INDUCTIVE / DEDUCTIVE TEACHING METHODS, CARIBBEAN IMPORT DEMAND FOR STARCHY FOOD, AND SELECTION BETWEEN AIDS AND ROTTERDAM DEMAND MODELS

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PREFACE

Three separate essays constitute the body of this dissertation. The first essay emerged from my advisor's desire of finding the best way of teaching an introductory class in Agricultural Economics (AG ECON 1114) to undergraduate students at Oklahoma State University. Strong basic knowledge is a prerequisite for success in a given field. Just like a house cannot stand if its base is weak, a student cannot have good knowledge accumulation if he or she fails in the basic classes. It is the responsibility of the school system to find ways of helping students have the strong background needed for future success. Traditional teaching methods in economics are based on lectures. However, economics is in the daily life of every single individual, given that everyone is a consumer and must often make decisions about allocating a limited budget among a tremendous number of goods that may be needed. There has been a new wave of thought leading toward teaching economics as an experimental science. In this new perspective, students learn from being placed in a simulated economic environment. My first essay addresses the question whether or not, in terms of improving students' performance, the traditional teaching method must be preferred to the experimental teaching method or must be combined together, allowing for students' personal characteristics. Trade knowledge is chosen as a means of comparison.

The second essay goes beyond teaching trade in a classroom environment by looking at a real trade situation involving the U. S., the Caribbean countries, and the Rest-of-the-World. Starchy foods like wheat, rice, corn, and fresh potatoes are the traded commodities. Since these staples form the basic diet in most developing countries including the Caribbean, trade can have the virtue of improving food security in these countries through imports, in a context of insufficient domestic production. At the same time, it can serve the goal of market expansion of the exporting countries. The price at which the starchy staples are traded in the international market is not under the control of the Caribbean importing countries and may change as a result of foreign policy changes or of international market adjustment mechanism. The effect of possible changes in foreign prices of the starchy staples on Caribbean imports or Caribbean food security is analyzed through a Restricted-Source-Differentiated Almost Ideal Demand System model that fits the data.

The third essay goes beyond the practice of picking a demand model to see whether or not it fits the data before performing an analysis. Using U. S meat demand data, it develops a parametric bootstrap method for selecting at the forefront between two commonly known demand models, the Almost Ideal Demand System and the Rotterdam model. It also compares results from this method with those of previous studies that use an orthodox approach to select between the AIDS and the Rotterdam for the U. S. meat demand.

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A Case Study in Learning Economics: Quantitative and Qualitative Assessment of Effectiveness of Inductive / Deductive Teaching Methods, and Students' Characteristics.

Abstract

This is a case study questioning whether changing the method of teaching the Agricultural Economics 1114 class to undergraduate students at Oklahoma State University is worth considering. Besides the teaching method which can be purely deductive (i. e. based on lecture) or purely inductive (i. e. based on experiential learning) or a combination of the two, the study also looks at other factors from students' cognitive and affective characteristics and learning style that may affect students' performance. Furthermore, it measures students' subjective learning assessment with respect to the inductive and the deductive teaching methods. Performance is measured by the students' score in tests based on trade-related concepts and trade-related exercises.

The results suggest that the inductive teaching method increases the students' performance, as compared to the deductive method. In addition, a teaching method that incorporates both the inductive and the deductive methods in the order inductive first and deductive second is beneficial to the students.

The students' subjective learning assessment with respect to the inductive teaching method is independent of the teaching method itself, and the students' cognitive, affective, and learning style characteristics. However, the students' subjective learning assessment with respect to the deductive teaching method depends on their GPA level, their pretest score in solving trade-related exercises, their opinion about economics, and their visual / verbal learning style dimension.

Keywords: Affective characteristics, cognitive characteristics, deductive teaching method, inductive teaching method, learning style.

A Case Study in Learning Economics: Quantitative and Qualitative Assessment of Effectiveness of Inductive / Deductive Teaching Methods, and Students' Characteristics.

Introduction

Students have different intellectual capabilities and learning styles that favor or limit knowledge accumulation. As a result, instructors are interested in ways to effectively cause students to better understand and learn. Professors often ask what will bring about a better understanding of the material he or she wants to communicate. If college students do not have a good understanding of what they are taught, once they graduate and start working they may not be more efficient at the work place. Employers are looking for employees who are productive and can address practical matters. Some studies have investigated ways academic and professional programs can match the employers' needs, like the development of a new curriculum in business management that incorporates conceptual thinking and problem-solving capabilities and departs from traditional classroom approaches (Litzenberg, Gorman, and Schneider, 1983).

From the students' perspective, time spent in ineffective learning environments is costly and frustrating. Furthermore, in countries where no free education exists, education costs may take a substantial part of the family budget. In the United States, part of the cost burden of education on families is paid by the society as a whole through the use of tax revenues to support public education. Even then, many families devote a significant portion of their income to educational investment. A second cost is the opportunity cost of students' time.

Education produces its payoff to individuals or to society only in the future. Some studies look at the salary returns (Broder and Deprey, 1988) or the social returns of education (Link and Rutledge, 1975). When students learn more, the overall future returns of education at both the private and social levels are higher. It is the responsibility of the educational institutions and instructors to seek more effective ways of teaching in order to meet individuals' and society' s expectations from education. Changing teaching method may help an institution meet its goal of achieving a better standard of education.

Teaching method can either be inductive or deductive or some combination of the two. The inductive teaching method process goes from the specific to the general and may be based on experiments. Deductive teaching methods progress from the general to the specific. The choice of a teaching method may impact positively on quality of knowledge accumulation. Quality in this context refers to the matching of what a professor is trying to transfer to his or her students and what these students learn from the professor's class. Failures occur when students maintain preconceived and incorrect beliefs about the subject matter taught, or misunderstandings or misconceptions are created by the instruction. A teaching method can be considered effective if it reduces the number of misunderstandings or misconceptions.

This case study is designed to appraise two methods of teaching agricultural economics to undergraduate students at Oklahoma State University. At the national level, it can be considered as an observation in "constructing a meta-analysis of instructional strategies and their effectiveness in teaching students to comprehend conceptual material"[1] in economics.

Objectives

The objectives are to:

1) Determine the relative effectiveness (as measured by students' test scores) of inductive and deductive teaching methods in teaching trade theory concepts in an introductory agricultural economics class (AG ECON 1114) at Oklahoma State University, along with consideration to the students' cognitive, affective, and learning style characteristics[2].
2) Determine whether the order in which students are exposed to the two teaching methods influences the effectiveness of the two methods, along with all the other factors mentioned in 1.
3) Determine whether students' subjective learning assessment with respect to the two teaching methods depends upon the order of exposure to the two methods and variables from the students' cognitive, affective and learning style characteristics.

Literature Review

Although Thielens has found that lecturing occupies 80 percent of the class time in college classes (Thielens, 1987), there is evidence that both inductive and deductive methods have been used in several fields of studies: economics, language, sociology,

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[1] This idea is from Bonwell (1999). Furthermore, Bonwell reported that a meta-analysis has been undertaken by Hake in physics. A meta-analysis is an analysis at the macro level.

[2] These concepts are made operational in the hypothesis section.

training science, calculus, philosophy, literature, social education, education, chemistry, business, anthropology, management, biology, and physics. The results of these studies suggest that the inductive method is widely used, often successfully.

Hosen (1976) has successfully used the inductive instructional method in his introductory college economics course. However, Bartlett and King think that there is a general reluctance among economists to teach economics as a laboratory science. Bloom (1971) recommends that experiences in the laboratory or in the field be used in the learning process to better meet educational objectives.

Ashby-Davis (1986) has presented a method for improving reading comprehension through direct instruction of inductive reasoning. Seliger (1975) examined the common assumption that the inductive method is more effective than the deductive one in foreign language instruction. Newton (1973) has discussed the philosophical problem of "how one knows," using inductive reasoning and the use of inductive reasoning in social studies programs. Stiehm (1978) has made a contrastive analysis of Spanish word order, first discussed in non-sentence constructions, and then in sentences and sentence-like constructions. Cortes (1977) has proposed a method in teaching grammar to the adult remedial learner which is inductive in nature and which allows the student to form generalization about grammar. Neuberg (1991) has examined the inductive approach to learning, which helps ensure an interactive environment where students use their language processes to learn. Nixon-Ponder (1995) thinks that posing problems is a tool for developing and strengthening critical thinking skills. According to Nixon-Ponder, inductive questioning processes structure dialog in the classroom. This process has five steps including describing the content, defining the problem, personalizing it, discussing it, and discussing alternatives.

Yeany (1975) has looked at the relationship between teaching strategies and student outcomes and has supported the use of inductive method / indirect teaching strategies. Klauer (1996) has shown that training in an inductive strategy enhances performance on tests measuring fluid intelligence, supports learning and school-relevant declarative knowledge, and improves problem solving.

Lackner (1971) has conducted a pilot study on teaching the derivative concept in beginning calculus by inductive and deductive approaches. Tanner (1975) has sketched a model of the inductive method for teaching literature.

Clarke (1989) has argued that teachers can use inductive method to show how theories are formed in the social sciences. He has explained how students can practice inductive thinking, analyze information, or organize information-gathering in a research project.

Mandelson (1988) has argued that teaching arrangement inductively offers an alternative to the standard imitation of business communication text model. He has asserted that the inductive method stimulates individual rather than formulating responses to the problem of organization. Spindler (1990) has presented an approach to teaching cultural anthropology that combines an inductive method and ethnographic case studies.

Cova et al. (1993) have looked at how the European School of Management has evolved a curriculum based on inductive pedagogy. Its five major focuses are case study method, "memoire," in-company placements, lectures, and language learning.

Lambert (1989) has described a simulation game designed to reinforce the biological concept of poisoning, encourage critical thinking and deductive reasoning and be enjoyed by the students. Radetsky has examined Thomas Kane's deductive approach to the study of dynamics and his advances in explaining classic mechanics. He has also looked at the advantages of his methods in the formulation of equations of motion and in application to space technology. Strassenburg (1977) has suggested that physics should be taught inductively, with emphasis on experimentation as opposed to the focus on theory and abstract problem solving used in college physics courses for science and engineering major.

Theoretical Framework

This study has its theoretical ground on a model of school learning proposed by Benjamin Bloom and presented by Keefe (1987). According to Keefe, the learning theory is based on three important elements: student characteristics, instruction, and learning outcomes; and there are three sets of variables that account for the greatest degree of variance in student learning:

1. Cognitive entry behaviors, the extent to which the student has already learned the basic prerequisites to the learning to be undertaken.
2. Affective entry characteristics, the extent to which the student is or can be motivated to engage in the learning process.
3. Quality of instruction, the extent to which the instruction to be provided is appropriate to the learner.

Student's learning style has been considered as an important factor in knowledge accumulation. Felder (1995) suggests four learning style dimensions: 1) active/reflective, 2) sensing/intuitive, 3) visual/verbal, 4) sequential/global. Moreover, Felder asserts that instructors tend to impose their own learning style to the students or to teach the way they were taught. By so doing, they disregard students' own learning style preferences.

For the purpose of this study, Bloom's model has been adjusted to include learning style as defined by Felder and Soloman. The modified Bloom learning model is schematically presented in figure 1.1 where learning outcomes are represented as level and type of achievement, rate of learning, and affective outcomes.

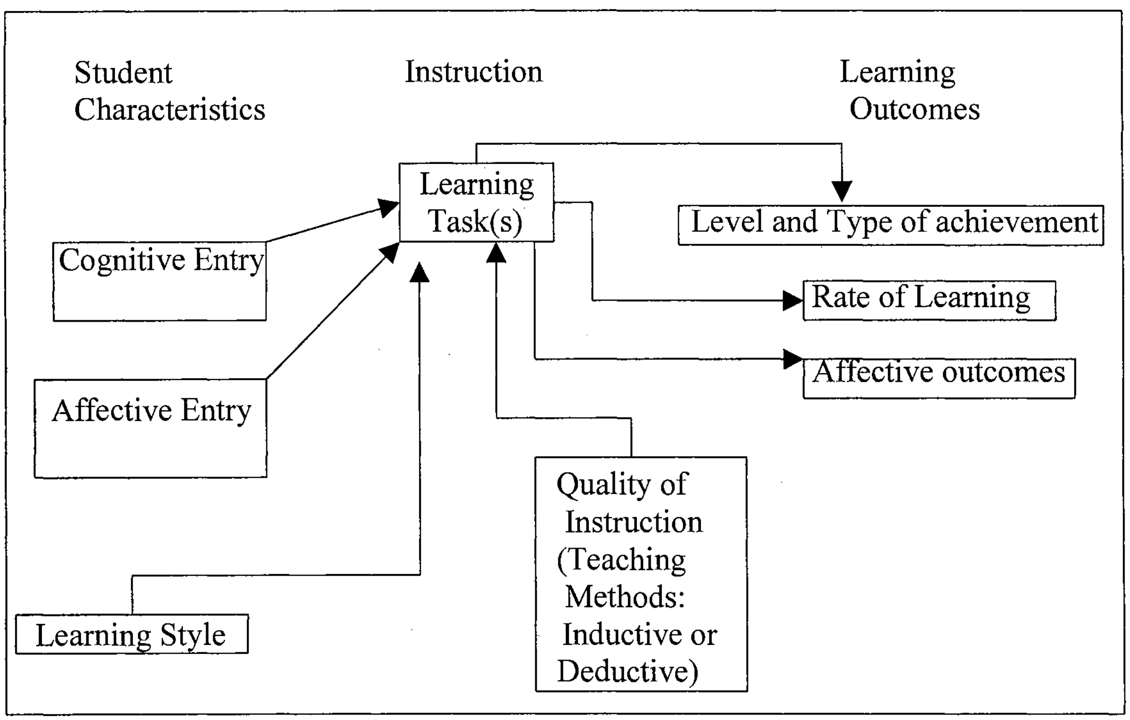

Figure 1.1. Modified Bloom's Learning Model

Hypotheses

1. Student's test performance in learning trade concepts and solving trade-based exercises is related to the teaching method (inductive or experiment, deductive or lecture, or a combination of the two), the student's cognitive and affective characteristics, and the student's learning style.
2. Students' subjective learning assessment with respect to the two teaching methods is related to their order of exposure to them, their cognitive characteristics, their preconceived affective opinions toward economics, and their learning style.

Definition of the concepts in the hypotheses

The modified Bloom's model in figure 1.1 describes learning primarily from an instructional standpoint and considers students' personal characteristics. In this study, the professor's teaching methods (inductive and deductive) represent the quality of instruction.

A student's personal characteristics are cognitive, affective, and include learning style. The cognitive characteristics are represented by the student's pretest score, his or her previous background in mathematics and economics, his or her GPA and ACT test scores, his or her major (Ag Econ or Animal Science or other). A student's affective characteristics are represented by his or her preconceived opinion about economics, which is measured by his or her response to the following statement: " economics is a boring subject."

Students learning style is a variable with four dimensions defined as 1) active / reflective 2) sensing / intuitive 3) visual / verbal 4) sequential / global. Each dimension corresponds to a set of questions in the index of learning style questionnaire (see Felder and Soloman's index of learning style questionnaire in the appendix). The independent variable considered for each dimension of learning style can range from -11 to +11. A positive number between 0 and 11 is related to the first element of a learning style dimension (for instance the element called active in the learning style dimension called active / reflective). A negative number between –11 and 0 is related to the second element of a learning style dimension (for instance, the element called reflective in the learning style dimension called active / reflective).

All the above variables are assumed to explain a student's test score and a student's subjective learning assessment about the two teaching methods. Students' test score measures the level of achievement in a concept-based exam and a problem-solving-based exam. These two exams were parts of one pretest. A student's subjective learning assessment with respect to the two teaching methods was measured on a Likert scale from 1 to 7.

Procedure

In this section, we discuss 1) the questionnaire and pre-test / test, 2) the teaching approaches, 3) the implementation design, 4) the grading system, 5) the empirical analysis, and 6) the statistical or econometric tests.

1. ***Questionnaire and Pre-Test / Tests***

All students were asked to fill out an information sheet and an information questionnaire (see appendix) the first day of class to collect data on their previous background in mathematics and economics, their current grade point average (GPA) and academic test score (ACT), their field of study, their preconceived opinions about economics and about interacting with other students, and their academic level (freshman, sophomore, junior, senior). Also, all students were given a standard pre-test on trade in the middle of the semester (see the pre-test in the appendix). The teaching of the professor was adjusted such that trade-related topics were not covered prior to taking the pre-test. The pre-test was conceived hard enough because all subsequent tests related to this study were basically the same as the pre-test, allowing only for slight modifications such as re-ordering of the questions, and changing numbers in exercises. As said earlier, the pre-test had two parts. The first part was concepts, and the second part was problem solving. Problem solving for students at this level refers only to doing trade-related exercises.

In order to minimize the memorization effect, none of the tests were returned to the students. All the students took a given test at the same time for fairness purposes i.e. to make sure they all have been exposed to the test questions the same number of times. The number of students enrolled in the class was 182. The tests were knowledge-based, given that we were testing at level one for students in an introductory class i.e. knowledge level (Anderson, 1994). To the extent possible, each question in the concept part of the test as well as in the problem-solving part allowed for a single answer.

The pre-test / test questions were drawn from trade-related questions proposed by Bergstrom and Miller and from the author's own experience in teaching trade. In order for the results of the study to be reliable, the Bergstrom and Miller book was not seen by the students, since some test questions were drawn from it.

2. Covered Trade Topics

Both the inductive and the deductive teaching methods focused on the same trade concepts which were the following: comparative advantage, free trade, gains from trade, free trade winners and losers, individual, national, and international production possibility frontiers. The deductive teaching method used lectures, which were given on the three-panel diagram, on comparative advantage and production possibility frontiers. The inductive method used an experiential learning exercise suggested by Bergstom and Miller, where students had to make production and trade decision in order to maximize output. Experiment 11 from these authors' book was used.

2. Implementation Design

To implement the deductive and inductive methods, students from the Agricultural Economics 1114 class were randomly assigned to two groups (A and B) with the same number of observations. Each group was subdivided into two subgroups to ease the implementation of the experiment, given that there were 182 students in the class. Figure 1.2 shows the different steps of the implementation design (excluding the subgroups) in time. First of all, students were pre-tested and asked to fill out a general information questionnaire. Second, participants in each group (A and B) were randomly selected (lottery) from the 182 students. Third, the inductive session was given to group A only in two consecutive days (one day for each of the two subgroups in A). Fourth, a test (test # 1) was given to all the students in the class. Fifth, lectures of the deductive session took place and were addressed to the whole class at a time. Sixth, another test (test # 2) was given to the whole class, posterior to the deductive session. Seventh, students in group B were given the inductive session in two consecutive days (one day for each of the two subgroups in B). Eighth, a final test (test #3) was given to the whole class. In summary, students in each group were sequentially assigned to the two teaching methods but in reverse order. Finally ninth, an ex-post evaluation survey was conducted. This survey provided data on the students' subjective learning assessment, among other information.

Figure 1.2 also identifies two steps (step 1 and 2). At step 1, the whole class has half of the students (from group A) with knowledge from the inductive method and the other half (from group B) with knowledge from the deductive method. At step two, students from both groups A and B went through both teaching methods but in the reverse order.

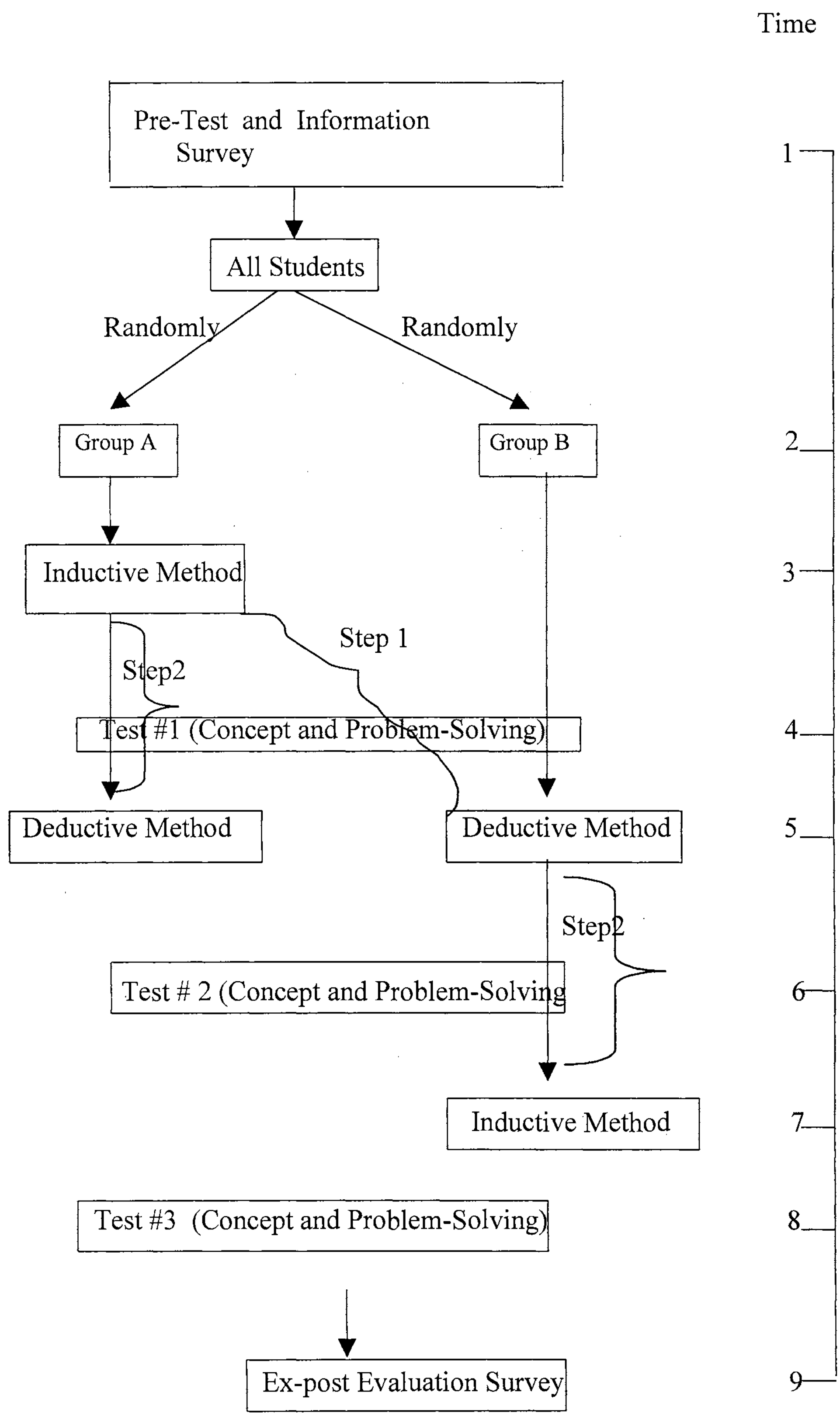

Figure 1.2. Design of the Study including Tests

Figure 1.3 shows the design of the game used for the inductive method. Since groups A and B were divided into two subgroups (A1, A2, and B1, B2), each subgroup had approximately 40 students. Following Bergstrom and Miller, students within each subgroup were assigned to be residents of Poorland or residents of Richland. Each country was considered as an island. In an actual inductive session, one-third of the students were considered as Richlanders (say subgroup A11), and two-thirds as Poorlanders (say subgroup A12). In Richland, a resident takes 1 hour to produce a fish and 1.5 hour to produce a loaf of bread. In Poorland, life is harder and it takes 3 hours to produce a fish and 2 hours to produce a loaf of bread. Each student in a country was a resident of that country and had a total of twenty (20) hours available to produce two goods: fish and bread. Fish and bread can be used to make sandwiches in the proportion of one fish for two loaves of bread.

First, in the absence of trade either within or between countries, residents of each country could make sandwiches only with the bread and fish that they have produced themselves. In a country, a resident was asked to choose an allocation of his 20 hours of time between producing fish and producing bread.

Second, assuming free trade between countries, before deciding what to produce with their 20 hours of time available, residents in each country looked around for possible trading partners and discussed the terms at which they would trade. When students decided on their time allocation, the market manager gave them fish and/ or bread tickets that represented the number of fish and loaves of bread that they produced. To simplify trading, the market manager did not give tickets for fractional units of bread or fish, but rounded down to the next smaller whole number.

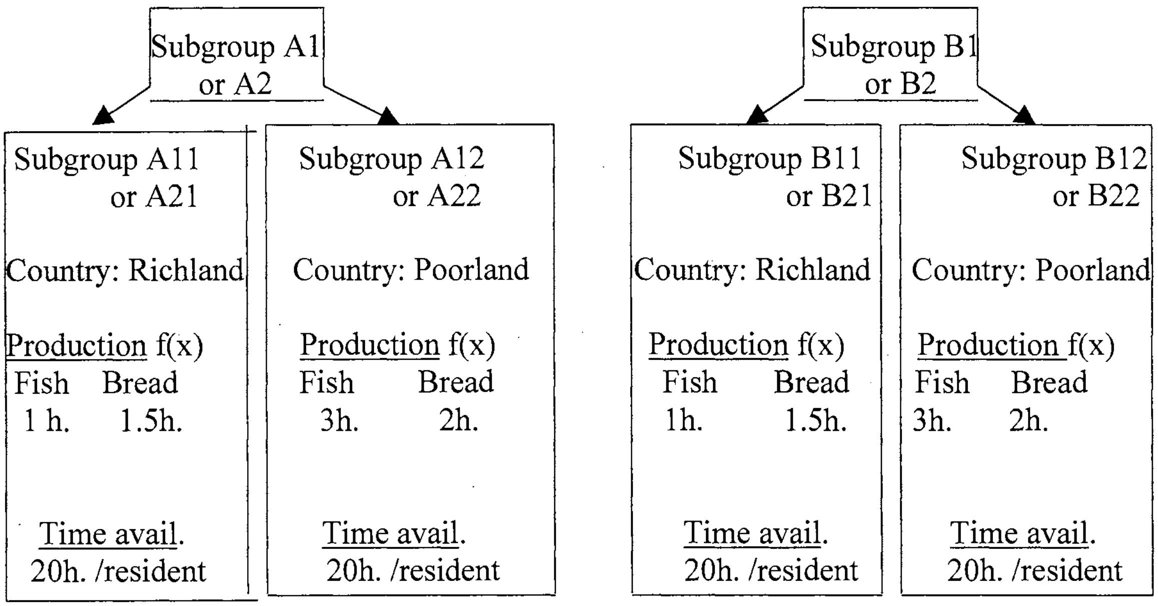

Figure 1.3. Implementation design of the inductive method

After they had received their fish and bread tickets, residents in each country traded with anyone living in the other country. To make a trade, they had only to exchange tickets[3]. Trade in fractional tickets was not allowed, but fractional prices could be achieved by, for example, trading 2 fish for 1 loaf of bread, or 2 fish for 3 loaves of bread.

When they had completed trading, residents in each country were asked to compute their payoffs, which were the minimum of the number of fish and the number of loaves of bread that they had at the end of trading. There was no real payment to the students for

[3] Students were required to write down the name of the person they traded with, the price at which they traded and the quantity of fish or bread traded. A side benefit of the game is that it served as a mixer. Students were forced to get to know each other.

sandwiches made after trade. When trading ceased, the market manager surveyed the group to determine whether there was anyone who still had extra fish that was not matched by loaves of bread, or extra loaves of bread that were not matched by fish.

There was a second round of free trade in which students demonstrated a better trading performance, given they learned from the first round. Once again, residents decided how to allocate their time between producing fish and producing bread. They received new tickets.

4. ***Grading System***

Each part of the pretest or test was graded as if it was a separate exam by itself and the related scores were recorded separately, along with other variables of interest for each student. The pretest and test were as precise as possible, and the grading system was objective.

5. ***Empirical Analysis***

Regression analysis is used to determine the relative effectiveness of the two teaching methods, along with students' characteristics. Referring to figure 1.2 above, at each step (step 1 and step 2), two equations are estimated, one for learning trade concepts and the other for solving trade exercises. Therefore, a total of four equations are estimated to measure students' performance using ordinary least squares. The dependent variable is the student's test score and the independent variables are the same for each of the regressions, except that the teaching method is allowed to be the deductive or the inductive methods in the first two equations, and a combination of the two methods in some order in the last two equations.

Test score = f(*teaching method, concepts pre-test score, exercises pre-test score, calculus high school, calculus at OSU, econ background, major Ag Econ, major Animal Science, opinion about economics, ACT, GPA, active / reflective, sensing / intuitive, visual / verbal, sequential / global)* *(1)*

In this equation, four different test scores separetely constitute the test score variable, say score 1, score 2, score3, and score 4. **Score 1** and **score 2** are the concept and problem solving scores when one-half of the students have participated in the experiments only (group A), and the other one-half have had the lectures only (group B). **Score 3** and **score 4** are concept and problem solving scores when one-half of the students participated in the experiments and then in the lecture (group A), and the other half have had the lecture and then the experiments (group B)

teaching method is a dummy variable equal to 1 if students are in group A and equal to 0 if they are in group B,

concepts pre-test score is students' pre-test score for trade concepts,

exercises pre-test score is students' pre-test score for trade exercises,

calculus high school is a dummy variable equal to 1 if students have some calculus in high school and equal to 0 if students have no calculus in high school or have algebra or trigonometry,

calculus at OSU is a dummy variable equal to 1 if students have some calculus at OSU and equal to 0 if students have no calculus at OSU or have algebra or trigonometry,

econ background is previous background in Economics (highest level of previous economics class completed), is equal to 1 for some background and is equal to 0 for no background,

major Ag Econ is a dummy variable equal to 1 if major is Agricultural Economics, and equal to 0 otherwise,

major Animal Science is a dummy variable equal to 1 if major is Animal Science, and equal to 0 otherwise,

opinion about economics is opinion that economics is boring on scale 1-7 (i.e. from in favor to not in favor of economics),

ACT is student's academic test score,

GPA is student's cumulative grade point average (no high correlation between ACT and GPA)

Active / reflective, sensing / intuitive, visual / verbal, sequential / global are the different dimensions of the learning style variable. Each of the dimensions ranges from –11 to 11. *Reflective, intuitive, verbal, global* range from –11 to 0. *Active, sensing, visual, sequential* range from 0 to 11.

To assert the students' ex-post subjective learning assessment with respect to the two teaching methods, two equations (one for each method) of the following form are estimated using ordered logit:

Subjective learning assessment = f(*teaching method, concepts pre-test score, exercises pre- test score, calculus high school, calculus at*

OSU, econ background, major Ag Econ, major Animal Science, opinion about economics, ACT, GPA, active / reflective, sensing / intuitive, visual / verbal, sequential / global) (2)

where *subjective learning assessment* is students' ex-post opinion about active learning (inductive method), or about learning from lectures (deductive method) measured on a Likert scale from 1 to 7 (i. e. with **strongly disagree=1, disagree=2, slightly disagree=3, indifferent=4, slightly agree=5, agreee=6, strongly agree=7** . The statement to be evaluated for the inductive method was **" Active experiences help learning."** The statement to be evaluated for the deductive method was **"I learn a great deal from lectures".** The actual response profiles were 1, 2, 4, 5, 6, 7 for the inductive method, and 1, 2, 3, 4, 5, 6, 7 for the deductive method,

teaching method is equal to 1 if the order of exposure to the teaching methods is inductive first and deductive second, and is equal to 0 otherwise. All other variables are defined as previously.

The logistic regression models are first estimated with all the explanatory variables, and then with forward selection to avoid the inclusion of non-relevant explanatory variables. The statistical technique of forward selection is commonly used with logistic regression.

6. ***Statistical or Econometric Tests***

The Shapiro-Wilk test of normality and misspecification tests are performed. The misspecification tests include the tests for functional form and for heteroskedasticity. A score test (chi-square test) for the proportional odds assumption in the logit models is conducted. This test asserts the goodness-of fit of the proportional odd logit model. In the proportional odds logit model multiple intercept parameters are estimated for the cumulative logit function but only one set of parameters corresponding to the explanatory variables is estimated. The intercept parameter corresponds to a reference or baseline group, and the other parameters correspond to incremental effects over that baseline group for the other group. A score test (chi-square test) of the global null hypothesis that all the estimated parameters of the proportional odds logit model are zero is also performed.

Subjects and Data

Students from the Agricultural Economics 1114 class (Spring 2000) were the subjects of the study. They were from different fields of studies. Referring to table 1.1, they were mostly from the Agricultural Economics (25 percent) and Animal Science (37 percent) majors. They had some background in economics (31 percent), in high school calculus (14 percent), in calculus at OSU or other 4-year college (13 percent). The mean academic test (ACT) score of the class was 23.49 points. The mean grade point average (GPA) of the class was 2.90. The students also expressed different learning style characteristics, and had different opinion about economics. In average, students' preconceived opinion that economics is boring was somewhere between "slightly disagree" and "indifferent" (mean = 3.22). In average, the class was more active than reflective (mean = 1.68), more sensing than intuitive (mean = 4.26), more visual than verbal (mean = 4.87), more sequential than global (mean = 1.38). In average, students' responses as to whether they were happier in a lecture class than in an experiment were somewhere between "slightly disagree" and "indifferent" (mean = 3.25). Average values of the dependent variables were 63.62, 57.74, 49.76, and 55.77 points for score 1, score 2, score 3, and score 4, respectively (see definition of these scores above).

Table 1.1 shows the summary statistics of the variables of interest. Dependent, explanatory and other variables are presented in terms of mean, standard deviation, minimum value, maximum value, and sample size.

Table 1.1 Summary Statistics of All Variables of Interest

Variable	Mean	Std. Dev.	Min.	Max.	Sample Size
1. Explanatory variables					
- Teaching method	0.36	0.48	0	1	177
- Pretest score for trade concepts	69.94	16.19	0	100	155
- Pretest score for trade exercises	47.87	17.85	0	100	155
- Hours of math completed in high school 1= calculus, 0= none, algebra, trigon.	0.14	n.a.	0	1	172
- Hours of math completed at OSU or other 4-year college 1= calculus, 0 = none, algebra, trigon.	0.13	n.a.	0	1	171
- Highest level of previous economic class completed 1= some background, 0 = no background	0.31	n.a.	0	1	172
- AG Econ major 1=AGEC, 0=else	0.25	n.a.	0	1	179
- Animal Science major 1=Animal Science, 0=else	0.37	n.a.	0	1	179
- Opinion about economics (statement: economics is boring) on Likert scale 1=strongly disagree, 2=disagree, 3=slightly disagree, 4=indifferent, 5=slightly agree, 6=agree, 7=strongly agree	3.22	1.45	1	7	169

Table 1.1 (continued)

Variable	Mean	Std. Dev.	Min.	Max.	Sample Size
- ACT score	23.49	3.62	13	34	164
- GPA (grade point average)	2.90	0.65	0.50	4	165
- Active / reflective learning style	1.68	5.15	-11	11	167
- Sensing / intuitive learning style	4.26	4.69	-11	11	167
- Visual / verbal learning style	4.87	4.24	-7	11	167
- Sequential / global learning style	1.30	4 .24	-11	11	167
2. Dependent variables					
- Trade concept test scores with half of the class assigned to inductive and the other half assigned to deductive **variable name: score 1**	63.62	17.73	25	100	123
- Trade exercises test scores with half of the class assigned to inductive and the other half to deductive **variable name: score 2**	57.74	16.77	5	95	126
- Trade concept test scores after all students have been assigned to the two teaching methods in a certain order, **variable name: score 3**	49.76	14.95	0	85	138

Table 1.1 (continued)

Variable	Mean	Std. Dev.	Min.	Max.	Sample Size
- Trade exercises test scores after all students have been assigned to the two teaching methods in a certain order, **variable name: score 4**	55.77	17.51	0	100	139
- Students' ex-post subjective learning assessment the inductive method(statement: active experience help learning) on Likert scale 1=strongly disagree, 2=disagree, 3=slightly disagree, 4=indifferent, 5=slightly agree, 6=agree, 7=strongly agree.	5.97	1.07	1	7	153
- Students' ex-post subjective learning assessment with respect to the deductive method (statement: learn a great deal from lecture) on Likert scale 1=strongly disagree, 2=disagree, 3=slightly disagree, 4=indifferent, 5=slightly agree, 6=agree, 7=strongly agree	4.78	1.48	1	7	152
3. Other variable					
- Students responses to the statement " I was happier in a lecture class than in an experiment" on a Likert scale from 1 to 7 defined as above	3.25	1.49	0	7	153

Source: Students' Ex-post Evaluation Survey

Results

The Shapiro-Wilk normality test indicates that the residuals are normally distributed[4] in all the equations. From the misspecification test (joint conditional mean test), no functional form problem[5] is detected. Furthermore, heteroskedasticity does not exist[6] in any of the estimated equations.

When one- half of the students in the class had been subjected to the inductive teaching method and the other one- half had had the deductive session, the parameter estimates, standard errors in the equation of expected test score for learning trade concepts (dependent variable: score 1) are shown in table 1.2 . There is evidence that the teaching method has an impact on the students' test score for learning trade-related concepts. Students' test score in learning trade concepts increases by 25.12 points when the teaching method is inductive. When students are assigned to the inductive or to the deductive teaching method, their score in the concept part of the pretest positively affects their performance in the same part. This may simply be due to some familiarity with the concept test after taking the pretest, although no two tests were exactly the same. Furthermore, the more students think that economics is a boring subject, the better they perform in the concept part of the test. Therefore, students' negative opinion about economics does not negatively influence their test score in learning trade concepts. Students with higher academic test (ACT) score perform better in learning trade

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[4] The tests for normality in the four possible cases presented by equation 1 are as follows:
case 1: Shapiro-Wilk statistic = 0.9899 p-value = 0.5860
case 2: Shapiro-wilk statistic = 0.9889 p-value = 0.4935
case 3: Shapiro-Wilk statistic = 0.9221 p-value = 0.4120
case 4: Shapiro-Wilk statistic = 0.9917 p-value = 0.6754

[5] The p-values in the functional form tests for the four cases defined in equation 1 are 0.1720, 0.7678, 0.6743, and 0.4592 respectively.

concepts. The more students are from the active learning style characteristic, the higher their performance in learning trade concepts[7]; or identically, the more students are from the reflective learning style characteristic, the lower their performance in learning trade concepts.

Table 1.2. Learning Trade Concepts: Dependent Variable is Concept Test Score for Students (Score 1), where Half of the Students Had Participated in the Inductive Experiments (Teaching Method = 1), and Half Had Had the Lecture of the Deductive Session (Teaching Method = 0).

Variable	Parameter Estimate	Standard Error
Intercept	0.96	11.14
Teaching method	25.12**	2.31
Concepts pre-test score	0.26**	0.08
Exercises pre-test score	0.07	0.08
Calculus high school	0.49	3.18
Calculus at OSU	4.95	3.59
Econ. background	-1.94	2.63
Major Ag. Econ.	-2.85	3.25
Major Animal Science	-2.44	2.95
Preconceived Opinion about economics	1.96**	0.89
ACT score	1.29**	0.45

[6] The p-values in the heteroskedasticity tests are 0.7467, 0.6610, 0.2645, and 0.2392 for the four cases defined in equation 1, respectively.

[7] Recall that the dimensions of the learning style variable range at most from -11 to + 11. In this particular case, reflective =] -11, 0), and active = (0,11[

Table 1.2 (continued)

Variable	Parameter Estimate	Standard Error
GPA	-1.56	2.29
Active / reflective	0.47*	0.27
Sensing / intuitive	0.33	0.30
Visual / verbal	-0.28	0.30
Sequential / global	-0.23	0.35

** means significant at 0.05, * means significant at 0.10. The sample size (n) is 110. R-square is 0.6292. The mean square error is 136.75, and the F value is 10.63 with a p-value <.0001.

The estimated equation of expected test score for **solving trade-related exercises** (dependent variable: score 2) when the entire class is split between the inductive and the deductive teaching methods is presented in Table 1.3. The results indicate that the teaching method has an impact on students' performance in the exercise-solving part of the test. With the inductive teaching method, students' test score in solving trade-related exercises increases by 11.68 points. After being exposed to one or the other of the two teaching methods, students' performance in the exercise-solving part of the test is influenced positively by their pretest score in this part and by their academic test (ACT) score. However, students' whose declared major is Agricultural Economics (AG Econ) have lower performance in solving trade-related exercises than students from other majors. The decrease in test score for the students in the Agricultural Economics major is

6.83 points. Students' learning style characteristics do not impact on their performance in solving trade-related exercises.

Table 1.3. Solving Trade Exercises: Dependent Variable is Exercises Solving Test Score for Students (Score 2), where Half of the Students Had Participated in the Inductive Experiments (Teaching Method = 1), and Half Had Had the Lecture of the Deductive Session (Teaching Method = 0).

Variable	Parameter Estimate	Standard Error
Intercept	-0.30	12.00
Teaching method	11.68**	2.62
Concepts pre-test score	0.05	0.09
Exercises pre-test score	0.40**	0.09
Calculus high school	2.10	3.62
Calculus at OSU	-2.95	4.08
Econ background	-0.74	2.95
Major Ag. Econ.	-6.83*	3.69
Major Animal Science	-1.76	3.31
Preconceived Opinion about economics	0.47	1.00
ACT score	1.51**	0.51
GPA	-2.08	2.51
Active / reflective	0.04	0.30
Sensing / intuitive	0.35	0.34
Visual / verbal	-0.13	0.34
Sequential / global	0.31	0.39

** means significant at 0.05, * means significant at 0.10. The sample size (n) is 112. R-square is 0.4517. The mean square error is 176.78, and the F- value is 5.27 with a p-value <.0001.

After the two teaching methods have been assigned to the two groups of students but in a different order for each group, the parameter estimates, standard errors in the equation of the students' expected test score in **learning trade concepts** (dependent variable: score3) are presented in Table 1.4. Teaching first inductively and then deductively to students seems to have a significant positive impact on students' performance in learning trade-related concepts. Exposing the students to the two teaching methods in the order inductive first and deductive second increases test score of learning trade concepts by 10.22 points. Students' ACT score positively affects performance in learning trade concepts. More reflective students perform better in learning trade concepts when the students have been exposed to the two teaching methods in some order. This is a reversal situation, as compared to the one where the students have been exposed to one or the other of the teaching methods. Therefore, in terms of learning trade concepts, applying one or the other of the two teaching methods benefits students who are active learners. However, applying both methods in some order benefits reflective learners more. In addition, students who are more from the global learning style characteristic perform better in learning trade concepts.

Table 1.4. Learning Trade Concepts: Dependent Variable is Concept Test Score for Students (Score 3) when One-Half of the Class Had Had Experiments then Lecture (Teaching Method = 1), and the Other Half Had Had Lecture then Experiments (Teaching Method = 0)

Variable	Parameter Estimate	Standard Error
Intercept	6.30	10.04
Teaching method	10.22**	2.34
Concepts pre-test score	0.11	0.08
Exercises pre-test score	0.10	0.07
Calculus high school	0.32	3.14
Calculus at OSU	-1.32	3.23
Econ background	-3.84	2.63
Major Ag. Econ.	4.45	3.28
Major Animal Science	1.17	2.80
Preconceived opinion about economics	-1.34	0.90
ACT score	1.37**	0.42
GPA	-0.36	2.20
Active / reflective	-0.52*	0.28
Sensing / intuitive	0.10	0.28
Vissual / verbal	0.41	0.31
Sequential / global	-0.59*	0.31

** means significant at 0.05, * means significant at 0.10. The sample size (n) is 122. R-square is 0.4459. The mean square error is 146.78, and the F value is 5.69 with a p-value <.0001.

When evaluating the order of the two methods, the parameter estimates and standard errors in the equation of expected test score for **solving trade-related exercises** (dependent variable: score 4) are presented in Table 1.5. Once again, the order of exposure to the two teaching methods matters. Students who have been exposed first to the inductive method and second to the deductive method have an increase of 12.49 points in their test score in solving trade- related exercises. When the two teaching methods have been assigned to the students in some order, pretest score in solving trade-related exercises positively affects students' performance in the problem-solving part of the test. Furthermore, students' ACT score impacts positively on students' performance. There is no evidence that students' learning style affects performance in this particular context.

Table 1.5. Solving Trade Exercises: Dependent Variable is Trade Exercises Test Score for Students (Score 4), when One-Half of the Class Had Had Experiments then Lecture (Teaching Method = 1), and the Other Half Had Had Lecture then Experiments (Teaching Method = 0)

Variable	Parameter Estimate	Standard Error
Intercept	-2.17	11.23
Teaching method	12.49**	2.72
Concepts pre-test score	0.13	0.09
Exercises pre-test score	0.14*	0.08
Calculus high school	3.72	3.66
Calculus at OSU	-2.41	3.76
Econ. background	-2.89	3.05
Major Ag. Econ.	-1.16	3.82
Major Animal Science	3.62	3.25

Table 1.5 (continued)

Variable	Parameter Estimate	Standard Error
Preconceived opinion about economics	-1.83	1.04
ACT score	1.99**	0.49
GPA	-0.94	2.46
Active/ reflective	-0.03	0.33
Sensing / intuitive	0.21	0.32
Visual / verbal	-0.15	0.36
Sequential / global	-0.27	0.36

** means significant at 0.05, * means significant at 0.10. The sample size (n) is 123. R-square is 0.4466. The mean square error is 198.79, and the F value is 5.76 with a p-value <.0001

The results of the estimated proportional odds ordered logit model for the students' subjective learning assessment with respect to the inductive teaching method are in Table 1.6. Only two explanatory variables are significant: the teaching method order and the students' ACT score. The overall test (score test) of the global null hypothesis that all the parameter estimates of the proportional odds ordered logit model are equal to zero gives support for this null hypothesis with a chi-square value of 12.40 with 15 degrees of freedom and a p-value of 0.6482. Furthermore, we reject the proportional odds assumption with a chi-square of 187.78 with 60 degrees of freedom and a p-value < .0001.

Table 1.6. Proportional Odds Ordered Logit Model where Dependent Variable is Students' Subjective Learning Assessment with Respect to the Inductive Teaching Method, and Teaching Method Equals 1 if Students Had Had Experiments then Lecture, and Equals 0 if Students Had Had Lecture then Experiments.

Variable	Maximum Likelihood Estimate	Asymptotic Standard Error	Odds Ratio
Intercept	-1.86	1.60	
Intercept2	0.25	1.60	
Intercept3	1.97	1.62	
Intercept4	2.88**	1.68	
Intercept5	4.01**	1.87	
Teaching Method	-0.62*	0.34	0.536
Concept pre-test score	0.01	0.01	1.010
Exercises pre-test score	-0.01	0.01	0.989
Calculus high school	0.07	0.47	1.076
Calculus at OSU	-0.21	0.49	0.809
Econ. background	0.37	0.39	1.448
Major Ag. Econ.	0.0007	0.49	1.001
Major Animal Science	0.35	0.40	1.424
Preconceived opinion about econ.	-0.09	0.13	0.912
ACT score	0.12**	0.07	1.125
GPA	-0.59	0.33	0.554
Active / reflective	0.01	0.04	1.014
Sensing / intuitive	0.01	0.04	1.015
Visual / verbal	-0.001	0.05	0.999
Sequential / global	0.06	0.05	1.062

** means significant at 0.05, * means significant at 0.10. In the score test for the proportional odds assumption, the chi-square is 187.78 with 60 degrees of freedom, and a p-value <.0001. Sample size (n) is 179.

The proportional odds ordered logit model used to explain students' subjective learning assessment with respect to the inductive method is not a good fit with the set of predictor variables considered. Forward selection can be used with the proportional odds ordered logit model to find the relevant explanatory variables. When this process is used, no explanatory variable enters the model at the 0.05 level of significance. Only intercept terms are fitted into the model. The residual chi-square test, which is also a score test of goodness-of-fit for a set of additional terms not in the model, indicates a chi-square statistics of 12.40 with 15 degrees of freedom and a p-value of 0.6482. This asserts the adequacy of the model with intercept terms only. Consequently, students' subjective learning assessment with respect to the inductive teaching method is independent of all the explanatory variables specified in the model. In other words, with the set of data at hand, students subjective learning assessment with respect to the inductive teaching method is totally unrelated to the teaching method order, and students' cognitive, affective, and learning style attributes.

Table 1.7 shows the results of the estimated proportional odds ordered logit model for the students' subjective learning assessment with respect to the deductive teaching method. Seven explanatory variables are significant: the pretest score for solving trade-related exercises, Agricultural Economics major, Animal Science major, students' preconceived opinion about economics, which is measured on a Likert scale from 1 to 7 from the statement that "economics is a boring subject", students' GPA, students' active/reflective learning style characteristic, and students' visual/verbal learning style characteristic. The overall test (score test) of the global null hypothesis that all the parameter estimates of the proportional odds ordered logit model are zero gives support for the alternative joint hypothesis that the parameter estimates are not zero with a chi-square value of 35.43 with 15 degrees of freedom and a p-value of 0.0021. However, with this set of explanatory variables considered, the proportional odds assumption is rejected with a chi-square of 256.97 with 75 degrees of freedom and a p-value < .0001.

Table 1.7. Proportional Odds Ordered Logit Model where Dependent Variable is Students' Subjective Learning Assessment with Respect to the Deductive Teaching Method, and Teaching Method Equals 1 if Students Had Had Experiments then Lecture, and Equals 0 if Students Had Had Lecture then Experiments.

Variable	Maximum Likelihood Estimate	Asymptotic Standard Error	Odds Ratio
Intercept	0.18	1.57	
Intercept2	2.76*	1.59	
Intercept3	4.16**	1.61	
Intercept4	4.89**	1.62	
Intercept5	5.98**	1.64	
Intercept6	7.71**	1.73	
Teaching Method	0.28	0.33	1.317
Concept pre-test score	0.001	0.01	1.001
Exercises pre-test score	0.02*	0.01	1.020
Calculus high school	0.64	0.48	1.895
Calculus at OSU	0.10	0.48	1.107
Econ. background	0.07	0.38	1.075
Major Ag. Econ	1.05**	0.48	2.868
Major Animal Science	0.87**	0.39	2.378
Preconceived opinion about econ.	-0.40**	0.13	0.671
ACT score	-0.05	0.06	0.956

Table 1.7 (continued)

Variable	Maximum Likelihood Estimate	Asymptotic Standard Error	Odds Ratio
GPA	-0.71**	0.33	0.491
Active / reflective	0.07*	0.04	0.929
Sensing / intuitive	-0.03	0.04	0.974
Visual / verbal	-0.11**	0.05	0.899
Sequential / global	0.002	0.05	1.002

** means significant at 0.05, * means significant at 0.10. In the score test for the proportional odds assumption, the chi-square is 256.97 with 75 degrees of freedom, and a p-value <.0001. The sample size (n) is 179.

Therefore, the proportional odds assumption is not a good one with the set of predictor variables considered. Forward selection is once again used to reduce the explanatory variables in the ordered logit model down to the relevant ones. The parameter estimates, asymptotic standard error and odds value obtained with forward selection are given in Table 1.8. Four explanatory variables are relevant in explaining students' subjective learning assessment with respect to the deductive teaching method: students' pretest score in solving trade-related exercises, students preconceived opinion about economics, i.e. the extent to which they consider economics as a boring subject, students' GPA, and students' visual/verbal learning style. The score test of the proportional odds assumption with forward selection, (also considered as a goodness-of-fit test), shows a failure to reject the null hypothesis of proportional odds assumption in the reduced model with four explanatory variables with a chi-square of 26.41 with 20 degrees of freedom and a p-value of 0.1527. Furthermore, the score test of the global null hypothesis that all the coefficients are zero indicates that this null hypothesis is rejected with a chi-square of 25.49 with 4 degrees of freedom and a p-value < 0.0001. The residual chi-square test indicates a chi-square of 12.05 with 11 degrees of freedom with a p-value of 0.3600

The statement that had to be evaluated for students' subjective learning assessment with respect to the deductive method was the following "**I learn a great deal from lectures**". Possible answers were from "**strongly disagree**" =1 to "**strongly agree**"=7. Given that the order in the model is from 1 to 7, an increase in the odds ratio[8] corresponds to a move toward agreeing more with the statement or higher subjective learning assessment with respect to the deductive teaching method. A decrease in the odds corresponds to a move toward disagreeing with the statement or to lower subjective learning assessment with respect to the deductive teaching method. Note that a student's answer to the above statement is taken as a measure of his or her level of subjective learning assessment with respect to the deductive method. For instance, referring to table 1.8, as GPA increases by one unit, the estimated odds ratio decreases by 50.70 percent [i.e. (1-0.493)*100]. In other words, students' subjective learning assessment with respect to the deductive teaching method decreases by 50.70 percent as GPA increases by one

[8] The logistic regression model has linear form for the logit of this probability $\pi(x)$

$\log it[\pi(x)] = \log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \alpha + \beta x$ where $\frac{\pi(x)}{1-\pi(x)} = \exp(\alpha + \beta x) = e^{\alpha}(e^{\beta})^{x}$, the term

$\frac{\pi(x)}{1-\pi(x)}$ is called the odds or odds ratio. This exponential relationship provides an interpretation for β :

the odds increase multiplicatively by e^{β} for every one-unit increase in x. That is the odds at level x+1 equal the odds at x multiplied by e^{β}. When $\beta = 0$, $e^{\beta} = 1$, and the odds do not change as x changes. (Agresti, 1996, p 107) point, everything else equal. Consequently, students with higher GPA said they learn less from the deductive teaching method.

Controlling for students' GPA, for students' opinion about economics, and for students visual / verbal learning style characteristic, a one-unit increase in students' pretest score in solving trade-related exercises increases the estimated odds by 2.4 percent [i.e (1.024–1)*100]. Therefore, everything being equal, students' subjective learning assessment with respect to the deductive method increases by 2.4 percent for one point increase in students' pretest score in solving trade-related exercises.

Students' preconceived opinion about economics was captured with the following statement: " **economics is a boring subject**". Possible answers ranged from "**strongly disagree**"=1 to "**strongly agree**"=7. Moving from 1 to 7 corresponds to moving toward less favorable opinion about economics. Controlling for students' GPA, for students' pretest score in solving trade-related exercises, and for students' visual / verbal learning style characteristic, a one-unit increase in students' opinion about economics (from favoring to not favoring economics) leads to a 30.10 percent [i.e. (1 - 0.699)*100] decrease in the estimated odds of students subjective learning assessment with respect to the deductive method. Therefore, as students have less favorable opinion about economics, they said they learn less from the deductive method, everything else equal.

Controlling for students' GPA, for students' opinion about economics and for students' pretest score in solving trade-related exercises, the more students are visual the less the estimated odds of students' subjective learning assessment with respect to the deductive method. A one-unit increase in students' visual characteristic leads to a 11.20 percent [i.e. (1 –0.888)*100] decrease in the estimated odds. Therefore, more visual students tend to say they learn less from the deductive teaching method, everything else being the same (or stated differently, more verbal students tend to say they learn more from the deductive teaching method, ceteris paribus).

Table 1.8. Proportional Odds Ordered Logit Model with Forward Selection where Dependent Variable is Students' Subjective Learning Assessment with Respect to the Deductive Teaching Method, and Teaching Method Equals 1 if Students Had Had Experiments then Lecture, and Equals 0 if Students Had Had Lecture then Experiments.

Variable	Maximum Likelihood Estimate	Asymptotic Standard Error	Odds Ratio
Intercept	-0.31	1.02	
Intercept2	2.15**	1.02	
Intercept3	3.46**	1.05	
Intercept4	4.11**	1.06	
Intercept5	5.12**	1.09	
Intercept6	6.84**	1.22	
Exercises pre-test score	0.02**	0.009	1.024
Preconceived opinion about econ.	-0.36**	0.12	0.699
GPA	-0.71**	0.29	0.493
Visual / verbal	-0.12**	0.04	0.888

** means significant at 0.05. In the residual chi-square test, chi-square is 12.05 with a p-value of 0.36. In the score test of the proportional odds assumption, the chi-square is 26.41 with 20 degrees of freedom, and a p-value of 0.1527. The sample size (n) is 179.

Conclusion

The teaching method has a significant impact on students' performance in learning trade concepts and solving trade-related exercises. The inductive teaching method substantially improves the students' performance. If both methods are used, inductive first and deductive second is preferred. The students' cognitive characteristics as measured by their pretest score, their ACT score, and their major are related to performance. In general, students' pre-test scores in learning trade concepts and in solving trade-exercises have a significant positive impact on performance. Since the pretest and the tests are not identical even though they are based on the same concepts, some exposure to the test material before any teaching takes place seems to be beneficial to the students. Students with high ACT scores tend to perform better in both the concept and the exercise-solving tests, no matter whether the performance test was given after students have been exposed to one or the other of the teaching methods or to both in a certain order. Students from majors other than Agricultural Economics perform better in solving trade related exercises when one-half of the class has been assigned to the inductive method and the other half has been assigned to the deductive method. The students' affective characteristic as measured by their preconceived opinion about economics somewhat impacts on their performance in learning trade concepts. However, expression of negative opinion about economics does not negatively influence test score in learning trade concepts.

The students' learning style does not affect their performance in solving trade-related exercises. However, in terms of learning trade concepts, students who are more reflective or global learners seem to have better results in a situation where they have been exposed to the two teaching methods in some order. In contrast, active learners seem to perform better when the students have been exposed to one or the other of the two teaching methods.

Students' subjective learning assessment with respect to the inductive teaching method is totally unrelated to the teaching method, and their cognitive, affective, and learning style attributes. However, globally, students say they learn more from the inductive method than from the deductive method[9]. Everything else equal, students' subjective learning assessment with respect to the deductive teaching method decreases as GPA increases. Consequently, students with higher GPA say they learn less from the deductive teaching method. Everything else equal, students' subjective learning assessment with respect to the deductive teaching method increases with students' pretest score in solving trade-related exercises. As students have less favorable opinion about economics, they say they learn less from the deductive method, everything else constant. Furthermore, students with more visual learning style characteristic tend to say they learn less from the deductive teaching method, everything else being the same.

[9] As shown in Table 1.1, the mean of the subjective learning assessment with respect to the inductive method is higher than the mean of the subjective learning assessment with respect to the deductive method.

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APPENDIX

Student Information Sheet
Agricultural Economics 1114
Daniel S. Tilley, Professor
Alix Dameus, assistant

Spring 2000

Name: ______________________________ Major: ______________________________

Advisor's Name: ______________________________ Date of Birth: __________
Campus Address: ______________________________
Campus Phone: ______________________________
Home Phone: ______________________________
Email Address: ______________________________

Previous courses in Economics, Mathematics:

Course Name:	Year Taken	School (Include highest level in High School)

Other classes this semester:	Day and time:

Major extracurricular activities this semester:

____
____
____
____
____

Career Objectives:

____
____
____

I have received the syllabus for AGEC1114 and it has been explained to me.

______________________________ __________
Signature Date

Information Questionnaire

Name______________________________

Information you provide in this questionnaire All individual information you provide in this questionnaire will not be available to the instructor of this course until grades have been assigned.

Use a number from 1 to 7 to indicate the extent to which you agree or disagree with the following statements.

1	2	3	4	5	6	7
Stongly Disagree	Disagree	Slightly Disagree	Indifferent	Slightly Agree	Agree	Strongly Agree

____ 1. Students who have taken Agricultural Economics 1114 say it is easy.
____ 2. This course will help me make better personal financial decisions.
____ 3. This course will help me make better business decisions.
____ 4. I like to interact with other students while learning.
____ 5. I learn a great deal from lectures.
____ 6. I like courses that have laboratory exercises.
____ 7. Active experiences help me learn.
____ 8. I expect to spend more than 1 hour per day outside of class for this course.
____ 9. Economics is a boring subject.
____10. I want to meet more of my classmates.

11. In my high school class, I ranked in the top _____ percent.

12. My overall ACT composite score was ______.

13. I have completed _____ hours of college credit at Oklahoma State University.

14. My grade point average is ______.

15. Interacting with other students while learning is enjoyable
    ______ Yes ______ No

16. I like classes with laboratory exercises.
    ______ Yes _______ No

Evaluation Questionnaire

Student id number ____________________ Name (Optional) _________________________

Use a number from 1 to 7 to indicate the extent to which you agree or disagree with the following statements.

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Slightly Disagree	Indifferent	Slightly Agree	Agree	Strongly Agree

_____ 1. I was happier in a lecture class than in an experimental session.
_____ 2. Agricultural Economics 1114 say is an easy class.
_____ 3.More laboratory exercises will make Agricultural Economics more fun.
_____ 4 This course will help me make better personal financial decisions.
_____ 5.This course will help me make better business decisions.
_____ 6. I enjoyed interacting with other students while learning.
_____ 7. I learn a great deal from lectures.
_____ 8. The lecture notes on the web site were helpful.
_____ 9. Economics courses should be encouraged to have laboratory exercises.
_____ 10. Active experiences help me learn.
_____ 11. Student should expect to spend more than 1 hour per day outside of class for this course.
_____ 12. Economics is a boring subject.
_____ 13. I want to meet more of my classmates.
_____ 14. As a result of this class I have new friends.
_____ 15. The laboratory exercises were a waste of time.
_____ 16. The laboratory exercises should have been done in class.
_____ 17. Knowing my learning style helped me study for this and other classes.

18. Interacting with other students while learning is enjoyable
______ Yes ______ No

19. I like classes with laboratory exercises.
______ Yes _______ No

20. In the space below, please feel free to make any additional comments that you feel would help the development of this class.

NC STATE UNIVERSITY

Index of Learning Styles Questionnaire

Barbara A. Soloman
First-Year College
North Carolina State University
Raleigh, North Carolina 27695

Richard M. Felder
Department of Chemical Engineering
North Carolina State University
Raleigh, NC 27695-7905

Directions

Please provide us with your full name. Your name will be printed on the information that is returned to you.

Full Name

For each of the 44 questions below select either "a" or "b" to indicate your answer. Please choose only one answer for each question. If both "a" and "b" seem to apply to you, choose the one that applies more frequently. When you are finished selecting answers to each question please select the submit button at the end of the form.

1.I understand something better after I
(a) try it out.
(b) think it through.

2.I would rather be considered
(a) realistic.
(b) innovative.

3.When I think about what I did yesterday, I am most likely to get
(a) a picture.
(b) words.

4.I tend to
(a) understand details of a subject but may be fuzzy about its overall

structure.
(b) understand the overall structure but may be fuzzy about details.

5.When I am learning something new, it helps me to
(a) talk about it.
(b) think about it.

6.If I were a teacher, I would rather teach a course
(a) that deals with facts and real life situations.
(b) that deals with ideas and theories.

7.I prefer to get new information in
(a) pictures, diagrams, graphs, or maps.
(b) written directions or verbal information.

8.Once I understand
(a) all the parts, I understand the whole thing.
(b) the whole thing, I see how the parts fit.

9.In a study group working on difficult material, I am more likely to
(a) jump in and contribute ideas.
(b) sit back and listen.

10.I find it easier
(a) to learn facts.
(b) to learn concepts.

11.In a book with lots of pictures and charts, I am likely to
(a) look over the pictures and charts carefully.
(b) focus on the written text.

12.When I solve math problems
(a) I usually work my way to the solutions one step at a time.
(b) I often just see the solutions but then have to struggle to figure out the steps to get to them.

13.In classes I have taken
(a) I have usually gotten to know many of the students.
(b) I have rarely gotten to know many of the students.

14.In reading nonfiction, I prefer
(a) something that teaches me new facts or tells me how to do something.
(b) something that gives me new ideas to think about.

15.I like teachers
(a) who put a lot of diagrams on the board.

(b) who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
   (a) I think of the incidents and try to put them together to figure out the themes.
   (b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
   (a) start working on the solution immediately.
   (b) try to fully understand the problem first.

18. I prefer the idea of
   (a) certainty.
   (b) theory.

19. I remember best
   (a) what I see.
   (b) what I hear.

20. It is more important to me that an instructor
   (a) lay out the material in clear sequential steps.
   (b) give me an overall picture and relate the material to other subjects.

21. I prefer to study
   (a) in a study group.
   (b) alone.

22. I am more likely to be considered
   (a) careful about the details of my work.
   (b) creative about how to do my work.

23. When I get directions to a new place, I prefer
   (a) a map.
   (b) written instructions.

24. I learn
   (a) at a fairly regular pace. If I study hard, I'll "get it."
   (b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
   (a) try things out.
   (b) think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
   (a) clearly say what they mean.

(b) say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
    (a) the picture.
    (b) what the instructor said about it.

28. When considering a body of information, I am more likely to
    (a) focus on details and miss the big picture.
    (b) try to understand the big picture before getting into the details.

29. I more easily remember
    (a) something I have done.
    (b) something I have thought a lot about.

30. When I have to perform a task, I prefer to
    (a) master one way of doing it.
    (b) come up with new ways of doing it.

31. When someone is showing me data, I prefer
    (a) charts or graphs.
    (b) text summarizing the results.

32. When writing a paper, I am more likely to
    (a) work on (think about or write) the beginning of the paper and progress forward.
    (b) work on (think about or write) different parts of the paper and then order
    them.

33. When I have to work on a group project, I first want to
    (a) have "group brainstorming" where everyone contributes ideas.
    (b)brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
    (a) sensible.
    (b) imaginative.

35. When I meet people at a party, I am more likely to remember
    (a) what they looked like.
    (b) what they said about themselves.

36. When I am learning a new subject, I prefer to
    (a) stay focused on that subject, learning as much about it as I can.
    (b) try to make connections between that subject and related subjects.

37.I am more likely to be considered
(a) outgoing.
(b) reserved.

38.I prefer courses that emphasize
(a) concrete material (facts, data).
(b) abstract material (concepts, theories).

39.For entertainment, I would rather
(a) watch television.
(b) read a book.

40.Some teachers start their lectures with an outline of what they will cover. Such outlines are
(a) somewhat helpful to me.
(b) very helpful to me.

41.The idea of doing homework in groups, with one grade for the entire group,
(a) appeals to me.
(b) does not appeal to me.

42.When I am doing long calculations,
(a) I tend to repeat all my steps and check my work carefully.
(b) I find checking my work tiresome and have to force myself to do it.

43.I tend to picture places I have been
(a) easily and fairly accurately.
(b) with difficulty and without much detail.

44.When solving problems in a group, I would be more likely to
(a) think of the steps in the solution process.
(b)think of possible consequences or applications of the solution in a wide range of areas.

Pre-Test
International Trade
Agricultural Economics 1114
Spring 2000

Name----------------------------- SEAT NUMBER-------------- Date----------------

PART ONE

1. The slope of the production possibilities frontier is --------------------
   a. the marginal rate of product substitution
   b. the marginal rate of technical substitution
   c. equal to the ratio of input prices
   d. none of the above.

2. The value of alternative choices given up in order to produce or consume any good or service is called ---------------------
   a. the budget constraint
   b. indifference curve evaluation
   c. the substitution effect of a price change
   d. opportunity cost.

3. Along the production possibilities curve for two goods, an increase in the output of one good can be obtained ------------- the output of the other good.
   a. without affecting
   b. by increasing
   c. by decreasing
   d. all of the above
   e. none of the above.

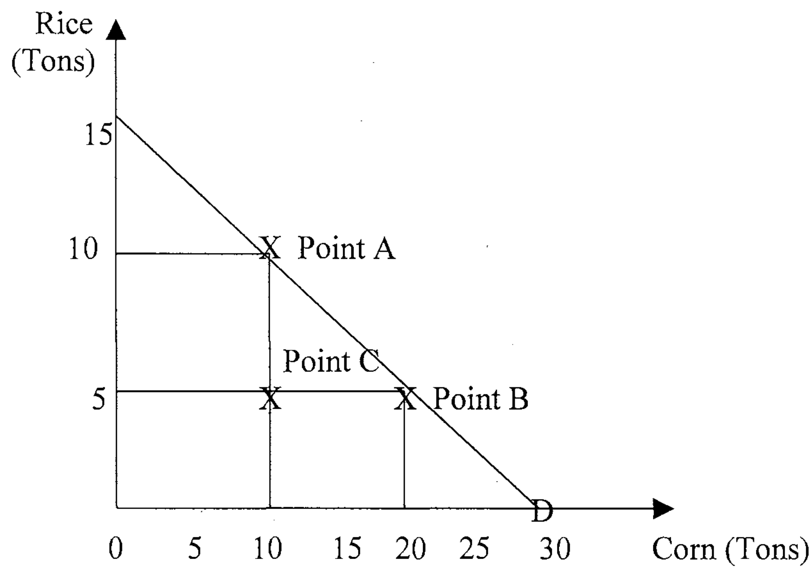
4. Decreasing opportunity costs means: ------------------
   a. other people's opportunities are falling
   b. the production possibilities curve is horizontal
   c. the boundary is shifting between what is and what is not possible
   d. less of one good has to be sacrificed to get greater amounts of another good
   e. all of the above
   f. none of the above.

5. The decision about what product to produce (assume the products use similar resources) would be best described as -----------
   a. a product-product substitution decision
   b. an input-input substitution decision
   c. an input-output decision
   d. not very important

e. none of the above.

6. A production possibilities set includes --------------
   a. only points on the production possibilities frontier
   b. points outside the production possibilities frontier
   c. points below and points on the production possibilities frontier
   d. none of the above.

Assume a small country can produce either 15 tons of rice or 30 tons of corn or any combination of the two crops represented on the line from 15 to 30 on the graph below. Answer questions 7 and 8 based on the following diagram:



7. Corn production at point A is -----------. Rice production at point A is ------------

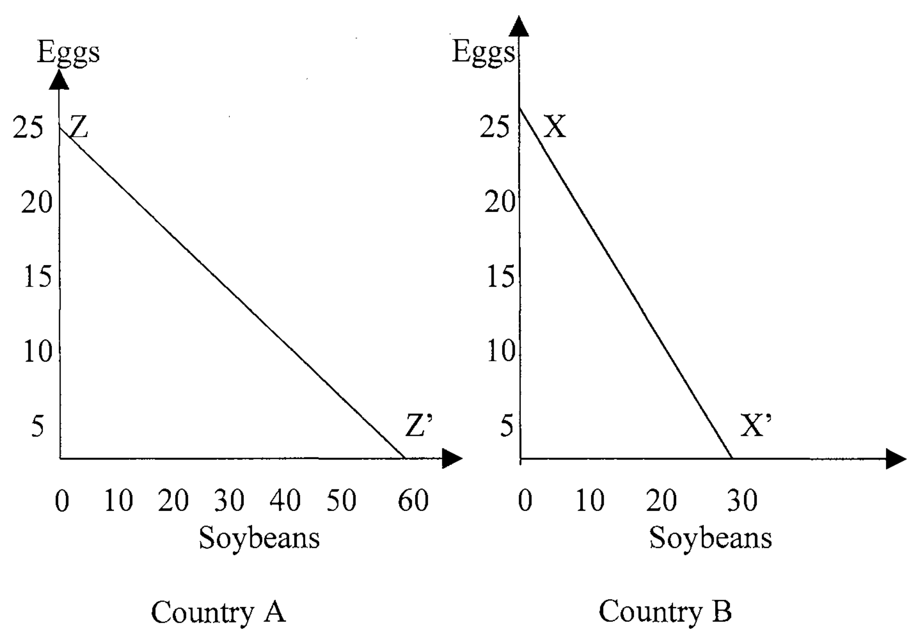
8. Which points represent efficient production ----------------
   a. B and C
   b. A and C
   c. A and B
   d. None of the above.

9. If you import a good from another country, it must be -------------
   a. more expensive in the country you are imported it from
   b. less expensive in your country
   c. less expensive in the country you are imported it from
   d. more expensive in your country
   e. a and b
   f. b and c
   g. c and d.

10. If U. S. producers export rice to Mexico, the price of rice in the U. S. must be ---------
    a. higher than the price of rice in Mexico
    b. lower than the price of rice in Mexico
    c. equal to the price of rice in Mexico
    d. none of the above.

PART TWO

Suppose that the production possibilities curves for two countries A and B before trade are represented in the two following diagrams. Each mark on the axes represents one unit in both graphs. **Answer questions 1 –5 based on these diagrams**



The relative values of eggs and soybeans in country A and country B are represented respectively by the slopes of the two lines ZZ' and XX'.

1. In country A, the number of units of soybeans needed to acquire one unit of eggs is

    a. 25/30
    b. 30/25
    c. 25/60
    d. 60/25

2. In country B, eggs are relatively------- valuable relative to eggs than in country A.

    a. more
    b. less

3 If trade is free between the two countries, country A will ---------- eggs and ------- soybeans

    a. import, export
    b. export, import
    c. neither of the above

4. Which country has a comparative advantage in the production of eggs? -------------
   Which country has a comparative advantage in the production of soybeans---------

Answer questions 5-12 based on the following information:

Suppose it takes 1 hour to produce 1 potato and 2 hours to produce 1 steak in Idaho and it takes 2 hours to produce 1 potato and 1 hour to produce 1 steak in Oklahoma.

5. Write an equation for each country that states that the number of hours required to produce P potatoes and S steak is equal to 30

Idaho: --
Oklahoma: --

6. The productivity of Idaho in producing potatoes is ---------------
The productivity of Idaho in producing steak is ----------------
The productivity of Oklahoma in producing potatoes is --------------
The productivity of Oklahoma in producing steak is --------------

7. In Idaho, the ratio of the productivity in producing steak to the productivity in producing potatoes is ---------------

8. In Oklahoma, the ratio of the productivity in producing steak to the productivity in producing potatoes is --------------------

9. **Based on the ratios in questions 7 and 8**, which state has an absolute advantage in the production of steak? -------------------

Which state has a comparative advantage in the production of potatoes? ----------------

Which state has a comparative advantage in the production of steak? ------------------

Assume steaks and potatoes are always consumed together, one steak with one potato.

10. If a person from Oklahoma cannot trade with a person from Idaho, how many steak and potato meals can the Oklahoman produce and consume with 30 hours to spend on production? -------------------

11. If a person from Oklahoma cannot trade with a person from Idaho, how many steak and potato meals can the person from Idaho produce and consume with 30 hours to spend on production? -------------------

12. Assume the price of potatoes equals the price of steak and people from Idaho and Oklahoma have 30 hours to spend on production. If a person from Oklahoma and a person from Idaho are allowed to trade with each other, you would expect the person from Idaho to produce------------ steaks and ---------- potatoes and the person from Oklahoma to produce -------- steaks and --------- potatoes. They would then trade and each would have ------- steak and potato meals to consume.

Chapter II

Caribbean Demand of U. S. and Rest-of-the-World Starchy Food (Wheat, Rice, Corn, and Fresh Potatoes): A Restricted Source Differentiated Almost Ideal Demand System

Caribbean Demand of U. S. and Rest-of-the-World Starchy Food (Wheat, Rice, Corn and Fresh Potatoes): A Restricted Source Differentiated Almost Ideal Demand System

Abstract

This study provides elasticity estimates of the Caribbean demand for U. S. and Rest-of-the-World starchy foods (unmilled wheat and flour, rice, corn and fresh potatoes) using the Restricted Source Differentiated Almost Ideal Demand System (RSDAIDS) model. Caribbean per capita import demand curves for U.S. and Rest-of-the-World (ROW) are own-price unitary elastic for U. S. wheat, and own-price inelastic for U.S. rice and ROW wheat and rice. The implication is that reductions by any means in U. S. or ROW export prices of wheat and rice will increase U.S. or ROW exported quantities in the Caribbean, while at the same time securing food security through import quantity in the Caribbean. Wheat is not produced in the Caribbean. U. S. wheat price policy oriented toward a reduction in the export price of wheat to the Caribbean may increase the U. S. wheat market share in the Caribbean. For wheat and rice, no competition across source exists. Instead, there exists a complementarity relationship across source for each of the two products. In other words, the Caribbean distinguishes between the wheat or rice coming from the U. S. and the wheat or rice coming from the Rest-of-the-World.

Key words: Caribbean demand, elasticity estimates, food security, price policies, Restricted Source Differentiated Almost Ideal Demand System (RSDAIDS), starchy food.

Caribbean Demand of U. S. and Rest-of-the-World Starchy Food (Unmilled Wheat and Flour, Rice, Corn and Fresh Potatoes): A Restricted Source Differentiated Almost Ideal Demand System

Introduction

Starchy foods are an important dietary component for people in the Caribbean. The four highest volume starchy staples in the Caribbean are wheat, rice, corn, and fresh potatoes. There is no wheat production in the Caribbean region. Rice, corn and fresh potatoes are produced only in a few of the Caribbean countries (Table 2.1).

Table 2. 1. Countries Producing the four Staple Foods (Wheat, Rice, Corn, and Potatoes) in the Caribbean

Staple	Caribbean producer-countries
Wheat	None
Rice	Dominican Republic, Haiti, Jamaica , Puerto-Rico, Trinidad-Tobago
Corn	Antigua-Barbados, Bahamas, Barbados, Dominican Republic, Grenada, Dominica, Guadeloupe, Haiti, Jamaica, Montserrat, Puerto-Rico, St-Lucia, St-Vincent, Trinidad-Tobago
Potatoes	Bermuda, Dominica, Dominican Republic, Guadeloupe, Haiti, Jamaica, Montserrat, St Kitts and Nevis

Source: FAO

Caribbean production of starchy foods is frequently insufficient to satisfy the needs of the growing population. Therefore, the products are imported from the United States and from the Rest-of-the-World.

As shown in Table 2.2, Caribbean total wheat imports varied from year to year and exceeded 15,000 hundreds metric tons each year over a fifteen-year period (1982-96). In 1996, total wheat imports in the region were as high as 46,791 hundreds metric tons. The U. S. share of the Caribbean total volume of wheat imported exceeded 20 percent from 1982 to 1996. In 1995, this share reached its highest level of 41.16 percent over the fifteen-year period. More than half of the volume of wheat (unmilled and flour) imported in the Caribbean comes from the Rest-of-the World, which includes all wheat exporting countries but U. S.

Table 2.2. Caribbean Wheat (Unmilled and Flour) Imports from the U. S., and from the Rest-of-the-World (ROW) from 1982 to 1996.

Year	Imports from U. S. (MT)	Imports from ROW (MT)	Total Imports (MT)	U. S. Share of Total Imports (%)	ROW share of Total Imports (%)
1982	490,491	1,542,749	2,033,240	24.12	75.88
1983	542,501	1,785,449	2,327,950	23.30	76.70
1984	597,601	1,681,899	2,279,500	26.22	73.78
1985	720,745	1,597,955	2,318,700	31.08	68.92
1986	706,606	1,668,094	2,374,700	29.76	70.24
1987	711,284	1,768,516	2,479,800	28.68	71.32
1988	675,388	1,675,912	2,351,300	28.72	71.28
1989	657,801	1,607,199	2,265,000	29.04	70.96
1990	662,582	1,453,218	2,115,800	31.32	68.68
1991	609,272	1,712,428	2,321,700	26.24	73.76
1992	666,802	1,553,698	2,220,500	30.03	69.97
1993	671,832	1,259,668	1,931,500	34.78	65.22
1994	416,663	1,485,937	1,902,600	21.90	78.10
1995	686,931	982,169	1,669,100	41.16	58.84
1996	782,855	3,896,245	4,679,100	16.73	83.27

Sources: USDA data from Foreign Agricultural Trade of the U. S. (FATUS) Calendar Year (column 2)
FAO and USDA data used to compute column 3

Table 2.3 shows that U. S. export price (F.O.B. prices) of wheat was lower than the Rest-of-the-World price from 1982 to 1987. However, starting in 1988, U.S prices exceeded Rest-of-the-World prices, except in 1993. In 1996, the ratio of U. S. price to the Rest-of-the-World price was as high as 1.65. Over the period, the U. S. average export price of the wheat exported to the Caribbean was $168.98 per metric ton, and the Rest-of-the-World average export price was $161.12 per metric ton.

Table 2. 3. U.S. and Rest-of-the-World Export Price Ratio for Wheat (Unmilled and Flour) Exported to the Caribbean (F.O.B. Prices in $ / MT)

Year	U. S. Export Price[10] of Wheat ($ / MT)	ROW Export Price of Wheat ($ / MT)	Price Ratio U. S. / ROW
1982	169.26	230.44	0.73
1983	174.91	191.03	0.92
1984	172.71	202.25	0.85
1985	150.72	188.36	0.80
1986	134.26	159.37	0.84
1987	125.04	134.34	0.93
1988	159.24	124.70	1.28
1989	174.62	159.14	1.10
1990	166.40	144.77	1.15
1991	143.09	126.72	1.13
1992	166.84	124.17	1.34
1993	177.90	185.69	0.96
1994	187.95	156.92	1.20
1995	202.58	150.33	1.35
1996	229.17	138.58	1.65

Being only a total of about thirty small countries constituted of either one island, part of an island, or several islands, the Caribbean absorbs only a small fraction of the U. S. total

[10] U. S. and ROW Exports prices are calculated by dividing U. S. and ROW exports value by quantities exported.

wheat exports to the World. Table 2. 4 indicates that no more than 2.5 percent of the U. S. total wheat exports went to the Caribbean. However, the Caribbean bears a potential for the expansion of the wheat market for both the U.S. and the Rest-of-the-World, given its growing population. According to the Economic Commission for Latin America and the Caribbean, Caribbean population was 17,195 thousands of people in 1982 and raised to 22,053 thousands in 1996, i. e. an increase in population of 28.25 percent over fifteen years.

Table 2.4. World and Caribbean Total Quantity Imported from the U. S., and Caribbean Shares of Total Quantity Imported from the U. S. for Wheat (Unmilled and Flour) from 1982 to 1996.

Year	World Total of U. S. Wheat Exports (MT)	Caribbean Total Imports of Wheat from U. S. (MT)	Caribbean Share of total U. S. Wheat Exports (%)
1982	41,799,723	449,299	1.07
1983	40,387,589	556,427	1.38
1984	43,335,378	611,048	1.41
1985	26,159,952	735,656	2.81
1986	26,125,073	713,654	2.73
1987	32,067,002	724,998	2.26
1988	41,731,227	690,997	1.66
1989	37,525,138	660,913	1.76
1990	28,285,960	667,196	2.36
1991	31,940,373	613,024	1.92
1992	34,654,569	675,577	1.95
1993	36,728,131	677,221	1.84
1994	31,679,796	422,197	1.33
1995	33,458,389	692,137	2.07
1996	31,499,939	782,855	2.49

Source: USDA in Foreign Agricultural Trade of the U. S. (FATUS) Calendar Year.

Caribbean rice production was quite substantial and varied from one year to another between 1982 and 1996. Table 2.5 shows that rice production in the Caribbean ranged from 437 thousands to 705 thousands metric tons between 1982 and 1996. While the Caribbean population followed an upward trend over the period, domestic rice production and imports fluctuated. However, beginning 1990 Caribbean total imports of rice increased considerably, and had more than double from 1993 to 1996, as compared to the lowest level of 335 thousands metric tons of total imports in1984. Despite the increasing population, per capita and yearly rice availability increased from 50 to 70 kilograms from 1988 to 1996. The share of imports in total rice availability in the Caribbean was quite high and varied over time. For the entire period, its lowest level was 34.15 percent in 1984, and its highest level was 62.12 percent in 1993.

The U. S. share of the total quantity of rice imported in the Caribbean increased from 1982 to 1987 to the expense of the Rest-of-the-World. It decreased from 1989 to 1994 to the benefit of the Rest-of-the-World. Over the period, the lowest U. S. share (20.28 percent) of Caribbean total quantity of rice imports occurred in 1982 and the highest one (58.33 percent) occurred in 1989. Furthermore, average U. S. share was 38.39 percent and average Rest-of-the-World share was 61.61 percent.

Table 2.5. Caribbean Rice Production, Rice Imports from the U. S. and from the Rest-of-the-World (ROW), Rice Availability, Exporters' Shares of Caribbean Rice Imports, and Import Share of Availability from 1982 to 1996 .

Year	Production of Rice (1000 MT)	Imports of Rice from U.S. (MT)	Imports of Rice from ROW (MT)	Total Imports (MT)	Total Availab. (MT)	Population (1000 people)	Avail. per person (Kg)	U.S. Share of tot. imprts (%)	ROW Share of tot. imprts (%)	Import Share of Availab. (%)
1982	585	74,460	292,782	367,242	952,242	17,195	60	20.28	79.72	38.57
1983	624	85,661	287,098	372,759	996,759	17,555	60	22.98	77.02	37.40
1984	646	90,936	244,084	335,020	981,020	17,927	50	27.14	72.86	34.15
1985	578	114,956	290,304	405,260	983,260	18,116	50	28.37	71.63	41.22
1986	615	183,949	233,751	417,700	1,032,700	18,838	50	44.04	55.96	40.45
1987	600	252,611	206,909	459,520	1,059,520	19,183	60	54.97	45.03	43.37
1988	576	191,693	164,447	356,140	932,140	19,532	50	53.83	46.17	38.21
1989	599	258,337	184,533	442,870	1,041,870	19,878	50	58.33	41.67	42.51
1990	548	294,367	248,553	542,920	1,090,920	20,229	50	54.22	45.78	49.77
1991	437	268,147	305,093	573,240	1,010,240	20,332	50	46.78	53.22	56.74
1992	705	219,993	417,627	637,620	1,342,620	20,671	60	34.50	65.50	47.49
1993	556	268,023	643,577	911,600	1,467,600	21,012	70	29.40	70.60	62.12
1994	640	189,145	648,055	837,200	1,477,200	21,357	70	22.59	77.41	56.67
1995	633	380,565	558,055	938,620	1,571,620	21,703	70	40.55	59.45	59.72
1996	662	316,847	518,173	835,020	1,497,020	22,053	70	37.94	62.06	55.78

Sources: FAO Production Yearbook (column2)
USDA (FATUS, Calendar Year): column 3
ROW imports are computed using calculated Caribbean imports data from FAO Trade Yearbook and Caribbean imports data from U. S. found in FATUS, Calendar Year.

In general the U.S price of rice tended to be lower than the Rest-of-the-World price during the first six years, except in 1983 and 1984 (Table 2.6). The average U. S price for the six-year period was $394.91, while the average Rest-of-the World price was $436.70. However, from 1988 to 1996, the two prices were close to each other, with the U. S. price slightly higher than the Rest-of-the-World price. During this nine-year period, average U. S price was $336.38 and average Rest-of-the-World price was $320.02. Over the entire fifteen-year period, the ratio of U.S price to the Rest-of-the-World price exceeded one, two-thirds of the time. However, the average U. S. price was $359.79 and the average Rest-of-the-World price was $366.69 per metric ton.

Table 2.6. U.S. and Rest-of-the-World Export Price Ratio for Rice Exported to the Caribbean (F.O.B. Prices in $/MT)

Year	U. S. Export Price[11] of Rice ($ / MT)	ROW Export Price of Rice ($ / MT)	Price Ratio U. S. / ROW
1982	479.19	528.52	0.91
1983	489.35	387.82	1.26
1984	472.70	448.04	1.06
1985	392.02	446.19	0.88
1986	292.82	428.05	0.68
1987	243.35	381.55	0.64
1988	371.69	309.00	1.20
1989	335.43	313.84	1.07
1990	337.98	310.03	1.09
1991	355.54	355.00	1.00
1992	349.32	333.85	1.05
1993	275.89	290.33	0.95
1994	315.49	298.14	1.06
1995	308.87	310.29	1.00
1996	377.20	359.66	1.05

A substantial portion of the total U. S. rice exports goes to the Caribbean. Table 2.7 shows that the Caribbean absorbed between 2 and 11 percent of the total volume of U. S. rice exports between 1982 and 1996. In 1990, 11.73 percent of the volume of U. S. rice exports were purchased by the Caribbean. Therefore, the Caribbean represents an important buyer of rice from the U. S.

Table 2.7. World and Caribbean Total Quantity of Rice Imported from the U. S., and Caribbean Shares of the World Total Quantity of Rice Imported from the U. S. from 1982 to 1996.

Year	World Total of U. S. Rice Exports (MT)	Caribbean Total Imports of Rice from U. S. (MT)	Caribbean Share of total U. S. Rice Exports (%)
1982	2,574,047	74,460	2.89
1983	2,415,568	85,661	3.55
1984	2,194,226	90,936	4.14
1985	1,963,877	114,956	5.85
1986	2,546,830	183,949	7.22
1987	2,493,809	252,611	10.13
1988	2,303,093	191,693	8.32
1989	3,046,522	258,337	8.48
1990	2,509,047	294,367	11.73
1991	2,319,128	268,147	11.56
1992	2,180,712	219,993	10.09
1993	2,776,177	268,023	9.65
1994	2,983,219	189,145	6.34
1995	3,275,176	380,565	11.62
1996	2,839,044	316,847	11.16

Source USDA (FATUS, Calendar Year)

Caribbean corn production ranged between 170 and 290 thousands metric tons, and varied from year to year, as well as imports, over the fifteen-year period. Imports represented a major component of the total volume of corn available. Table 2.8 indicates that the volume of corn imports was about four-fifths of the total volume of corn available in the region during the period. In 1990, the share of the imported corn in the total volume of corn available in the Caribbean was as high as 86.59 percent.

[11] U. S. and ROW Exports prices are calculated by dividing U. S. and ROW exports value by quantities exported.

In general, the U. S. share of the total volume of corn imported in the region exceeded 50 percent over the entire period. Conversely, the Rest-of-the-World share was below 50 percent. From 1991 to 1996, the U. S. share was above 60 percent. In 1994, this share reached its highest level of 86.45 percent.

Corn availability per person did not follow any specific trend from 1982 to 1996. It ranged from 0.06 to 0.09 metric ton. In 1989, its highest level of 90 kilograms was reached and coincided with the highest level of domestic production of 290 thousands metric tons.

Table 2.8. Caribbean Corn Production, Corn Imports from the U. S. and from the Rest-of-the-World (ROW), Corn Availability, Exporters' Shares of Caribbean Corn Imports and Import Share of Availability from 1982 to 1996.

Year	Production of Corn (1000 MT)	Imports of Corn from U.S. (MT)	Imports of Corn from ROW (MT)	Total Imports (MT)	Total Availab. (MT)	Population (1000 people)	Avail. per person (Kg)	U.S. Share of tot. imprts (%)	ROW Share of tot. imprts (%)	Import Share of Availab. (%)
1982	208	486,395	422,035	908,430	1,116,430	17,195	60	53.54	46.46	81.37
1983	228	597,696	357,790	955,486	1,183,486	17,555	70	62.55	37.45	80.73
1984	267	527,490	468,710	996,200	1,263,200	17,927	70	52.95	47.05	78.86
1985	170	469,638	374,162	843,800	1,013,800	18,116	60	55.66	44.34	83.23
1986	265	479,948	519,552	999,500	1,264,500	18,838	70	48.02	51.98	79.04
1987	233	675,895	528,305	1,204,200	1,437,200	19,183	70	56.13	43.87	83.79
1988	213	726,608	593,792	1,320,400	1,533,400	19,532	80	55.03	44.97	86.11
1989	290	766,188	668,812	1,435,000	1,725,000	19,878	90	53.39	46.61	83.19
1990	210	804,637	551,163	1,355,800	1,565,800	20,229	80	59.35	40.65	86.59
1991	198	789,781	263,219	1,053,000	1,251,000	20,332	60	75.00	25.00	84.17
1992	283	862,824	138,776	1,001,600	1,284,600	20,671	60	86.14	13.86	77.97

Table 2.8 (continued)

Year	Production of Corn (1000 MT)	Imports of Corn from U.S. (MT)	Imports of Corn from ROW (MT)	Total Imports (MT)	Total Availab. (MT)	Population (1000 people)	Avail. per person (Kg)	U.S. Share of tot. imprts (%)	ROW Share of tot. imprts (%)	Import Share of Availab. (%)
1993	255	984,770	235,430	1,220,200	1,475,200	21,012	70	80.71	19.29	82.71
1994	281	840,935	131,765	972,700	1,253,700	21,357	60	86.45	13.55	77.59
1995	249	965,025	538,775	1,503,800	1,752,800	21,703	80	64.17	35.83	85.79
1996	285	1,011,455	212,345	1,223,800	1,508,800	22,053	70	82.65	17.35	81.11

Sources: FAO Production Yearbook (column2)
USDA (FATUS, calendar year): column 3
ROW imports are computed using calculated Caribbean imports data from FAO Trade Yearbook and Caribbean imports data from U. S. found in FATUS, calendar year.

The U. S. price (F.O.B. price) of the corn exported to the Caribbean remained in the interval of $100-$130 for thirteen years out of the fifteen year, while the Rest- of- the-World prices ranged from $112.39 to $267.89 over the period (Table 2.9). Yearly price comparison indicates that the U. S. export price of corn was always below the Rest-of-the-World price, except in 1995 where it was slightly above it. For the entire period, the average U. S price (F.O.B. price) of the corn exported to the Caribbean was $116.81 per metric ton, and the average Rest-of-the-World price was $176.59

Table 2.9. U.S. and Rest-of-the-World Export Price Ratio for Corn Exported to the Caribbean (F.O.B. Prices in $/MT)

Year	U. S. Export Price[12] of Corn ($ / MT)	ROW Export Price of Corn ($ / MT)	Price Ratio U. S. / ROW
1982	117.40	224.00	0.52
1983	127.84	187.84	0.68

[12] U. S. and ROW Exports prices are calculated by dividing U. S. and ROW exports value by quantities exported.

Table 2.9 (continued)

Year	U. S. Export Price[13] of Corn ($ / MT)	ROW Export Price of Corn ($ / MT)	Price Ratio U. S. / ROW
1984	147.96	193.98	0.76
1985	124.22	175.94	0.71
1986	103.20	128.39	0.80
1987	83.71	115.63	0.72
1988	105.48	129.09	0.82
1989	113.39	164.81	0.69
1990	113.98	164.41	0.69
1991	108.56	112.39	0.97
1992	107.89	256.59	0.42
1993	106.20	219.38	0.48
1994	111.25	267.89	0.42
1995	119.43	117.83	1.01
1996	161.65	190.71	0.85

The Caribbean share of the World total quantity of corn imported from the U.S. was small. Indeed, only between 1 and 2.46 percent of the total quantity of corn exported by the U. S. went to the Caribbean between 1982 and 1996 (Table 2.10). This share did not follow any specific pattern over the period. The highest share of 2.46 percent was reached in 1993.

[13] U. S. and ROW Exports prices are calculated by dividing U. S. and ROW exports value by quantities exported.

Table 2.10. World and Caribbean Total Quantity of Corn Imported from the U. S., and Caribbean Shares of the Total Quantity of Corn Imported from the U. S. from 1982 to 1996.

Year	World Total of U. S. Corn Exports (MT)	Caribbean Total Imports of Corn from U. S. (MT)	Caribbean Share of total U. S. Corn Exports (%)
1982	48,789,208	486,395	1.00
1983	47,528,000	597,696	1.26
1984	48,940,427	527,490	1.08
1985	43,931,815	469,638	1.07
1986	27,030,110	479,948	1.78
1987	40,765,456	675,895	1.66
1988	46,283,560	726,608	1.57
1989	56,444,899	766,188	1.36
1990	52,003,938	804,637	1.55
1991	44,361,003	789,781	1.78
1992	42,992,617	862,824	2.01
1993	40,045,911	984,770	2.46
1994	35,645,041	840,935	2.36
1995	60,017,511	965,025	1.61
1996	52,177,803	1,011,455	1.94

Source: USDA (FATUS, calendar year)

Caribbean fresh potato production varied from 29 to 61 thousands metric tons over the period (Table 2.11). This production was insufficient to satisfy the needs of the population. A high portion of the fresh potatoes consumed in the Caribbean is imported. Imports and domestic production together provided a constant quantity of 10 kilograms available per person over the period. The share of total imports in the total quantity of fresh potatoes available in the region mostly exceeded 60 percent. The highest share was reached in 1986 and was 80.63 percent.

The U. S. share of total imports of fresh potatoes was low. It ranged from 0.77 percent to 4.36 percent over the period. Conversely, the Rest-of-the-World share of the Caribbean total imports of fresh potatoes exceeded 95 percent.

Table 2.11. Caribbean Fresh Potatoes Production, Fresh Potatoes Imports from the U. S. and from the Rest-of-the-World (ROW), Fresh Potatoes Availability, Exporters' Shares of Caribbean Fresh Potatoes Imports and Import Share of Availability from 1982 to 1996 .

Year	Production of Potatoes (1000 MT)	Imprts of Pot. from U.S. (MT)	Imprts of Pot. from ROW (MT)	Total Imports (MT)	Total Availab. (MT)	Population (1000 people)	Avail. per person (Kg)	U.S. Share of tot. imprts (%)	ROW Share of tot. imprts (%)	Import Share of Availab. (%)
1982	30	3,474	100,880	104,354	134,354	17,195	10	3.33	96.67	77.67
1983	37	3,272	86,214	89,486	126,486	17,555	10	3.66	96.34	70.75
1984	37	2,421	89,767	92,188	129,188	17,927	10	2.63	97.37	71.36
1985	33	714	91,546	92,260	125,260	18,116	10	0.77	99.23	73.65
1986	29	1,416	119,301	120,717	149,717	18,838	10	1.17	98.83	80.63
1987	47	1,010	98,465	99,475	146,475	19,183	10	1.02	98.98	67.91
1988	48	1,051	87,530	88,581	136,581	19,532	10	1.19	98.81	64.86
1989	51	2,404	73,733	76,137	127,137	19,878	10	3.16	96.84	59.89
1990	44	1,624	92,490	94,114	138,114	20,229	10	1.73	98.27	68.14
1991	48	1,571	88,359	89,930	137,930	20,332	10	1.75	98.25	65.20
1992	51	1,306	103,444	104,750	155,750	20,671	10	1.25	98.75	67.26
1993	37	1,713	114,675	116,388	153,388	21,012	10	1.47	98.53	75.88
1994	39	1,434	107,767	109,201	148,201	21,357	10	1.31	98.69	73.68
1995	61	2,081	99,068	101,149	162,149	21,703	10	2.06	97.94	62.38
1996	54	3,791	83,065	86,856	140,856	22,053	10	4.36	95.64	61.66

Sources: FAO Production Yearbook (column2)
USDA (FATUS, calendar year): column 3
ROW imports are computed using calculated Caribbean imports data from FAO Trade Yearbook and Caribbean imports data from U. S. found in FATUS, calendar year.

Over the period, the U. S. export price (F.O.B. price) of fresh potatoes to the Caribbean always exceeded the Rest-of-the-World export price, except in 1991 (Table

2.12). The ratio of the U. S. price to the Rest-of-the-World price had no specific pattern and varied between 1.37 to 1.96 from 1982 to 1990, and between 1.01 to 2.04 from 1992 to 1996. For the entire period, the U. S. average export price of fresh potatoes per metric ton was $424.12, and the Rest-of-the-World average export price per metric ton was $296.89.

Table 2.12. U.S. and Rest-of-the-World Export Price Ratio for Fresh Potatoes Exported to the Caribbean (F.O.B Prices in $/MT)

Year	U. S. Export Price[14] of Fresh Potatoes ($ / MT)	ROW Export Price of Fresh Potatoes ($ / MT)	Price Ratio U. S. / ROW
1982	390.04	250.36	1.56
1983	391.50	268.04	1.46
1984	474.60	303.66	1.56
1985	372.55	272.06	1.37
1986	448.45	229.29	1.96
1987	433.66	263.33	1.65
1988	398.67	250.62	1.59
1989	462.98	294.64	1.57
1990	556.64	317.07	1.76
1991	360.92	378.29	0.95
1992	386.68	350.15	1.10
1993	333.33	298.32	1.12
1994	405.16	336.07	1.21
1995	356.56	352.57	1.01
1996	590.05	288.81	2.04

Table 2.13 shows that the Caribbean share of the world total quantity of fresh potatoes imported deteriorated after 1990. From 1982 to 1986, it varied between 1.17 percent and

4.37 percent. It reached a peak of 10.29 percent in 1987, because the World total imports of potatoes were low. It varied between 2.17 percent and 5.79 percent between 1988 to 1990, and was less than 1 percent from 1991 to 1995.

Table 2.13. World and Caribbean Total Quantity of Fresh Potatoes Imported from the U. S., and Caribbean Shares of the World Total Quantity of Fresh Potatoes Imported from the U. S. from 1982 to 1996.

Year	World Total of U. S. Corn Exports (MT)	Caribbean Total Imports of Corn from U. S. (MT)	Caribbean Share of total U. S. Corn Exports (%)
1982	152,081	6,077	4.00
1983	143,821	6,286	4.37
1984	131,024	4,782	3.65
1985	112,691	1,324	1.17
1986	128,766	5,010	3.89
1987	60,395	6,212	10.29
1988	179,442	10,389	5.79
1989	283,227	8,227	2.90
1990	339,715	7,378	2.17
1991	331,396	3,196	0.96
1992	425,165	2,420	0.57
1993	474,967	2,559	0.54
1994	577,298	3,299	0.57
1995	629,820	5,008	0.80
1996	652,443	8,362	1.28

Source: USDA

Table 2.14 shows that wheat, rice and corn had an average price lower in the U. S. than in the Rest-of-the-World during the 1982-1996 period. However, the average price of fresh potatoes in the U. S. exceeded the average price of fresh potatoes in the Rest-of-the-World.

[14] U. S. and ROW Exports prices are calculated by dividing U. S. and ROW exports value by quantities exported.

Table 2.14. Caribbean Average Prices of Imported Starchy Food (Unmilled Wheat and Flour, Rice, Corn, Fresh Potatoes) from the U. S. and the Rest-of-the-World (1982-1996).

Product	U. S. Average Prices ($/MT)	Rest-of-the-World Average Prices ($/MT)
Wheat	168.98	161.12
Rice	359.79	366.69
Corn	116.81	176.59
Potatoes (fresh)	424.12	296.89

The shares of total per capita expenditures on imports of each starchy food are presented in Table 2.15. In general, the Caribbean spends a lower share of its per capita budget for importing starchy food in the U.S. than in the Rest-of-the-World for all the starchy foods, except corn. Furthermore, the U. S. has a lower export price (net of transportation cost) per metric ton than the Rest-of-the-World, for rice and corn.

Table 2.15. Caribbean per Capita Budget Shares of Starchy Food (Unmilled Wheat and Flour, Rice, Corn, and Fresh Potatoes) Imported from the United States and the Rest-of-the-World (1982-1996).

Product	U. S. Shares %	Rest-of-the-World Shares %
Wheat	15.82	41.02
Rice	5.00	8.33
Corn	18.01	9.33
Potatoes (fresh)	0.05	2.44

In summary, imports represent an important part of the total volume of the starchy foods [wheat (unmilled and flour), rice, corn, and fresh potatoes] available for consumption in the Caribbean. This suggests that food security via total volume of starchy staple available for people to eat in the Caribbean can be achieved only through imports, outside any improvement in domestic production. These staples are imported either from the U. S. or from the Rest-of-the- World, which includes countries other than the U. S. and the Caribbean exporting the four staples to the Caribbean. These two suppliers (U. S. and ROW) have different and sometimes fluctuating market shares in the Caribbean for the four starchy foods. From 1982 to 1996, the U. S. had a higher average export price for wheat than the Rest-of-the-World. More than half of the volume of wheat imported in the Caribbean came from the Rest-of-the-World. For rice, the U. S. had an average export price lower than the Rest-of-the-World, but average U. S. share was lower than average Rest-of the-World share, with a tendency for the U. S. to gain some market share through time. For corn, the U. S. had a lower average price than the Rest-of-the-World, and its share of the Caribbean total imports is higher than the Rest-of-the-World share. For fresh potatoes, the U. S. had a higher price than the Rest-of-the-World and its share of the Caribbean total imports was low. In general the Caribbean spent a higher share of its per capita budget for importing starchy foods from the Rest-of-the-World than from the U. S., except for corn.

Several countries or regions in the world, including developed, developing and less developed ones, import the four staples from the United States. The Caribbean as a whole, as a developing area, generally has a low share of the world total volume of wheat, corn, and fresh potatoes imported from the U.S.

An interesting question that the above presentation of the data suggests is about how one can expect price changes by any means (policies or market adjustment mechanism) in either the U. S. or in the Rest-of-the-World to affect the Caribbean import demand for starchy foods. There is a linkage between imports of starchy foods, food availability in the Caribbean, and foreign supplier market shares. Consequently, changes in the Caribbean import demands of starchy foods due to changes in the foreign supplier prices will impact on both food availability and foreign supplier market share in the Caribbean. Indeed, in the absence of any technological progress to bring about an increase in Caribbean domestic production, higher imports correspond to improvement in Caribbean food availability. Furthermore, if the Caribbean imports more from any of the two sources (U. S. or Rest-of-the-World), the Caribbean market share for this source will increase. In addition, we do not know whether a starchy food from two different origins (U. S. and Rest-of-the-World) is in source-competition or in source-complementarity. We do not know either the magnitude of the possible impact of price changes in the U. S. or in the Rest-of-the-World on the Caribbean imports of starchy foods from the two sources.

As far as Caribbean food availability through imports, as well as U. S. and Rest-of-the-World market shares in the Caribbean through Caribbean imports are concerned, there is a need for determining the responsiveness of the Caribbean starchy food import demand to price changes in the U. S. and the Rest-of-the-World. Given its relatively small share of the total U. S. and total Rest-of-the-World market, the Caribbean is a price taker and does not influence the U. S. and the Rest-of-the-World prices of starchy foods. Therefore, U. S. and Rest-of-the-World prices are exogenous for the Caribbean.

Objectives

The general objective of this paper is to estimate the Caribbean demand of starchy food (wheat, rice, corn, and fresh potatoes) imported from the United States and the Rest-of-the-World and to present the Caribbean import demand elasticities for these staples, using a Restricted-Source-Differentiated Almost Ideal Demand System (RSDAIDS).

This study aims at achieving the three following specific objectives:

1. Determine the impact of price changes in the U. S. and the Rest-of-the-World on Caribbean demand for starchy foods coming from these two foreign suppliers (along with the impact on Caribbean food availability and foreign suppliers market share).
2. Determine whether competition or complementarity relationship exists between a U. S. starchy food and a starchy food from the Rest-of-the-World suppliers of the Caribbean
3. Identify the potentialities for U. S. market expansion in the Caribbean.

Theoretical Model: The Restricted Source Differentiated Almost Ideal Demand System (RSDAIDS)

The Restricted Source Differentiated Almost Ideal Demand System (RSDAIDS) was proposed by Yang and Koo (1994). The Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980a) is modified to allow source differentiation. Two-stage budgeting and separability assumptions are embedded in the RSDAIDS models

The Caribbean is assumed to allocate its import budget to starchy food (wheat, rice, corn, and potatoes), other food products, and non-food products at the first budgeting stage. Once expenditures on imported starchy foods are determined from this first stage, the Caribbean region is assumed to allocate these expenditures to wheat, rice, corn and fresh potatoes. The necessary and sufficient condition for this allocation is that the utility function generating the behavior is weakly separable. Starchy food imported by the Caribbean is assumed to be separable from all other imported food and non-food items and from domestically-produced starchy food. Weak separability requires that the marginal rate of substitution between any two staples belonging to the starchy food group be independent of the quantity consumed of any commodity belonging to the other food-product group or non-food-product group.

The AIDS model has its ground in a Price Independent Generalized Logarithmic (PIGLOG) type of preference from which is derived a cost or expenditure function (Deaton and Mueller 1980a). However, an AIDS model that differentiates by source (Source Differentiated AIDS or SDAIDS) incorporates in the expenditure function the importer's behavior that differentiates goods from different origins (Yang and Koo, 1994). Under the restriction of block substitutability, the Source Differentiated AIDS model becomes the Restricted Source Differentiated AIDS model. Block substitutability means that only an aggregate price of the other products enters the equation of a given source-differentiated product. In other words, Caribbean demand for U.S. rice has the same price response to U. S. wheat and Rest-of-the-World wheat. That is to say that the cross-price effects are not source differentiated between products, while the cross-price effects are source differentiated within a product (Andayani and Tilley).

With the bloc substitutability assumption, the Restricted Source Differentiated AIDS model can be written in the following way:

$$w_{ih} = \alpha_{ih} + \sum_k \gamma_{ihik} \ln(p_{ik}) + \sum_{j \neq i} \gamma_{ihj} \ln(p_j) + \beta_{ih} \ln\left(\frac{E}{P}\right) \qquad (1)$$

where $\ln(p_j) = \sum_k w_{jk} \ln(p_{jk})$, w_{ih} is the budget share of good i imported from source h, α_{ih} is an intercept term, γ_{ihik} is the price coefficient of good i from the different sources k (with k including h) in the equation of good i from origin h, p_{ik} is the price of good i imported from sources k (with k including h), γ_{ihj} is a cross-price coefficient of the non-source differentiated or aggregated good j in the equation of good i from origin h, p_j is the price of the non-source differentiated or aggregate good j (for j not equal to i), β_{ih} is the real expenditure coefficient, E is group expenditures, and P is the Stone price index [15].

The demand restrictions of adding-up, homogeneity and symmetry for the RSDAIDS are as follows:

$$\sum_i \sum_h \alpha_{ih} = 1; \quad \sum_h \gamma_{ihik} = 0; \quad \sum_i \sum_h \gamma_{ihj} = 0; \quad \sum_i \sum_h \beta_{ih} = 0; \qquad \text{(Adding-up)} \qquad (2)$$

[15] The Stone index is a linear approximation (Deaton and Muellbauer). In this context of RSDAIDS the Stone index is $\ln(P) = \sum_i \sum_h w_{ih} \ln(p_{ih})$ where i and h are respectively good and source, w is budget share and p is price.

$$\sum_{k}\gamma_{ihik} + \sum_{j \neq i}\gamma_{ihj} = 0 \; ; \qquad \text{(Homogeneity)} \tag{3}$$

$$\gamma_{ihik} = \gamma_{ikih} \qquad \text{(Symmetry)} \tag{4}$$

Marshallian elasticities are computed from the estimated parameters using the following formulas proposed by Yang and Koo :

$$\varepsilon_{ihih} = -1 + \frac{\gamma_{ihih}}{w_{ih}} - \beta_{ih} \qquad : \text{ own price elasticity} \tag{5}$$

$$\varepsilon_{ihik} = \frac{\gamma_{ihik}}{w_{ih}} - \beta_h\left(\frac{w_{ih}}{w_{ih}}\right) \qquad : \text{cross- price elasticity with same good but a different origin (k different from h)} \tag{6}$$

$$\varepsilon_{ihj} = \frac{\gamma_{ihj}}{w_{ih}} - \beta_{ih}\left(\frac{w_j}{w_{ih}}\right) \qquad : \text{ cross-price elasticity with a different good.} \tag{7}$$

$$\eta_i = 1 + \frac{\beta_{ih}}{w_{ih}} \qquad : \text{ expenditure elasticity} \tag{8}$$

Hicksian elasticities are computed using the following formulas:

$$\delta_{ihih} = -1 + \frac{\gamma_{ihih}}{w_{ih}} + w_{ih} \qquad : \text{ own price elasticity} \tag{9}$$

$$\delta_{ihik} = \frac{\gamma_{ihik}}{w_{ih}} + w_{ik} \qquad : \text{ cross- price elasticity with same good but a different origin (k different from h)} \tag{10}$$

$$\varepsilon_{ihj} = \frac{\gamma_{ihj}}{w_{ih}} + w_j \qquad : \text{ cross-price elasticity with a different good.} \tag{11}$$

Standard errors of the estimated elasticities can be obtained from the variance-covariance matrix of the parameter estimates. T statistics can be computed by dividing the elasticities by their standard error.

Model Specification and Procedure

The model in equation 1 is applied to the Caribbean starchy food import demands. The model is specified as a system of eight equations of the following form:

$$Wheat_{U.S.} = f(P_{wheat,U.S}, P_{wheat,ROW}, P_{rice}, P_{corn}, P_{potatoes}, Expenditure_{starchy}) \quad (12)$$

$$Wheat_{ROW} = f(P_{wheat,U.S}, P_{wheat,ROW}, P_{rice}, P_{corn}, P_{potatoes}, Expenditure_{starchy}) \quad (13)$$

$$Rice_{U.S.} = f(P_{rice,U.S.}, P_{rice,ROW}, P_{wheat}, P_{corn}, P_{potatoes}, Expenditure_{starchy}) \quad (14)$$

$$Rice_{ROW} = f(P_{rice,U.S.}, P_{rice,ROW}, P_{wheat}, P_{corn}, P_{potatoes}, Expenditure_{starchy}) \quad (15)$$

$$Corn_{U.S.} = f(P_{corn,U.S.}, P_{corn,ROW}, P_{wheat}, P_{rice}, P_{potatoes}, Expenditure_{starchy}) \quad (16)$$

$$Corn_{ROW} = f(P_{corn,U.S.}, P_{corn,ROW}, P_{wheat}, P_{rice}, P_{potatoes}, Expenditure_{starchy}) \quad (17)$$

$$Potatoes_{U.S.} = f(P_{potatoes,U.S.}, P_{potatoes,ROW}, P_{wheat}, P_{rice}, P_{corn}, Expenditure_{starchy}) \quad (18)$$

$$Potatoes_{ROW} = f(P_{potatoes,U.S.}, P_{potatoes,ROW}, P_{wheat}, P_{rice}, P_{corn}, Expenditure_{starchy}) \quad (19)$$

where the left-hand sides are per capita budget shares of the source-differentiated starchy foods (wheat, rice, corn, potatoes), *P* stands for price, *ROW* stands for Rest-of-the-World, and expenditure on starchy foods is per capita real expenditure.

The estimation method used is seemingly unrelated regression (SUR). One equation is dropped to avoid singularity. Homogeneity restrictions are tested and imposed. Source differentiation and block substitutability give a peculiar feature to the model. Each pair of one-product-source-differentiated equations has the same explanatory variables and represents a subset of the system of eight equations. The eight equations constitute a system because the dependent variable in each equation is a share of total import expenditure on starchy food. The right-hand side variables are not totally identical across all eight equations, given the assumptions of one- product source differentiation and block substitutability. With such a feature, symmetry restrictions among goods are not possible (Yang and Koo, 1994).

There are estimation problems using a nonlinear price index to deflate expenditures. It is suggested that the Stone index be used as a linear approximation. However, the use of this index may generate a simultaneity problem, given that dependent variable and expenditure shares in the index would be the same. Remedies are to use the lagged share (Eales and Unnevehr) or the average share (Haden) in the computation of the Stone index. In this study, the lagged budget share is used to construct the Stone index that deflates expenditures. Moschini argues that the Stone index is not invariant to units of measurement and suggests using mean-scaled prices to overcome such a problem. This suggestion is used in this study.

Caribbean demands of starchy food are estimated on per capita basis. Consequently, total expenditures on starchy food as well as budget shares of each staple are computed on per capita basis. Total expenditures are divided by the Caribbean population, as well as total quantities imported of the four staples.

Normality, misspecification, separability, product aggregation, homogeneity, symmetry, and endogeneity tests are conducted.

Normality and Misspecification Tests

The Shapiro-Wilk test is used to test normality. Misspecification tests including normality, joint conditional mean and joint conditional variance tests are performed, using the method proposed by McGuirk et al. (1995). The joint conditional mean test investigates structural change, non-linearity, and temporal dependence. The joint conditional variance test investigates the presence of dynamic and static heteroskedasticity.

Separability Test

Two prominent studies on separability in demand analysis are from Hayes, Wahl, and Williams (1990) and from Moschini, Moro, and Green (1994). The Hayes, Wahl and Williams' approach has been used in most studies dealing with the RSDAIDS model. This method of testing for separability is also applied in this paper.

In Moschini, Moro and Green's view (p.62) the separability test proposed by Hayes, Wahl, and Williams " is consistent with direct weak separability only if the subutility groups are homothetic (thus, it cannot be used to justify second-stage demand systems)." They suggested a likelihood ratio test for testing proposed local separability restrictions (in equation 20 of their paper). Their approach is also used in this paper to test for separability. We perform their separability test with homogenity and symmetry imposed.

The separability assumption is tested to determine whether or not individually or jointly the starchy foods in the model are separable from other starchy foods. If this form of separability holds for each equation, prices of other starchy foods are not relevant arguments in a given equation of the starchy food model. The following restriction on the RSDAIDS model is to be tested for block separability using the Hayes, Wahl, and William's approach:

$$\gamma_{ihj} = w_{ih}\gamma_{ij} \quad \nabla\ j \neq i, \tag{20}$$

where γ_{ij} is the cross-price parameter between groups i and j, and it is estimated from a non-source differentiated AIDS model under the assumption of perfect substitution among all the starchy foods in the model (i.e. no quality difference among starchy staples from different origins).

The separability restriction proposed by Moschini, Moro, and Greene is as follows:

$$\gamma_{ik} = -\alpha_i\alpha_k + (\gamma_{jm} + \alpha_j\alpha_m)\frac{(\alpha_k + \beta_k)(\alpha_k + \beta_k)}{(\alpha_j + \beta_j)(\alpha_m + \beta_m)} \tag{21}$$

where the alphas are intercept terms, the betas are real expenditure coefficients, the gammas are price coefficients, i and j are goods in the same group, k and m are also goods in the same group (with a possibility that i = j or k = m).

Product Aggregation (or Source Differentiation) Test

Testing product aggregation is equivalent to testing the restrictions that the parameters (intercept, own-price, and source-differentiated cross-price parameters) of the RSDAIDS model are the same as in a non-source-differentiated AIDS model. For the purpose of this test, the following restrictions are imposed on the RSDAIDS model:

$$\alpha_{ih} = \alpha_i \quad \nabla\ h \in i, \tag{22}$$

$$\gamma_{ihjk} = \gamma_{ij} \quad \nabla\ h, k \in i, j,$$

$$\beta_{ih} = \beta_i \quad \nabla\ \text{h} \in \text{i}.$$

Homogeneity and Symmetry Tests

Separate and joint tests of homogeneity and symmetry are performed. The homogeneity and symmetry restrictions tested are the ones shown in equations 3 and 4 (with homogeneity and symmetry, adding-up is redundant). If the null hypothesis of existence of homogeneity and symmetry is rejected, these restrictions must be imposed in the estimation process.

Endogeneity Test

The Wu-Hausman endogeneity test as described by Blundell (1987) is conducted. For the purpose of this test, we regress the natural logarithm of the real expenditure variable in the RSDAIDS on the natural logarithm of the aggregate prices of the commodities in the model, and on the natural logarithm of the Caribbean total gross domestic product adjusted for the exchange rate differences among countries. From this regression, we recover the residual. Then, the model with the budget share equations is re-estimated with the inclusion of this residual as an additional explanatory variable. By jointly testing (with an F-test) whether or not the coefficients of the residual in the budget shares equation of the model are significantly equal to zero, we determine whether or not the real expenditure variable is exogenous or endogenous. The null hypothesis is that the real expenditure variable is exogenous.

Data

United States and Rest-of-the-World prices of exports of starchy food (wheat, rice, corn, potatoes) to the Caribbean are one set of variables that are important in this study. Other important variables are quantities of the commodities under consideration imported by the region from the United States and the Rest-of-the-World. Prices are computed as total value of imports divided by quantity imported. The data available for this study are annual and cover a period of fifteen years (from 1982 to 1996).

Wheat is imported in different forms: unmilled wheat, wheat flour, bulgur wheat, and other wheat products. Wheat is aggregated into a single product in both value and quantity terms. In the aggregation of wheat, bulgur wheat and other wheat products are excluded because they are more likely for tourists and others in restaurants. Rice and corn enter our analysis as non-processed products. Potatoes are imported as fresh and as frozen product. However, only fresh potatoes are considered in this study because frozen potatoes are more likely for tourists and others in restaurants.

For each product or product specification, United States exports quantities and total exports values for all parts of the world are given in Foreign Agricultural Trade of the United States (USDA). Total quantities and values of imports of each of the products for all countries are available in the FAO Trade Yearbook (FAO). Therefore, total import quantities, and values of imports from the Rest-of-the-World for the Caribbean region are computed using the data from the FAO reference and the data from the USDA reference. The latter data correspond to import quantities and values of imports from the United States for the Caribbean. Prices are computed as total value divided by total quantity. Production data are from the FAO Production Yearbook (FAO).

Import expenditures on starchy food in the region are computed as the sum of import expenditures on each product, with import expenditures on each product equal to import price multiplied by quantity imported. Total import expenditures on starchy food and quantity imported of each product are calculated on a per-capita basis. Population data for the Caribbean region are from Economic Commission for Latin America and the Caribbean. Caribbean gross domestic product (GDP) is computed as a per capita average over fifteen Caribbean countries for which GDP data are from International Monetary Fund (IMF). Countries GDP are first converted into U.S. dollars by division by the exchange rate[16] which is available in the same source in units of domestic currency per U. S. dollar.

Results

The normality assumption of the error terms in all the estimated equations is not rejected[17] at 0.05 level of significance. In the joint conditional mean test (misspecification test), we fail to reject the null hypotheses[18] of no structural change, no non-linearity and no temporal dependence, for all the estimated equations at the 0.05 level of significance. In the joint conditional variance test (misspecification test), we fail to reject the null

[16] The IMF reference presents the market exchange rate of the countries either as end-of-period value or as period average. Whatever is available is used, however; when both are available, the period average was chosen.

[17] The Shapiro-Wilk test statistics and their p-values for the seven estimated demand equations (equations 12-18) are:
equation 12: 0.9417 and 0.4797 equation 13: 0.9187 and 0.2408 equation 14: 0.9494 and 0.5898
equation 15: 0.9668 and 0.8532 equation 16: 0.9658 and 0.8399 equation 17: 0.9425 and 0.4907
equation 18: 0.9564 and 0.6979

[18] In the joint conditional mean tests, the p-values for testing for structural change, functional form, and autocorrelation in the seven estimated equations (equations 12-18) are respectively:
equation 12: 0.6808, 0.9699, and 0.4040 equation 13: 0.5867, 0.7657, and 0.3415
equation 14: 0.2841, 0.3923, and 0.9681 equation 15: 0.2794, 0.2790, and 0.6306
equation 16: 0.5953, 0.7490, and 0.4627 equation 17: 0.2814, 0.1850, and 0.4894
equation 18: 0.1417, 0.1803, and 0.8860

hypotheses[19] of no dynamic and no static heteroskedasticity at the same level of significance.

The results of the tests for separability based on Hayes, Wahl, and Williams' suggestion are presented in Table 2.16 which also includes the product aggregation test results and the auxiliary regression of real expenditures to test for endogeneity. The F-test statistic for the null hypothesis that wheat is separable from all starchy foods (i.e. rice, corn and potatoes) is 19.43. For rice and corn, the test statistics are 6.05, 9.79, respectively. Individual and joint hypotheses are rejected at the 0.01 level of significance. We reject the null hypothesis of block separability. We also reject the null hypotheses (individual and joint) of product aggregation. The F-statistic for the joint test of product aggregation is 19919.7. Therefore, there is strong evidence that the source-differentiated model is appropriate.

The F-test statistics for testing homogeneity and symmetry are 5.15 and 5.38, respectively with p values of 0.0002 and 0.0001. These two restrictions have been imposed in the estimation process.

The Wu-Hausman endogeneity test indicates that group expenditures is exogenous in all the equations of the model. Indeed, the null hypothesis that there is no relationship between group expenditures and the error term of the auxiliary regression in table 2.16 below is not rejected at the 0.05 level of significance. This model is free of concerns of group expenditure endogeneity problem that may arise in the AIDS model (LaFrance).

[19] In the joint conditional variance tests, the p-values for testing for static and dynamic heteroskedasticity in the seven estimated equations (equations 12-18) are respectively:

equation 12: 0.4176, 0.9808	equation 13: 0.5552, 0.2896
equation 14: 0.2157, 0.7813	equation 15: 0.3025, 0.2360,
equation 16: 0.1609, 0.1302	equation 17: 0.8577, 0.1983
equation 18: 0.9357, 0.4874	

Table 2.16. Results of Block Separability, Product Aggregation, and Endogeneity Test for the RSDAIDS Model

Type of Test	Test Results
Block Separability	H0: Wheat is separable from all other starchy foods. F = 19.43** df:6 for numerator and 59 for denominator
	H0 : Rice is separable from all other starchy foods. F = 6.05** df: 6 for numerator and 59 for denominator
	H0: Corn is separable from all other starchy foods. F = 9.79** df: 6 for numerator and 59 for denominator
	H0: All of the above F = 11.60** df: 18 for numerator and 59 for denominator
Source Differentiation	H0: Wheat can be aggregated. F = 714.19** df: 5 for numerator and 68 for denominator
	H0: Rice can be aggregated. F = 172.94** df: 5 for numerator and 68 for denominator
	H0: Corn can be aggregated. F = 156.75** df: 5 for numerator and 68 for denominator
	H0: Potatoes can be aggregated. F = 78635.1** df: 5 for numerator and 68 for denominator
	H0: All of the above F = 19919.7** df: 20 for numerator and 68 for denominator
Auxiliary Regression of Real Expenditures to Test for Endogeneity	$\ln(E/P) = -2.71^{**} - 1.17^{*}LP_{Wheat} + 1.41LP_{Rice} + 2.22^{*}LP_{Corn}$ (1.03) (0.51) (2.01) (1.06) $-16.17^{*}LP_{Potatoes}$ $-0.76Lag_{RealExp}$ $-0.0007LogGDP$ (8.15) (0.72) (0.003)

Note: (*) and (**) denote significance at the 10% and 5%, respectively. Number in parentheses are standard errors.

The Moschini, Moro, and Greene likelihood ratio test of separability indicates that each of the starchy foods is separable from all other starchy foods (just like the Hayes, Whal and Williams' test) at the 5 percent level of significance. The calculated likelihood ratio test statistic is 17.755 with 2 degrees of freedom is greater than the critical value of 5.99 of a chi-square with 2 degrees of freedom, implying a rejection of the joint null hypothesis that all the starchy foods are separable from each other.

The estimated budget shares equations[20] are as follows:

$$W_{wheat,U.S} = \underset{(0.113)}{0.1072} \underset{(0.030)}{-0.0059} \ln P_{Wheat,U.S.} \underset{(0.035)^{**}}{-0.1118} \ln P_{Wheat,ROW} \underset{(0.348)}{-0.1307} \ln P_{Rice} \underset{(0.170)}{+0.0452} \ln P_{Corn} \underset{(0.341)}{+0.2032} \ln P_{Potatoes} \underset{(0.072)}{-0.0308} \ln \textit{Real expenditure} \quad (23)$$

$$W_{Wheat,ROW} = \underset{(0.204)^{**}}{0.9421} \underset{(0.035)^{**}}{-0.1118} \ln P_{Wheat,U.S.} \underset{(0.063)^{**}}{+0.2791} \ln P_{Wheat,ROW} \underset{(0.575)^{**}}{+1.7498} \ln P_{Rice} \underset{(0.288)}{-0.1460} \ln P_{Corn} \underset{(0.589)^{**}}{-1.7711} \ln P_{Potatoes} \underset{(0.131)^{**}}{+0.3264} \ln \textit{Real expenditure} \quad (24)$$

$$W_{Rice,U.S.} = \underset{(0.044)}{0.0330} \underset{(0.014)}{+0.0059} \ln P_{Rice,U.S.} \underset{(0.011)^{**}}{-0.0777} \ln P_{Rice,ROW} \underset{(0.042)^{**}}{-0.1457} \ln P_{Wheat} \underset{(0.093)}{+0.0266} \ln P_{Corn} \underset{(0.072)^{**}}{+0.1909} \ln P_{Potatoes} \underset{(0.028)}{-0.0088} \ln \textit{Real expenditure} \quad (25)$$

[20] In the budget shares equations the values in parentheses are standard errors, and two asterisks (**) denote significance of the coefficients at 0.05

$$W_{Rice,ROW} = \underset{(0.103)}{-0.1439} - \underset{(0.011)^{**}}{0.0777}\ln P_{Rice,U.S.} + \underset{(0.022)}{0.0175}\ln P_{Rice,ROW} + \underset{(0.097)}{0.1202}\ln P_{Wheat} +$$

$$+\underset{(0.163)}{0.1705}\ln P_{Corn} - \underset{(0.132)}{0.2305}\ln P_{Potatoes} - \underset{(0.065)^{**}}{0.1443}\ln \textit{Real expenditure} \qquad (26)$$

$$W_{Corn,U.S.} = \underset{(0.082)}{0.0256} + \underset{(0.034)^{**}}{0.1861}\ln P_{Corn,U.S.} + \underset{(0.014)}{0.0073}\ln P_{Corn,ROW} - \underset{(0.077)^{**}}{0.2936}\ln P_{Wheat} - \underset{(0.226)^{**}}{1.5222}\ln P_{Rice}$$

$$+\underset{(0.216)^{**}}{1.6223}\ln P_{Potatoes} - \underset{(0.052)}{0.0917}\ln \textit{Real expenditure} \qquad (27)$$

$$W_{Corn,ROW} = \underset{(0.161)}{0.0126} + \underset{(0.014)}{0.0073}\ln P_{Corn,U.S.} - \underset{(0.029)}{0.0123}\ln P_{Corn,ROW} - \underset{(0.143)}{0.0027}\ln P_{Wheat} - \underset{(0.370)}{0.0126}\ln P_{Rice}$$

$$+\underset{(0.362)}{0.0203}\ln P_{Potatoes} - \underset{(0.102)}{0.0493}\ln \textit{Real expenditure} \qquad (28)$$

$$W_{Potatoes,U.S.} = \underset{(0.0007)}{0.0011} + \underset{(0.0002)}{0.0008}\ln P_{Potatoes,U.S.} - \underset{(0.0003)^{**}}{0.0002}\ln P_{Potatoes,ROW} + \underset{(0.0007)^{**}}{0.0015}\ln P_{Wheat} - \underset{(0.001)}{0.0017}\ln P_{Rice}$$

$$-\underset{(0.002)}{0.0005}\ln P_{Corn} + \underset{(0.0005)}{0.0004}\ln \textit{Real expenditure} \qquad (29)$$

Marshallian and Hicksian elasticity estimates are computed based on the budget share equations. These elasticity estimates and their standard errors are in Tables 2.17, and 2.18, respectively. In general, the own-price coefficients of Caribbean per capita demand for both U. S. and Rest-of-the-World starchy foods are negative and significant, except for the demand for U. S. corn and the demand for U. S. potatoes where they are positive and non significant. We perform our analysis only on the basis of significant elasticity estimates.

Table 2.17 indicates that the own-price Marshallian per capita demand elasticities for U. S. wheat and U. S. rice are higher than the own-price Marshallian per capita demand elasticities for the Rest-of-the-World wheat and rice. Caribbean per capita demand for U. S wheat is unitary elastic to U.S. wheat price, and Caribbean per capita demand of rice from the U. S. is own-price inelastic. Furthermore, Caribbean per capita demands for the Rest-of-the-World wheat and rice are own-price inelastic, and Caribbean per capita demand for the Rest-of-the-World corn is own-price elastic.

From the U. S. perspective alone, the implication of these results is that reduction in the price of the U. S wheat would be more effective than reduction in the price of U. S. rice in addressing eventual issue of food security through imports in the Caribbean, or equivalently, in increasing U. S. exports to the Caribbean. Because the own- price elasticity estimates for U. S corn and U. S. potatoes are not significant, no conclusion related to own-price elasticities of Caribbean per capita demand for U. S. corn and U. S. potatoes can be drawn.

From the Rest-of-the-World perspective alone, changes in the wheat price would have the same impact on Caribbean per capita demand for the Rest-of-the-World wheat as would changes in the rice price on Caribbean per capita demand for the Rest-of-the-world rice. A 1 percent change in the price of wheat and rice in the Rest-of-the-World would lead to less than 1 percent change in the Caribbean per capita demands for these two staples, given that these demands are own-price inelastic.

Table 2.17. Marshallian Elasticities for Starchy Food (Wheat Unmilled and Flour, Rice, Corn, and Fresh Potatoes) Import Demand in the Caribbean (1982-1996).

Product equation	Variables	U. S. equation	Rest-of-the- World (ROW)
Wheat (unmilled and flour)	$LogPWHT_{US}$	-1.01 **	-0.40**
		(0.23)	(0.12)
	$LogPWHT_{ROW}$	-0.63 **	-0.65 **
		(0.22)	(0.15)
	$LogP_{RICE}$	-0.80	4.16 **
		(2.23)	(1.42)
	$LogP_{CORN}$	0.34	-0.57
		(1.11)	(0.73)
	$LogP_{POTATOES}$	1.29	-4.34**
		(2.15)	(1.43)
	$Log(Exp / P)$	0.81	1.80**
		(0.46)	(0.32)

Table 2.17 (continued)

Product equation	Variables	U. S. equation	Rest-of-the- World (ROW)
Rice	$LogP_{RICE\,US}$	-0.87 **	-0.85**
		(0.29)	(0.14)
	$LogP_{RICE\,ROW}$	-1.54 **	- 0.65 **
		(0.23)	(0.28)
	$LogP_{WHEAT}$	-2.81 **	2.43**
		(0.78)	(1.12)
	$LogP_{CORN}$	0.58	2.52
		(1.92)	(2.03)
	$LogP_{POTATOES}$	3.81 **	-2.72
		(1.43)	(1.59)
	$Log(Exp/P)$	0.82	- 0.73
		(0.56)	(0.78)
Corn	$LogPCORN_{US}$	0.12	0.17
		(0.22)	(0.26)
	$LogPCORN_{ROW}$	0.09	-1.08 **
		(0.08)	(0.33)
	$LogPWHEAT$	-1.34 **	0.27
		(0.39)	(1.57)
	$LogP_{RICE}$	-8.31**	0.01
		(1.28)	(4.07)
	$LogP_{POTATOES}$	9.02 **	0.23
		(1.20)	(3.88)
	$Log(Exp/P)$	0.49	0.47
		(0.29)	(1.10)

Table 2.17 (continued)

Product equation	Variables	U. S. equation	Rest-of-the- World (ROW)
Potatoes	$LogP_{POTATOES\ US}$	0.61 (0.41)	
	$LogP_{POTATOES\ ROW}$	-0.40 (0.57)	
	$LogPWHEAT$	2.80 (1.42)	
	$LogP_{RICE}$	-3.67 (2.05)	
	$LogPCORN$	-1.19 (3.40)	
	$Log(Exp/P)$	1.84 (0.99)	

$Log(Exp/P)$ stands for logarithm of deflated per capita expenditures in imports of starchy food in the Caribbean.
$LogP$ stands for logarithm of price.
** denotes that elasticity is significant at the 0.05 level of significance
The numbers in parentheses are standard errors.

In the very short term, it is plausible to assume that price changes of a staple from one source do not affect the demand for this staple in the other source. Under this condition, Caribbean short-term security in wheat and rice consumption through imports will be better achieved by reducing (ceteris paribus) U. S. wheat and rice prices than by reducing (ceteris paribus) Rest-of-the-World wheat and rice prices. This is due to the larger size of the U. S. own-price elasticities for wheat and rice. Everything else kept constant, reducing U. S. prices of wheat and rice would increase Caribbean imports from U. S. more than would reducing Rest-of-the-World prices. Therefore, everything else constant, for wheat and rice, U. S market share through Caribbean imports would increase more if a price reduction occurs in the U.S than if it occurs in the Rest-of-the-World. For corn, a 1 percent change in the Rest-of-the-World price would generate a more than 1 percent change in the Caribbean per capita demand (elasticity is 1.08). Consequently, reduction in the Rest-of-the-World corn price would have a substantial impact on Caribbean security in corn consumption. Furthermore, keeping everything else fixed, this price reduction would increase the Rest-of-the-World market share for corn in the Caribbean.

In the intermediate or long runs, price changes of a staple from one source are likely to have repercussion effects on the demand of the same staple from the other source. Therefore, a 1 percent change in the U. S wheat price would lead to a change in the opposite direction of 1 percent in the per capita demand for U. S. wheat, and of 0.4 percent in the per capita demand for ROW wheat in the Caribbean (i.e. the per capita demand for U. S. wheat is unitary elastic to U. S. price, and the per capita demand for ROW wheat is inelastic to U. S. price). Caribbean wheat security through imports from both sources can be achieved through reduction in the price of the U. S. wheat. Keeping the prices of all the other starchy staples constant (i.e. ceteris paribus assumption), a reduction in the U. S. price of wheat by 1 percent will increase U. S. and Rest-of-the-World wheat exports to the Caribbean by 1 percent and 0.4 percent respectively. Depending on the size of the price reduction and the initial market shares, the U. S. may even gain wheat market share over the Rest-of-the World in the Caribbean[21] through the price reduction. However, a ceteris paribus reduction in the price of the Rest-of-the-World wheat will always favor the Rest-of-the-World in terms of market share in the Caribbean, while also improving food security in the Caribbean through increased imports of wheat from both sources (note Caribbean per capita demand elasticities to the Rest-of-the-World price are –0.65 and –0.63 for U. S. wheat and ROW wheat, respectively).

For rice, a ceteris paribus reduction in the U. S export price to the Caribbean would certainly improve Caribbean food security through increased imports of rice from both sources. However, U. S. market share gain over the Rest-of-the-World would be more difficult to achieve, given the quasi-equality of the two elasticity estimates for the U. S. price of rice in both the U. S. and the ROW equations (-0.87 and –0.85, respectively). If the reduction occurred in the price of the ROW rice, it would also improve Caribbean food security through increased imports of rice from both sources, but with a possibility for the U. S. to gain market share over the ROW, depending on the size of the ROW price reduction and initial shares conditions (Caribbean demand elasticities to ROW price of rice are -1.54, and –0.65 in the U. S and the ROW equations, respectively).

For corn, reduction in the ROW price would improve food security in the Caribbean through increased imports of corn from the Rest-of-the-World (for certain). At the same time, this price reduction may favor the Rest-of-the-World in terms of market share gain,

[21] Let's assume that a high price reduction occurred in the U. S. and the market shares of the two sources (U. S. and ROW) were close to each other. The increase of 1 percent in Caribbean demand for U. S. wheat for every 1 percent reduction in the U. S price is higher than 0.4. This latter value is the corresponding percent increase in the Caribbean demand for the ROW wheat for a 1 percent reduction in the U. S. wheat

based on the extent of the price reduction and initial market share conditions (elasticity estimate is –1.08)

In addition, the source-differentiated Marshallian cross-price elasticities between wheat from the U. S. and from the Rest-of-the-World (as well as between rice from the U. S. and from the Rest-of-the-World) are negative and significant. Therefore, there is no competition among sources for these two products. This suggests that wheat and rice from the U. S. and from the Rest-of-the-World might be considered as two different products in the Caribbean. For corn, the source-differentiated Marshallian cross-price elasticities in the U. S. and the Rest-of-the-World equations are also negative but not significant. The same is true in the U. S. potatoes equation.

Focusing only on the significant Marshallian elasticity estimates, we have no conclusion about the nature of the cross relationship between the Caribbean per capita demand for U. S. wheat and the price of the three other staples (rice, corn and potatoes). However, in the Caribbean, rice from all sources seems to be a substitute for the Rest-of-the-World wheat (cross-price elasticity = 4.16), and complement to the U. S corn (cross-price elasticity = -8.31. Potatoes from all sources seems to be complement to the Rest-of-the-World wheat (cross-price elasticity = -4.34), and substitute to the U.S rice (cross-price elasticity=3.81) and to the U. S. corn (cross-price elasticity = 9.02). Wheat from all sources appears to be substitute to the Rest-of-the-world rice (cross-price elasticity =2.43), but complement to the U. S. rice (cross-price elasticity = -2.81) and to the U. S. corn (cross-price elasticity = -1.34).

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price. In absolute term, the U.S share may overshoot the Row share for this product in the Caribbean, given the size of the price reduction in the U. S. and the closeness of the two shares before this price reduction.

Growth that brings about increased per capita real expenditure in starchy food consumption in the Caribbean is likely to increase Caribbean per capita demand for the Rest-of-the-World wheat (elasticity=1.80). However, there is no evidence that growth in the Caribbean would affect its demand for U. S. starchy foods in general, and for the Rest-of-the-World rice and corn, given that the related elasticity estimates are not significant.

Table 2.18. Hicksian or Compensated Price Elasticities for Starchy Food (Wheat Unmilled and Flour, Rice, Corn, and Fresh Potatoes) Import Demand in the Caribbean (1982-1996).

Product equation	Variables	U. S. equation	Rest-of-the- world (ROW)
Wheat (unmilled	$LogPWHT_{US}$	-0.88** (0.19)	-0.11 (0.09)
and flour)	$LogPWHT_{ROW}$	-0.30 (0.22)	0.09 (0.15)
	$LogP_{RICE}$	-0.69 (2.20)	4.40 ** (1.40)
	$LogP_{CORN}$	0.55 (1.08)	-0.08 (0.70)
	$LogP_{POTATOES}$	1.31 (2.15)	-4.29** (1.44)

Table 2.18 (continued)

Product equation	Variables	U. S. equation	Rest-of-the- world (ROW)
Rice	$LogP_{RICE\ US}$	-0.83 **	-0.88 **
		(0.28)	(0.13)
	$LogP_{RICE\ ROW}$	-1.47 **	-0.71 **
		(0.22)	(0.27)
	$LogP_{WHEAT}$	-2.34 **	2.01
		(0.85)	(1.17)
	$LogP_{CORN}$	0.80	2.32
		(1.86)	(1.95)
	$LogP_{POTATOES}$	3.83 **	-2.74
		(1.44)	(1.59)
Corn	$LogPCORN_{US}$	0.21	0.26
		(0.19)	(0.15)
	$LogPCORN_{ROW}$	0.13	-1.04**
		(0.08)	(0.31)
	$LogPWHEAT$	-1.06 **	0.54
		(0.43)	(1.53)
	$LogP_{RICE}$	-8.32 **	-0.002
		(1.25)	(3.97)
	$LogP_{POTATOES}$	9.03**	0.24
		(1.20)	(3.88)

Table 2.18 (continued)

Product equation	Variables	U. S. equation	Rest-of-the- world (ROW)
Potatoes	$LogP_{POTATOES\ US}$	0.61 (0.41)	
	$LogP_{POTATOES\ ROW}$	-0.36 (0.58)	
	$LogPWHEAT$	3.85 ** (1.57)	
	$LogP_{RICE}$	-3.42 (2.08)	
	$LogPCORN$	-0.68 (3.28)	

$Log(Exp / P)$ stands for logarithm of deflated per capita expenditures in imports of starchy food in the Caribbean.
$LogP$ stands for logarithm of price.
** denotes that elasticity is significant at 0.05 level of significance.
The numbers in parentheses are standard errors.

Discussions

The estimated elasticities may slightly change as a result of incorporating tariffs and /or quotas into the model. Trade liberalization has become an issue in the Caribbean since the creation of the Caribbean Common Market (CARICOM) in 1973. As an economic integration, CARICOM, which currently includes 13 countries in the region (see appendix), virtually removes trade barriers between the participant countries and adopts a common external tariff to imports for countries other than the ones in the CARICOM

(Kazarian and Ames, 2000). A common practice in all developing nations including the Caribbean was to impose high tariff rates on imports as a means of increasing government revenues or of protecting domestic production. For instance, Haiti initiated trade liberalization policies in 1987 in a context where tariff rates on rice and corn were as high as 50 percent (Dameus, 1988). Efforts undertaken by GATT / WTO [22] toward eliminating trade barriers through the Uruguay Round entail more trade relaxation or liberalization policies around the world. As an example, from 1993 to 1998, the CARICOM countries reduced their tariff structure from 0-35 percent to 0-20 percent (Association of Caribbean States, 1997). Trade agreements have been a major tool used throughout the second half of the twentieth century to open trade among nations. In this regard, efforts are being made to extend the North American Free Trade Agreement (NAFTA), which currently involves U. S., Canada, and Mexico, to all nations in the American continent, except Cuba. Discussions around this issue[23] will be held on Spring 2001 in Quebec. Kazarian and Ames mentioned that other trade agreements involving the Caribbean countries are:

1) CARIBCAN: a free trade agreement between the Caribbean and Canada
2) Caribbean Basin Initiative (CBI): initiated by the American President Ronald Reagan in the early 1980's. Its objectives were to improve the Caribbean economy and political atmosphere through trade and investment and to remove U. S. tariffs on some products exported by some of the Caribbean countries.

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[22] GATT stands for General Agreement on Tariff and Trade.
WTO stands for World Trade Organization

[23] Thirty-five (35) representatives of the nations in the American continent will be present in Quebec in the meeting called the Summit of the Americas (source: http://www.haitionline.com/2000/904.htm)

3) Lome Convention: involves the European Union and some developing countries in Africa, the Caribbean and the Pacific Ocean. Its objective is to allow duty free entry of goods from these developing countries into the European Union countries.
4) Bilateral trade agreements: for instance, Trinidad and Tobago is involved in a free trade agreement with Venezuela and is looking forward to having trade agreements with Mexico and with Colombia.

In an expanding free trade environment where the Caribbean is involved as an actual or potential partner, our estimated elasticities might need some adjustment in magnitude to take into account actual and future trade liberalization policies in the Caribbean. However, it is likely that the needed adjustment is not as high as one might expect. The following reasoning might help clarify this point. More trade liberalization may or may not result in an important increase in the Caribbean imports of starchy foods. On one hand, economic theory tells us that trade generates growth[24]. A country growth can be measured by the growth rate of its gross domestic product (GDP). Increased GDP in the Caribbean through trade is likely to partly shift Caribbean consumption from starchy staples to meat. The marginal propensity to spend on starchy staples is less than 1 at a certain level of GDP. On the other hand, if the Caribbean population keeps on increasing, imports of starchy foods may increase to satisfy the needs of the increased population despite the growth. Therefore, the overall impact of both growth from trade liberalization and increased population might only be a slight increase in our elasticity estimates under the assumption of Caribbean fixed exogenous import prices. However, these import prices are likely to change as a result of international market adjustment. It is not certain whether the world prices of starchy foods will increase or decrease. If the demand of starchy foods in the international market increases, the world prices will increase. At the same time, given the general context of trade liberalization, countries producing the starchy foods will do so more efficiently by using their comparative advantage. As a result, the world supply of starchy foods is likely to increase and this increase will tend to reduce the world prices of starchy foods. When both the likely increase in demand and the likely increase in supply are considered, the overall price change in the international market depends only on the elasticities of the excess demand and excess supply schedules in the world market. If the world price of starchy foods increases or decreases, our elasticity estimates will decrease or increase. As a whole, in a changing world environment with more trade agreements and trade liberalization policies, with increasing population, and with possible randomness in the world supply of starchy foods, we do not know for sure whether our elasticity estimates will increase or decrease in the future. However, we do know that, no matter the direction of the change, the size of this change is likely to be small, given the interaction of several different counteracting factors.

The import demand elasticities resulting from the study are not expected to be affected by the amount of food aid (in terms of wheat and flour, rice, and corn) received by a very few countries in the Caribbean only some years within the time period of the data. Tables 2.A1, 2.A2, and 2.A3 in appendix show the Caribbean total consumption share of the U. S. aid for wheat and flour, rice, and corn during the years the aid was given by the United States. Indeed, food aid in terms of wheat and flour

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[24] This is the argument of export-growth theory.

does not generally exceed 5 percent of the Caribbean total consumption of wheat and flour. For rice, the aid does not exceed 5 percent of the Caribbean total consumption of rice over the five-year data period. For corn, the aid was given only during three years.

Because complete data series by countries for all the variables of interest could not be obtained, we were not able to work on specific Caribbean countries as we initially planned to. Using available Caribbean aggregate data was the only remaining choice. Furthermore, in the partitioning of the Caribbean import sources, data on exports of starchy foods by country of destination, or identically data on Caribbean imports of starchy foods by country of origin would allow us to consider all the possible Caribbean import sources in our model. Unfortunately, available data on exports or imports for countries other than the U. S. are not partitioned by destination or source. Partitioned trade data by destination or source are detailed country-specific data that can only be obtained from the countries themselves. In an attempt to incorporate Canada as a third Caribbean import source, we contacted the Canadian Ministry of Agriculture for their data on exports of starchy foods to the Caribbean. Unfortunately, their data were so incomplete that it was worthless to consider them in our analysis. Given the difficulty in obtaining the necessary data for incorporating more sources into our analysis, we were only left with the alternative of considering only two Caribbean import sources, the U. S. and the Rest-of-the-World. A second aggregation was made by grouping all countries other than the U. S. and the Caribbean countries into the so called Rest-of-the-World.

Using aggregated import data across Caribbean countries and an aggregate Rest-of-the-World source prevents from interpolating the elasticity results to a single Caribbean country and to any other possible Caribbean import source outside the U. S. However, the elasticity estimates for the U. S. source are precise.

If data series on imports of starchy foods by source for all the Caribbean countries were available, the Caribbean import demand by source could have been computed as a weighted average of import quantities across all Caribbean countries, where the weights could have been the ratio of each Caribbean country population to the total Caribbean population. In the absence of such data, we were left with the alternative of using per capita import quantities. This may not correspond to a representative Caribbean household, but it is the best that could be done in a limited data situation.

Summary and Conclusion

Caribbean production of starchy staples (unmilled wheat and flour, rice, corn, and fresh potatoes) is insufficient to satisfy domestic consumption. As a result, imports of starchy foods play a major role in securing food in the Caribbean. Caribbean foreign suppliers of starchy foods are both the United States and the Rest-of-the-World, which export their products at different prices to the Caribbean. Available data showed that average prices of rice and corn exported to the Caribbean over the 1982-1996 period was lower in the U.S. than in the Rest-of-the-World. However, for wheat and potatoes, they were lower in the Rest-of-the-World than in the U. S. during the same time period. Furthermore, the U.

S. share of the total volume of starchy foods imported by the Caribbean was in general lower than the Rest-of-the-World share, except for corn.

Foreign suppliers' prices are not under the control of the Caribbean, which does not have any bargaining power, given its size in the overall international market. Consequently, the prices faced by the Caribbean in the foreign markets may exogeneously change at any time by policy means from the exporters' side or by changes in international market conditions. The questions are about how these likely price changes can affect food security through imported quantities in the Caribbean and possibly foreign suppliers' gain in market shares, and how the Caribbean views a starchy food coming from two different sources.

This study uses the Restricted Source Differentiated Almost Ideal Demand System (RSDAIDS) developed by Yang and Koo to model the Caribbean per capita import demand for the four starchy foods (unmilled wheat and flour, rice, corn and fresh potatoes) and to estimate Caribbean import demand elasticities for U. S. and Rest-of-the-World starchy foods. Appropriate econometric tests justify the use of this model with homogeneity and symmetry restrictions imposed. The results of the study suggest that reducing U. S. prices of wheat and rice is likely to improve food security in the Caribbean through an increase in imports of these two commodities with or without cross-market repercussion effects. The same is true for reducing Rest-of-the-World prices of wheat and rice. Moreover, Caribbean per capita demand is own-price unitary elastic for U. S wheat and own-price inelastic for U. S. rice, and Rest-of-the-World wheat and rice. Among the four starchy staples, wheat or rice does not seem to be in price-based source competition in the Caribbean. Instead, there exists a complementarity relationship across source for each of the two products. In other words, the Caribbean distinguishes between the wheat or rice coming from the U. S. and the wheat or rice coming from the Rest-of-the-World. The import demand elasticities resulting from the study are not expected to be affected by the relatively small amount of food aid (in terms of wheat and flour, rice, and corn) received by a very few countries in the Caribbean only some years within the time period of the data. Furthermore, due to the fact that starchy foods are staples, trade liberalization policies through trade agreements in the Caribbean are not very likely to have a major impact on the elasticity estimates in the long run. More trade liberalization in the future is likely to generate income growth that would not necessarily be spent in importing more starchy foods, unless the Caribbean population keeps increasing. Because of the interaction of various internal and external counteracting factors, trade liberalization policies are not expected to considerably inflate our elasticity estimates in the future. However, non-availability of complete and precise data on the Caribbean trade policies throughout the time period of the study prevents investigating the impact of the Caribbean trade liberalization policies on the source differentiated import demands of starchy foods.

Limitations of the Study

Available complete series data on all the variables in this study could be built up to only fifteen years (1982-1996). The aggregate nature of the study does not allow any development about specific country in the Caribbean or in the Rest-of-the-World group. Data limitations prevent expanding the model toward investigating possible effects of

Caribbean trade policies or agreements on the Caribbean import demands of starchy foods.

Suggestion for Further Research

The real nature of the complementarity relationship across source for wheat and rice is not known. Further research requiring country-specific data (which are not always accessible) is needed to determine whether or not quality difference and/ or trade agreements between the Caribbean and some specific foreign suppliers in the Rest-of-the-World group are likely causes of the observed complementarity relationship. If the required data are made available, such a research may also investigate the possibility of using a model that would fit the inclusion of trade policies or agreements, quality differences, trade creation and diversion (if any) originated from the existence of the Caribbean Common Market (CARICOM)[25].

[25] In the appendix are attached some information about CARICOM and a list of the Caribbean Countries including the CARICOM countries which is in table A4.

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Appendix

Table 2.A1. Wheat and Flour: U. S. Aid Quantity, Caribbean Total Quantity Consumed, and Share of U. S. Aid in Caribbean Total Consumption

Year	U. S. Aid (MT)	Caribbean Total Quantity Consumed (MT)	Share of U. S. Aid in Caribbean Total Consumption (MT)
1982	2,840	2,033,240	0.14
1983	2,973	2,327,950	0.13
1984	21,400	2,279,500	0.90
1985	93,187	2,318,700	4.02
1986	66,052	2,374,700	2.78
1987	143,519	2,479,800	5.79
1988	181,985	2,351,300	7.74
1989	6,500	2,265,000	0.29
1990	n.a.	2,115,800	n.a.
1991	n.a.	2,321,700	n.a.
1992	93,190	2,220,500	4.20
1993	49,328	1,931,500	2.55
1994	35,300	1,902,600	1.86
1995	24,710	1,669,100	1.48
1996	23,950	4,679,100	0.51

Sources : column 2: USDA (1982-1989), FAO (1992-1996). Column 3 is the same as total imports in previous table 2.2 in the text.

Table 2.A2. Rice: U. S. Aid Quantity, Caribbean Total Quantity Consumed, and Share of U. S. Aid in Caribbean Total Consumption

Year	U. S. Aid (MT)	Caribbean Total Quantity Consumed (MT)	Share of U. S. Aid in Caribbean Total Consumption (MT)
1992	36,102	1,342,620	2.69
1993	68,074	1,467,600	4.64
1994	47,500	1,477,200	3.22
1995	50,360	1,571,620	3.20
1996	44,590	1,497,020	2.98

Source: FAO (column 2) .Column 3 is part of total availability in previous table 2. 5 in the text.

Table 2.A3. Corn: U. S. Aid Quantity, Caribbean Total Quantity Consumed, and Share of U. S. Aid in Caribbean Total Consumption

Year	U. S. Aid (MT)	Caribbean Total Quantity Consumed (MT)	Share of U. S. Aid in Caribbean Total Consumption (MT)
1992	143,055	1,284,600	11.14
1993	192,700	1,475,200	13.06
1994	16,400	1,253,700	1.31

Source: FAO (column 2). Column 3 is part of total availability in previous table 2.8 in the text.

Some Information on CARICOM

For the last twenty-five or thirty years, some of the Caribbean countries have tended to emerge as a group. On July 4, 1973 four countries Barbados, Guyana, Jamaica, and Trinidad-Tobago signed a treaty establishing a Caribbean Community and Common Market (CARICOM). Six less developed countries of the former Caribbean Free Trade Association (CARIFTA), Belize, Dominica, Grenada, St Lucia, St Vincent and the Grenadines, and Montserrat signed the CARICOM Treaty in April 1974. In July 1974, Antigua and the Associated State of St Kitts-Nevis- Anguilla acceded to membership. In July 1983, the Bahamas signed the treaty as a member of the Caribbean Community but not as a member of the Common Market. In July 1995, Suriname acceded to membership of the Caribbean community and Common Market. Haiti became a provisional member of the CARICOM in July 1997.The Caribbean community has three areas of activity: 1) economic integration 2) cooperation in non-economic areas, and operation of certain common services, 3) coordination of foreign policies of independent member states. Table A4 presents two basic indicators for these countries, such as their population and their gross domestic product (GDP) per capita.

Table 2.A4. Some Indicators of the Caribbean Countries

Caribbean Countries	Population (thousands)	GDP per capita 1995 (U.S. $)
1. CARICOM –Independent countries		
Antigua and Barbuda	64	6,640
Bahamas	279	12,258

Table 2.A4 (continued)

Caribbean Countries	Population (thousands)	GDP per capita 1995 (U.S. $)
CARICOM –Independent Countries (continued)		
Barbados	264	7,120
Belize	217	2,696
Dominica	74	2,754
Grenada	780	809
Haiti	7,180	285
Jamaica	2,500	1,762
St Lucia	145	3,083
St Kitts and Nevis	42	4,642
St-Vincent and Grenadines	110	2,032
Surinam	409	1,066
Trinidad and Tobago	1,262	4,101
CARICOM	13,424	1,511
2. Non-Grouped Countries		
Cuba	10,964	1,113
Dominican Republic	7,250	1,663
3. Netherland Territories		
Aruba	82	16,810
Netherland Antilles	207	7,871

Table 2.A4 (continued)

Caribbean Countries	Population (thousands)	GDP per capita 1995 (U.S. $)
4. British Territories		
Anguilla (1)	10	5,932
Montserrat (1)	10	5,155
British Virgin Islands	18	18,487
Cayman Islands	32	28,125
Turks and Caicos Islands	15	7,021
5. French Departments		
French Guina * (1)	141	9,908
Guadeloupe	447	7,585
Martinique*	360	10,895
6. U.S. Territories		
Puerto-Rico	3,700	11,450
U.S. Virgin Islands	102	13,163

(1) : these countries are non-independent countries but members of the CARICOM
* : data from 1992
Source: Association of the Caribbean States
http://www.acs-aec.org/Bdatos/cuadro1.htr

Chapter III

AIDS versus Rotterdam: A Cox Nonnested Test with Parametric Bootstrap

AIDS versus Rotterdam: A Cox Nonnested Test with Parametric Bootstrap

Abstract

A Cox nonnested test with parametric bootstrap is developed to select between the linearized version of the First Difference Almost Ideal Demand System (FDAIDS) and the Rotterdam model. The Cox test with parametric bootstrap is expected to be more powerful than the various orthodox tests used in past research. The new approach is then used for U. S. meat demand (beef, pork, and chicken) and compared to results obtained from orthodox tests. The orthodox test gives inconsistent results depending on the inclusion or exclusion of fish and the time period covered. In contrast, under the same varied conditions, the Cox test with parametric bootstrap consistently indicates that the Rotterdam model is preferred to the FDAIDS.

Keywords: First Difference Almost Ideal Demand System, meat demand, nonnested hypotheses, parametric bootstrap, Rotterdam model.

AIDS versus Rotterdam: A Cox Nonnested Test with Parametric Bootstrap

Introduction

Functional form is an important issue in empirical production and consumption studies. A necessary condition for valid statistical inference is that the right model be chosen. In agricultural economics, policy recommendations are often based on elasticity estimates obtained from a certain model specification. Different functional forms often result in very different elasticity estimates.

The two most commonly used models in demand analysis are the Almost Ideal Demand System (AIDS) and the Rotterdam model. Most researchers arbitrarily pick one model or the other. The two models are nonnested and recent interest has focused on developing proper nonnested tests of the two demand systems.

The two prominent studies presenting techniques of selecting between the AIDS and the Rotterdam demand systems are from Alston and Chalfant (AC) in 1993 and from LaFrance in 1998. In their study, AC used a compound-model approach to select between the First Difference AIDS (FDAIDS) and the Rotterdam models, using U.S. meat demand data (beef, pork, chicken, and fish). They found support for the Rotterdam model. However, LaFrance pointed out that AC's least squares test approach is biased and inconsistent because the explanatory variables include the variable to be explained (or a transformation of it). Using the same data, he conducted both a Lagrange multiplier test (t-test) and a likelihood ratio test and failed to reject either demand system. The compound model approach used by LaFrance is known to have the correct asymptotic size, but low power (Pesaran). Thus, the failure to reject either null hypothesis may simply be the result of using a test with low power[26]. Most of the previous nonnested tests have been developed for models that have the same dependent variables (e.g. Pesaran). Coulibaly and Brorsen show that a Cox's nonnested test based on the parametric bootstrap has high power, is relatively easy to use, and is applicable to any model that can be simulated.

The objectives of this paper are to:

1. develop a Cox's nonnested test with parametric bootstrap
2. determine whether the Rotterdam or the FDAIDS[27] is the best model for U. S. meat demand.

Like both AC and LaFrance, we use a nonnested test to test the AIDS vs the Rotterdam for U. S. meat demand. A difficulty in using the parametric bootstrap is in simulating quantities from the Rotterdam model. The approach eventually adopted is based on a Taylor's series expansion similar to Kastens' and Brester's approach. Our formulation differs from Kastens and Brester's formulation since their approach often leads to predictions of negative quantities.

Tomek's suggestions on how to make research more cumulative are followed in the accomplishment of the second objective. First, LaFrance's orthodox test technique based on likelihood ratio and convex combination is applied on the particular FDAIDS and Rotterdam models used, and the nonnested test based on parametric bootstrap is used on LaFrance's data. Then, both LaFrance's technique and the parametric bootstrap technique

[26] Note that the papers by LaFrance and by Alston and Chalfant are misnamed. The lambdas in Alston and Chalfant are not silent and the lambdas in Lafrance do not bleat.
[27] We used the linearized version of the FDAIDS, i. e. the Stone price index is used to deflate expenditures.

are used on updated data. LaFrance's 1967-1988 data[28] set on U. S. meat demand includes four commodities beef, pork, chicken, and fish. The updated data have a 1970-1997 time span, come from a different source and do not include fish[29]. For the purpose of better comparison, the two techniques are also applied to LaFrance's data set excluding fish. As Tomek argues, such an approach allows determining whether differences in results across studies are due to differences in approach (orthodox versus Cox's test) or to differences in data. The differences in data may be based either on the time period, or on the data values or source, or on inclusion or exclusion of fish in LaFrance's data set.

Nonnested Hypothesis Tests

Nonnested hypothesis tests select between two regression models where one model cannot be written as a special case of the other. In such a case, the models themselves are said to be nonnested. Suppose we have two nonnested models A and B with the same set of explanatory variables to choose from using the same set of data. To test that model A is the true model[30], the nonnested hypotheses for the two models can be written in the following general form:

$$H_0 \; : f_{it}(y_{it}) = X_t^{'}\beta_{0,i} + \mu_{0,i,t} \qquad \text{model A} \qquad (1)$$

$$H_1 \; : g_{i,t}(y_{i,t}) = X_t^{'}\beta_{1,i} + \mu_{1,i,t} \qquad \text{model B} \qquad (2)$$

[28] In fact, the data used by LaFrance are the ones from Alston and Chalfant

[29] According to Nick Piggott and Derrell S. Peel, the fish data are not reliable (personal communication). Piggotis a professor at North Carolina State University. Peel is a professor from the Agricultural Extension Service at Oklahoma State University and provides the updated data set.

[30] Note that we can also present the hypotheses with model B as the null and model A as the alternative. In this case, we would test that model B is the true model.

where the two left-hand sides are the functional form of the dependent variables of the two models A and B, respectively, i = 1,...,n (i.e. n equations), and t = 1,...,T (i.e. T observations in each equation), y_{it} is quantity, $X_t^{'}$ is a vector of explanatory variables, $\beta_{0,i}$ and $\beta_{1,i}$ are parameter vectors under the null and alternative hypotheses, and $\mu_{0,i,t}$ and $\mu_{1,i,t}$ are vectors of error terms under the null and alternative hypotheses.

Three types of nonnested hypothesis tests presented in the literature are the orthodox test, the J test, and the Cox test. All these tests have the correct asymptotic size and are consistent in the sense that the probability of rejecting the null hypothesis when a fixed alternative hypothesis is true tends to unity as the sample size increases, but they have different asymptotic power for local alternatives (Pesaran, 1982). Pesaran has also shown that the J test and the Cox nonnested test have the same asymptotic power, but the power of the orthodox test is lower than that of these two tests. He argues that the power of the Cox and J nonnested tests is related to the number of overlapping variables. A larger number of non-overlapping variables give more powerful J and Cox nonnested tests, as compared to the orthodox test, in large samples. When there is only one overlapping variable, the power of the three nonnested hypothesis tests (orthodox, J, and Cox tests) is identical.

The J-test is used only for linear models and is not applicable in the present case where the demand models are nonlinear. Pesaran recommends that it is replaced by a P test for nonlinear models to increase power. P-test or J-test are likely to require identical dependent variables. Given that in our demand systems, the dependent variables are not identical, the two choices we are left with are the orthodox and the Cox tests. A Cox test is preferred asymptotically, but it has incorrect size in small samples. A bootstrap is a convenient way of correcting the small size of the Cox's test in small samples.

Orthodox Test

The orthodox test is based on a supermodel obtained by linear combination of the two models in the null and alternative hypotheses. Referring to the previous example of the two models A and B in equations (1) and (2), the supermodel can be written in the following way:

$$(1-\lambda)f_{i,t}(y_{i,t})+\lambda g_{i,t}(y_{i,t})=X_t^{'}\beta_i+\mu_{it} \qquad (3)$$

where $\beta_i=(1-\lambda)\beta_{0,i}+\lambda\beta_{1,i}$ and $u_{i,t}=(1-\lambda)\mu_{o,i,t}+\lambda\mu_{1,i,t}$, i = 1,…,n and t = 1,…,T. The parameter λ is a parameter used to linearly combine the two models. All other elements are as defined above.

Testing that model A is the true model is equivalent to testing that the parameter λ is equal to zero. On the other hand, testing that model B is the true model corresponds to a test of λ equal to 1. In general, an F test is used as a statistical procedure in making the selection decision between the two models. Greene argues that the orthodox test does not really distinguish between the null and the alternative hypotheses, but rather distinguishes between the alternative and a hybrid model. This is because the supermodel uses a combination of the parameters from the two models that is not captured in the F test.

Cox Test and Parametric Bootstrap

The Cox test in its generic version proposed by D. R. Cox is based on the log-likelihood ratio of two models under consideration. In our example of the two models A and B, under the null hypothesis that model A is the true model, the log-likelihood ratio statistic can be computed as the difference between the log likelihood values of models A and B. In general, the Cox test statistic has the following representation in testing the null hypothesis H_0 against H_1.

$$T_0 = L_{01} - E(L_{01}), \tag{4}$$

where $L_{01} = L_0(\hat{\theta}_0) - L_1(\hat{\theta}_1)$. $L_0(\hat{\theta}_0)$ and $L_1(\hat{\theta}_1)$ are the maximum log-likelihoods under H_0 and H_1, respectively, $E_0(L_{01})$ is the expected value of L_{01} under H_0, and $\hat{\theta}_0$ and $\hat{\theta}_1$ are the maximum likelihood parameter estimates of the null and the alternative models, respectively. T_0 is asymptotically distributed with mean zero and variance v_0^2 under H_0 (Cox, 1962). The test statistic for testing H_1 against H_0 would be $T_1 = L_{10} - E(L_{10})$.

The difficulty in implementing the Cox test is in obtaining analytical formulas for $E(L_{01})$ and v_0^2. Pesaran derived analytical results for the linear regression models with the same dependent variable. Both Pesaran and Deaton and Pesaran and Pesaran have developed a version of the Cox test with transformed dependent variables such as needed for testing linear versus log-linear models. However, their test statistics have very poor size properties in small samples.

Coulibaly and Brorsen (1999) have shown that a Cox test associated with a parametric bootstrap approach gives a test statistic with correct size and high power, even in small samples. This test statistic is the likelihood ratio of the two models but the parametric bootstrap is used to estimate its distribution under the null. With the parametric bootstrap, Monte Carlo samples are generated using the parameters estimated under the null hypothesis. Samples are generated with the same number of observations as the original data. The hypothesis test is performed by computing a p-value, which is the percentage of simulated likelihood ratio statistics that are less than the likelihood ratio computed from the actual data. This p-value is calculated using the actual and the generated data and in the following way (Coulibaly and Brorsen, 1999):

$$p-value = \frac{\left(numb\left[L_o(\hat{\theta}_{oj}, y_j) - L_1(\hat{\theta}_{1j}, y_j) \le L_{o1} \right] + 1 \right)}{N+1} \qquad (5)$$

where numb[ ] stands for the number of elements of the set for which the specified relationship is true, N is the number of realizations, L_{o1} is the actual value of the likelihood function under the null and alternative hypotheses, $L_0(.)$ and L_1 (.) are the values of the log-likelihood function with the generated data respectively under the null and the alternative hypotheses. The one is added to the numerator and denominator as a small sample correction. A small p-value indicates rejection of the null hypothesis in favor of the alternative hypothesis.

Selecting between the AIDS and the Rotterdam Models for U. S. Meat Demand

The Selected Models

Previous studies by AC and LaFrance used orthodox tests to select between the AIDS and the Rotterdam models for U. S. meat demand. For the Rotterdam, AC present two alternative models with seasonal dummy variables. One uses the Divisia volume index as real income, and the other uses deflated expenditures (with the Stone index). They show that these two specifications give nearly the same parameter estimates. For the AIDS model, AC use four alternative specifications of the first-difference model (this model can also be in non-difference form) with seasonal dummy variables. Parameter estimates for these four specifications are the same. For the purpose of this study, we only select one specification of each model. We use model VI for the AIDS and model II for the Rotterdam from AC's paper. These two models are also considered in LaFrance's paper.[31] The first-difference linearized version of the AIDS model with quarterly seasonal dummy and real expenditure variables (using the Stone index) presented as AC's model VI is:

$$\Delta s_i = \tau_i + \sum_j \theta_{ij} D_j + \sum_j \gamma_{ij} \Delta \ln p_j + \beta_i [\Delta \ln x - \Delta \ln P] \qquad (6)$$

In this model s denotes budget share (with the bar above it, it denotes average budget share between two time periods), j = i =1,...,n goods, D is a quarterly seasonal dummy variable, p is price , x is the total expenditure on the n goods, $\tau, \theta, \gamma, \beta$ are parameters

[31] LaFrance's paper is a comment on AC's paper. These two papers use the same data and the same AIDS and Rotterdam models.

for intercept, quarterly dummy, prices, and real expenditures, respectively, Δ is a first-difference operator, and P is the Stone index.

The Rotterdam model II with real expenditure variable computed with the average budget share between two time periods in the index has the following specification in AC's paper

$$\bar{s}_i.\Delta \ln y_i = \tau_i + \sum_{j=1}^{4} \theta_{ij} D_j + \sum_{j=1}^{4} \gamma_{ij} \Delta \ln p_j + \beta_i \left[\Delta \ln x - \sum_{j=1}^{4} \bar{s}_j . \Delta \ln p_j \right] \qquad (7)$$

where y denotes quantity, all the other elements are defined as above. The term in brackets is the real expenditure term where s with the bar sign above it is the average budget share.

Orthodox Tests and Selection between the AIDS and Rotterdam

The two major studies by AC and LaFrance are based on orthodox tests, with a difference in estimation methods and in the representation of the compound model equation. While AC adopt a least squares approach that does not account for endogeneity, LaFrance uses full information maximum likelihood to address the bias and inconsistency associated with AC's least squares test, given that (as he argues) dependent variables are also found as explanatory variables in AC's approach. In relation to the two models in equations (6) and (7), AC present a compound model equation that can be used to directly test the linearized version of the FDAIDS in equation (6) or to test the Rotterdam model in equation (7). AC's compound model adjusted to equations (6) and (7) is the following:

$$\begin{aligned}(1-\lambda)\bar{s}_i.\Delta \ln y_i + \lambda s_i &= \tau_i + \sum_{j=1}^{4} \theta_{ij} D_j + \sum_{j=1}^{4} \gamma_{ij} \Delta \ln p_j \\ &+ \beta_i \{ \Delta \ln x - [(1-\lambda) P_1 + \lambda P_0] \} + \mu_i\end{aligned} \qquad (8)$$

where $P_1 = \sum_{j=1}^{4} \bar{s}_j \Delta \ln p_j$ is the index of the Rotterdam model, and $P_0 = \Delta \ln P$ is the index in the FDAIDS, where P is the Stone index, the last term is an error term. All the other elements are defined as previously. In this compound model, testing $\lambda = 1$ is equivalent to testing that FDAIDS model is the true model. Testing $\lambda = 0$ corresponds to testing that the Rotterdam model is the true model.

LaFrance conducted a similar orthodox test based on likelihood ratio for selecting between the AIDS and the Rotterdam, using a compound model like the one presented in equation (3) but allowing for convex combination of the two competing models. Using LaFrance's compound model with convex combination to conduct a likelihood ratio test for selecting between the two models in equations (6) and (7) is a better approach than performing the same likelihood ratio test with AC's adjusted compound model in equation (8). This is because the compound model with convex combination presented by LaFrance not only accounts for different explanatory variables in the two models[32] but also introduces additional parameters, (besides the parameter lambda) that take into account the alternative model's expenditures in each equation. This compound model fits the case where the indices in the two models are different, like in equations (6) and (7). LaFrance's compound model with convex combination is presented below for the purpose of relating the variables to the FDAIDS and the Rotterdam models with U. S. meat demand.

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[32] LaFrance's compound model accounts for different explanatory variables in the two competing models because the mathematical representation of the two models in equation (3) shows that a linear combination of corresponding parameters from the two models for each equation is possible.

First, let's consider LaFrance's compound model without convex combination[33]. For the same set of data for which a model (FDAIDS or Rotterdam) must be chosen, the null and alternative hypotheses are stated as follows:

$$H_0 \ : \ f_i(y_i) = \tau_i + \sum_{j=1}^{4} \theta_{ij} D_j + \sum_{j=1}^{4} \gamma_{ij} \Delta \ln p_j + \beta_{i0}.(\Delta \ln x - P_0) + \mu_{0,i} \quad \text{FDAIDS} \quad (6')$$

$$H_1 \ : \ g_i(y_i) = \tau_i + \sum_{j=1}^{4} \theta_{ij} D_j + \sum_{j=1}^{4} \gamma_{ij} \Delta \ln p_j + \beta_{i1}.(\Delta \ln x - P_1) + \mu_{1,i} \quad \text{Rotterdam} \quad (7')$$

where i = 1,…,n (i.e. n equations) and $f_i(y_i)$ is the left-hand side variable of the FDAIDS as a function of quantity y_i, $g_i(y_i)$ is the left-hand side variable of the Rotterdam model as a function of quantity y_i, $\beta_{i0,}$ and β_{i1} are real expenditure parameters under the null and alternative hypotheses, and $\mu_{0,i}$ and $\mu_{1,i}$ are error terms under the null and alternative hypotheses. All other variables are defined as previously.

When the first difference LA-AIDS model in equation (6) is the null hypothesis, $f_{it}(y_{it}) = s_{i,t} - s_{i,t-1}$, while $g_{it}(y_{it}) = \frac{1}{2}(s_{i,t} + s_{i,t-1})[\log(y_{i,t}) - \log(y_{i,t-1})]$ forms the Rotterdam alternative, where t =1,…,T observations, $y_{i,t}$ is the quantity consumed of the ith good in the tth period, $s_{i,t} = p_{i,t} y_{i,t} / x_t$ is the share of the ith good in the consumer budget for the group of meat commodities under consideration, and $x_t = \sum_i p_{i,t} y_{i,t}$ is total expenditure on the meat group in period t. Either of the two models can be in the null hypothesis. When one model is H_0, the other is H_1.

To test H_0 against H_1, LaFrance's compound model with convex combination is constructed in the following way:

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[33] The superscipt t (number of observations) is not considered.

$$\lambda.f_i(y_i)+(1-\lambda).g_i(y_i)=\tau_i+\sum_{j=1}^{4}\theta_{ij}D_j+\sum_{j=1}^{4}\gamma_{ij}\Delta\ln p_j+\lambda\beta_{i0}.(\Delta\ln x-P_0)$$
$$+(1-\lambda)\beta_{i1}.(\Delta\ln x-P_1)+\lambda\mu_{0i}+(1-\lambda)\mu_{1i} \qquad (8')$$

where all the elements are defined as previously.

When the convex combination approach is considered with the above compound model in (8'), two real expenditure parameters (one for the null and one for the alternative) are added in each equation. Therefore, LaFrance's implicit compound model for equations (6') and (7') is presented in the following way:

$$u_{i,t}=(1-\lambda).\frac{1}{2}\left[\left(\frac{p_{i,t}}{x_t}\right)y_{i,t}+s_{i,t-1}\right].\log\left(\frac{y_{i,t}}{y_{i,t-1}}\right)+\lambda.\left[\left(\frac{p_{i,t}}{x_t}\right)y_{i,t}-s_{i,t-1}\right]$$
$$-\tau_i-\sum_{j=1}^{3}\theta_{i,j}\left(D_{j,t}-D_{4,t}\right)-\sum_{j=1}^{3}\gamma_{i,j}.\log\left(\frac{p_{j,t}\cdot p_{4,t-1}}{p_{j,t-1}\cdot p_{4,t}}\right)$$
$$-\beta_{i0}.(1-\lambda)\{ \qquad (9)$$
$$\log\left(\frac{x_t}{x_{t-1}}\right)-\frac{1}{2}\sum_{j=1}^{3}\left[\left(\frac{p_{j,t}}{x_t}\right)y_{j,t}+s_{j,t-1}\right].\log\left(\frac{p_{j,t}\cdot p_{4,t-1}}{p_{j,t-1}\cdot p_{4,t}}\right)-\frac{1}{2}\left(1+s_{4,t-1}\right).\log\left(\frac{p_{4,t}}{p_{4,t-1}}\right)\}$$
$$-\beta_{i,1}.\lambda\left\{\log\left(\frac{x_t}{x_{t-1}}\right)-\sum_{j=1}^{3}\left(\frac{p_{j,t}}{x_t}\right)y_{j,t}.\log\left(\frac{p_{j,t}}{p_{4,t}}\right)+\sum_{j=1}^{3}s_{j,t-1}.\log\left(\frac{p_{j,t-1}}{p_{4,t-1}}\right)-\log\left(\frac{p_{4,t}}{p_{4,t-1}}\right)\right\}$$

for i = 1,2,3 meat commodities and t = 1,…,T observations where μ_i is assumed to be i.i.d. N (0, Σ) and $\gamma_{i,j}=\gamma_{j,i}\ \nabla\ i\neq j$ for symmetry (homogeneity and adding-up are embedded in the equation above). All other elements are defined in previous sections. Equation (9) is an error term equation (in general form) of the compound Rotterdam and FDAIDS models in equations (6) and (7) with adding-up and homogeneity. Adding-up implies reducing the Slutsky matrix by one row (i.e. one equation), and homogeneity implies reducing it by one column (i.e. one price column). Symmetry can only be imposed if equation (9) is written in its explicit form. The parameters in this equation can be determined by maximum likelihood estimation. From AC's perspective, a test of one model against the other can be conducted, based on the value of the parameter λ. In LaFrance's view, "a likelihood ratio test should be used to discriminate between the two competing models, rather than simply examining the t-ratio for the estimated lambda". Using a t-test or a likelihood ratio test on a compound model to select between the two models does not eliminate the fact that the test performed is an orthodox test. Orthodox tests have correct size when the number of non-overlapping variables is greater than one but low power. Such a drawback can be resolved by using a Cox test with parametric bootstrap to choose between the two models.

Cox Test and Parametric Bootstrap with AIDS and Rotterdam

Using the Cox nonnested test with the parametric bootstrap for selecting between the AIDS and the Rotterdam models requires the following steps: 1) estimate the two models under consideration using the actual data set, 2) based on the likelihood values of the two estimated models, compute the actual likelihood ratio of the two models, 3) generate random deviates from the estimated multivariate normal distribution to create a large number of data sets with the same number of observations as the original data , 4) re-estimate the two models, 5) compute the simulated log-likelihood ratio with each simulated data set, and 6) compute the p-value presented in equation (5). The calculation of the p-value is done first by letting one of the two models (say the FDAIDS) represent the null hypothesis, and second under the assumption that the other model (say the Rotterdam) represents the null hypothesis.

Using parametric bootstrap in the context of nonlinear model is clearly a new addition to the literature. However, the task of generating the data for the FDAIDS and the Rotterdam turns out to be not an easy one.

Parametric Bootstrap and Difficulties in Data Generation

The data that must be generated in the context of the FDAIDS and Rotterdam models are quantity data. However, as seen above, quantity is not explicit in the left-hand side of both the AIDS and the Rotterdam when the two models are estimated.

The approach used requires predicted quantity. However, it is difficult to simulate data from the Rotterdam model. " Since the Rotterdam involves nonlinear transformation of quantity on the left-hand side, predicted or expected quantities are not immediately derived by taking the inverse functional transformation of the model- predicted left-hand side (Kastens and Brester p. 303, 1996)." Kastens and Brester proposed a method for obtaining the expected quantities from the Rotterdam model, using a second-order Taylor series expansion of the predicted left-hand side variable around some needed predicted quantity, say y_o. Their starting point is the predicted equation of the Rotterdam model, which can be written as follows with an error term.

$$\frac{1}{2}(s + s_{t-1})(\ln y - \ln y_{t-1}) = X_t^{'} \hat{\beta}_1 + \varepsilon \qquad (10)$$

where the variables s and y without subscript are current budget shares and current quantities and right-hand side is the predicted left-hand side (predLHS). By means of calculus manipulations equation (10) can be expressed as one where all the terms with y are in the left-hand side (LHS). Then, a second-order Taylor series expansion around some quantity (say y_0) is used on this LHS expression. To do so, the quantity y_0 is substituted for y in the LHS result. Then, the first and second derivatives of the LHS with respect to y_0 are computed and substituted in the following formula of the second-order Taylor series expansion:

$$\frac{f(y_0)}{0!} + \frac{f'(y_0)}{1!}(y - y_0) + \frac{f''(y_0)}{}(y - y_0)^2 \tag{11}$$

where f is the LHS function. The next step is to take the expectations of both the LHS and the right-hand side (RHS) of the extended equation (10) where all the terms with y were put in the LHS, to move terms and to solve for the expected value of y. Doing some calculus manipulations on the expression that multiplies the variance term, grouping terms, setting E(y) = y_0, and transferring y_0 in the RHS yield the result of the following equation proposed by Kastens and Brester:

$$\frac{xs_{t-1} - py_o}{2py_o^2(1 + \ln y_o - \ln y_{t-1})} E\left[(y - y_o)^2\right] + \frac{xs_{t-1}(1 - \ln y_o + \ln y_{t-1}) + py_o + 2x(\Pr edLHS)}{p(1 + \ln y_o - \ln y_{t-1}) + \frac{xs_{t-1}}{y_o}} - y_0 = 0 \tag{12}$$

where the equation-specific *i* subscript and the *t* subscript are dropped except when there is a lag variable, *x* denotes expenditures, *s* is budget share, *p* is prices and *y* is quantity, PredLHS is predicted left-hand side. The expected value of the squared difference between y and y_0 is the variance of the predicted quantity.

Kastens and Brester argue that y_0 (which they called quantity prediction out of sample time t) can be obtained by solving the above equation (12). Attempts to use equation (12) to find the expected quantity y_0 of the Rotterdam model under the Newton method did not always lead to positive value for y_0. One way to overcome this problem is to go on by eliminating all parentheses through further calculus operations after taking the expectation of the extended equation (10), instead of solving for E(y) like Kastens and Brester did. Basically, the resulting equation should not differ from the Brester and Kastens' one in (12), but it is presented as a cubic equation. The Newton and secant methods seem to work better when equation (12) is expressed in the following equivalent cubic form[34]:

$$f(y_0) = 2xs_{t-1}\ln y_0 y_0^2 + 2p(\ln y_0 - \ln y_{t-1})y_0^3 + (py_0 - xs_{t-1})E(y - y_0)^2 - 4x(\Pr edLHS) \tag{13}$$

For the FDAIDS, Kastens and Brester propose the following predicted equation:

$$\frac{Py}{x} - s_{t-1} = X_t^{'}\hat{\beta}_0 + \varepsilon \tag{14}$$

where the variables have the same definition as before. Solving for y and taking the expected value of y yield the following results representing what they called the quantity prediction at out-of-sample time t, which is used to simulate the FDAIDS model:

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[34] It may be that using equation (9) tends to lead the search of the Newton and secant algorithms in the wrong direction

$$y_o = \frac{[\Pr edLHS + y_{t-1}]}{P} x \qquad (15)$$

In the current study, equations (13) and (15) are used to simulate quantity for the Rotterdam and the FDAIDS models, respectively.

AIDS and Rotterdam Likelihood Functions and Likelihood Ratio

To use the Cox statistics the likelihood functions of both the AIDS and the Rotterdam models must be converted to the same units. The dependent variables in the FDAIDS model are budget share differences or budget shares, depending on whether the model is presented in difference form or not. In the Rotterdam model the dependent variables are log–quantity-differences multiplied by average expenditure shares. The log-likelihood functions are written as a function of quantity in both demand systems. So, a Jacobian term is required.

The log-likelihood functions of the AIDS and Rotterdam models are derived from an understanding of LaFrance's log-likelihood function of the compound model for AIDS and Rotterdam. If we consider the AIDS model in its implicit form as $f_{j,t}(y_{j,t})$, the t^{th} error term of the i^{th} equation is:

$$\varepsilon_{it} = \sum_{j=1}^{i} r_{j,i}[f_{j,t}(y_{j,t}) - X_t^{'}\beta_j] \qquad (16)$$

for all i, j = 1,…n and all t = 1,…,T. The term in brackets represents the error of the whole system, and the $r_{j,i}$ term comes from a Cholesky decomposition[35] of the variance-covariance matrix of the system. The Jacobian for the change of variables from ε_t to the quantity y_t is:

$$\left|\frac{\partial \varepsilon_t}{\partial y_t'}\right| = \prod_{i=1}^{N}\left[r_{ii} \frac{\partial f_{i,t}(y_{i,t})}{\partial y_{i,t}} \right] \qquad (17)$$

Therefore, the log-likelihood function for the AIDS model is:

$$\begin{aligned} L = -\frac{NT}{2}\log(2\pi) + \sum_{t=1}^{T}\sum_{i=1}^{N}\left(\log(r_{i,i}) + \log\frac{\partial f_{i,t}(y_{i,t})}{\partial y_{i,t}} \right) \\ -\frac{1}{2}\sum_{t=1}^{T}\sum_{i=1}^{N}\left(\sum_{j=1}^{i} r_{j,i}\left(f_{j,t}(y_{j,t}) - X_t'\beta_j\right)\right)^2 \end{aligned} \qquad (18)$$

where the second term is the Jacobian, $f_{i,t}(y_{i,t})$ or $f_{j,t}(y_{j,t})$ represent the LHS dependent variable in the AIDS model as a function of quantity *y*.

By the same token, the log-likelihood function for the Rotterdam model can be written as:

$$\begin{aligned} L = -\frac{NT}{2}\log(2\pi) + \sum_{t=1}^{T}\sum_{i=1}^{N}\left(\log(r_{i,i}) + \log\frac{\partial g_{i,t}(y_{i,t})}{\partial y_{i,t}} \right) \\ -\frac{1}{2}\sum_{t=1}^{T}\sum_{i=1}^{N}\left(\sum_{j=1}^{i} r_{j,i}\left(g_{j,t}(y_{j,t}) - X_t'\beta_j\right)\right)^2 \end{aligned} \qquad (19)$$

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[35] We assume that $u_t = \left[u_{1,t} \ldots u_{N,t}\right]'$ is i.i.d. N(0, Σ) and $\Sigma^{-1} = RR'$ where R is upper triangular and u_t is the matrix of the error component of the whole system. In particular, $\varepsilon_t = R'u_t$ is i.i.d. N(0, I).

where $g_{i,t}(y_{i,t})$ or $g_{j,t}(y_{j,t})$ represents the LHS dependent variable in the Rotterdam model as a function of the quantity y. The likelihood ratio of the AIDS versus the Rotterdam model is the difference between the log- likelihood function value of the AIDS model (in equation 18) and the log-likelihood function value of the Rotterdam model (in equation 19).

Meat Demand Data

AC and LaFrance used data on U. S. demand and prices of beef, pork, chicken, and fish to select between the AIDS and the Rotterdam. The data used in their studies are quarterly per capita consumption and retail prices of beef, chicken, pork, and fish in the United States, for the years 1967-1988.

We use the same data used by AC and LaFrance, and a different set of updated quarterly data on beef, pork and chicken. Since the latter data do not include fish (because of the poor quality of the U. S. fish data), for comparison purposes, we also run both the orthodox and the Cox tests with parametric bootstrap on AC and LaFance's data set without fish. Such an approach allows identifying the effect on the model choice results of difference in method, difference in data, and difference in both data and method, as recommended by Tomek. Conducting the orthodox test or the parametric bootstrap requires parameters estimation.

Estimation Methods

The two available sets of data are used to estimate the two models. The Model Procedure (PROC MODEL) in SAS with the option full information maximum likelihood (FIML) is used to conduct the orthodox test on the two sets of data. The Interactive Matrix Language Procedure (PROC IML) in SAS with the Seemingly Unrelated Regression (SUR) estimation method is used to implement the Cox test with parametric bootstrap. The estimation methods SUR and FIML incorporate the homogeneity, symmetry, and adding-up restrictions. The advantage of the FIML on the SUR method is that it addresses the issue of group expenditure endogeneity (LaFrance). However, it has some computational difficulties in terms of programming it in PROC IML for the Cox test with parametric bootstrap approach.

Results

Different results are obtained when the orthodox test based on the likelihood ratio test and convex combination is performed on different data sets. Table 3.1 shows that this test fails to reject either model under both null hypotheses with the 1967-1988 data including fish. In contrast, both models are rejected with the 1970-1997 data without fish. However, the FDAIDS is favored with the 1967-1988 data without fish under the two null hypotheses. Consequently, the orthodox test gives inconsistent results that vary depending on the data used.

The Cox test with parametric bootstrap selects the Rotterdam model in all cases (Table 3.2). For instance, under the two null hypotheses the estimated p-values (0.000999 when testing that the FDAIDS is the true model, and 0.853147 when testing that the Rotterdam is the true model) gives evidence in favor of the Rotterdam model with the 1967-1988 data set. That is to say that, under the two null hypotheses and with the 1967-1988 data set including fish, the simulated log-likelihood ratios between the two competing models in one thousand (1000) realizations from a simulation process are less than or equal to the actual log-likelihood ratio (see equation 5) 0.1 percent of the time when the FDAIDS is the null hypothesis, and 85 percent of the time when the Rotterdam model is the null hypothesis. Similar interpretation can be made for the other two columns of the table. In all the cases, a small p-value indicates a rejection of the null and a large p-value indicates a failure to reject the null.

This study gives additional evidence of the high power of the Cox test, as compared to an orthodox test. However, an orthodox test with convex combination, as the one recommended by LaFrance for U. S. meat demand, is likely to genereate unreliable test results, given that it introduces nuisance parameters under the null hypotheses. Indeed, under each null hypothesis corresponding to an appropriate restriction on the parameter lambda (i.e. lamda = 0, or 1), the real expenditures parameters of the alternative model become nuisance parameters that cannot be estimated when the compound model is based on a convex combination. In the presence of nuisance parameters, the distribution of the likelihood ratio test statistics is unknown. It is no longer chi-square under the null.

Table 3.1 Model Choice with LaFrance's Orthodox Test (Likelihood Ratio Test with Convex Combination) Using Full Information Maximum Likelihood (FIML) as Estimation Method

	Using LaFrance's 1967-88 Data		Using Updated Data
	including Fish	without Fish	without Fish (1970-97)
Likelihood Values:			
FDAIDS:	113.203	-10.5193	-77.5151
Rotterdam:	115.7532	-24.5448	-73.8432
Joint :	116.203	-7.9027	-65.4324
Likelihood Ratios:			
$H_0 : FDAIDS$	6.00	5.23	24.27**
$H_0 : Rotterdam$	0.90	33.28 **	16.82**
Conclusion	**Fail to Reject Both**	**Reject Rotterdam**	**Reject Both**

** means significant at 0.05.

Note: the likelihood ratio test statistics (say TS) is computed with the following formula : TS = 2 (ln unrestricted – ln restricted). It is distributed as a chi-square with 4 degrees of freedom (= 9.49 with alpha=0.05) for the first set of data, and with 3 degrees of freedom (= 7.81 with alpha = 0.05) for the second and third sets of data. The reason is that, they are four additional parameters (lambda and three real expenditure parameters) in the unrestricted convex combination of the two competing models with four equations in the first data set (one equation is dropped out in the estimation process). Similarly, they are three additional parameters (lambda and two real expenditure parameters) in the unrestricted convex combination of the two competing models with three equations in the second and third sets of data (one equation is dropped out in the estimation process).

Table 3.2 Cox Test with Parametric Bootstrap Using Seemingly Unrelated Regression (SUR) as Estimation Method.

	Using LaFrance's 1967-88 Data		Using Updated Data
	including Fish	without Fish	without Fish (1970-97)
p-values			
$H_0 : FDAIDS$	0.000999**	0.000999**	0.000999**
$H_0 : Rotterdam$	0.853147	0.850150	0.959041
Conclusion	**Reject FDAIDS**	**Reject FDAIDS**	**Reject FDAIDS**

** means significant at 0.05

Conclusion

This study develops a Cox nonnested test with parametric bootstrap approach and uses it to select between the FDAIDS and the Rotterdam models for U. S. meat demand. Results of an orthodox test are included for comparison. Orthodox tests are known to have low power. A Cox test with parametric bootstrap can overcome the low power of an orthodox test in choosing between consumption models. This study confirms LaFrance's results that neither of the two models (FDAIDS and Rotterdam) can be rejected with the orthodox test, using his data. Furthermore, it shows that, with the same estimation procedure (FIML) and under the null hypothesis of the FDAIDS, results from an orthodox test for selecting between the FDAIDS and the Rotterdam for U. S. meat demand vary depending on the data set. Therefore, the orthodox test is not robust. Unlike the orthodox test, the Cox test with parametric bootstrap yields results that do not vary with differences in data sets. This gives additional evidence to the low power of an orthodox test technique, as compared to a Cox test with parametric bootstrap. The two approaches are used with different estimation procedures (FIML in the orthodox test and SUR in the Cox test with parametric bootstrap). Relative power of the two approaches is independent of the estimation method used. Therefore, the Cox test with parametric bootstrap is expected to remain more powerful than an orthodox test under FIML estimation procedure.

There is a disadvantage in using a convex combination in the orthodox test to select between the two competing FDAIDS and Rotterdam models. Under the null hypothesis, the convex combination introduces nuisance parameters corresponding to the real expenditure parameters of the alternative model. In the presence of nuisance parameters, the distribution of the likelihood ratio test statistics is no longer chi-square under the null. It is unknown and can be estimated using Monte Carlo studies.

The Cox test with parametric bootstrap approach developed in this study does not suffer from any lack of generality. It can easily be used to test any functional form, like for instance, a double-log demand model, the Almost Ideal Demand System in levels, the Rotterdam and the AIDS with different expenditure deflators.

Limitations of the Study and Suggestion for further Research

Due to difficulties in programming the FIML estimation procedure in Proc IML in SAS, this study does not use a uniform estimation procedure for both the orthodox test and the Cox test with parametric bootstrap. LaFrance's concern of group expenditure endogeneity has not been addressed in the Cox test with parametric bootstrap. Further research is needed to take into account the endogeneity concern in the Cox test with parametric bootstrap.

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Appendix: IRB Form

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	January 12, 2000	IRB #:	AG-00-052
Proposal Title:	"EXPERIMENTAL LEARNING IN INTRODUCTION TO AGRICULTURAL ECONOMICS"		
Principal Investigator(s):	Dan Tilley Alix Dameus Jeanine Flores-Bastides		
Reviewed and Processed as:	Exempt		

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson, Director of University Research Compliance

January 12, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

Alix Dameus

Candidate for the Degree of

Doctor of Philosophy

Thesis: INDUCTIVE / DEDUCTIVE TEACHING METHODS, CARIBBEAN IMPORT DEMAND FOR STARCHY FOOD, AND SELECTION BETWEEN AIDS AND ROTTERDAM DEMAND MODELS

Major Field: Agricultural Economics

Biographical:

Education: Graduated from Lycée Anténor Firmin High School, Port-au-Prince, Haiti in June 1975; received a Bachelor of Science degree in Agronomy from l' Université d' Etat d' Haiti, Faculté d' Agronomie et de Médecine Vétérinaire (FAMV), Port-au-Prince, Haiti in June 1980; completed four-year course work (option no degree) in law, at Faculté de Droit et des Sciences Economiques, Port-au-Prince, Haiti in June 1980; completed four year-course work (option no degree) in Business Management, at Institut National d' Administration, de Gestion, et des Hautes Etudes Internationales, Port-au-Prince, Haiti in June 1985. Completed the requirements for the Master of Science degree with a major in Agricultural Economics at Iowa State University in May 1988. Completed the requirements for the degree of Doctor of Philosophy with a major in Agricultural Economics at Oklahoma State University in December 2000.

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