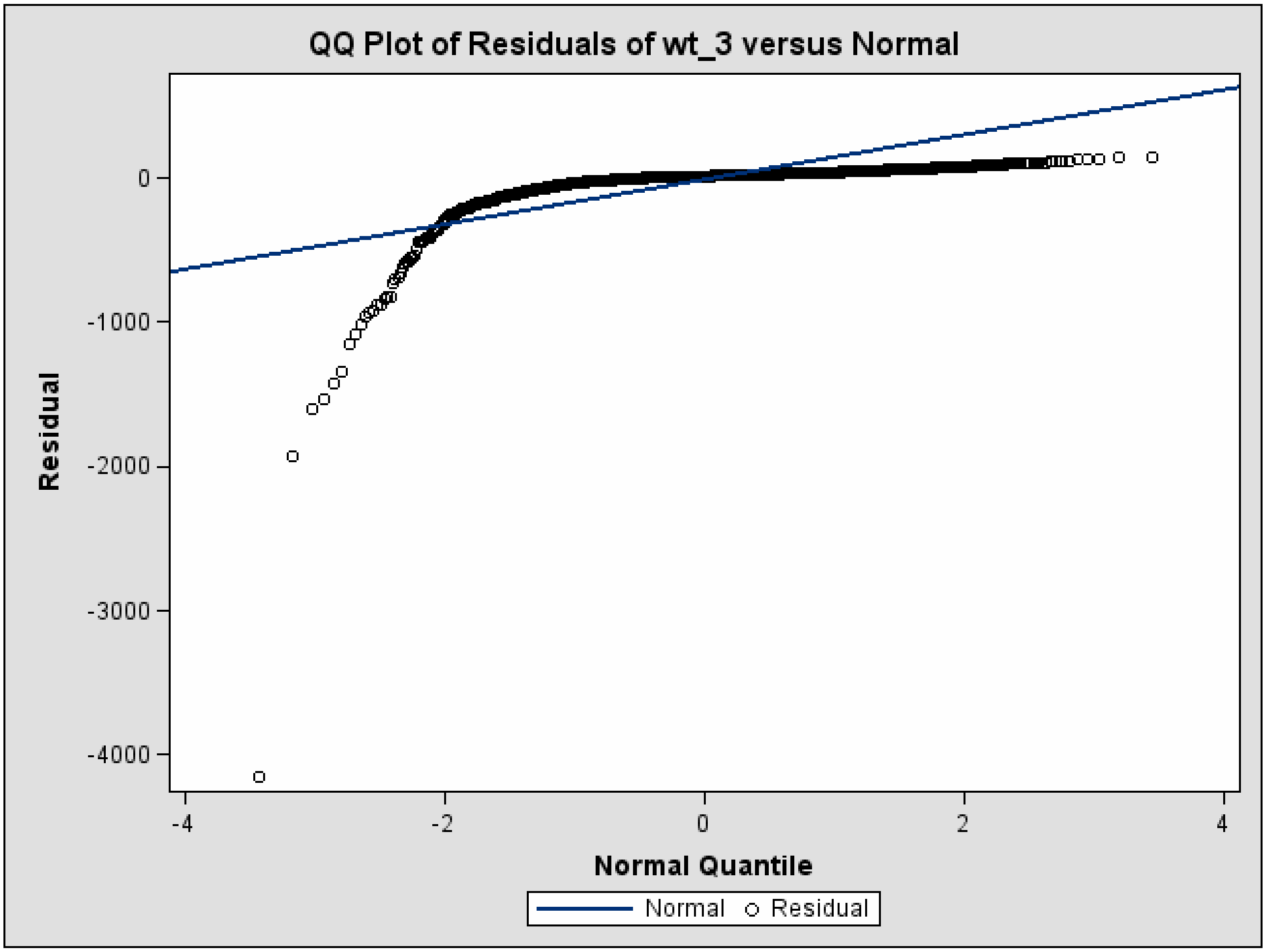

QQ Plot of Residuals of wt_2 versus Normal
Residual
0
-5000
-10000
-15000
-20000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

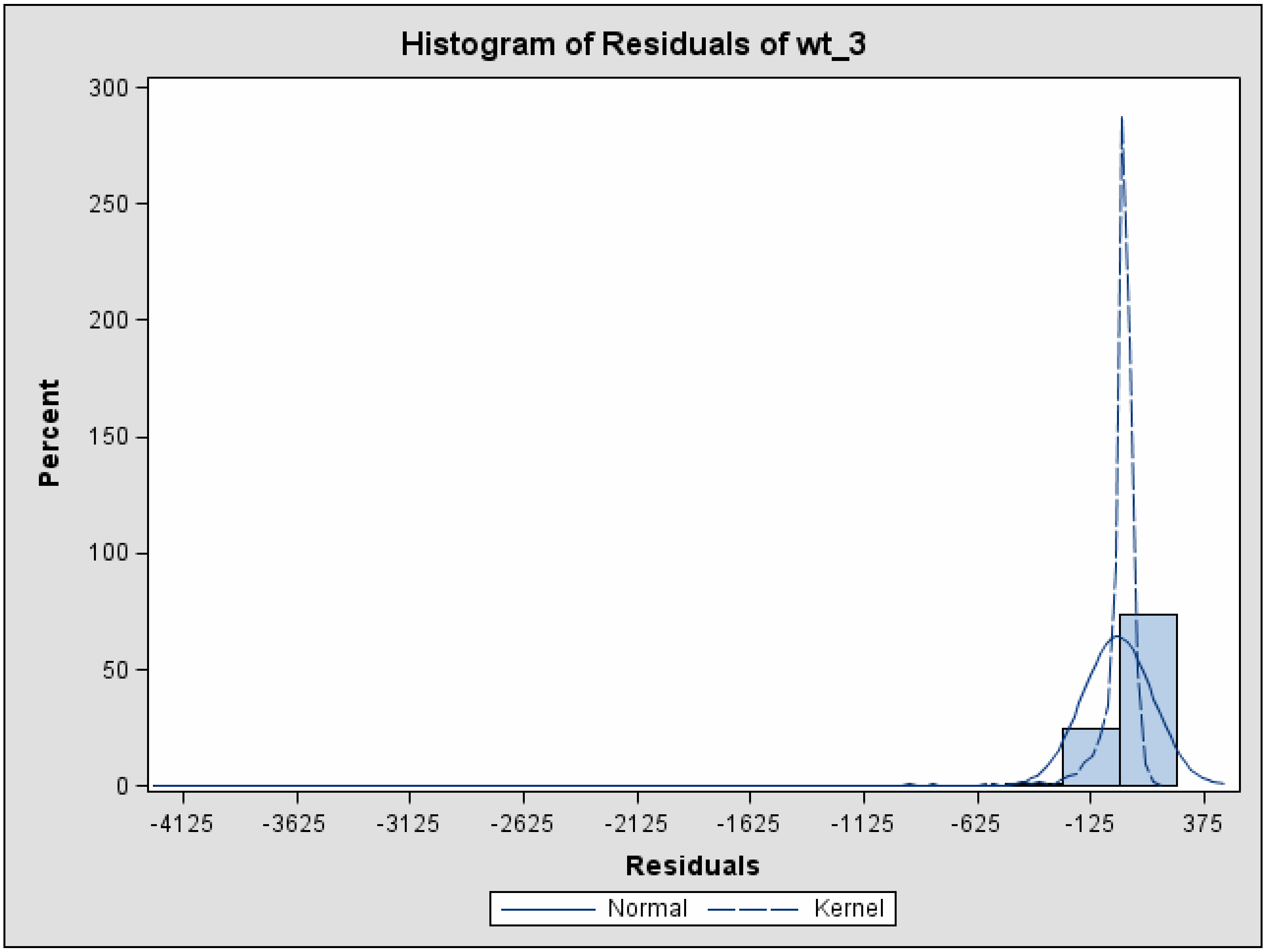

Histogram of Residuals of wt_2
Percent
150
100
50
0
-22200
-19800
-17400
-15000
-12600
-10200
-7800
-5400
-3000
-600
1800
Residuals
Normal
Kernel

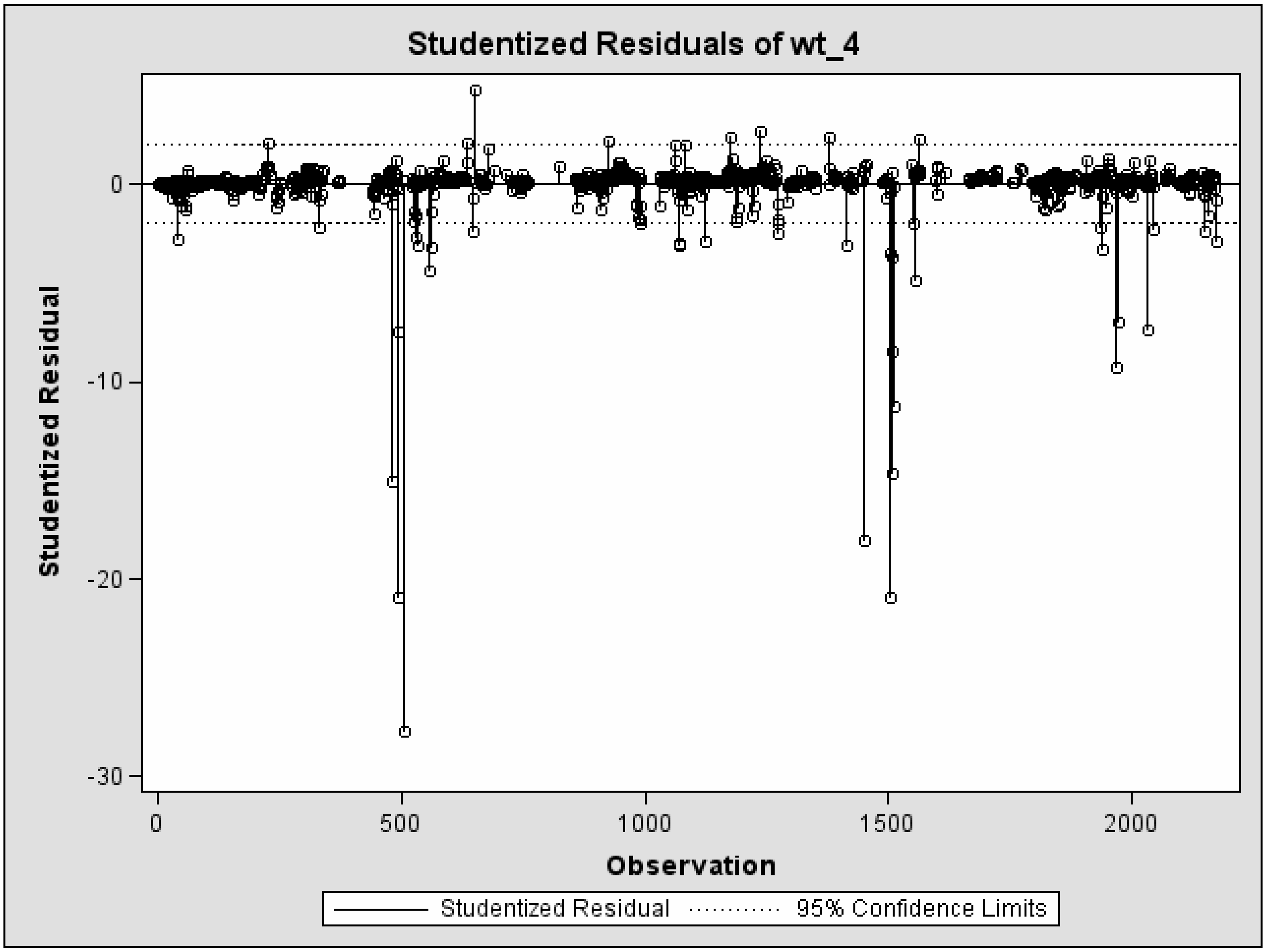

Studentized Residuals of wt_3
Studentized Residual
0
-10
-20
0
500
1000
1500
2000
Observation
Studentized Residual
95% Confidence Limits

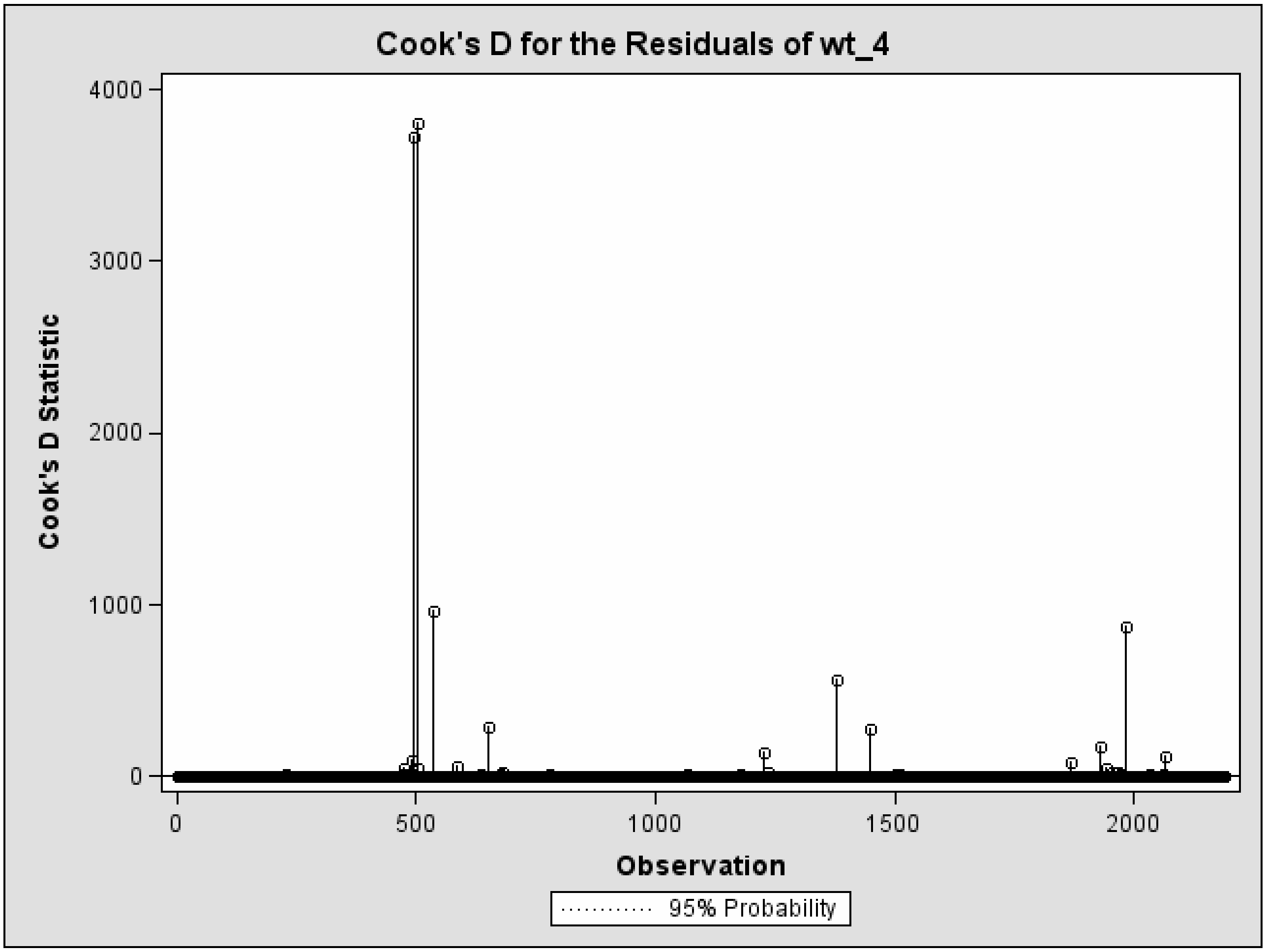

Cook's D for the Residuals of wt_3
Cook's D Statistic
1500
1000
500
0
0
500
1000
1500
2000
Observation
95% Probability

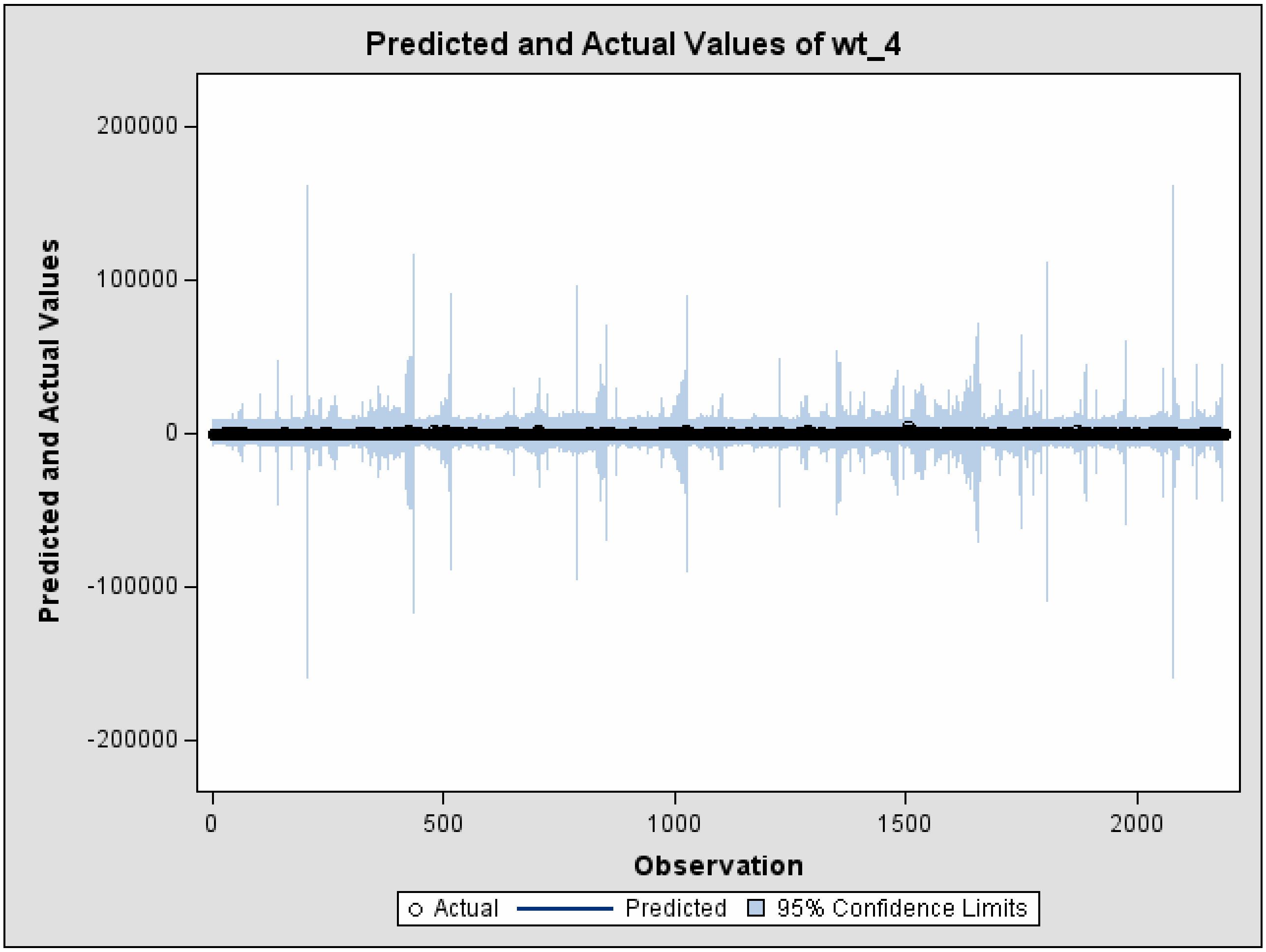

Predicted and Actual Values of wt_3
Predicted and Actual Values
400000
200000
0
-200000
-400000
0
500
1000
1500
2000
Observation
○ Actual
Predicted
95% Confidence Limits

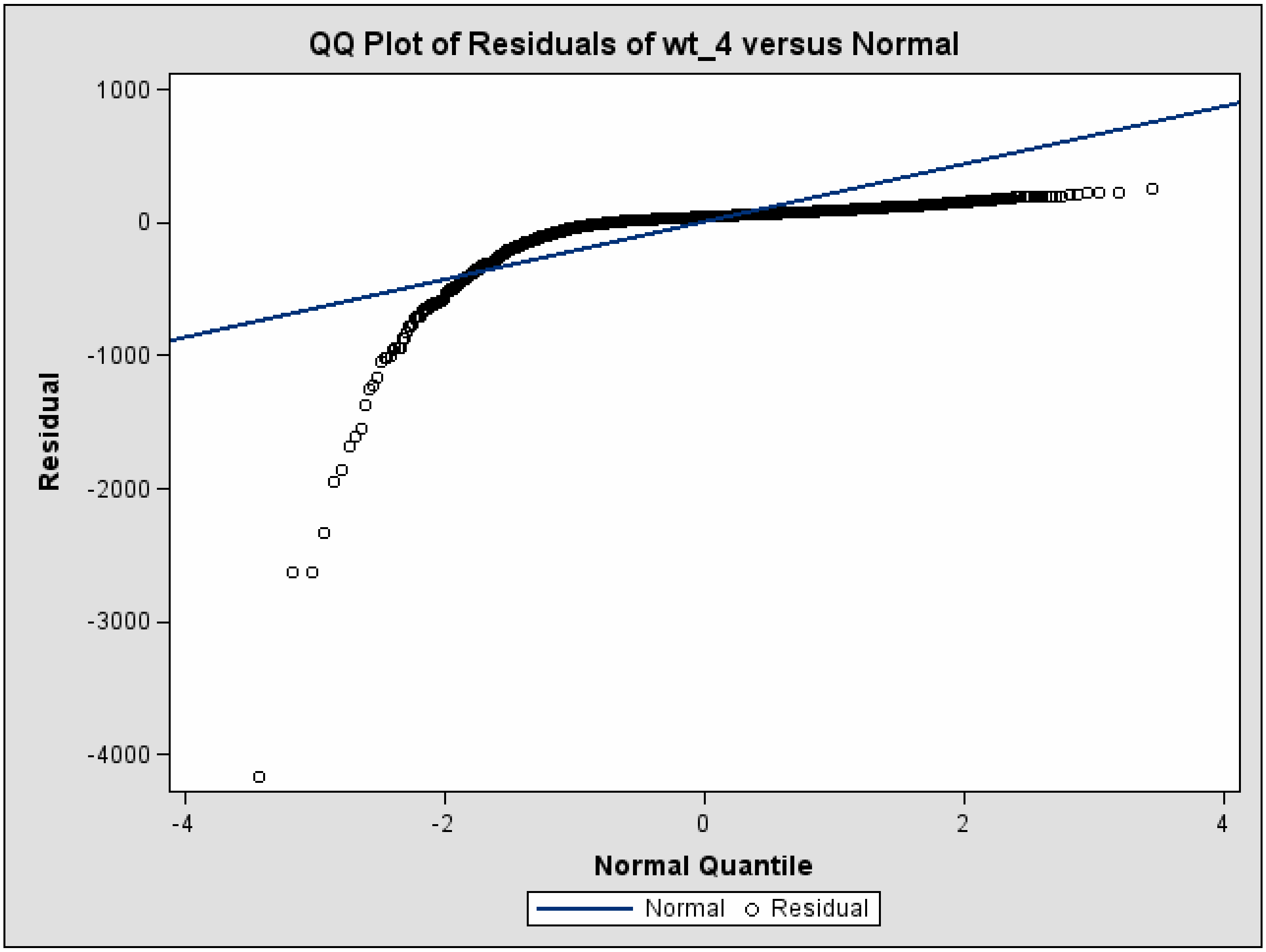

QQ Plot of Residuals of wt_3 versus Normal
Residual
0
-1000
-2000
-3000
-4000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

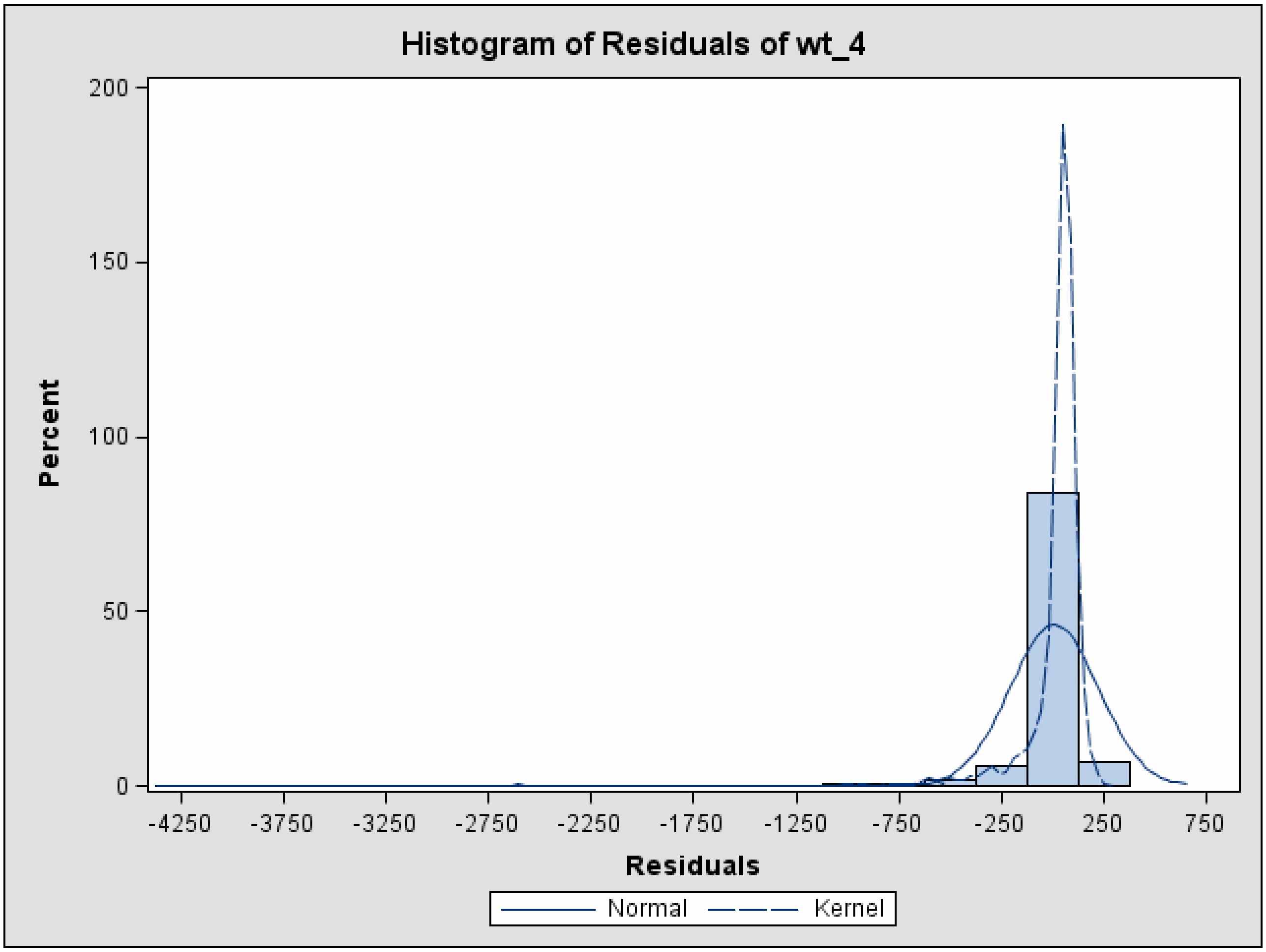

Histogram of Residuals of wt_3
Percent
300
250
200
150
100
50
0
-4125
-3625
-3125
-2625
-2125
-1625
-1125
-625
-125
375
Residuals
Normal
Kernel

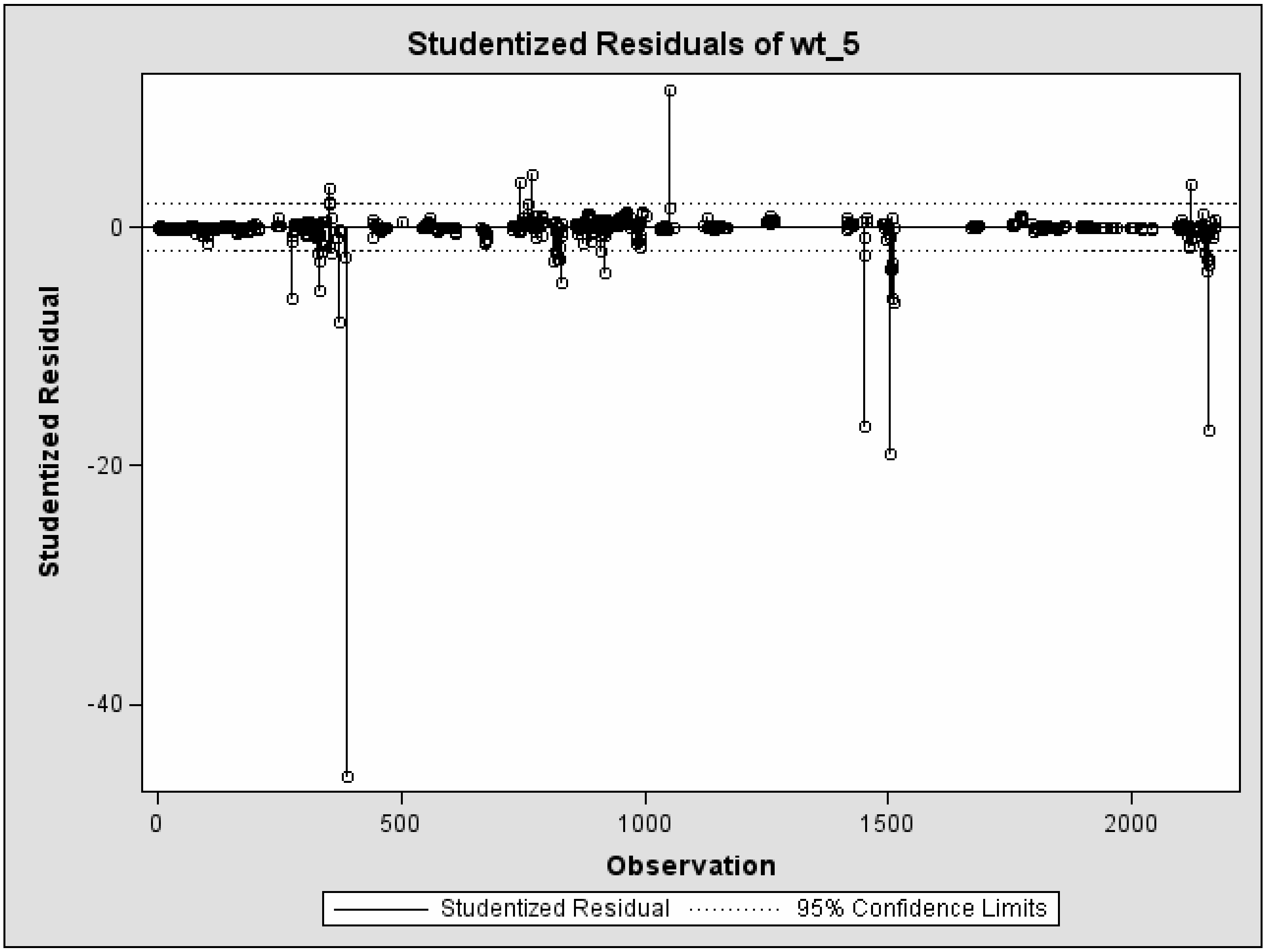

Studentized Residuals of wt_4
Studentized Residual
0
-10
-20
-30
0
500
1000
1500
2000
Observation
Studentized Residual
95% Confidence Limits

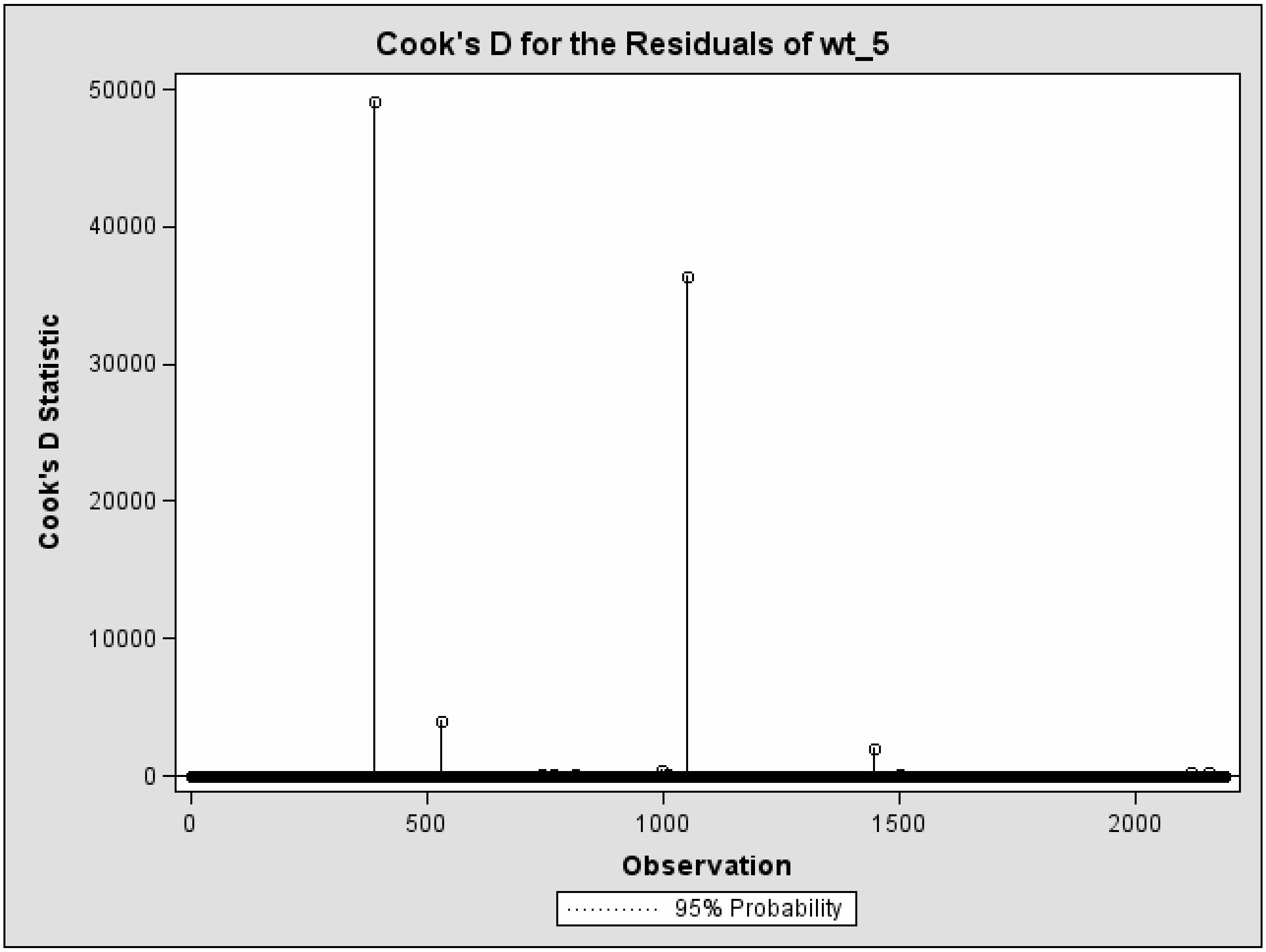

Cook's D for the Residuals of wt_4
Cook's D Statistic
4000
3000
2000
1000
0
0
500
1000
1500
2000
Observation
95% Probability

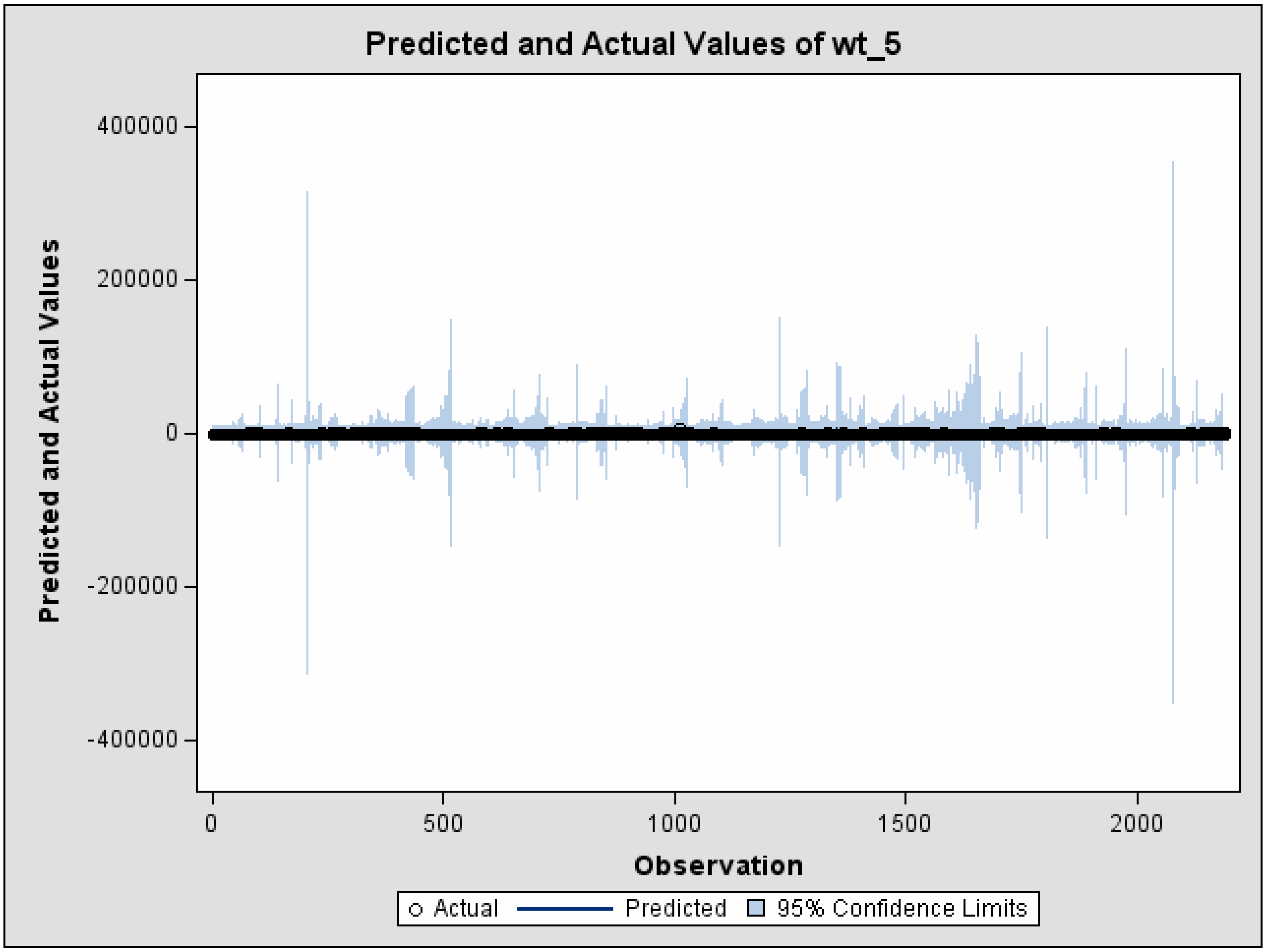

Predicted and Actual Values of wt_4
Predicted and Actual Values
200000
100000
0
-100000
-200000
0
500
1000
1500
2000
Observation
○ Actual
Predicted
95% Confidence Limits

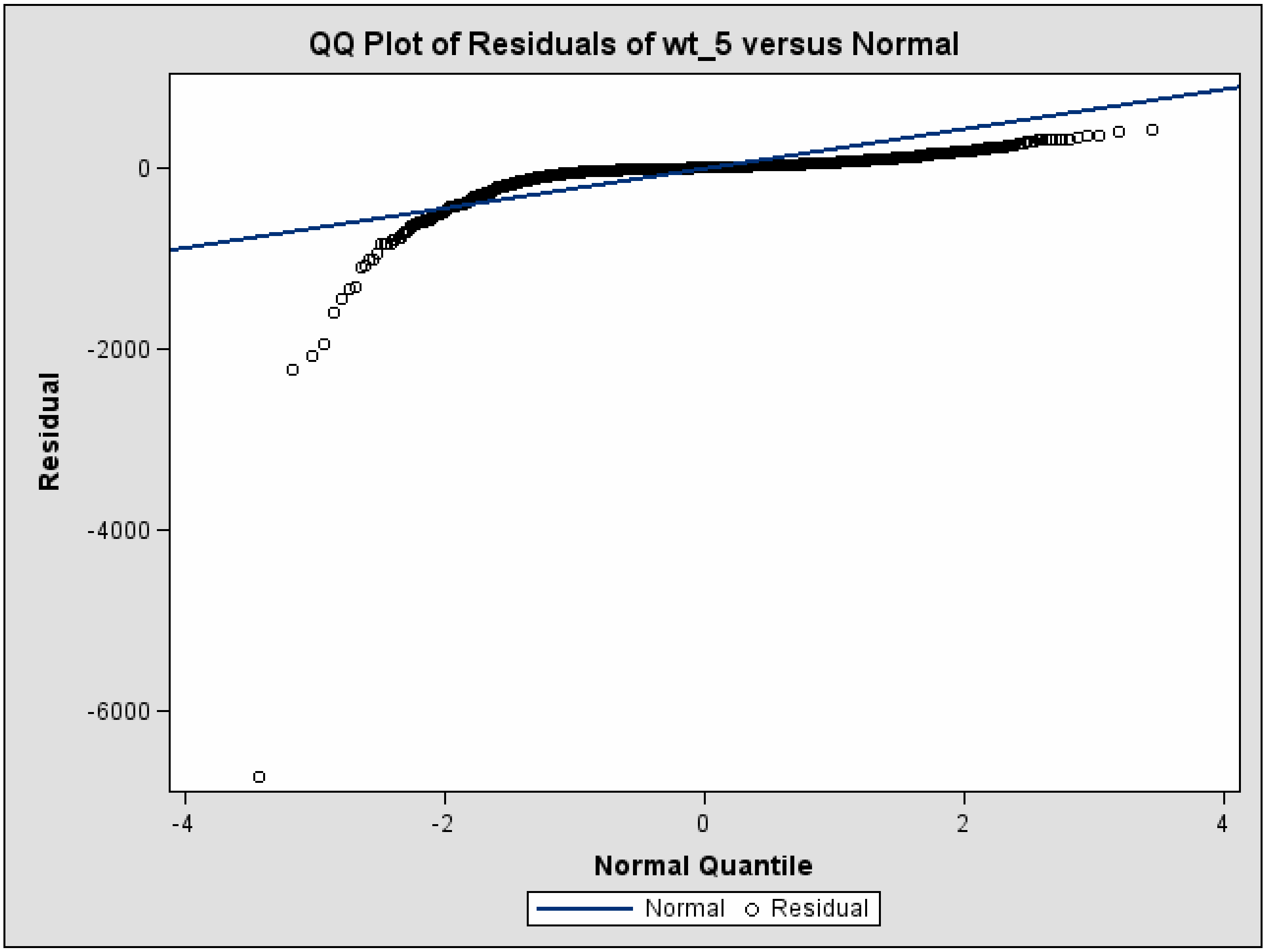

QQ Plot of Residuals of wt_4 versus Normal
1000
0
-1000
-2000
-3000
-4000
Residual
-4
-2
0
2
4
Normal Quantile
Normal
Residual

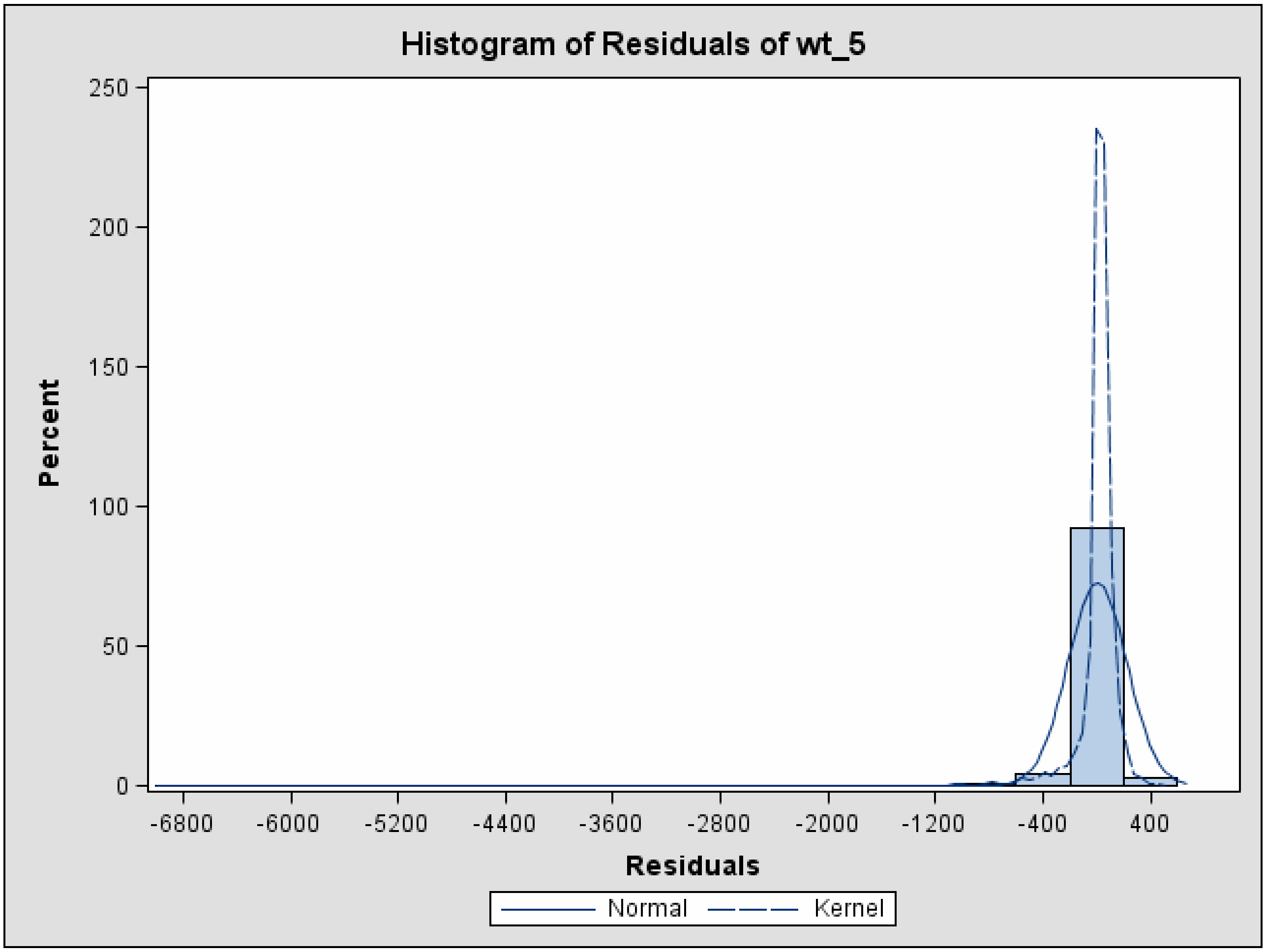

Histogram of Residuals of wt_4
Percent
200
150
100
50
0
-4250
-3750
-3250
-2750
-2250
-1750
-1250
-750
-250
250
750
Residuals
Normal
Kernel


Studentized Residuals of wt_5
Studentized Residual
0
-20
-40
0
500
1000
1500
2000
Observation
Studentized Residual
95% Confidence Limits


Cook's D for the Residuals of wt_5
Cook's D Statistic
50000
40000
30000
20000
10000
0
0
500
1000
1500
2000
Observation
95% Probability


Predicted and Actual Values of wt_5
Predicted and Actual Values
400000
200000
0
-200000
-400000
0
500
1000
1500
2000
Observation
○ Actual
Predicted
95% Confidence Limits


QQ Plot of Residuals of wt_5 versus Normal
Residual
0
-2000
-4000
-6000
-4
-2
0
2
4
Normal Quantile
Normal
Residual

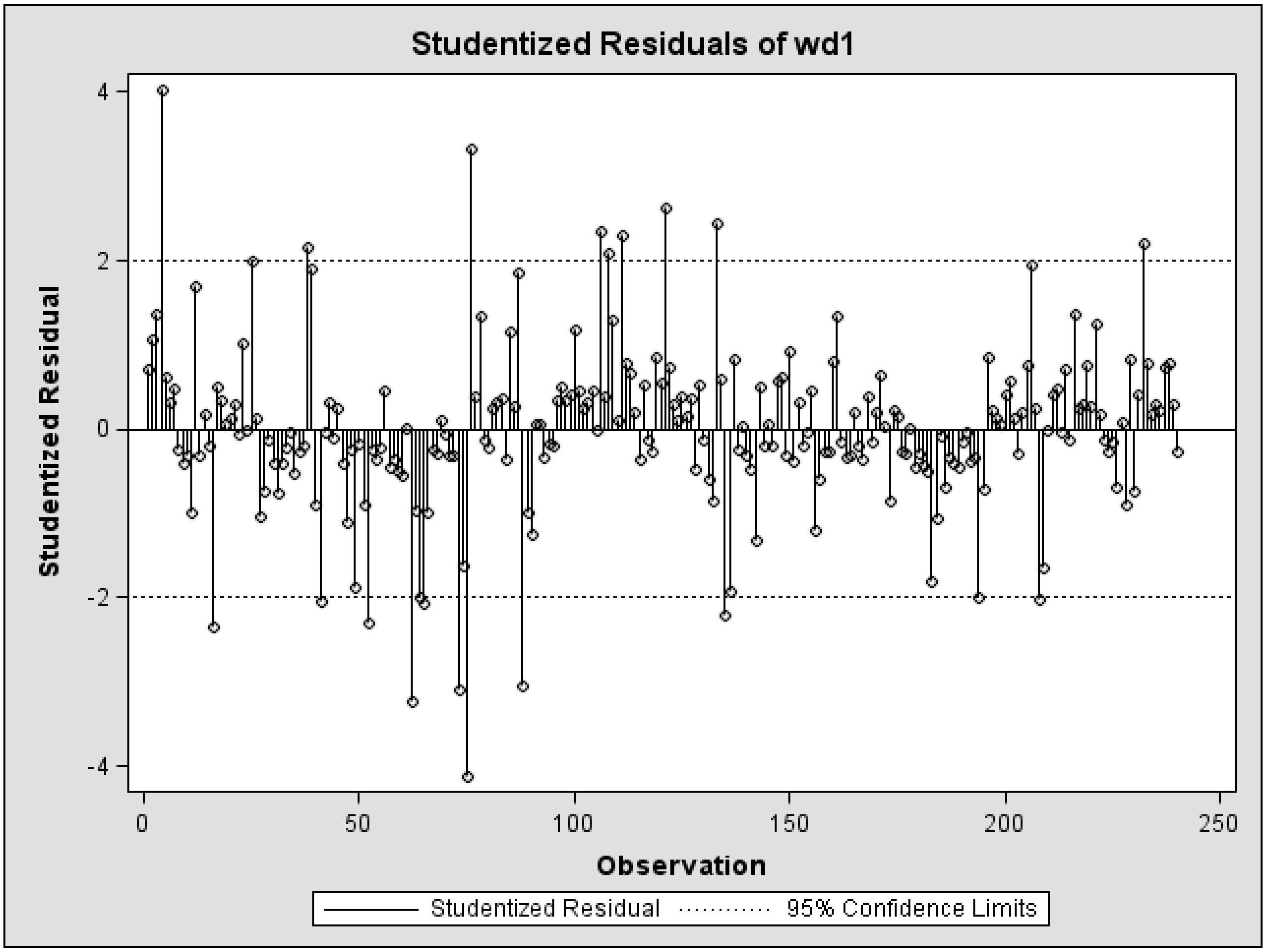

Histogram of Residuals of wt_5
Percent
250
200
150
100
50
0
-6800
-6000
-5200
-4400
-3600
-2800
-2000
-1200
-400
400
Residuals
Normal
Kernel

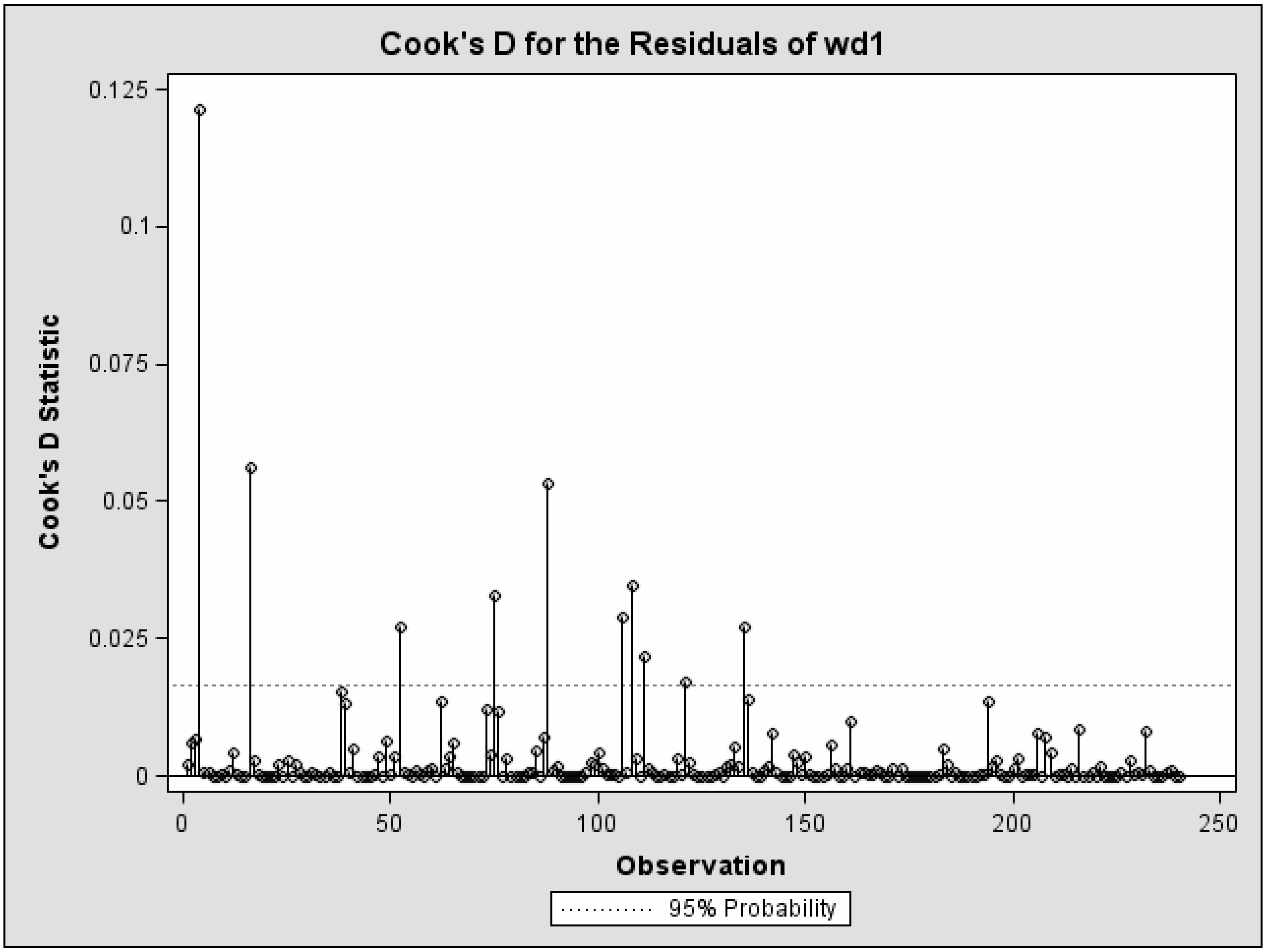
Appendix 6: Consumer Demand Modeling Results

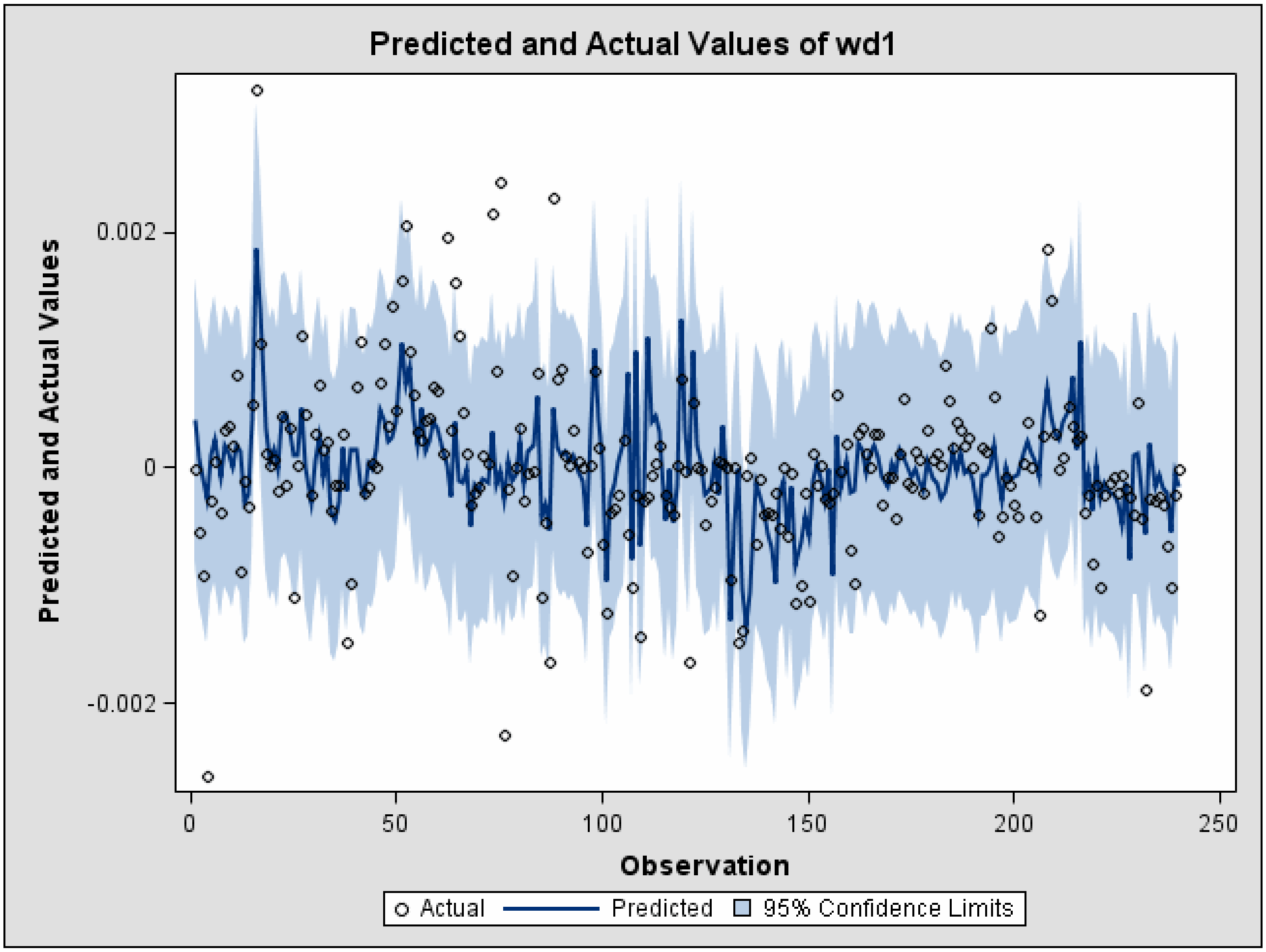
Nonlinear FIML Summary of Residual Errors							
Equation	**DF Model**	**DF Error**	**SSE**	**MSE**	**Root MSE**	**R-Square**	**Adj R-Sq**
wd1	5	235	0.000085	3.625E-7	0.000602	0.3258	0.3143
wd2	5	235	0.000083	3.529E-7	0.000594	0.8749	0.8728
wd3	5	235	0.0179	0.000076	0.00873	0.3330	0.3217
wd4	5	235	0.3096	0.00132	0.0363	0.7831	0.7794

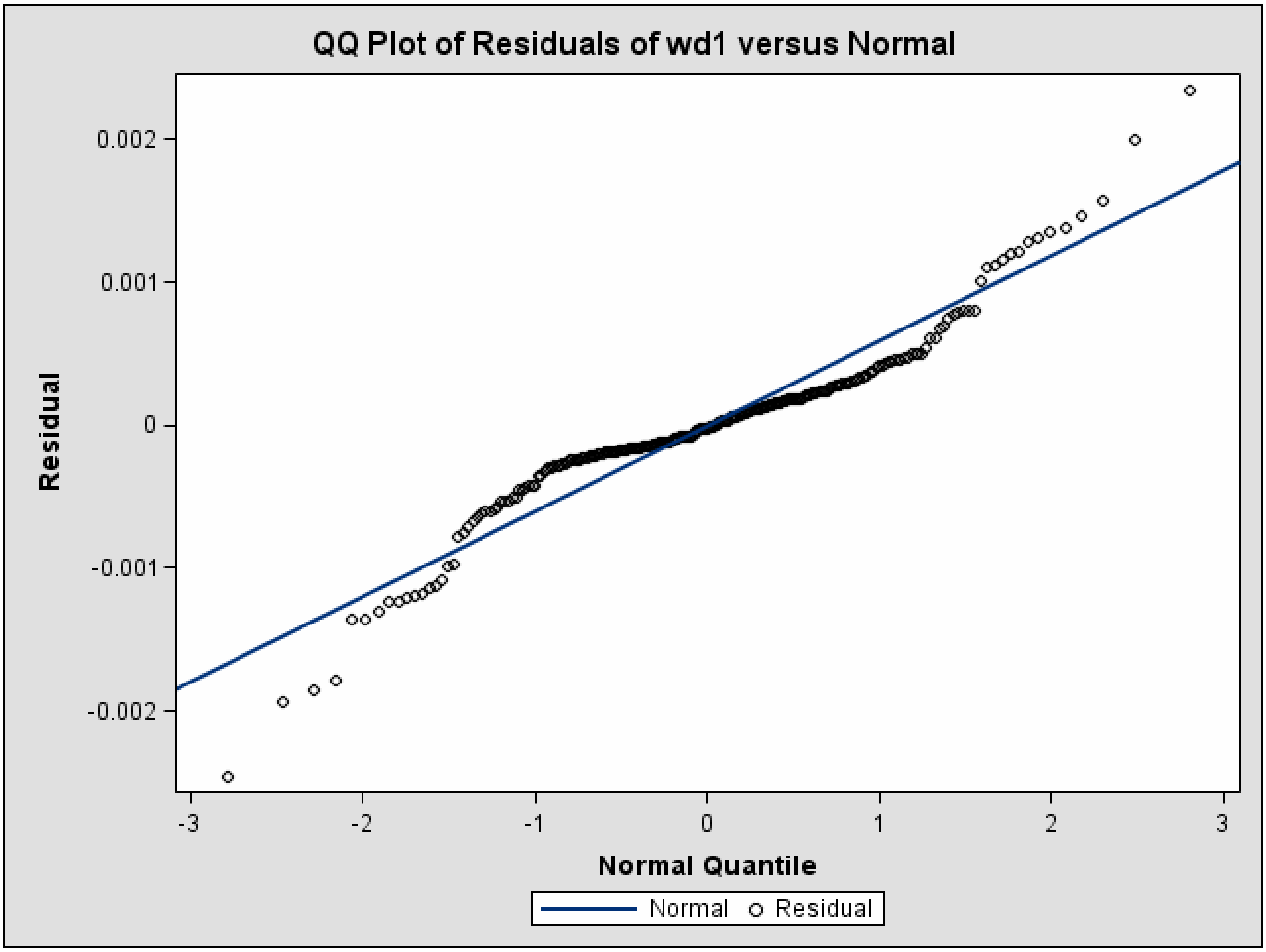
Nonlinear FIML Parameter Estimates				
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**
gb11	-0.00045	0.000039	-11.43	<.0001
gb12	-7.01E-6	0.000046	-0.15	0.8790
gb13	0.000313	0.000099	3.16	0.0018
gb14	0.000145	0.000108	1.34	0.1809
gb22	-0.00154	0.000041	-37.51	<.0001
gb23	8.781E-6	0.000131	0.07	0.9466
gb24	0.001541	0.000136	11.30	<.0001
gb33	0.005671	0.00145	3.90	0.0001
gb34	-0.00599	0.00144	-4.15	<.0001
gb44	0.004307	0.00145	2.97	0.0032
ab	-5.99E-6	0.000044	-0.13	0.8930
gb15	-0.00001	0.000356	-0.03	0.9757
bb	0.00034	0.000598	0.57	0.5697
O1	0.92844	0.0747	12.43	<.0001
ap	-1.59E-6	0.000041	-0.04	0.9692

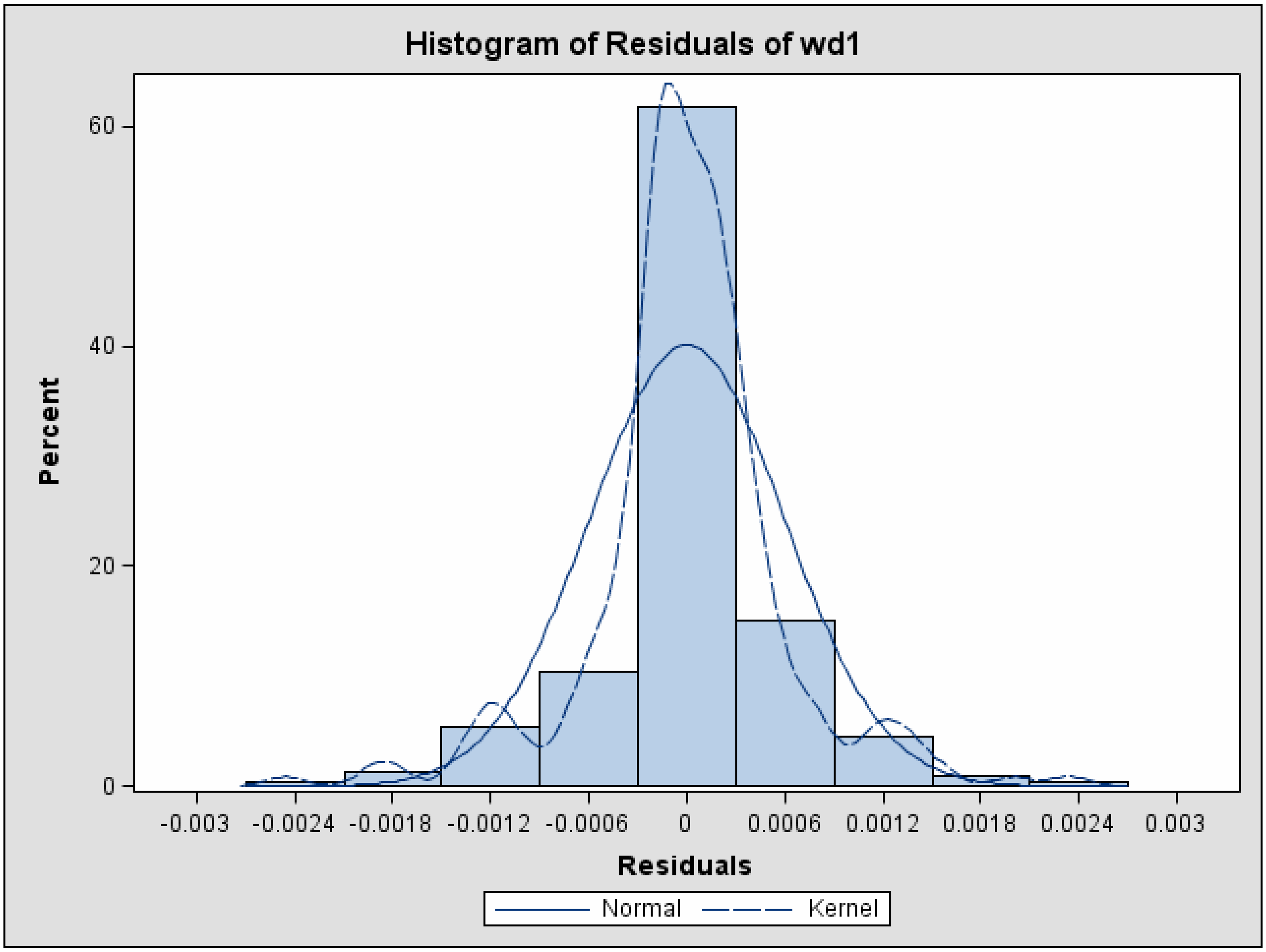
Nonlinear FIML Parameter Estimates				
Parameter	**Estimate**	**Approx Std Err**	**t Value**	**Approx Pr > |t|**
gb25	0.001309	0.000414	3.16	0.0018
bp	-0.00171	0.000572	-2.99	0.0031
af	0.001131	0.000605	1.87	0.0628
gb35	-0.02632	0.00549	-4.80	<.0001
bf	0.027469	0.0106	2.58	0.0104
as	-0.00797	0.00255	-3.12	0.0020
gb45	0.265256	0.0210	12.63	<.0001
bs	-0.32643	0.0449	-7.28	<.0001
O2	0.029993	0.00821	3.65	0.0003
Restrict0	1812.132	1544.5	1.17	0.2415
Restrict1	5707.713	1464.5	3.90	<.0001
Restrict2	-386.91	153.2	-2.53	0.0113
Restrict3	153.5198	34.8236	4.41	<.0001

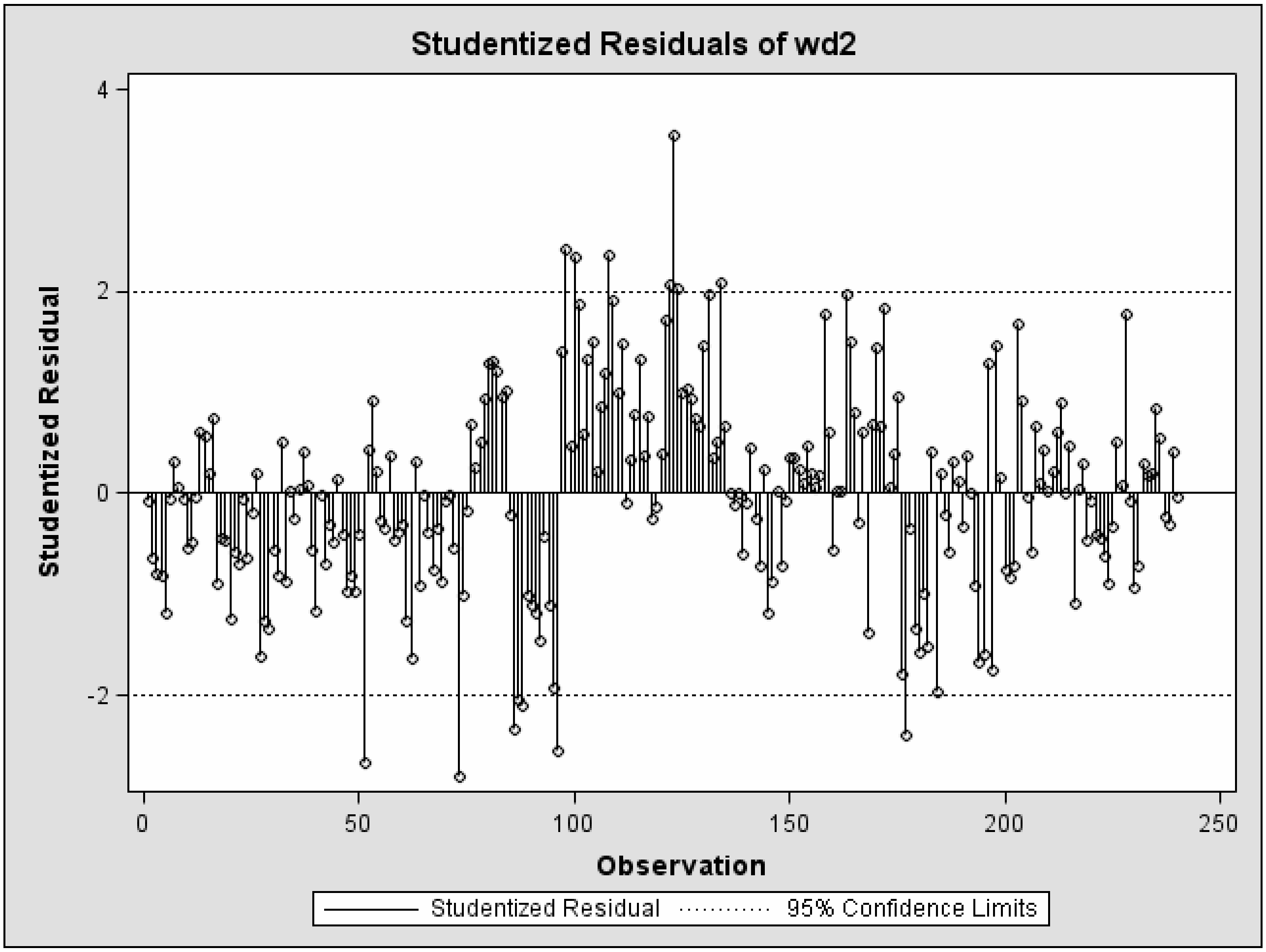

Studentized Residuals of wd1
Studentized Residual
4
2
0
-2
-4
0
50
100
150
200
250
Observation
Studentized Residual
95% Confidence Limits

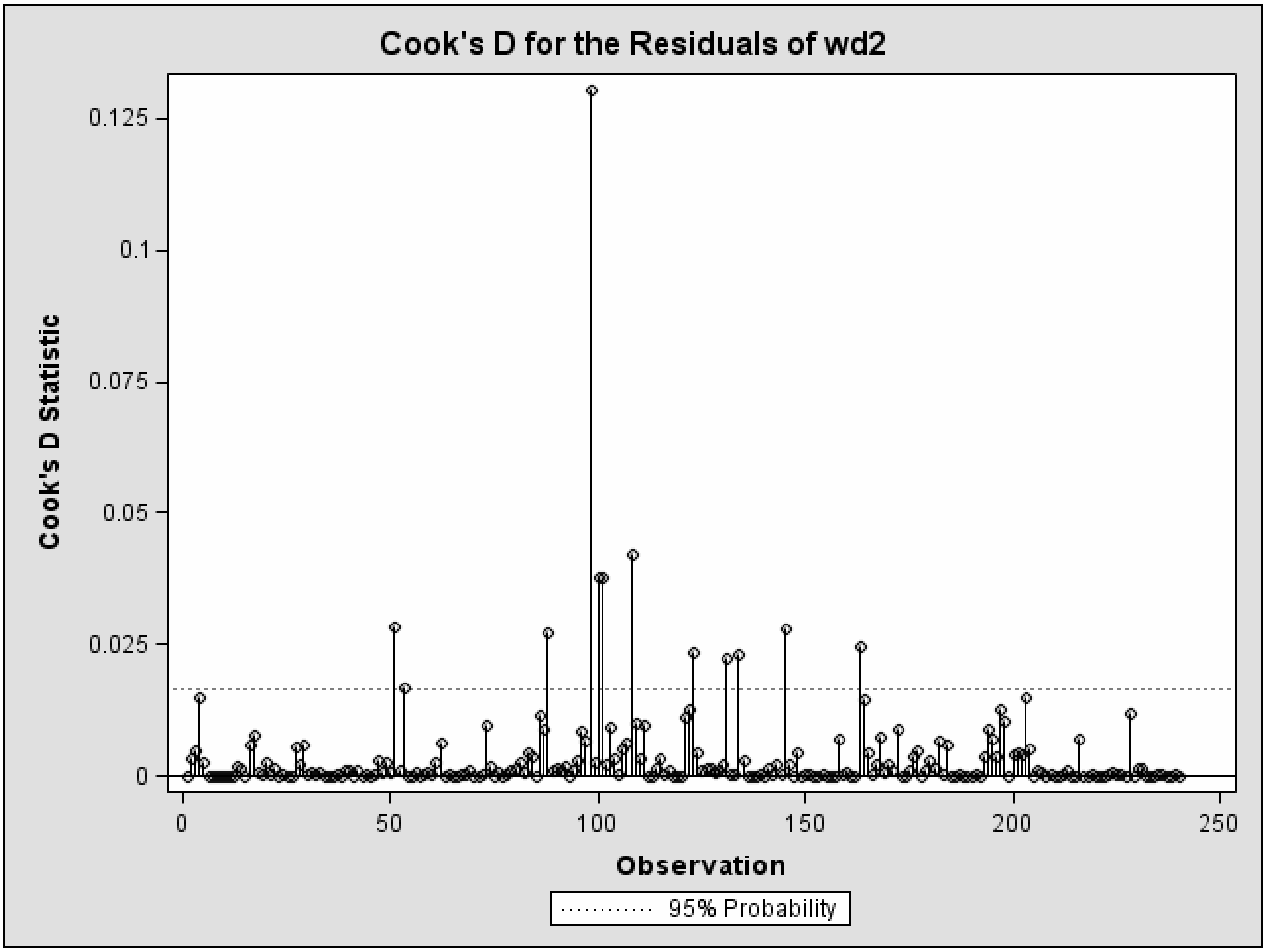

Cook's D for the Residuals of wd1
Cook's D Statistic
0.125
0.1
0.075
0.05
0.025
0
Observation
0
50
100
150
200
250
95% Probability

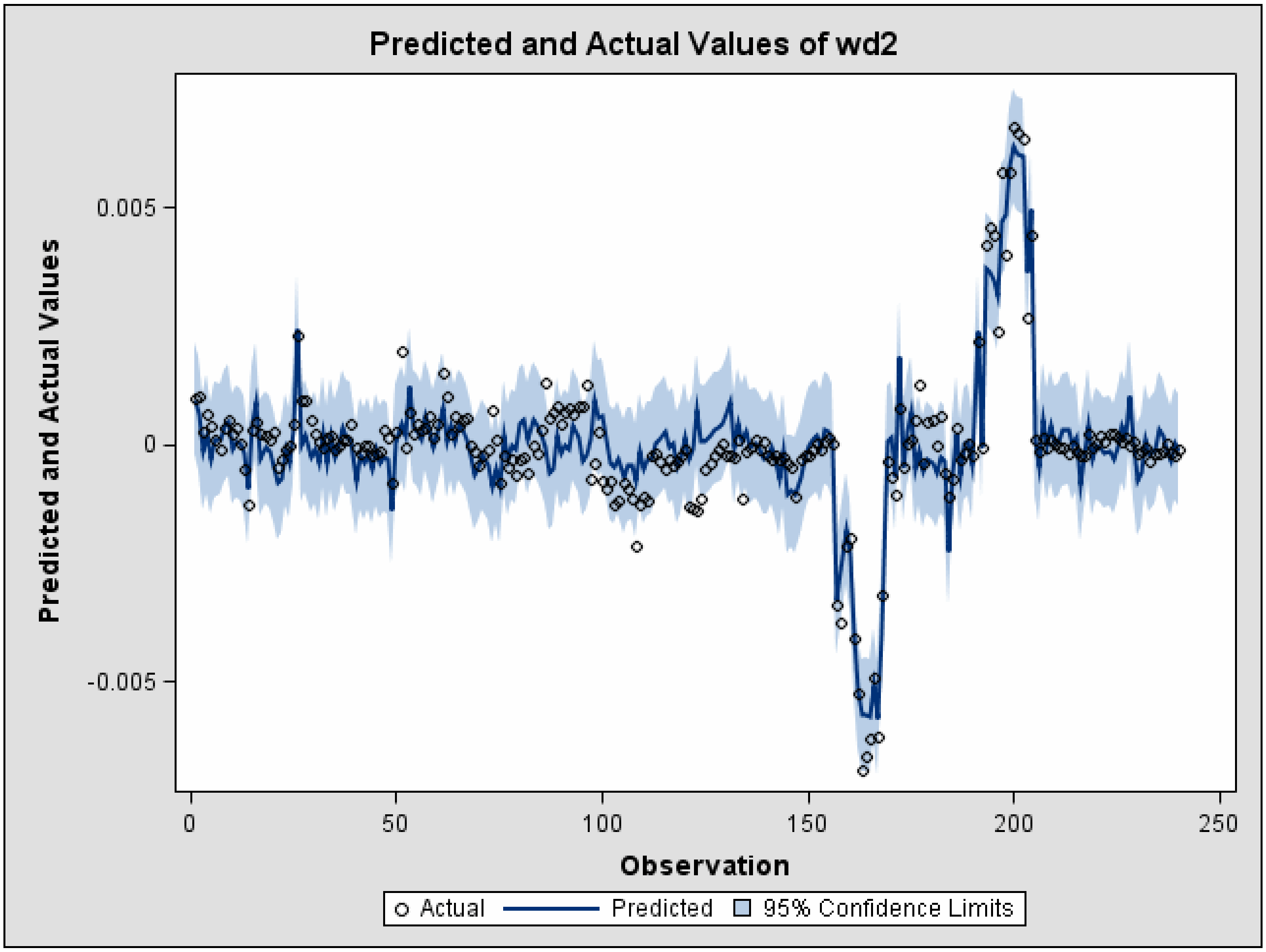

Predicted and Actual Values of wd1
Predicted and Actual Values
0.002
0
-0.002
0
50
100
150
200
250
Observation
○ Actual
Predicted
95% Confidence Limits

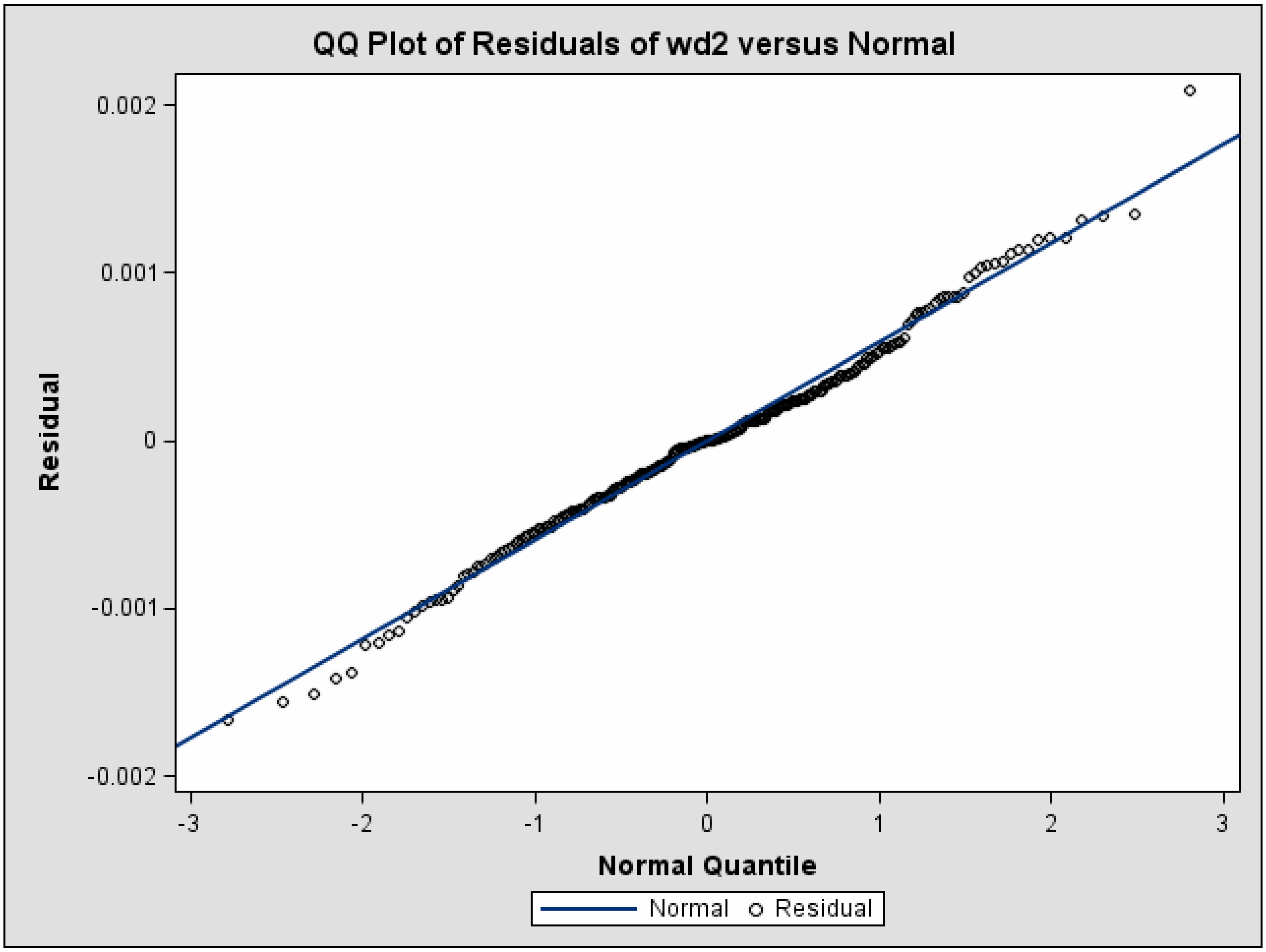

QQ Plot of Residuals of wd1 versus Normal
Residual
0.002
0.001
0
-0.001
-0.002
-3
-2
-1
0
1
2
3
Normal Quantile
Normal
Residual

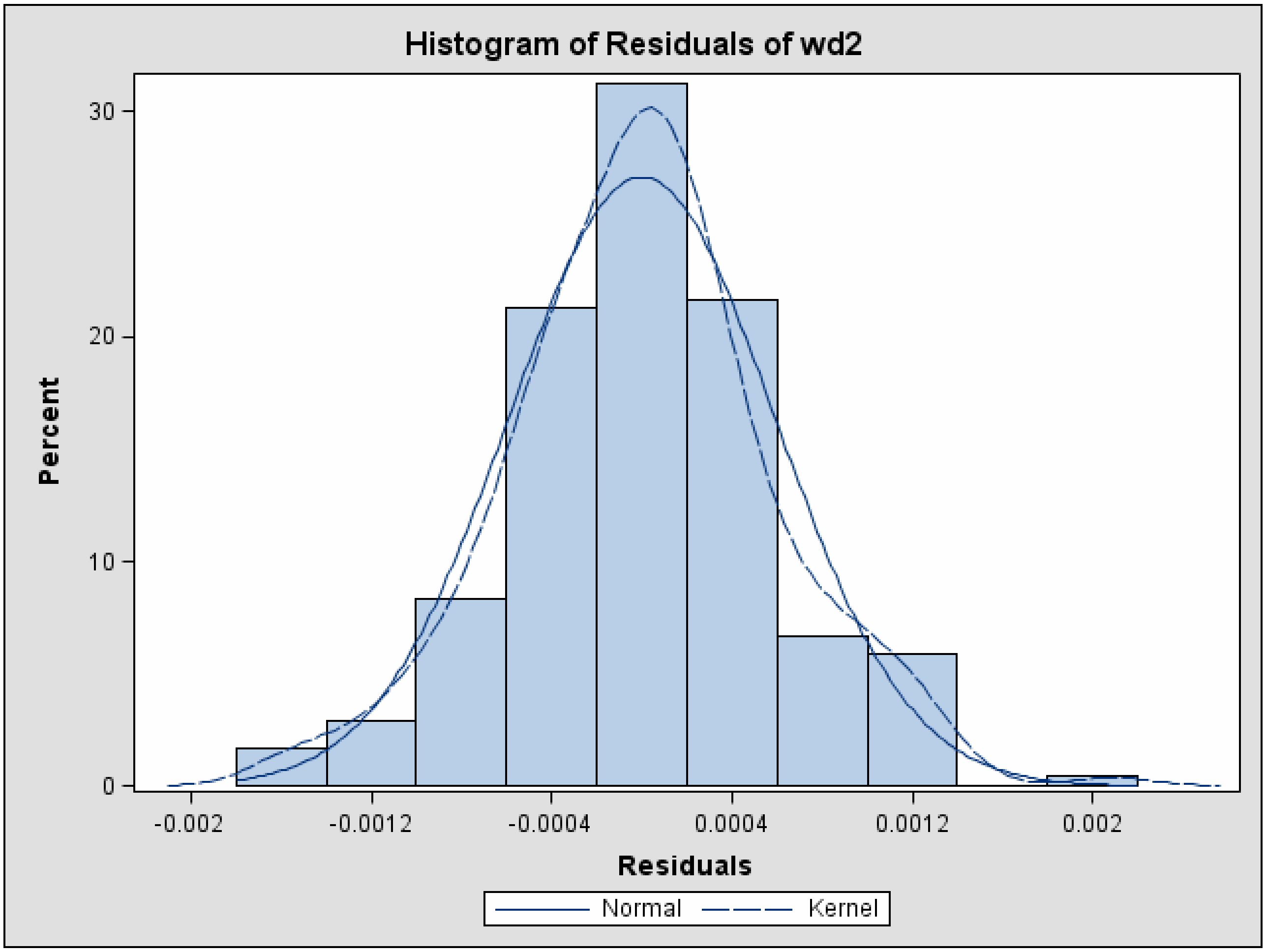

Histogram of Residuals of wd1
Percent
60
40
20
0
-0.003
-0.0024
-0.0018
-0.0012
-0.0006
0
0.0006
0.0012
0.0018
0.0024
0.003
Residuals
Normal
Kernel

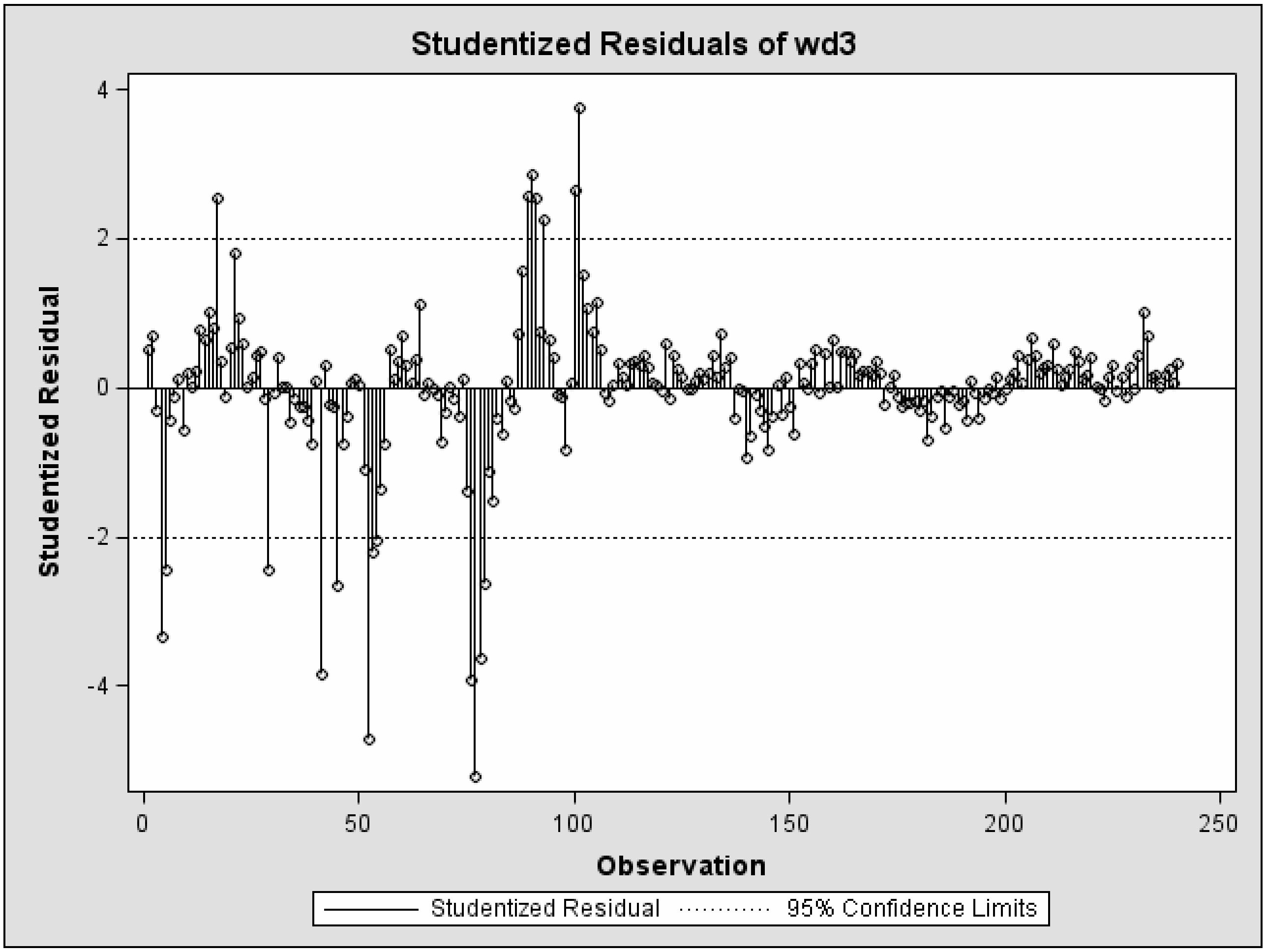

Studentized Residuals of wd2
Studentized Residual
4
2
0
-2
0
50
100
150
200
250
Observation
Studentized Residual
95% Confidence Limits

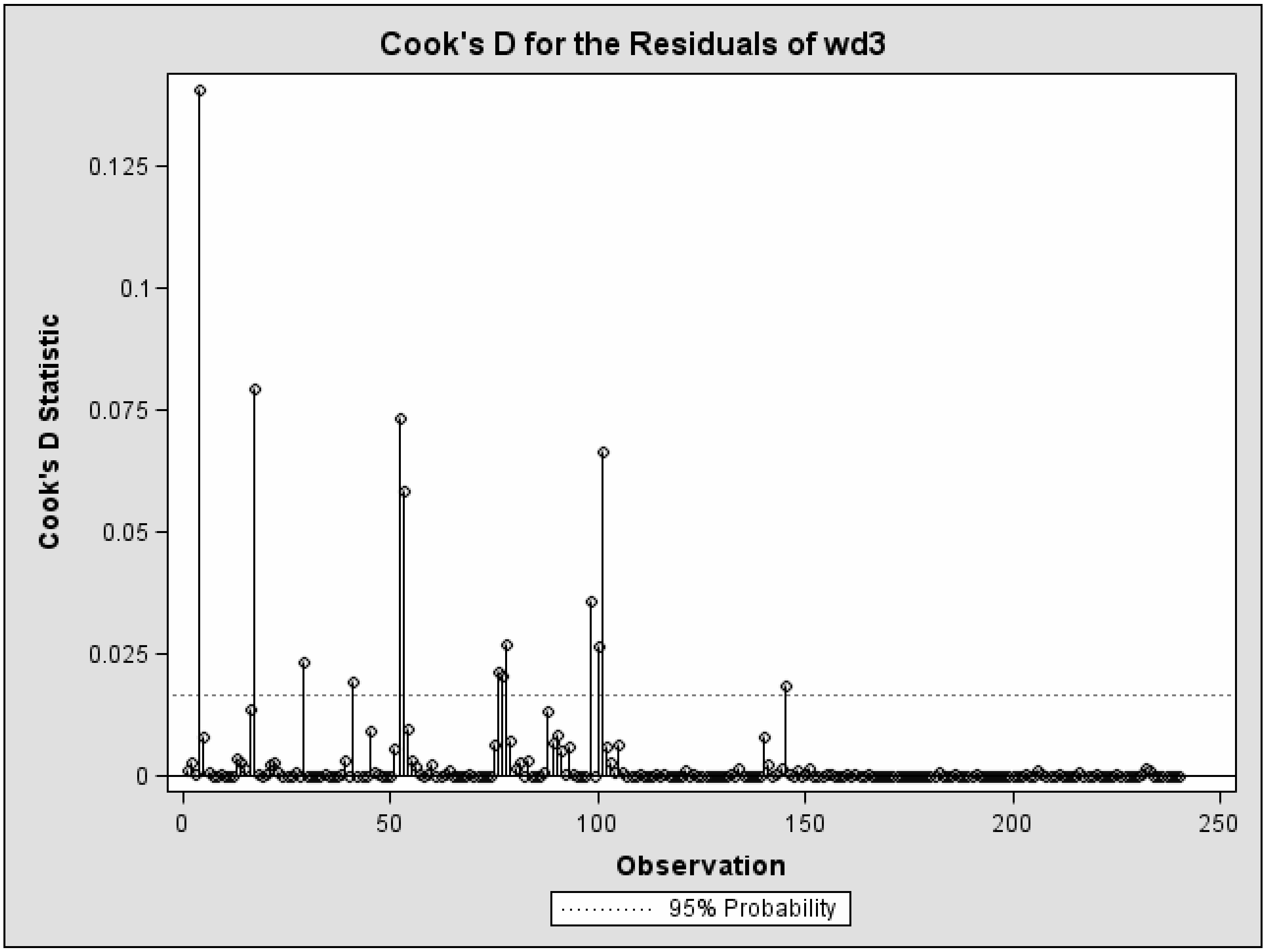

Cook's D for the Residuals of wd2
Cook's D Statistic
0.125
0.1
0.075
0.05
0.025
0
0
50
100
150
200
250
Observation
95% Probability

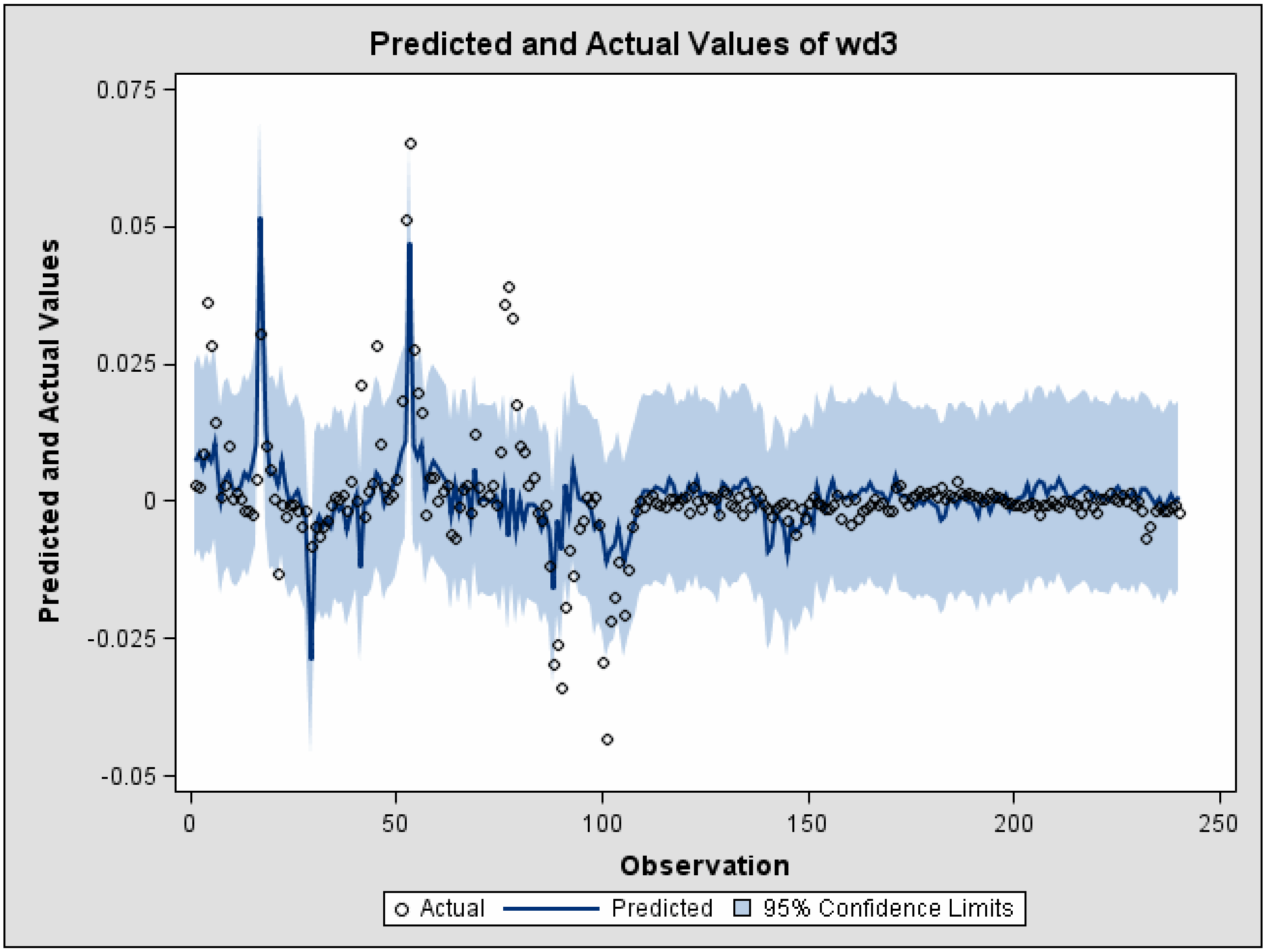

Predicted and Actual Values of wd2
Predicted and Actual Values
0.005
0
-0.005
0
50
100
150
200
250
Observation
○ Actual
Predicted
95% Confidence Limits

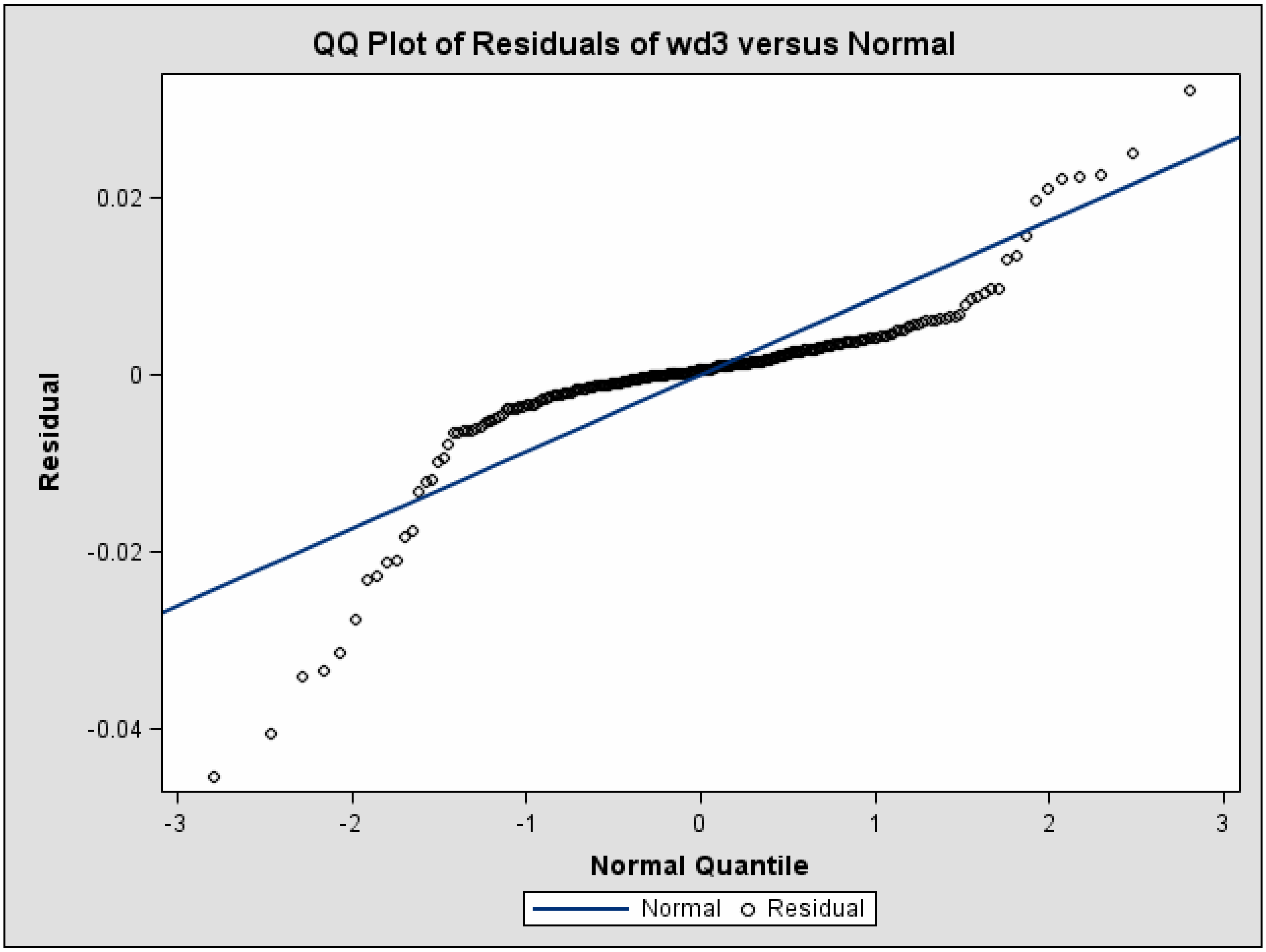

QQ Plot of Residuals of wd2 versus Normal
Residual
0.002
0.001
0
-0.001
-0.002
-3
-2
-1
0
1
2
3
Normal Quantile
Normal
Residual

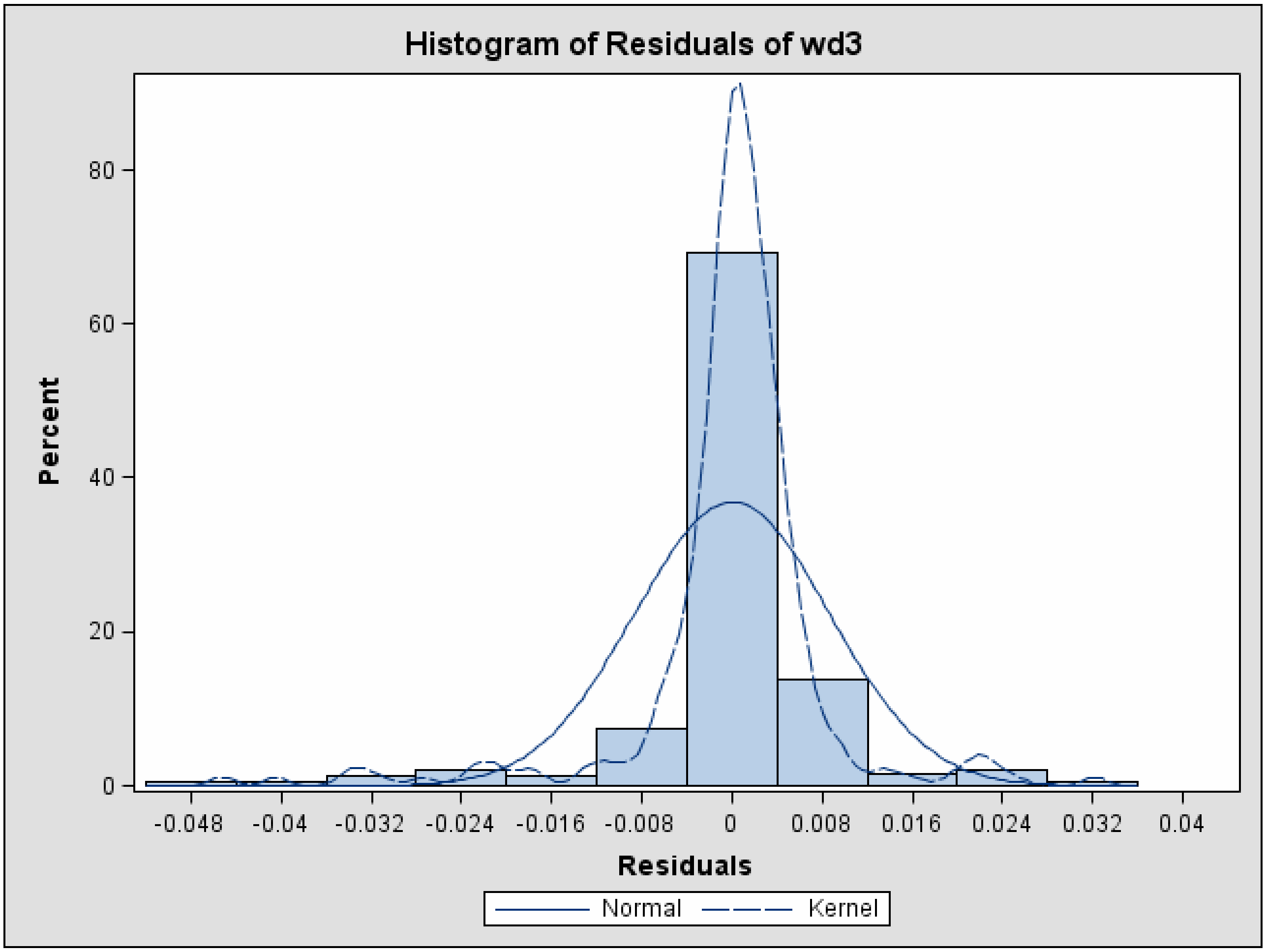

Histogram of Residuals of wd2
Percent
30
20
10
0
-0.002
-0.0012
-0.0004
0.0004
0.0012
0.002
Residuals
Normal
Kernel

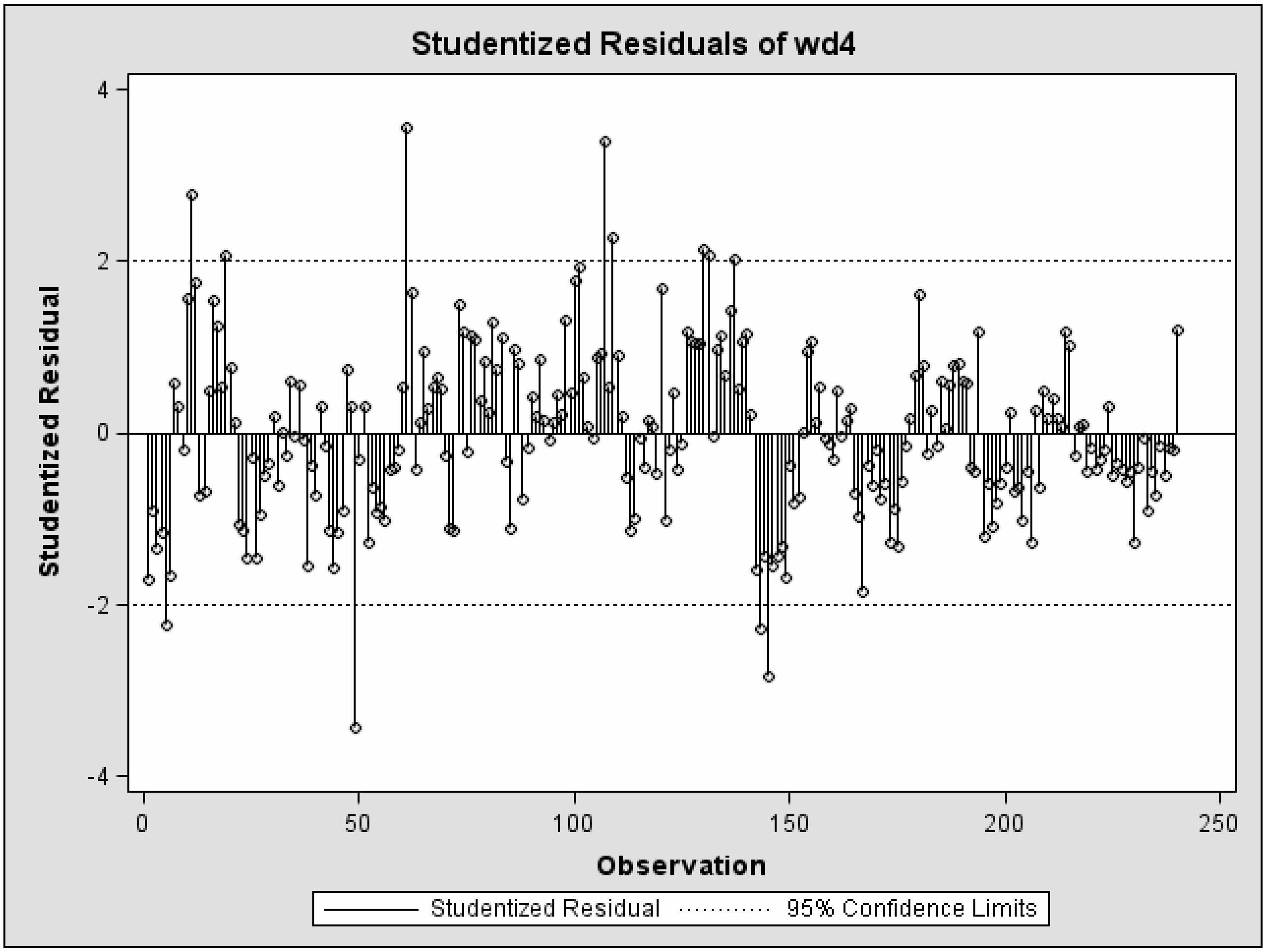

Studentized Residuals of wd3
Studentized Residual
4
2
0
-2
-4
0
50
100
150
200
250
Observation
Studentized Residual
95% Confidence Limits

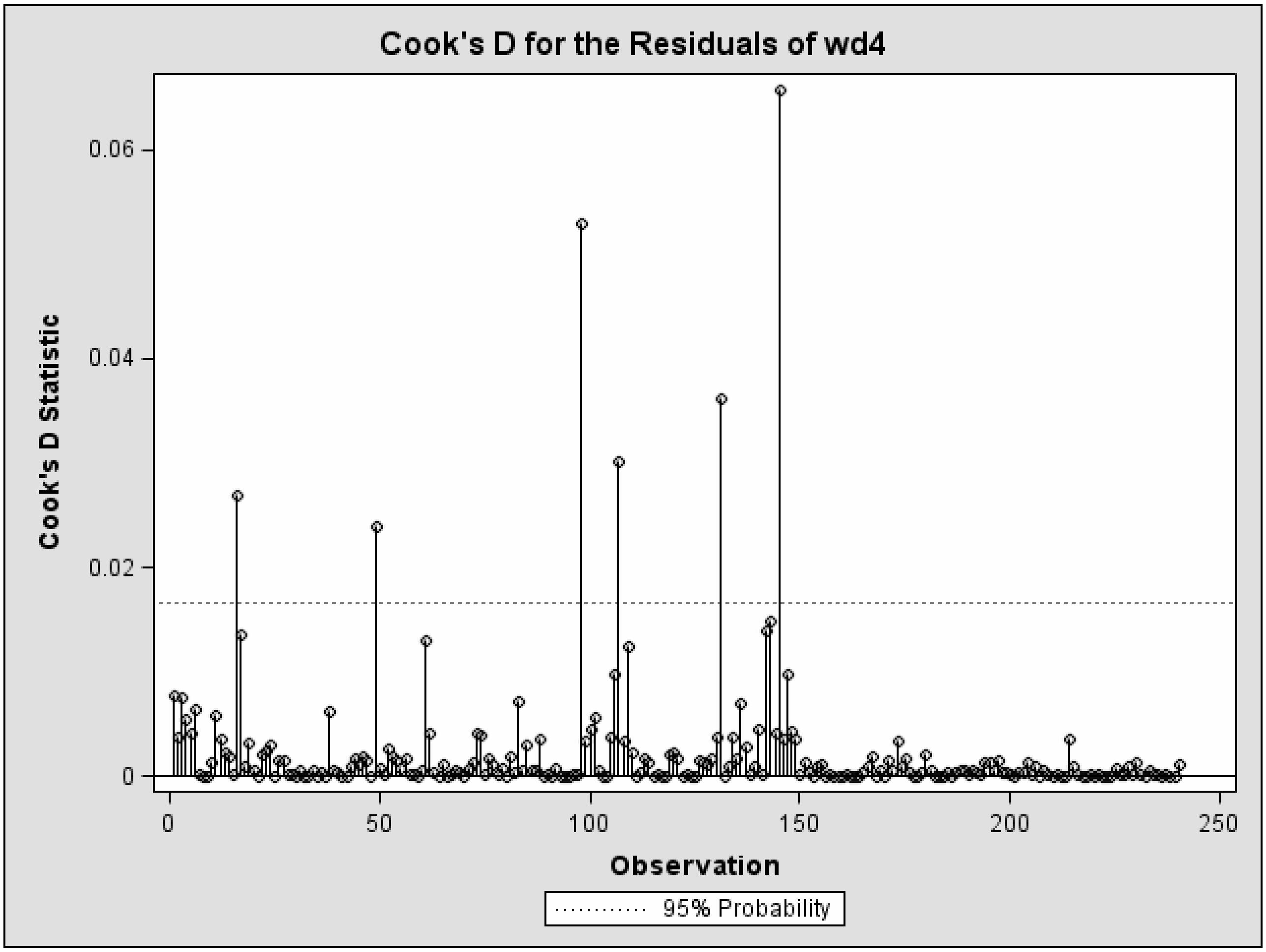

Cook's D for the Residuals of wd3
Cook's D Statistic
0.125
0.1
0.075
0.05
0.025
0
0
50
100
150
200
250
Observation
95% Probability

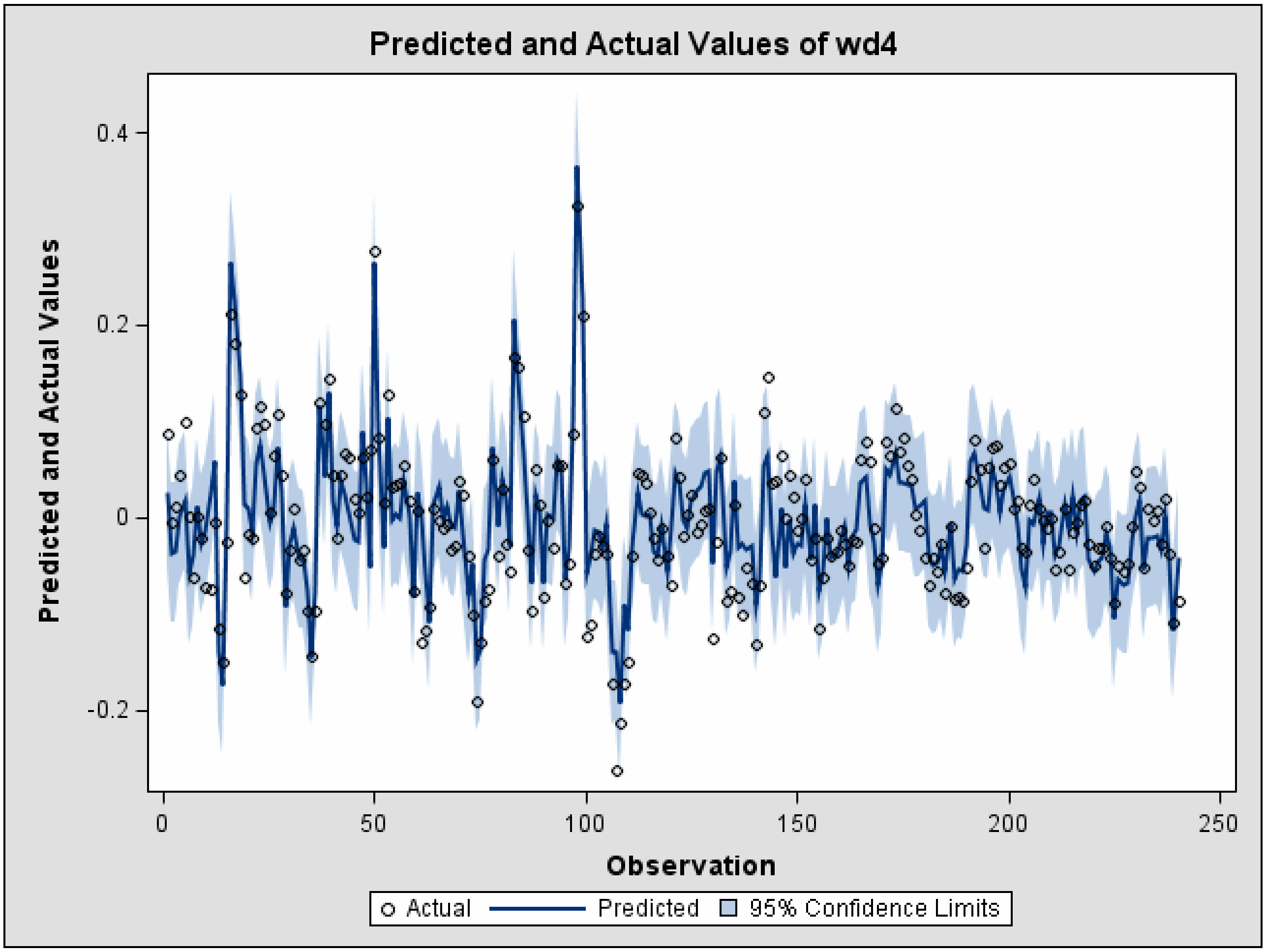

Predicted and Actual Values of wd3
Predicted and Actual Values
0.075
0.05
0.025
0
-0.025
-0.05
0
50
100
150
200
250
Observation
○ Actual
Predicted
95% Confidence Limits

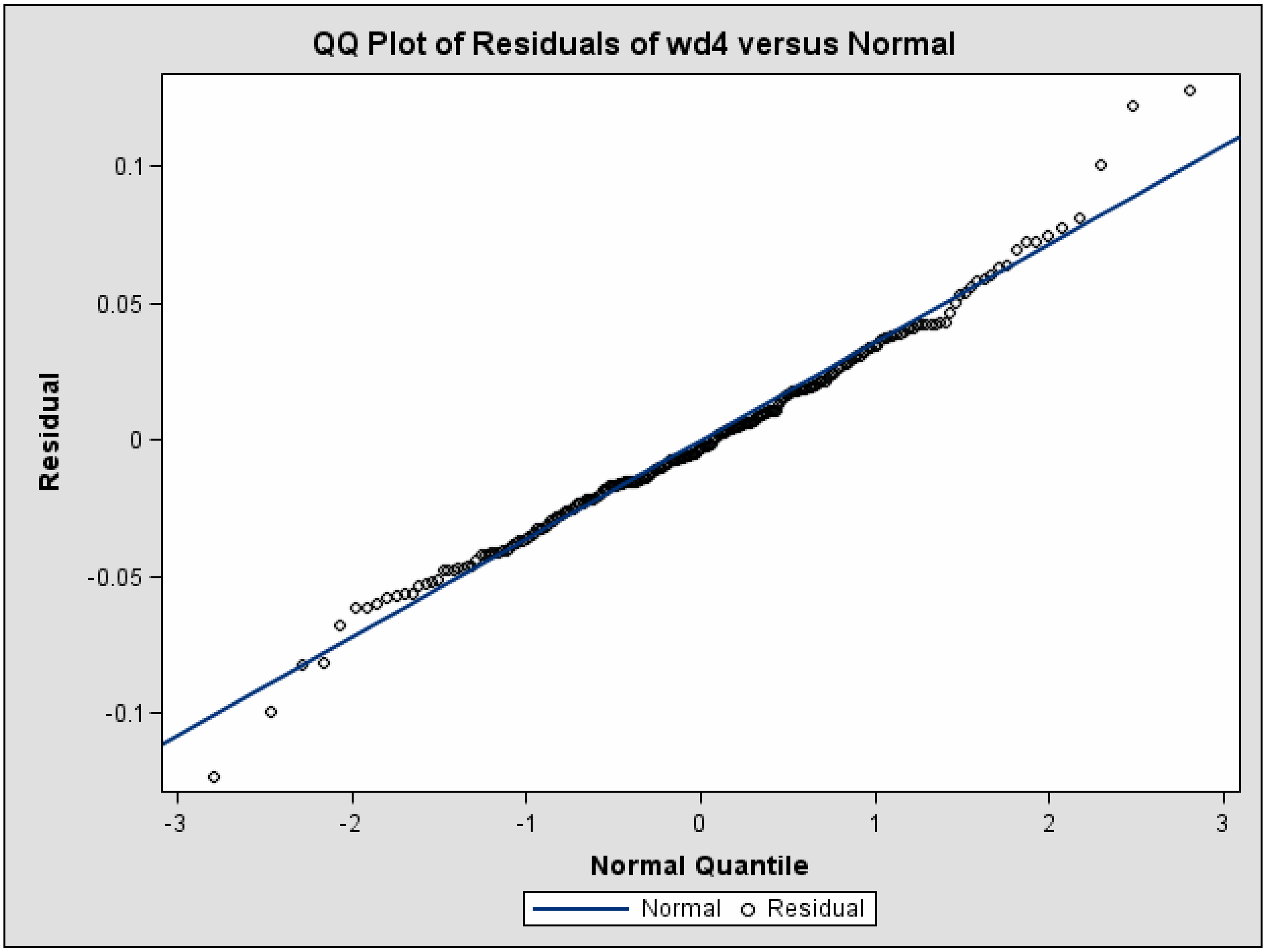

QQ Plot of Residuals of wd3 versus Normal
Residual
0.02
0
-0.02
-0.04
-3
-2
-1
0
1
2
3
Normal Quantile
Normal
Residual

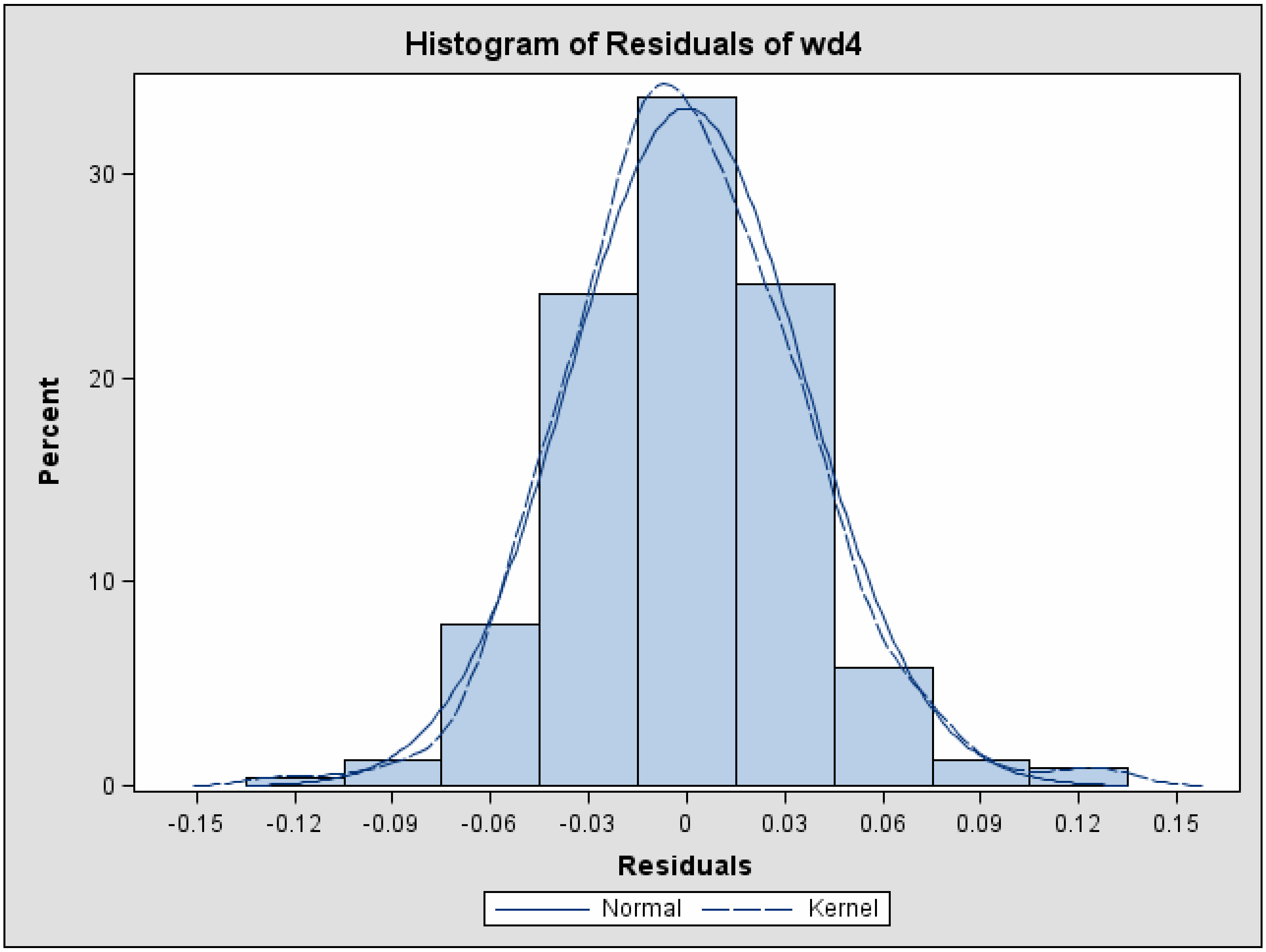

Histogram of Residuals of wd3
Percent
0
20
40
60
80
-0.048
-0.04
-0.032
-0.024
-0.016
-0.008
0
0.008
0.016
0.024
0.032
0.04
Residuals
Normal
Kernel


Studentized Residuals of wd4
Studentized Residual
4
2
0
-2
-4
0
50
100
150
200
250
Observation
Studentized Residual
95% Confidence Limits


Cook's D for the Residuals of wd4
Cook's D Statistic
0.06
0.04
0.02
0
0
50
100
150
200
250
Observation
95% Probability


Predicted and Actual Values of wd4
Predicted and Actual Values
0.4
0.2
0
-0.2
0
50
100
150
200
250
Observation
○ Actual
Predicted
▨ 95% Confidence Limits


QQ Plot of Residuals of wd4 versus Normal
Residual
0.1
0.05
0
-0.05
-0.1
-3
-2
-1
0
1
2
3
Normal Quantile
Normal
Residual


Histogram of Residuals of wd4
Percent
0
10
20
30
-0.15
-0.12
-0.09
-0.06
-0.03
0
0.03
0.06
0.09
0.12
0.15
Residuals
Normal
Kernel