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Dr. Larry R. Dale

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ECONOMICS EDUCATION ARTICLES

DOES COLLECTING AND GRADING HOMEWORK ASSIGNMENTS IMPACT STUDENT ACHIEVEMENT IN AN INTRODUCTORY ECONOMICS COURSE?

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ABSTRACT

This study asks whether instructor-developed homework assignments need to be collected and graded in order to have an impact on student achievement as measured by exam scores. Earlier studies relying on t-tests concluded with few exceptions that grading homework does not significantly impact exam scores. A more recent study using regression analysis contradicts these results. This paper relies on regression analysis, but concludes that grading assignments does not increase student achievement. Comparing the two regression based studies points to the possibility that inexperienced college students benefit from graded assignments while experienced students do just as well with generalized feedback.

INTRODUCTION

Surveys of academic economists in the United States conducted in 1995 and 2000 by Becker and Watts (2001) find that "instructor-developed problem sets are popular in all courses". While these problem sets are an important component of teaching strategies employed in economics courses, only little systematic study has been devoted to how these homework assignments have to be administered in order to be effective, a notable exception being the paper by Grove and Wasserman (2006a).

Casual observation suggests that students frequently do not complete voluntary homework assignments. Collecting and grading homework assignments is one method to motivate students to spend more time on task, identified as one of the seven principles for good practice in undergraduate teaching by Chickering and Gamson (1987). The general consensus is that the more time students spend on learning, the greater the amount of learning (Sorcinelli, 1991).

Grading homework assignments also is one way to incorporate a second principle of good teaching, namely giving prompt feedback. This reasoning suggests that collecting and grading homework assignments can be expected to positively impact student learning. However, giving frequent feedback on different types of assessments is very costly in terms of instructor time, especially in larger introductory courses. In particular, the question arises whether homework assignments need to be collected and graded in order to generate increased student learning, or whether it is sufficient to make problem sets and solutions available to students. Does the feedback need to be student specific or is it sufficient to provide generalized feedback accessible to all students? Grading homework assignments is a sure way to increase an instructor's time on task and may positively influence student evaluations of a course (Dudley & Shawver, 1991), but does it succeed in increasing student achievement?

Using the theoretical model of student behavior developed by Becker (1982), one can ask whether collecting and grading homework assignments will succeed in changing the amount of time students allocate to studying economics. A change in instructional technology, here the way in which homework assignments are structured, may not increase the amount of learning if students simply allocate a fixed amount of time to different productive activities so that homework completion simply substitutes for time spent in other activities such as reading the textbook or working through lecture notes. Also, students could simply change the timing of work on a homework assignment. Instead of working on a graded assignment before a due date, students may just access the non-graded homework assignment with solutions before an exam, producing the same effect in terms of exam scores. It is thus conceivable that the practice of collecting and grading homework assignments will not produce a significant gain in student achievement as measured by exam scores. This reasoning is somewhat different from Grove and Wasserman (2006a) who contend that there are two sets of students who would not be affected by a grade incentive for homework assignments: those who would have completed the problem sets without any incentives and those for whom the expected payoff remains too low relative to the value of their time. In either case, the fact remains that grade incentives may not produce any impact on student achievement, but are very costly in terms of instructor time. Thus, it is important to find the optimal mix of feedback and use of instructor time in those classes.

This study seeks to determine whether instructor-developed homework assignments need to be collected and graded in order to have an impact on student achievement as measured by exam scores. By comparing two student groups, a

control group and a treatment group, this study asks whether collecting and grading homework assignments generates a statistically significant impact on exam performance. The hypothesis is that grading homework assignments will increase exam scores. Results of the present study are interpreted in light of previous research on the impact of required versus voluntary homework assignments. The major conclusion is that more inexperienced college students seem to benefit from graded assignments while more experienced students do just as well with generalized feedback.

PREVIOUS STUDY RESULTS

While a large number of studies concerning the impact of homework on student achievement have been conducted for elementary and secondary education levels, fewer studies of post-secondary student achievement exist. A quantitative synthesis of homework research for elementary and secondary students by Paschal, Weinstein and Walberg (1984) concluded that there is a "moderately large average effect of assigned homework that is commented upon or graded" on achievement measures. Cooper's (1989) meta-study on the use of homework in elementary and secondary schools refines this point. A frequently cited result found by Cooper (1989) is that the correlation between time spent on homework and achievement measures is dependent on students' grade level. While the correlation between time spent on homework and achievement measures shows a negative correlation for elementary school students, the correlation is small but positive for middle school students, and more strongly positive for high-school students. Based on this evidence one may draw the conclusion that homework should increase achievement measures for college students also, since they are more similar to high-school students in age, but here the evidence is very mixed. Foyle (1988) concludes that at the college level other methods aimed at increasing student achievement work as well as traditional homework that is focused on practice.

With few exceptions, the studies directly comparing graded (compulsory) versus non-graded (voluntary) homework tend to conclude that grading homework does not significantly impact achievement measures. For the public school setting, Cooper (1989) states that only one study has compared these effects and has reported non-significant differences. On the college level, Stephen (1977), Milligan and Reid (1971), Wiebe (1982), Vruwinkle and Otto (1987), and Peters, Kethley and Bullington (2002) all find that grading homework does not increase achievement measures compared to a control group that does not have to turn in

assignments for grading. Only Weems (1998) finds that college algebra students perform better with collected and graded homework. All these studies share a common methodology. They all perform t-tests to compare control and treatment groups. The study by Grove and Wasserman (2006a) is the only other study that finds improved student performance on exams in response to a grade incentive for homework assignments. Their study differs from previous work in the empirical methodology used. Grove and Wasserman (2006a) use an educational production function approach to control for student characteristics such as academic aptitude and demographic characteristics, and to establish whether students in the experimental group, where assignments count towards the course grade, outperform students in the control group on exams. They find that the grade incentive to complete assignments throughout the semester boosts "the exam performance of freshman and did so by at least one-third of a letter grade in Economics 101 compared with control-group students who received identical assignments but no direct grade incentive to complete them" (Grove & Wasserman, 2006a).

The present study uses a methodology and experimental set-up that is very similar to the one employed by Grove and Wasserman (2006a), but confirms the results of earlier studies, showing no significant effect of graded assignments on exam scores. The paper will highlight differences with Grove and Wasserman's results (2006a). This should be helpful for instructors in making the decision when to require graded homework assignments which count towards a final course grade, and when voluntary homework assignments are sufficient.

EXPERIMENT AND DATA

This study compares student performance in four sections of a Principles of Macroeconomics class at Weber State University, a regional university in the Utah state system. Data was collected for four sections taught during the fall of 2003 and during the spring of 2004 with an enrollment of about 40 students in each section. Thus, there was no difference in class size that could have had an impact on student performance (Caviglia-Harris, 2004; 2005). A total of 162 students completed the course in all sections. Two sections of the course, meeting back to back at the same days during the morning, were taught by the same instructor using identical instructional materials and assessments during each semester. The common course requirements consisted of four exams throughout the semester, an attendance grade carrying 5% of the overall course grade, and a writing project. Students in all sections had access to an on-line course page on which the instructor posted

assignments. There were five assignments, the same number of assignments for the semester as in the Grove and Wasserman (2006a) and Miller and Westmoreland (1998) studies. In one section students were told (in the syllabus and orally) that they were required to turn in the homework assignments at a specified due date and that the homework would be graded and carried a 15% weight in computing the final course grade. In a parallel section of the course, students were told that the assignments were available and that they should work on them before the due date, after which the solution sheet would be available, but the assignments would not carry any weight in computing the final course grade. The instructor made it clear to both sections that the assignments should be considered good preparation for the exams because each of the four exams conducted over the course of the semester contained a number of essay-type problems, along with multiple-choice problems, that would draw upon the homework assignment. This point was underscored by making practice exams available on the course page. Both assignments and exams were graded by the instructor one problem at a time to ensure maximum consistency with respect to the grading practice.

The ideal experimental set-up to compare instructional techniques would have relied on randomizing test subjects within each section taught so as to control for section-level and instructor effects. Due to the difficulty of setting up such an experiment, this study did not use such a set-up, thus presenting the possibility of selection bias (Pozo & Stull, 2006). To best avoid this bias, students in each section were not made aware of the fact that they were part of an experiment. Later in the semester, students commented on the fact that the other section did not have to turn in assignments, making it clear that the different instructional techniques had not caused them to choose one section over another. Also, students did not switch sections after the syllabus was handed out and the different course requirements were revealed. The most common consideration in terms of signing up for sections of one class tended to be the instructor and scheduling issues, since virtually all students work at least part-time off-campus and take courses in a block during a few days during the week. Based on this evidence it is reasonable to assume that selection bias is not a huge concern.

As pointed out by Miller and Westmoreland (1998), if homework assignments are poorly conceived, then the completion of homework assignments might not improve test performance. A cursory way of testing whether the homework assignments in this study can be reasonably expected to correlate with exam performance is to use Cooper's (1989) classification of types of homework assignments. Cooper (1989) distinguishes between different purposes of homework,

namely practice, preparation, extension and integration. Assignments that focus on practice and integration of course material previously covered through lectures, class discussions and readings, should be better suited to serve as preparation for exams that focus on core course material. Assignments with the goal of preparing students for new material and showing extensions of core material may help in improving class participation and lead to a deeper understanding of newly covered material, but may be less directly related to test performance. For the present study, the instructor roughly classified each assignment problem according to its major purpose and then compared the assignment problems to the essay questions students had to complete on each exam. The majority of assignment problems fell into the practice category and about half of all the essay questions on the exams were directly related to a question found on a previously assigned homework. This suggests that it is reasonable to expect a positive impact of thorough homework completion on test performance for the present study. On the other hand, students may have used the solution sheets as a study guide and could have gained the same information necessary to improve exam performance.

Within the graded group, 75% of all students handed in all five assignments, 95% handed in at least four assignments, and 5% handed in less than four assignments. This compares favorably with the rate of homework completion in Grove and Wasserman (2006a). As would be expected, the section that was required to turn in assignments generated more in-class questions and discussion concerning the homework. In order to control for this difference, the instructor made sure that similar discussions took place in both sections.

The students enrolled in the principles of macroeconomics course typically have a junior standing and are business or accounting majors, completing part of the required business core courses. All students enrolled in the course have completed the principles of microeconomics course and college algebra. Student data on class performance and absences were collected and recorded by the instructor. Data on students' GPA and the course grade for the prerequisite principles of microeconomics course were compiled from university records so as to avoid student reporting errors (Emerson & Taylor, 2004). More than 70% of the students are male.

Table 1: Student Characteristics			
Variable	Mean values for Control Group (non-graded) N = 86	Mean values for Experimental Group (graded) N = 76	t-statistic
Gender (1 for males)	.756	.68	1.06
Cumulative # of credit hours completed before taking macro	75.1	72.9	.56
GPA	3.26	3.22	.56
Previous semester GPA	3.34	3.193	1.62
Principles of Microeconomics grade (prerequisite)	3.07	2.92	1.16
Mean Exam Score	77.7	76.8	.54
Absences	4.47	3.77	.99
Majors (1 for majors within the school of business)	.756	.813	-.89
Age	23.95	23.19	1.30

For all the characteristics described in Table 1 no statistically significant difference in the means of the control and experimental groups exists.

Instruction in the class was mostly in the form of lectures, supplemented with some in-class group exercises that were similar to homework assignments. About two-thirds of all assignment problems were of the practice type, based on the lectures and in-class exercises. Exams contained multiple-choice, as well as essay-type questions that required some problem solving and graphing.

METHODOLOGY AND RESULTS

The method used to estimate the effect of grading assignments on student achievement follows the commonly-used practice of formulating a reduced form educational production function (Emerson & Taylor 2004). Such a function defines student achievement, the output, as a function of various inputs, here academic

ability, student characteristics, number of absences, and membership in an experimental group.

> *Student achievement = f (a c a d e m i c   a b i l i t y ,   s t u d e n t characteristics, number of   absences, membership in the experimental group).*

The dependent variable student achievement is measured as the mean exam performance of all four exams taken over the course of a semester. This variable can take on values between 0 and 100. The minimum value observed in the sample is 50.5 and the maximum value observed for one student is 98.5. The next highest score of 96.5 is achieved by two students. The dependent variable does not exhibit characteristics of a censored sample with observations clustered at an upper threshold. This warrants use of the simple ordinary least squares method in favor of more complicated estimation methods such as a tobit regression.

The dependent variable that is the focus for this study is membership in the experimental group. Students in the experimental control group, enrolled in the course sections that do not collect and grade assignments, are assigned the dummy variable 0. Students in the experimental treatment group, enrolled in the course sections where graded homework assignments are part of the course requirements, are assigned the dummy variable 1. The hypothesis is that membership in the treatment group will have a statistically significant, positive impact on the exam performance of these students.

The other dependent variables control for student ability, student characteristics and student motivation. For regression (1) academic ability is measured by the collegiate GPA prior to taking the principles of macroeconomics course. For regression (2) academic ability is measured by the grade received in the principles of microeconomics course, a pre-requisite completed by all students prior to enrolling for macroeconomics. Both measures of academic ability cannot be used in the same regression because the two variables are highly correlated and the microeconomics grade is an input for the overall GPA. While the use of GPA as a measure of academic ability is common in the literature (Caviglia-Harris, 2004; Emerson & Taylor, 2004), Grove and Wasserman (2006b) use a standardized measure of semester GPA to account for variability in grading practices. To address this issue, the present paper also uses the microeconomics grade as a measure of academic ability. This grade is less likely to suffer from large variability in grading

practices compared to general education courses and courses taken in other colleges and departments.

The only student characteristics controlled for are gender, major and total credit hours completed before enrolling in the course. There is virtually no heterogeneity with respect to ethnicity, fraternities/sororities are virtually non-existent on campus, and SAT scores are generally not available since Weber State has an open enrollment policy. These variables, included in the Grove and Wasserman (2006a) paper, are thus omitted in the present study. Since attendance was part of the final course grade, the instructor kept records of attendance, and the number of absences enters the educational production function as an explanation for student motivation.

Estimation results are presented in Table 2, with t statistics in parentheses.

Table 2: Estimation Results		
Variable	(1)	(2)
Constant	27.41**(4.63)	53.27** (13.56)
GPA	14.86** (10.34)	n/a
Microeconomics Grade	n/a	8.39** (10.44)
Graded Group	-0.47 (-0.37)	0.04 (0.03)
Absences	-0.07 (-0.07)	-0.15 (-0.98)
Male	1.00 (.07)	-1.05 (-0.74)
Total Cumulative Credit Hours	-0.01 (-0.27)	-0.02 (-0.71)
Business School Major	2.62* (1.67)	1.93 (1.24)
Adjusted R-square	43.1	43.6
* significant at the 10% level, ** significant at the 1% level		

For both regressions, the only variable significant at the 1% level is the measure of student ability, GPA and the grade received for the pre-requisite microeconomics course. In regression (1), a one point increase in GPA increases the mean exam score by almost 15%, the difference between a C+ and an A. The only other variable with a significant impact on student performance (at the 10% level) in regression (1) is a student's major. Being a business major increases the mean exam score by about 2.6%. In both regressions exam performance is not affected

in a statistically significant way by whether students were a member of the graded group or the non-graded group. Thus, the practice of collecting and grading assignments cannot be shown to positively impact student achievement in this study. The hypothesis that grading homework assignments has a positive impact on exam performance has to be rejected.

CONCLUSION

The present study uses a methodology and experimental set-up that is very similar to the one employed by Grove and Wasserman (2006a), but confirms the results of earlier studies that relied on t-tests. Grading homework assignments does not produce any significant effect on exam scores. For the particular classroom setting studied, it can be concluded that the generalized feedback provided on homework assignments was just as good as the individualized feedback on completed assignments in terms of generating increased performance on exams. Compared to the Grove and Wasserman (2006a) study, multiple reasons such as the use of non-standardized GPA, homework design and the nature of the experiment may have contributed to the difference in results. While those differences cannot be explored due to the lack of comparable data, one factor, namely student experience, is measurably different in the two studies. The average age of students in the present study is more than 23 years and the average number of credit hours completed is 74, meaning that the majority of students had at junior standing at the time of the study. The Grove and Wasserman (2006a) experiment included freshman and sophomores only. This difference points to the possibility that something akin to the grade-level effects found in the studies of elementary and secondary education levels exists on the college level. More inexperienced college students are found to benefit from graded homework assignments or more individualized feedback, while more experienced students are able to gather the necessary information from generalized feedback. An instructor deciding how to allocate time should thus choose to grade homework assignments for freshmen and sophomores, but may choose to give generalized feedback to more experienced students without adverse effects on exam performance. This conclusion points to further research based on a larger, multi-section study that includes students from freshmen to seniors, ideally at different institutions. Such a study should carefully consider homework design, a topic not yet explored in the context of teaching economics.

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TESTING THE DIFFERENTIAL EFFECT OF A MATHEMATICAL BACKGROUND ON STATISTICS COURSE PERFORMANCE: AN APPLICATION OF THE CHOW-TEST

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ABSTRACT

This paper focuses on understanding the differential effect of students' mathematical background (prerequisite) knowledge on Statistics course. Introductory Statistics is one of the required courses for business and economics majors. Students can choose one of several mathematics based prerequisite courses to gain necessary background knowledge for the Statistics course. Among several possible prerequisite courses, we considered only two different calculus courses as background knowledge for Statistics course to compare; namely Applied Calculus and Calculus-I. Students' success on subsequent course is greatly affected by the prerequisite courses taken by students. Mathematical topics vary widely among these courses providing different breadth of background knowledge to prepare students for the Statistics course. Therefore, the objective of this research is to observe the significance and magnitude of differential effect of two different calculus courses on the Statistics course performance.

Chow test is being applied through regression models provided consistent conclusions about the significance and differential effect of mathematical background knowledge on the performance of Statistics course. Specifically, we have found that students who took the Calculus-I received higher grades on average in Statistics course than did students who took Applied Calculus. Thus, students with added traditional calculus orientation do have greater statistical proficiency. Furthermore, the analysis also reveals that students' are situated in an advantageous position when taking Calculus-I than with Applied Calculus.

INTRODUCTION

Identifying appropriate prerequisite course is a key ingredient in designing the optimum curriculum program. An academic advisor's primary challenge is to match students' background knowledge with the courses they are taking. Identifying the most suitable course among the several available alternative prerequisite courses to meet students' need is a source of continuous debate among the academicians. This paper addresses the issue of students with different mathematical background perform differently in Statistics course. Higgins (1999) recognized that statistical reasoning should be considered an important component of any undergraduate program. Further discussion on statistical reasoning can be found in Garfield (2002) and DelMas et. al.(1999). Several different factors may affect students' performance (Dale & Crawford, 2000) in a course, including students' background knowledge. Therefore, understanding (Choudhury, Hubata & St. Louis, 1999) and acquiring the proper background knowledge is the primary driver of success (Bagamery, Lasik & Nixon, 2005; Sale, Cheek & Hatfield, 1999).

Students' performance (Trine & Schellenger, 1999) in a course is primarily affected by the prerequisite courses taken that fabricate their background knowledge. Because of their diverse level of preparedness and accumulated background knowledge that builds their long-term human capital, differential effect that is attributable to different perquisite courses can be evaluated through students' performance on subsequent courses. Literatures in this area of research offer little guidance, as to which prerequisite is more appropriate. Performance measures of prerequisite courses have been studied in various disciplines (Buschena & Watts, 1999; Butler, et. al., 1994; Cadena et. al., 2003). A remarkable discussion on the effect of prerequisite courses has been found in Potolsky, et. al.(2003).

For this study, data were collected from a Mid-Western university. Statistics is a required course for all business and economics majors at this university. Statistics course stresses application of statistical concepts to decision problems facing business organizations. All sections of this course taught at the college of business use a common text book and cover the same basic topics. The course includes descriptive statistics, probability concepts, sampling processes, statistical inference, regression, and nonparametric procedures. Among the several available prerequisite courses we analyze the differential effect of Applied Calculus and Calculus-I on the Statistics course performance. Since, this will be fascinating to observe if there is any differential effect due to different arrangement of calculus course. If so, what is the propensity of the differential effect?

We hypothesize that students' performance in Statistics course as measured by the final course grade varies due to the diverse preparedness by different prerequisite courses. The question that we ask is that whether Applied Calculus or Calculus-I are availing themselves to the same background knowledge and prepare students equally for the Statistics course. Specifically, this research addresses the question; does the different mathematical background knowledge attained by students from Applied Calculus or Calculus-I create a differential effect on their performance in the Statistics course? Applied Calculus covers non-linear functions, intuitive differential, integral and multivariate calculus applications. Calculus-I covers Polynomial, exponential, logarithmic, and trigonometric functions; Differentiation with associated applications; Introduction to integration with applications.

Business and Economics students in general try to avoid (or delay) taking Statistics course. The fear of statistics may be a result of lack of acquaintance in mathematical thinking (Kellogg, 1939). Therefore, a proper prerequisite course that can build confidence against mathematical anxiety and develop mathematical thinking could help alleviate these problems. Although both prerequisite courses considered in this study are calculus, we perceive that students obtain a higher level of "mathematical maturity and thought process" from the traditional calculus than applied calculus. The reason may be traditional calculus takes students' into the journey of deeper level of quantitative reasoning compared to the applied calculus.

Authors in this study analyze the differential effect of background knowledge accumulated from two different prerequisite courses on students' performance in Statistics course. Results from the Chow-test provided strong justification for differential effect on Statistics course performance due to different mathematical background and the null hypothesis of equality of two different regression models could be rejected. This result enabled consideration to be given to traditional Calculus as a prerequisite for Statistics when advising students to accumulate background knowledge that develops quantitative reasoning skill. They found that students who took the traditional Calculus obtain higher average grades in Statistics than did students who took applied Calculus. Furthermore, their analysis reveals that students with Calculus-I background starts at an advantageous position with higher intercept value (see, Table 2B and Table 2C) compared to those with Applied Calculus. This finding implies that traditional calculus may be more effective in building quantitative concepts and reasoning.

DATA AND METHODOLOGY

Data were collected from the records of all students enrolled in the Statistics course for three consecutive semesters. Students were grouped by the prerequisite courses completed prior to enrolling in Statistics course. There were no recruitment (or selection) attempts to draw students into either of these courses. As there is no indication presented to the student about the prerequisite course, nor there is any control for which students enrolled in which course. For these reasons, it will be assumed that the students are of comparable mathematical abilities when taking a prerequisite course.

Performance comparisons are made between these two prerequisite courses (Applied Calculus and Calculus-I) on the basis of Statistics course grade. Course grades are classified in the usual manner: A, B, C, D, and F. For the purpose of comparing the average grades of the course in question, the grades assumed the standard quantitative values. An A was weighted at 4 points, a B at 3 points, a C at 2 points, a D at 1 point, and an F at 0. Students were grouped into two different groups— 1) Calculus-I and 2) Applied Calculus.

The objective of this paper is to observe the differential performance in Statistics (ST) course as a result of generating background knowledge from Applied Calculus (AC) or Calculus-I (CL). We perform Chow-test to analyze the differential effect due to different prerequisite courses. The **Chow test** (see Chow, 1960; Gujarati, 1970) is a statistical test to test the equality of regression coefficients in two different linear regression models for two different data sets. In program evaluation, the Chow-test is often used to determine whether the independent variables have different impacts due to different subgroups of the population. In our study, we examine the differential effect of two different prerequisite courses taken by two different groups of students.

The specification of the regression model for our analysis purpose can be of the following form:

$$STG_i \;=\; \alpha + \; \beta\, MATG_i + \; \varepsilon_i \qquad i=1,.....n \quad (1)$$

$$STG_{AC,i} = \alpha_{AC} + \beta_{AC}\, ACG_{AC,i} + \varepsilon_{AC,i} \qquad i=1,....n_{AC} \quad (2)$$

$$STG_{CL,i} \;= \alpha_{CL} + \beta_{CL}\, CLG_{CL,i} + \varepsilon_{CL,i} \qquad i=1,....n_{CL} \quad (3)$$

where, equation (2) and equation (3) are representing Applied Calculus and Calculus-I respectively and equation (1) is for both groups combined. STG denotes Statistics grade, ACG for Applied Calculus grade, CLG for Calculus-I grade, and MATG for combined mathematics (both calculus) grade.

Therefore, the null hypothesis of Chow-test asserts that both intercepts and slopes are equal, i.e., H_0 : $\alpha_{AC} = \alpha_{CL}$ and $\beta_{AC} = \beta_{CL}$. Thus, the structure of the Chow-test takes the form:

$$\frac{\left[\dfrac{\{S_{MAT} - (S_{AC} + S_{CL})\}}{k}\right]}{\left[\dfrac{(S_{AC} + S_{CL})}{(N_{AC} + N_{CL} - 2k)}\right]}$$

where, S_{MAT} be the sum of squared residuals from the combined data, S_{AC} be the sum of squares from the Applied Calculus group, and S_{CL} be the sum of squares from the Calculus-I group. N_{AC} and N_{CL} are the number of observations in each group and k is the total number of parameters (in this case, 2). This test statistic is then follows the F distribution with k and $N_{AC} + N_{CL} - 2k$ degrees of freedom.

EMPIRICAL RESULTS

We present Statistics course grade distributions in Graph 1 for both background (prerequisite) courses. The letter grade distributions in Graph 1 reveal that higher percentage of students who took Calculus-I received a better grade (A or B) in Statistics course than those who took Applied Calculus. As for example, who took Calculus-I, 74.00% received an 'A' or "B" in Statistics course. In contrast, only 64% of those who took Applied Calculus received an 'A' or "B" in the Statistics course. This difference reverses when we compare them for lower grades, such as C or D (see Graph 1). About 33% of Applied Calculus students received either a 'C' or 'D' in the Statistics course while only 23% of the Calculus-I students received these low grades.

Graph 1: Grade Distributions of Statistics Course by Background Knowledge.

Grades: F, D, C, B, A respectively.
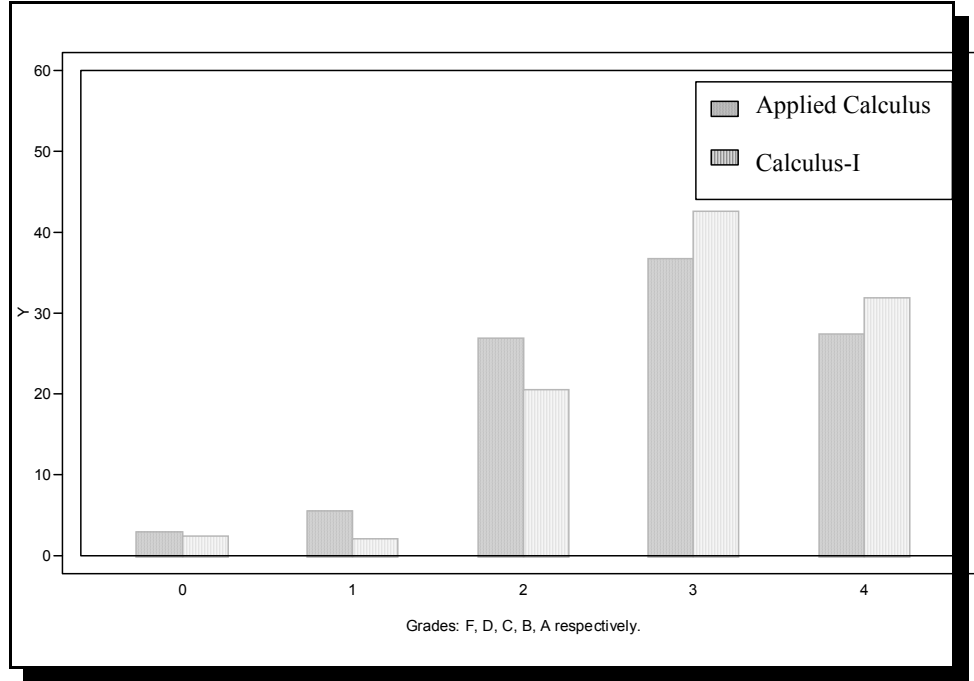
1st bar: Statistics performance attributable to applied calculus.
2nd bar: Statistics performance attributable to calculus-I.

In Table 1, we present summary statistics for all course grades. Although, students acquired higher grade on average in Applied Calculus than Calculus-I course (2.63 vs. 2.46). We observe that there is a difference in average grade points in Statistics course between students with Applied Calculus and those with Calculus-I prerequisite. Specifically, in general students perform better in Statistics course with Calculus-I background than Applied Calculus. For example, those who took Calculus-I as a prerequisite received an average grade of 3.0 in Statistics course compared to 2.8 for those who had Applied Calculus. These results suggest that Calculus-I leads to accumulate quality human capital in terms preparedness for Statistics course and results in substantially better performance. This provided the basis to perform hypothesis test on the differential effect on Statistics course performance as a result of different calculus background. Since, the outcome of

prerequisite selection has a substantial payoff, it is important for us to test the hypothesis and identify the prerequisite that has higher incremental impact on Statistics course performance.

Grade	Applied Calculus Grade	Calculus-I Grade	Both Calculus Combined Grade	Statistics Grade Applied Calculus]*	Statistics Grade [Calculus-I]*	Statistics Grade [Both Combined]*
Average	2.63	2.46	2.59	2.80	3.00	2.85
Median	3.00	2.00	3.00	3.00	3.00	3.00
Std	1.00	1.07	1.02	1.00	0.92	0.99
N	659	221	880	682	237	919

TABLE 1: Summary Statistics by Courses

Note: Maximum grade is 4 and minimum grade is 0, on a four-point scale.
* Statistics course grades with respective prerequisites; applied calculus, calculus-I and both combined.

To test the differential effect (if any) due to two different calculus backgrounds we perform the Chow-test as below. First, we run a regression for the combined (both Calculus-I and Applied Calculus) calculus background and the estimated model is:

Regression model (with both Calculus):

$$STG_i = 1.93421^* + 0.35832^* MATG_i \qquad (4)$$

* Statistically significant at better than 1% level (see Table-2A)
where, S_{MAT} = sum of squared residuals (combined) = 731.315.

Combined estimated regression model above is highly statistically significant with a positive intercept and slope. This implies if their performance is better in Calculus then the performance in Statistics course will also be superior and the rate of increase is about 1/3 of a grade point (i.e., 0.35832).

TABLE-2A: Regression Results of Statistics Course Performance Attributable to Combined (both Calculus) Background					
Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	117.77136	117.77136	141.39	<.0001
Error	878	731.31500	0.83293		
Corrected Total	879	849.08636			
R-Square	0.1387		Adj R-Sq	0.1377	
Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.93421	0.08382	23.08	<.0001
MATH	1	0.35832	0.03013	11.89	<.0001

Consequently, we run both regression models separately to observe the difference in the intercept and slope due to different courses as background knowledge. If no difference exists, then we can postulate that there is no differential effect due to different calculus courses on the Statistics course performance. Estimated models are provided below:

Regression model (with Applied Calculus):

$$STG_{AC,i} \ = \ 1.74244^* + \ 0.40781^* ACG_{AC,i} \qquad (5)$$

* Statistically significant at better than 1% level (see Table-2B)
Where, S_{AC} = sum of squared residuals (applied calculus) = 549.376.

Regression model (with Calculus-I):

$$STG_{CL,i} \ = 2.37216^* + 0.25506 * CLG_{CL,i} \qquad (6)$$

* Statistically significant at better than 1% level (see Table-2C)
Where, S_{CL} = sum of squared residuals (Calculus-I) = 167.676.

TABLE-2B: Regression Results of Statistics Course Performance Attributable to Applied Calculus Background					
Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	110.03802	110.03802	131.59	<.0001
Error	657	549.37624	0.83619		
Corrected Total	658	659.41426			
R-Square	0.1669		Adj R-Sq	0.1656	
Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.74244	0.10004	17.42	<.0001
MATH	1	0.40781	0.03555	11.47	<.0001

Results of these regression models have been reported in Table-2B and Table-2C. Although, both models are highly statistically significant with positive intercepts and slopes. As expected, intercept is higher with Calculus-I compared to Applied Calculus (2.37 vs. 1.74). This result is consistent with the summary statistics reported in Table 1. This implies that students with Calculus-I background starts at an advantageous position which is more than half a point (.63) higher as oppose to students with Applied Calculus background. To establish this differential effect statistically, we calculate the following test statistic to perform the Chow-test.

$$F = \frac{\left[\dfrac{\{S_{MAT} - (S_{AC} + S_{CL})\}}{k}\right]}{\left[\dfrac{(S_{AC} + S_{CL})}{(N_{AC} + N_{CL} - 2k)}\right]} = \frac{\left[\dfrac{\{731.315 - (549.376 + 167.676)\}}{2}\right]}{\left[\dfrac{(549.376 + 167.676)}{(659 + 221 - 4)}\right]} = 8.712$$

Thus, the observed test statistic F=8.712 exceeds the critical test statistic F=4.61at 1% significance level with 2 and 876 degrees of freedom. Therefore, the null hypothesis of equality of intercepts and slopes is rejected. This implies that the two regression models are different, suggesting that there is a differential effect attributable to different calculus backgrounds. These tests results lead us to conclude

that students with added traditional calculus orientation do possess greater statistical proficiency. Perhaps, it is that enhanced mathematical maturity developed from the traditional calculus leading to a better understanding of statistical reasoning that resulted in elevated advantageous position for these students.

TABLE-2C: Regression Results of Statistics Course Performance Attributable to Calculus-I Background					
Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	16.32373	16.32373	21.32	<.0001
Error	219	167.67627	0.76565		
Corrected Total	220	184.00000			
R-Square	0.0887		Adj R-Sq	0.0846	
Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2.37216	0.14817	16.01	<.0001
MATH	1	0.25506	0.05524	4.62	<.0001

CONCLUSION

Findings of this study suggest that prerequisite is an important component in predicting academic performance in Statistics course. Specifically, we have found that students who took the Calculus-I received higher average grades in Statistics than students who took Applied Calculus. Our analysis illustrates the importance of selecting a proper and more relevant prerequisite course for business and economics majors. This selection process of prerequisite course matters in two ways. First, the proper prerequisite course provides students with required and relevant quantitative background knowledge needed to succeed in the Statistics course(s), and consequently be beneficial for other quantitative oriented business and economics courses. Second, the prerequisite course needs to have necessary components and topics included (including the course arrangement), so that, students have better

opportunity to improve their mathematical maturity needed for quantitative reasoning courses.

Therefore to improve students' performance in Statistics course, Calculus-I may be more appropriate prerequisite than Applied Calculus. Thus, it appears from our analysis that students with traditional calculus orientation may have greater statistical proficiency than with applied calculus. In addition, our analysis also reveals that students with Calculus-I background starts at an advantageous position as oppose to students with Applied Calculus background.

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ONE-SEMESTER PRINCIPLES
AND STUDENT PERFORMANCE
IN INTERMEDIATE THEORY COURSES

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ABSTRACT

 The Economics Department at California State University Northridge had the unique experience of replacing its two-semester principles course with a one-semester principles course. This was done on a large scale as the principles course, along with intermediate micro and macroeconomics, was required of all business and economics majors. The timing of course offerings made it impossible for students to select the one-semester principles course over the two-semester course. This environment allows us to investigate whether completion of a one-semester, rather than the standard two-semester, introductory course lowers student performance in intermediate micro or macroeconomic theory courses. Regression analysis indicates that students who complete the one-semester course earn slightly lower grades in both intermediate micro and macroeconomics. While we anticipated the direction of the results, the size is surprisingly small.

INTRODUCTION

 In 2001, the University mandated that all undergraduate degree programs cut their course requirements, within the major, to 45 units or less. All CSUN undergraduate degrees have a total of 120 units –48 units of general education, 45 units from the major, and 27 units of open electives. The Business College faced some tough decisions as its common core contained 54 units. College faculty argued that other CSU business schools rarely required any economics courses in their upper-division core. Both intermediate economic theory courses were subsequently removed from the core. At the same time, university administrators

were concerned about transfer problems and articulation agreements arising from the one-semester principles course. For example, it was difficult for a CSUN student to transfer to a University of California campus which would not accept one-semester as a substitute for two-semesters of principles. The Economics Department was thereby forced to remove the one-semester course and reinstate the two introductory (micro and macro) courses.

Most economics faculty welcomed this change as they believed the one-semester principles course did not allow enough time to cover many important topics and concepts. Faculty typically resorted to a one-semester course that was two-thirds micro and one-third macro. Naturally, there were concerns about how well the one-semester principles course prepared students for work in the subsequent micro and macro theory courses.

In this study, we investigate whether a one-semester principles course lowers student performance in economic theory courses by examining 2,555 students who completed intermediate micro or macro theory between spring 1996 and fall 1998. This timeframe allows us to focus on the period when the principles course changed (i.e., fall 1996) and when intermediate micro and macro were still required of all business students.

LITERATURE REVIEW

To date, only one study has examined the effectiveness of a one-semester principles course. Klos and Trenton (1969) compared comprehensive test scores of 170 students who completed a one-semester course against 223 students who completed the standard two-semester course. Their analysis of variance indicated no significant differences in mean test scores across the two groups.

Unfortunately, our department did not develop common tests for students enrolled in principles, so grades in intermediate theory courses are used as a proxy for student learning/preparedness. However, this study provides additional insights into the potential costs and benefits associated with condensing the two-semester principles course into a one-semester course.

This study also adds to the existing literature which analyzes the effects of quantitative prerequisites on course performance. Analysis of student performance in introductory economics dominates the literature. For example, Anderson, Benjamin, and Fuss (1994) found that a high school calculus course was significant in predicting performance in basic economics. Cohn et al. (1998) also found math skills were important but questioned math as a prerequisite, arguing that evidence

from other courses or SAT performance could suffice. Alternatively, Brasfield, McCoy, and Milkman (1992) concluded that math should be a prerequisite for introductory economics.

Some studies also examine how previous mathematical training impacts student performance in intermediate courses. For example, Von Allmen (1996) found that performance in intermediate microeconomics was significantly improved by higher grades in college calculus. Alternatively, Moore (1978) reported that prior hours completed in mathematics had no impact on student performance in intermediate micro. Ely and Hittle (1990) found that performance in managerial economics was improved by mathematical background and positive attitudes towards math.

Most of the remaining studies investigate how course or individual characteristics impact student success. For example, Durden and Ellis (1995) considered the importance of class attendance and found that excessive absenteeism is strongly associated with poor performance in introductory economics. Raimondo, Esposito, and Gershenberg (1990) examined the influence of class size and found that students who took a large lecture introductory macroeconomics course earned lower grades in intermediate macroeconomics. Horvath, Beaudin, and Wright (1992) investigated gender differences in course persistence and found that female students were less likely to persist in the introductory economics course sequence. Robb and Robb (1999) also explored gender differences and found that gender of the instructor did not impact performance in introductory microeconomics nor the likelihood that students would continue in economics.

ANALYSIS SAMPLES

This project analyzed course outcomes for students enrolled in intermediate microeconomic or macroeconomic theory between spring 1996 and fall 1998. Both theory courses are 3-unit semester courses that were required of all business and economics majors. Approximately 4,117 students enrolled into intermediate micro and 3,397 students enrolled into intermediate macro over this time period. However, approximately 60 percent of these students are excluded from our "micro" and "macro" analysis samples because they did not complete their introductory economics courses at CSUN. Another six percent are excluded because they withdrew from the intermediate theory course or had missing values for some of the explanatory variables. Thus, there are 1,428 students in the micro analysis sample and 1,127 students in the macro analysis sample.

Table 1 provides descriptive statistics for the analysis samples. Roughly 36 (50) percent of students in the micro (macro) sample completed the one-semester principles course between fall 1996 and summer 1998. The remaining 64 (50) percent completed the micro (macro) portion of the standard two-semester principles course between spring 1994 and summer 1996. It is important to emphasize that the one-semester principles course entirely replaced the two-semester course in fall 1996 for all business and economics students. This should ease any concerns about selection bias as a business student who disliked economics could not choose the one-semester principles course to avoid taking two-semesters of principles.

Table 1: Variable Definitions and Descriptive Statistics			
Variable	Definition	Sample 1: Micro	Sample 2: Macro
ECON 310	Grade in intermediate microeconomics	1.94 (1.1)	-----
ECON 311	Grade in intermediate macroeconomics	-----	1.90 (1.1)
Age	Age when enrolled in ECON 310 (311)	23.8 (4.0)	23.7 (4.1)
Female	Student is a female	45.3%	47.4%
EOP	Participant in Equal Opportunity Program	15.3%	14.4%
GPA	College GPA prior to ECON 310 (311)	2.54 (0.5)	2.51 (0.6)
Total Units	Credit hours prior to ECON 310 (311)	103.0 (26.5)	100.0 (25.7)
Econmaj	Student is an economics major	4.3%	4.1%
ECON 200	Satisfied a combined principles course	36.3%	49.8%
	Sample size	1,428	1,127
Note: standard deviation is in parentheses next to the mean. Otherwise, the statistics are percentages.			

METHODOLOGY

An ordered probit model is estimated separately for the micro and macro samples to determine whether students who complete one-semester of principles obtain lower grades in intermediate theory than students who complete two-semesters of principles.

The specification for the model is as follows:

$$ECON310* = \beta'x + \varepsilon,$$
$$\varepsilon \sim N[0,1]$$

where ECON310* is the unobserved continuous grade scale that underlies the students' course grades in intermediate microeconomics and **x** is the vector of explanatory variables. The same model is estimated separately for the intermediate macroeconomics course (i.e., ECON 311). The letter grades are coded so that F = 0, D = 1, C = 2, B = 3, and A = 4. These observed grades are related to the unobserved grading scale in the following manner:

$$ECON310 = 0 \quad \text{if } ECON310* \leq 0,$$
$$ECON310 = 1 \quad \text{if } 0 < ECON310* \leq \mu_1,$$
$$ECON310 = 2 \quad \text{if } \mu_1 < ECON310* \leq \mu_2,$$
$$ECON310 = 3 \quad \text{if } \mu_2 < ECON310* \leq \mu_3,$$
$$ECON310 = 4 \quad \text{if } \mu_3 \leq ECON310*.$$

The μ's are threshold parameters that provide the ranking in the model and are estimated with the beta coefficients. The estimation results (μ and β) allow a calculation of the conditional probability that a student receives a particular letter grade given her characteristics (**x**).

We assume that student performance in an intermediate theory course is influenced by personal characteristics, past achievement in college courses, choice of major, and completion of the one-semester principles course. Information regarding the student's age, gender, and participation in the University's Equal Opportunity Program is included in the regression. College grade point average and total units completed comprise past achievement in college courses. We distinguished economics majors from business majors.

REGRESSION RESULTS

The regression results are reported in Table 2. The estimated coefficients of the explanatory variables in an ordered probit regression are not the marginal effects normally interpreted in a linear regression model. If we let P_j represent the

probability of receiving a j grade (e.g., j = 0 is an F) then calculation of the marginal effects is as follows:

$$\partial P_j / \partial x_i = [\, f(\mu_{j-1} - \beta' x_i) - f(\mu_j - \beta' x_i)\,] \times \beta$$

where f is the standard normal density. It is clear that the marginal effects will vary with the values of **x**. Table 2 contains the marginal effects calculated at the means of the regressors (**x**). It is worth noting that the marginal effects are multiples of the coefficient vector. Thus, the magnitudes of the marginal effects are likely to be very different from the beta coefficients. See Greene (1993: 672-676) for a discussion of this regression technique.

      The findings indicate that completion of the one-semester principles course (ECON 200) slightly lowers student performance in intermediate micro and macroeconomic theory courses. The coefficient of ECON 200 is small, negative, and statistically significant in both regressions. The marginal effects suggest that students who complete the one-semester principles course are 4.9 (3.9) percent less likely to earn a grade of A or B in intermediate micro (macro) than otherwise comparable students. The negative impact of ECON 200 is not surprising. Obviously, students who complete one-semester of principles are exposed to half as many hours of classroom instruction. However, the small impact of ECON 200, especially on intermediate macro grades, was unexpected.

Table 2: Ordered Probit Analysis of ECON 310 and 311 Grades				
Variable	Sample 1: Micro		Sample 2: Macro	
Dependent	ECON 310 Grade		ECON 311 Grade	
	Coefficient	Mrg. Effect[a]	Coefficient	Mrg. Effect[a]
Constant	-3.375 (0.253)		-3.703 (0.278)	
Age	0.009 (0.008)	0.003	0.017 (0.008)**	0.005
Female	-0.043 (0.059)	-0.013	-0.124 (0.066)*	-0.037
EOP	-0.302 (0.081)***	-0.085	-0.297 (0.093)***	-0.081
GPA	1.750 (0.061)***	0.536	1.800 (0.068)***	0.535
Total Units	0.003 (0.001)***	0.001	0.004 (0.001)***	0.001
Econmaj	0.337 (0.141)**	0.114	0.324 (0.164)**	0.107
ECON 200	-0.161 (0.062)***	-0.049	-0.130 (0.067)**	-0.039

Table 2: Ordered Probit Analysis of ECON 310 and 311 Grades				
Variable	Sample 1: Micro		Sample 2: Macro	
Dependent	ECON 310 Grade		ECON 311 Grade	
	Coefficient	Mrg. Effect[a]	Coefficient	Mrg. Effect[a]
Mu(1)	0.892 (0.037)		0.847 (0.041)	
Mu(2)	2.233 (0.042)		2.196 (0.048)	
Mu(3)	3.363 (0.062)		3.368 (0.071)	
Sample size	1,428		1,127	
Log Likelihood	-1,737.4		-1,352.1	
Restricted Ln	-2,148.7		-1,699.5	
Chi-squared	822.4		694.9	
Notes: [a] marginal effects of the regressors on the probability that ECON 310 (311) grade is an A or a B. Standard error is in parentheses next to the coefficient. *, **, and *** indicate basic significance in a two-tailed test at the 10, 5, and 1 percent significance level.				

There are a couple of factors that might explain why one-semester of principles has such a small impact on student performance in subsequent theory courses. First, faculty teaching one-semester principles are forced to reduce the number of models and concepts covered. Naturally, faculty would eliminate material of lesser importance (e.g., monopolistic competition and exchange rates). This may give students greater focus and thereby a deeper understanding of the most important principles. Second, as mentioned previously, two-thirds of our students are transfers and complete their introductory economics courses at local community colleges. It is important to reiterate that our analysis samples only contain students who completed all introductory economics courses (i.e., one-semester or two-semester principles) at CSUN. This is done to eliminate the potential bias (positive or negative) from transfer courses that may offer students a different level of preparation. Given the wide diversity in student preparation, faculty cannot rely on a common level of knowledge among students taking intermediate theory courses. Consequently, faculty may teach intermediate theory from first principles which would reduce the anticipated negative impact of the one-semester principles course.

As mentioned previously, most of our faculty delivered a one-semester principles course which was two-thirds micro and one-third macro. Thus, we

expected ECON 200 to have a greater negative impact on student performance in intermediate macro than on micro. We offer two possible explanations for this result. First, our coverage of macroeconomic theory is typically based on microeconomic foundations. Second, students are more interested in and thereby more motivated to study the concepts and topics covered in intermediate macro. Topics in macro (e.g., unemployment, interest rates, exchange rates, monetary policy, etc.) are more likely to be covered by media outlets making them seem more immediate and important. Students might also find the material to be less abstract and analytically demanding than intermediate micro. If so, this might mitigate the negative impact of having substantially less exposure to macroeconomics in the one-semester principles course.

The focus of this study is the impact of one-semester principles on student performance in intermediate theory courses. However, there are some other noteworthy results. First, older and more experienced college students are expected to obtain higher grades in both intermediate theory courses. Age had no influence on student success in intermediate micro and it has only a slight positive impact on student success in macro. The number of completed units has a very small positive influence on student success in intermediate micro and macro.

Gender is included in the regression because some studies have found that male gender is a significant predictor of student success in introductory economics (see, for example, Anderson, Benjamin, and Fuss 1994). Our results suggest that males and females earn similar grades in intermediate micro. However, females earn slightly lower grades in macro. On average, females are 3.7 percent less likely to earn an A or B in intermediate macro.

CSUN has a large minority enrollment. Many of these students are first-generation college students and frequently come from homes where English is seldom spoken. Our best measure to capture this population was participation in the University's Equal Opportunity Program (EOP). Approximately 15 percent of our analysis samples are participants in EOP which provides disadvantaged students with specialized access to advisement resources, financial aid, and mentoring programs. Our findings indicate that EOP participants earned somewhat lower grades in both theory courses. EOP participants were roughly 8 percent less likely to earn an A or a B in intermediate micro and macro.

Students with higher college grade point averages (GPA) earn better grades in intermediate micro and macro. The coefficient on GPA is large, positive, and statistically significant. Moreover, the marginal effects indicate that holding a higher GPA substantially increases the probability of receiving an A or B in both

theory courses. This finding is consistent with previous pedagogical research in economics (Von Allmen 1996 and Brasfield, Harrison, and McCoy 1993) and confirms that previous success is a good indicator of future success in college courses.

College GPA was our best measure of student ability. The regressions did not include Scholastic Aptitude Test (SAT) scores because 40 percent of the students in our two analysis samples were missing this information. The University does not require submission of SAT scores for students who place in the top 10 percent of their high school graduating class; or transfer from local community colleges. However, in separate regression results (not reported), the inclusion of SAT scores did not alter the findings in a substantive manner. In particular, the marginal effect of ECON 200 (i.e., completing one-semester of principles) on intermediate course grades was still small, negative, and statistically significant.

Adding one variable –combined SAT scores– to each regression specified in Table 2 suggests that students who completed one-semester of principles were 7.1 (4.0) percent less likely to earn an A or B in intermediate micro (macro). Thus, the inclusion of SAT scores slightly changes the marginal effect of ECON 200 on intermediate micro (from -4.9 to -7.1); while the marginal effect of ECON 200 on intermediate macro remains virtually unchanged (from -3.9 to -4.0). Note: there are only 910 (676) students with SAT scores in the micro (macro) sample.

Finally, we expected economics majors to obtain higher grades than business majors in both intermediate courses. Students who have chosen economics as a major should have a greater aptitude and interest in studying economic theory. Our results indicate that economics majors were 11.4 (10.7) percent more likely to earn an A or B in intermediate micro (macro) than otherwise comparable business majors.

CONCLUSION

Our Economics Department, which is housed within the Business College at CSUN, had the unique experience of replacing its two-semester principles course with a one-semester principles course. This was done on a large scale as the principles course, along with intermediate micro and macro, was required of all business and economics majors. The timing of course offerings made it impossible for students to select the one-semester principles course over the two-semester course. This environment allows us to examine whether one-semester of principles lowers student performance in intermediate micro and macroeconomic theory

courses. In practice, most faculty resorted to teaching a one-semester principles course which was two-thirds micro and one-third macro. Thus, we expected to find that one-semester of principles would lower grades in both intermediate theory courses, especially in macro.

Our regression results indicate that students who completed one-semester of principles earned slightly lower grades in both intermediate courses when compared with students who completed two semesters of principles. More specifically, completion of the one-semester principles course reduces the probability of earning an A or B in intermediate micro (macro) by roughly 5 (4) percent. We do not find it surprising that replacing two semesters of principles with one semester of principles lowers student performance in intermediate theory courses. What is surprising is the small impact of this change. Perhaps making the one-semester principles course a four-unit (rather than a three-unit) course would eliminate any loss in intermediate theory performance.

Our results suggest that the cost of combining the two principles courses is a small reduction in intermediate theory performance. However, students may benefit from the one-semester principles configuration because it allows them to take an additional course. Assuming a business program maintains the same number of hours to graduate, students could take an upper-division economics course in place of the second principles course. Arguably, the knowledge acquired from an additional three-unit, upper-division economics course would outweigh the slight reduction in knowledge of intermediate theory. If your program goal is a higher level of economic understanding, then an upper-division economics course uses a higher level of cognitive skills.

Alternatively, our findings suggest that a one-semester principles course is a reasonable option for a business or economics program that is seeking to reduce course requirements. However, there are two important caveats. First, if most local universities require two-semesters of principles, interested programs may encounter difficulties with student transfers and articulation agreements. Second, our institutional setting may have reduced the negative impact of the one-semester principles course. Two-thirds of our students are transfers and complete their introductory economics courses at local community colleges. Given the wide diversity in student preparation, faculty may teach intermediate theory from first principles. Thus, one-semester principles may be inappropriate for schools that conduct intermediate theory courses which are more reliant on an accomplished level of knowledge from introductory material.

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ECONOMICS ARTICLES

THE EFFECTS OF MOTOR VEHICLE WEALTH TAXES ON HOUSEHOLDS' VEHICLE PURCHASE DECISIONS

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ABSTRACT

Wealth taxes on motor vehicles, in the form of personal property or privilege taxes, are utilized in nearly half of the states in the U.S. The taxing methodologies implemented in these states result in effective tax rates that are a declining function of vehicle age. Under such tax structures, consumers would be expected to make adjustments in their consumption portfolios in favor of older vehicles since they receive preferential tax treatment. As a result, vehicle taxes may have unintended environmental consequences since they provide households with the incentive to keep or purchase older vehicles with higher emissions. This analysis examines the effects of these taxes on households' vehicle purchases using data from the 2001 National Household Travel Survey. The analysis identifies households that purchased a vehicle in 2001 and models their choice of vehicle age to determine whether the relatively favorable tax treatment encourages the purchase of older vehicles. The results indicate that wealth taxes have a statistically significant negative effect on the probability that a household purchases a vehicle in a given year but have virtually no effect on vehicle age at the time of the purchase.

INTRODUCTION

As of 2001, annual wealth taxes on motor vehicles were used in twenty-eight states in the United States in the form of either an ad valorem personal property tax, a tax in lieu of a property tax or an age-based fee. In recent years, politicians have proposed the reduction or removal of motor vehicle wealth taxes to take advantage of their unpopularity to win votes. Such proposals have been very popular among the electorate but have been difficult to implement since these taxes represent a stable source of revenues for state and local governments. Empirical evidence from Dill et al. (1999) also suggests that motor vehicle wealth taxes are

less regressive than sales and gasoline taxes frequently used by state and local governments.

Despite these positive qualities, these taxes may be inefficient as they may distort household decisions regarding their vehicle fleets, which in turn may have consequences for the environment. Specifically, a high tax on vehicle wealth might encourage a household to keep or purchase an older vehicle, thereby possibly increasing air pollution. The incentive effects provided by annual motor vehicle wealth taxes have received relatively little consideration.[1] The potential unintended consequences of these taxes on vehicle age distributions, emissions and air quality suggest the importance of investigating the effects of these taxes on household vehicle purchase and vehicle age decisions.

Motor vehicle wealth taxes tend to be based on either the age or value of the vehicle which results in a tax liability that decreases with age. Given this structure, consumers have an incentive to make adjustments to their vehicle stocks in favor of older vehicles as they receive preferential tax treatment. Specifically, motor vehicle wealth taxes are expected to affect household vehicle purchase decisions in two ways. First, households that reside in a state with a wealth tax on vehicles are expected to delay the purchase of a newer vehicle. A household can expect to have a higher motor vehicle wealth tax liability when it replaces an older less valuable vehicle with a newer more expensive vehicle or makes an addition to its vehicle stock. All else constant, the higher tax liability may discourage many households from purchasing a vehicle. Second, those households living in wealth tax states that do purchase a vehicle are expected to purchase older vehicles on average, all else constant. Given that a household has decided to purchase a vehicle, the structure of motor vehicle wealth taxes provides an incentive to purchase older vehicles as their absolute tax liabilities, and in some cases their tax liabilities as a percentage of their value, are lower than those of newer vehicles. Thus, the age distribution of vehicles in states with a wealth tax is expected to be skewed towards older vehicles as consumers have the incentive to delay the purchase of a newer vehicle or to enter the used vehicle market.

If motor vehicle wealth taxes have indeed delayed fleet turnover, they might have resulted in additional unintended consequences, namely a decrease in air quality resulting from an increase in emissions from motor vehicles. Older vehicles are likely to emit larger amounts of harmful pollutants due to their less sophisticated emission control systems and the deterioration of these systems over time. Simulations using the Environmental Protection Agency's most recent emissions model (MOBILE6) reveal that a 20 percent age shift to older vehicles yields a 50

percent increase in hydrocarbon and carbon monoxide emissions and a 40 percent increase in nitrogen oxide emissions (Environmental Protection Agency, 2002(b)).[2]

Therefore, to the extent that motor vehicle wealth taxes affect vehicle age distributions, changes to these taxes may be viable options for governments charged with the task of decreasing mobile source emissions. Specifically, states with areas that have air pollution levels that persistently exceed ambient air quality standards and have thus been classified as nonattainment areas by the Environmental Protection Agency might be able to make adjustments to their wealth tax policies to achieve attainment status. As of 2002, nearly 57 percent of states with an ozone nonattainment area and 75 percent of states with a carbon monoxide nonattainment area were wealth tax states (EPA, 2002(a)).

The objective of this analysis is to examine the effects of motor vehicle wealth taxes on households' vehicle purchase and age decisions that might affect emissions and air quality so that policy makers might make more informed decisions regarding the future use and structure of these taxes. The manuscript is divided into five sections. The first section offers a brief review of previous literature on household vehicle purchase decisions followed by a section on the theoretical framework used to model households decisions. The third section presents a discussion of the data and methods used. The fourth section discusses the results of empirical models designed to isolate the effects of motor vehicle wealth taxes on households' vehicle purchase and age decisions. The final section summarizes the main conclusions and suggests directions for future research.

PREVIOUS LITERATURE

This analysis is certainly not the first to propose a relationship between tax structures, vehicle age and emissions. Nor is it the first to suggest that annual ownership taxes based on vehicle age influence the rate of fleet turnover. However, it does represent the first study to examine the effects of motor vehicle wealth taxes on household vehicle purchase and age decisions in the United States as existing research focuses either on the tax structures and vehicle fleets in other countries or aggregate state-level data in the U.S.

Estimation results from Johnstone et al. (2001) suggest that adjustments to consumption taxes in Costa Rica that increase the relative price of used cars by 10 percent would decrease their share of total vehicle sales by 5.6 percent. Further simulations indicate that such a change would have the potential to yield significant environmental gains as nitrogen oxide emissions would decrease by 17 percent,

carbon monoxide emissions by 10 percent, and hydrocarbon emissions by 4 percent after five years.

In recent years, the government of Singapore has recognized that higher registration taxes on newer vehicles may discourage households from replacing their vehicles or encourage them to enter the used vehicle market and has placed an annual tax on vehicles that is in part based on age. Each vehicle registered faces an annual road tax, and a surcharge of 10 percent for each additional year is imposed on vehicles above the age of ten. Thus, the objective of the surcharge is to discourage households from registering older vehicles that pollute more. Chia and Phang (2001) analyze the use of this tax as well as other motor vehicle taxes as environmental management tools. Although their analysis concludes that this age-based registration tax offers a double dividend (i.e. tax revenues and emissions reductions), they also note that it is difficult to isolate the direct impacts of this tax on air quality since it is often used simultaneously with other policy instruments.

An extensive body of literature has developed over the past several decades on household vehicle purchase and consumption decisions including Manski and Sherman (1980), Mannering and Winston (1983), McCarthy (1985), Hensher and LePlastrier (1985) and Hayashi et al. (2001). Many of these studies include various financial characteristics such as vehicle purchase price, operating costs, transaction-search costs, service and repair costs and sales taxes in multivariate choice models of purchase decisions, ownership levels and vehicle type decisions. However, Hayashi et al. is the only analysis that includes a measure of annual ownership taxes in multivariate models of household vehicle purchase decisions. Their results from an analysis of vehicle registration data from Japan indicate that increases in annual ownership taxes do indeed have a negative effect on fleet turnover.

Two recent studies have analyzed the effects of vehicle wealth taxes on purchase and registration decisions using data from the United States. Ott and Andrus (2000) examine the relative importance of consumer's perceptions of vehicle personal property taxes versus other factors on purchasing decisions. Their analysis is based on a survey of consumers who had recently purchased a new vehicle in a high-tax state (Mississippi or South Carolina) or a low-tax state (North Carolina and Utah). The authors' findings suggest that despite the fact that over 75.6 percent of respondents perceived the property tax to be too high, the tax appears to be of little consequence relative to other factors in the purchase decision process. However, 19.6 percent of respondents claimed that high vehicle property taxes would make them unlikely to buy a replacement vehicle in the next two years. Unfortunately, these results may suffer from selection bias given that the authors made no attempt

to elicit the opinions from individuals who decided not to purchase a new vehicle. Nor do the authors examine the impact of the tax on the age of the vehicle selected.

Beck and Bennett (2003) note that in addition to encouraging households to substitute older vehicles for newer ones, lower vehicle wealth taxes in neighboring states may have a negative effect on the proportion of registered vehicles that are new as consumers attempt to evade taxes by registering vehicles outside their state of residence. The authors use cross-sectional data from 1997 state vehicle registrations to estimate an OLS regression model of the proportion of total vehicle registrations that are new vehicles. The results indicate that taxes and license fees based on the value or age of the vehicle have a statistically significant negative effect on the share of registrations that are new vehicles. However, given that these results are based on state-level data it is impossible to determine the potential consequences these taxes may have on air quality in the consumer's state of residence. If households are purchasing new vehicles but are registering them out of state, there should be no negative environmental impacts. However, if the results are due to consumer's substituting older vehicles for newer vehicles, emissions will be higher in states with vehicle wealth taxes. An analysis of purchasing decisions and vehicle age decisions at the household-level is necessary to make any conclusions regarding the environmental impacts of these taxes.

THEORETICAL FRAMEWORK

The first model of interest in this analysis is that of households' vehicle purchase decisions. The outcome of this decision can only be observed in two states: the household purchases a vehicle or it does not. As a result a basic random utility model can be used to frame this decision. This model assumes that a household will compare the utility it receives from purchasing a vehicle to the utility it would receive if it decided not to purchase a vehicle. The probability that a household buys a vehicle is expressed as:

$$P = P(\text{Utility with vehicle purchase} > \text{Utility without vehicle purchase}) \quad (1)$$

Each household's utility from purchasing a vehicle (U_i) is measured by a latent index, which could be viewed as a "buying index", expressed by the following linear function:

$$U_i = X_i\beta + T_i\beta + W_i\beta + V_i\beta + \varepsilon_i \quad (2)$$

where X_i represents a vector of demographic and socioeconomic variables, T_i is a vector of state and local vehicle taxes, W_i is a vector of transportation use patterns including both private and public transportation, and V_i is a vector that includes characteristics of the household's vehicle stock. The betas represent coefficients which measure the magnitude of the impact of each independent variable. Finally, ε_i represents an error term which captures the impact of unobserved variables that impact a household's utility.

The idea of a latent index is that there is an underlying propensity to purchase a vehicle that generates the observed state. Although the value of this index can not be observed directly, at some threshold value a change in the buying index generates a change in the observed state, namely, whether the household purchases a vehicle. Therefore, households with larger values of this index purchase a vehicle, while those with smaller values do not. Thus the latent index is linked to the observed purchase decision (y_i) by the measurement equation:

$$y_i = \{1 \text{ if } U_i > \tau, \text{ or } 0 \text{ if } U_i = \tau\} \tag{3}$$

where τ is the threshold value which is typically normalized to be zero. When $y_i = 1$ the household decides to purchase a vehicle and when $y_i = 0$ the household does not purchase a vehicle. The probability that a household purchases a vehicle can now be expressed as:

$$P(y_i = 1 | x) = P(x\beta + \varepsilon > 0 | x) \tag{4}$$

where x is the vector of all the independent variables included in the buying index in equation 2.

Although the buying index is a continuous variable, since it is unobserved it can not be estimated with an ordinary least squares technique. Instead a maximum likelihood estimation technique is necessary to estimate the probability of the binary outcome represented in equation 4. This analysis assumes that the error terms are normally distributed and uses a probit model to estimate households' vehicle purchase decisions. For the probit model the cumulative distribution function of the standard normal model provides the probability that the event will occur and one minus this function provides the probability that it will not occur.[3]

The second model of interest in this analysis is that of households' vehicle age decisions. For those household who decide to purchase a vehicle, the age of the vehicle selected is assumed to be a function of household demographics and

socioeconomic variables, vehicle taxes, transportation use patterns, and vehicle stock characteristics as expressed by the following linear function:

$$Age_i = X_i\beta + T_i\beta + W_i\beta + V_i\,\beta + \varepsilon_i \qquad\qquad (5)$$

which can be estimated using OLS. The vector of vehicle taxes (T_i) includes a measure of the motor vehicle wealth tax in the household's state of residence, which is expected to have a positive impact on age as households are expected to purchase older vehicles in order to reduce their tax liabilities.

DATA AND METHODS USED

This analysis examines the effects of motor vehicle wealth taxes on household vehicle purchase and age decisions using data from the 2001 National Household Travel Survey (NHTS) conducted by the U.S. Department of Transportation between March 2001 and May 2002. The data contain a wealth of information on the demographics, travel patterns and vehicle stocks for a random sample of approximately 24,000 households living throughout the United States.[4] State and average local vehicle sales tax rates are collected from the 2001 U.S. Master Sales and Use Tax Guide (CCH Incorporated, 2003).

The first column of data in Table 1 provides a distribution of households with complete observations in the NHTS data set across various household demographics and other variables that may affect households' vehicle purchase and age decisions. These other variables include measures of public transportation use and taxes on vehicle transactions in the household's state of residence.[5] Households in the sample are likely to have two or fewer members, an annual income below $50,000 and a home of their own. Households are also likely to reside in a metropolitan statistical area (MSA), drive less than 10 miles to work, and most likely do not use public transportation. Nearly all households live in a state that imposes a tax on the transaction of vehicles, such as a sales, use or excise tax, and roughly 50 percent live in a state where local jurisdictions have the option of taxing the sale of vehicles. Finally, household survey respondents are likely to be white, without a college degree, and younger than the age of 56.

Table 1: Distribution of NHTS Households Across Various Characteristics					
		All HHs Percent	HHs without a purchase	HHs with a purchase	Average vehicle purchase age
Household size	1	20.00	23.13	11.39	5.04
	2	39.19	40.17	36.49	4.65
	3	16.50	15.09	20.40	5.27
	4	14.92	13.53	18.72	5.82
	5 or more	9.39	8.08	12.99	6.82
Race of HH respondent	Black	5.84	6.01	5.37	6.72
	White	82.79	82.83	82.69	5.08
	Other	11.36	11.16	11.93	6.38
Household income	0 - $9,999	5.26	5.78	3.84	10.06
	$10,000 - $19,999	10.85	11.77	8.40	8.28
	$20,000 - $29,999	13.83	14.75	11.36	7.00
	$30,000 - $39,999	14.00	14.27	13.26	6.53
	$40,000 - $49,999	11.76	11.64	12.07	5.44
	$50,000 - $59,999	10.07	9.92	10.47	4.82
	$60,000 - $69,999	7.36	7.09	8.10	4.16
	$70,000 - $79,999	6.36	5.95	7.46	4.33

Table 1: Distribution of NHTS Households Across Various Characteristics					
		All HHs Percent	HHs without a purchase	HHs with a purchase	Average vehicle purchase age
	$80,000 or more	20.51	18.82	25.04	3.37
College Degree	Yes	39.18	39.33	38.76	4.03
	No	60.82	60.67	61.24	6.14
Age of household respondent	17-25	6.03	5.02	8.80	6.71
	26-35	15.35	14.24	18.41	5.88
	36-45	21.52	20.13	25.34	5.79
	46-55	20.99	20.63	21.99	5.16
	56-65	15.63	16.30	13.77	4.40
	66 or older	20.49	23.68	11.69	3.78
Household life cycle	No children	34.59	35.31	32.60	4.87
	Youngest child 15 or younger	32.23	29.61	39.44	6.01
	Youngest child 21 or younger	5.87	4.60	9.37	6.05
	Retired adults	27.31	30.48	18.58	4.29
Home ownership	Yes	81.26	81.25	81.29	4.87
	No	18.74	18.75	18.71	7.27
Driver count	0	0.29	0.39	0.00	0.00
	1	28.32	32.24	17.50	5.90
	2	57.66	56.51	60.84	4.94

Table 1: Distribution of NHTS Households Across Various Characteristics					
		All HHs Percent	HHs without a purchase	HHs with a purchase	Average vehicle purchase age
	3 or more	13.72	10.86	5.95	5.94
Worker count	0	21.35	24.46	12.77	4.70
	1	33.12	34.57	29.14	5.63
	2	37.20	34.60	44.38	5.05
	3 or more	8.32	6.36	13.72	6.13
State vehicle transaction tax	Yes	98.24	98.20	98.36	5.30
	No	1.76	1.80	1.64	6.87
Local option transaction tax	Yes	63.29	63.44	62.87	5.48
	No	36.71	36.56	37.13	5.06
MSA category	More than 1 mil, heavy transit	14.17	14.84	12.34	3.96
	More than 1 mil, no transit	41.12	41.10	41.16	4.78
	Less than 1 mil	24.15	23.90	24.84	5.75
	Not in MSA	20.56	20.16	21.66	6.64
Public transportation use	Yes	18.12	18.05	18.33	5.15
	No	81.88	81.95	81.67	5.36
Average distance to work	Less than 5 miles	52.43	55.06	45.17	5.62
	5 - 9 miles	17.63	16.91	19.61	5.23
	10 -19 miles	18.17	17.09	21.13	4.95
	20 or more miles	11.78	10.94	14.09	5.05
Note: The number of observations is 21,253 for the first column of data, 15,597 for the second and 5,656 for the third.					

The survey data also include information on the year, make, model, and the length of current ownership for over 45,500 vehicles owned by households in the survey.[6] Thus, the survey data provide all the information necessary to identify the households that purchased a vehicle in 2001 and the age of each vehicle at the time of purchase. Specifically, the survey date and the length of time the household reports owning each of its vehicles are used to identify households that purchased a vehicle in 2001, while each vehicle's age at the time of purchase is derived using information on the model year of the vehicle, survey date and reported length of ownership.

In order to model the effects of motor vehicle wealth taxes on household vehicle purchase decisions, the survey data are supplemented with motor vehicle wealth tax data collected by various methods including mail surveys, personal interviews, and searches of state tax codes. Figure 1 highlights the twenty-eight states with motor vehicle wealth taxes as of 2001. The taxing methodologies used in these states generally fall into one of three categories: an ad valorem personal property tax, a state or local tax in lieu of a personal property tax or an aged-based fee. However, the taxing methodologies implemented in these states differ by more than just their classification. Specifically, states use different valuation methods, assessment ratios, tax rates and minimum tax thresholds. In some instances assessment ratios and tax rates also vary within a state based on the age of the vehicle.

Figure 1: States with Motor Vehicle Wealth Taxes in 2001
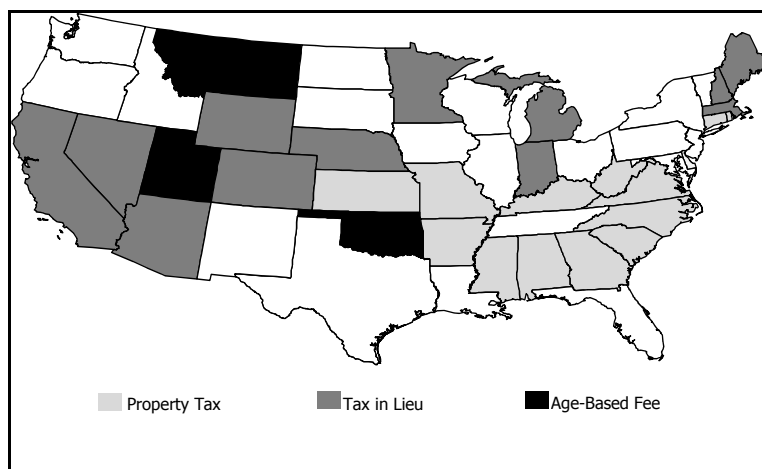
Given the disparities in the taxing methodologies used by states, it is virtually impossible to adequately represent motor vehicle wealth taxes with a simple measure such as a tax rate. Such a measure fails to capture the dynamic structure of the tax that results in a decline in tax liabilities with vehicle age. In theory, households' vehicle purchase and age decisions are expected to be more responsive in situations where the tax liabilities differ more dramatically by vehicle age. Therefore, the tax provisions of each state were used to create two measures of motor vehicle wealth taxes that compare the tax liability of a brand-new vehicle to the tax liability of a used vehicle. The Honda Accord was used as the representative vehicle in these calculations as it has been one of the best selling sedans in the U.S. over the past several years.

The present value of a ten-year stream of tax liabilities for a new 2001 Accord and a used 1998 Accord were calculated using the tax provisions of each respective state.[7] The 1998 Accord represents a reasonable substitute to the 2001 Accord as it is young enough to be driven for ten additional years, yet it has aged enough such that its associated wealth tax liability is lower than that of a new vehicle. Table 2 provides a list of the resulting tax liabilities by state. The average present value of a ten-year stream of tax liabilities was $1,417 for a new 2001 Accord across states with a wealth tax in 2001 and was $825 for a used 1998 Accord.[8]

Table 2: Motor Vehicle Wealth Tax Liabilities ($)				
	2001 Honda Accord	1998 Honda Accord	Difference	Ratio
Alabama	$704	$510	$194	1.38
Arizona	1,738	1,073	665	1.62
Arkansas	1,011	733	278	1.38
California	724	519	205	1.39
Colorado	1,374	585	789	2.35
Connecticut	2,083	1,509	574	1.38
Georgia	1,450	1,050	400	1.38
Indiana	1,080	444	636	2.43
Kansas	1,365	613	752	2.23
Kentucky	1,713	1,241	472	1.38
Maine	1,850	971	879	1.91

Table 2: Motor Vehicle Wealth Tax Liabilities ($)				
	2001 Honda Accord	**1998 Honda Accord**	**Difference**	**Ratio**
Massachusetts	1,419	572	847	2.48
Michigan	627	477	150	1.31
Minnesota	1,043	629	414	1.66
Mississippi	1,909	636	1,273	3.00
Missouri	2,368	1,716	652	1.38
Montana	1,011	537	474	1.88
Nebraska	1,662	975	687	1.70
Nevada	1,267	604	663	2.10
New Hampshire	1,518	790	728	1.92
North Carolina	1,258	911	347	1.38
Oklahoma	668	583	85	1.15
South Carolina	3,372	2,443	929	1.38
Utah	823	547	276	1.50
West Virginia	1,876	1,359	517	1.38
Wyoming	1,640	1,010	630	1.62
Note: Tax liabilities represent a 10 year present value stream of tax liabilities.				

Two measures of the wealth tax were created using the respective tax liabilities for the new 2001 Accord and the used 1998 Accord in each state. The first of these variables is the absolute difference, which is the 2001 Accord tax liability minus the 1998 Accord tax liability. Column three of Table 2 shows the result of this calculation by state. The average difference between these tax liabilities across states is $551. Mississippi has the largest difference ($1,273) while Oklahoma has the smallest ($85).   The second measure of the wealth tax is the relative difference in the tax liabilities of a new versus used vehicle, which is the ratio of the 2001 Accord tax liability to the 1998 Accord tax liability. The average wealth tax ratio across states is 1.72, indicating that on average the present value of a ten-year stream of tax liabilities for a brand new vehicle is 72 percent larger than that for a three-year-old vehicle. Both measures reflect the degree to which older vehicles receive favorable tax treatment relative to new vehicles under the motor

vehicle wealth tax provisions in each state. Larger values of both measures suggest that older vehicles receive more favorable tax treatment.

The maximum difference between the present value of a ten-year stream of tax liabilities in Table 2 ($1,273) represents roughly 5.6 percent of the manufacturer's suggested retail price (MSRP) of the 2001 Honda Accord, while the minimum difference ($85) represents only 0.37 percent of the Accord's suggested price. Absent further analysis, it is difficult to project whether these differences are large enough to affect households' decisions. Wheeler (1998) claims that motor vehicle wealth tax liabilities are such a small percentage of a vehicle's value that most individuals do not take the tax into consideration when purchasing a vehicle; however no prior empirical analysis has been conducted to support or refute this claim.

Roughly half of the households in the data set resided in a state that had a wealth tax on motor vehicles in 2001. From the final sample of 21,253 households, roughly 27 percent purchased at least one vehicle in 2001. Households living in states with a motor vehicle wealth tax were just as likely to purchase a vehicle in 2001 as households living in states without a motor vehicle wealth tax. Specifically, 26.49 percent of households living in states with a wealth tax purchased at least one vehicle, while 26.73 percent of households living in states without a motor vehicle wealth tax purchased a vehicle. However this simple comparison fails to control for the effects other variables may have on vehicle purchase decisions, such as household demographics, household composition, travel patterns, public transportation use and transaction taxes.

Columns two and three of Table 1 show the distribution of households across various characteristics by vehicle purchase status. Households that purchased a vehicle in 2001 were more likely to be larger in size, had higher annual incomes, and had a larger number of drivers and workers. Households that purchased a vehicle were also more likely to drive further distances to work. Of course, to isolate the effect wealth taxes have on vehicle purchase decisions from the effects of these other variables a multivariate strategy is required.

Households that decide to purchase a vehicle may be further influenced by the presence of motor vehicle wealth taxes in their choice of vehicle age since lower tax liabilities are associated with older vehicles. The summary statistics presented in Table 3 indicate that nearly half of the households that purchased a vehicle in 2001 lived in a wealth tax state. On average, households faced a relative difference in the present value of a ten-year stream of tax liabilities of a new and used vehicle

of 1.28 and an absolute difference of $207.37. These variables take on a value of one and zero respectively for households living in non-wealth-tax states.

Table 3: Summary Statistics of Wealth Tax Measures for NHTS Households That Purchased A Vehicle				
Variable	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Motor vehicle wealth tax dummy	0.48	0.50	0	1
2001 Honda Accord tax liability	596.28	761.7	0	3,372
1998 Honda Accord tax liability	388.91	519.33	0	2,443
Ratio (01/98)	1.28	0.41	1	3
Difference (01-98)	207.37	281.33	0	1,273
Note: Number of observations = 5,656				

Figure 2 shows the distribution of vehicle age at the time of purchase by the wealth tax status in the household's state of residence. The differences in these distributions are very minor. In fact, the average vehicle age at the time of purchase for households in wealth tax states is 5.42 years compared to 5.23 years for households in non-wealth-tax states, and these values are not statistically different. A Kolmogorov-Smirnov test applied to these distributions generates a corrected p-value of 0.158, suggesting that these distributions are not statistically different at the ten-percent level.

These results suggest that motor vehicle wealth taxes do not significantly influence the age of vehicles purchased. However, simply comparing the vehicle age distribution by wealth tax status fails to control for the effects of other variables may have on a household's vehicle age decision. As reported in Table 1, a household with a survey respondent that is white, older and has a college degree tends to purchase newer vehicles. Households that live in a metropolitan statistical area, have higher annual incomes and drive further distances to work also tend to purchase newer vehicles.

Again, to isolate the effects of motor vehicle wealth taxes from the effects of these other variables, a multivariate strategy is required.

Figure 2; Vehicle Age at Purchase by Motor Vehicle Wealth Tax Status
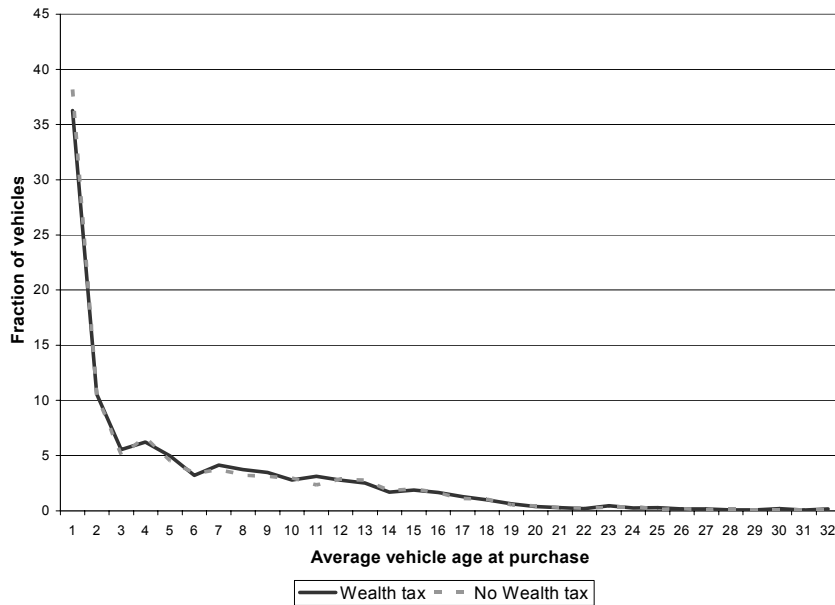
EMPIRICAL ANALYSIS OF HOUSEHOLDS'
VEHICLE PURCHASE DECISIONS

Three separate probit models using different measures of the motor vehicle wealth tax: a dummy variable indicating the presence of a wealth tax in the household's state of residence, the ratio of tax liabilities and the absolute difference in tax liabilities, were estimated to analyze the effects of motor vehicle wealth taxes on households' 2001 vehicle purchase decisions. In each of the models the dependent variable takes a value of one for households that purchased at least one vehicle in 2001. The models also include measures of household demographics, household composition, public transportation use and transaction tax rates as controls.

The wealth tax variable has a negative and statistically significant marginal effect on the probability that a household purchases a vehicle in two of the three models using a two-tailed test as reported in Table 4. The results from model 1 indicate that if a household lives in a state with a wealth tax on motor vehicles, its probability of purchasing a vehicle is 1.23 percentage points less than that for a

household living in a state without such a tax, all else constant. The baseline proportion of households in this sample that actually purchased a vehicle is 26.61 percent; therefore, this change represents a 4.62 percent decrease in the likelihood that a vehicle is purchased.

Table 4: Marginal Effects for the 2001 Vehicle Purchase Decision			
	Model		
Variable	**1**	**2**	**3**
Wealth tax dummy	-0.0123**		
	0.0062		
Wealth tax ratio		-0.0214***	
		0.0074	
Wealth tax difference (in $100s)			-0.0017
			0.0011
HH black	-0.0012	-0.0022	-0.0012
	0.0134	0.0133	0.0134
HH other	-0.0013	-0.0020	-0.0022
	0.0099	0.0099	0.0098
Household Income (in $1,000s)	0.0007***	0.0007***	0.0007***
	0.0001	0.0001	0.0001
College degree	-0.0274***	-0.0274***	-0.0274***
	0.0067	0.0067	0.0067
Age of respondent	-0.0030***	-0.003***	-0.003***
	0.0003	0.0003	0.0003
Life cycle 1 - no kids	-0.0569***	-0.0571***	-0.0569***
	0.0136	0.0136	0.0135
Life cycle 2 - youngest less than 16	-0.0561***	-0.0561***	-0.056***
	0.0147	0.0147	0.0145
Life cycle 4 - retired	-0.0264*	-0.0268*	-0.0267*
	0.0160	0.0160	0.0160
Home ownership	-0.0337***	-0.0337***	-0.0335***
	0.0090	0.0090	0.0091

Table 4: Marginal Effects for the 2001 Vehicle Purchase Decision			
	Model		
Variable	**1**	**2**	**3**
Household size	0.0113**	0.0112**	0.0112**
	0.0048	0.0048	0.0047
Worker count	0.0127**	0.0129**	0.0128**
	0.0054	0.0054	0.0054
Ratio vehicles to drivers	0.0983***	0.098***	0.0979***
	0.0063	0.0063	0.0058
State transaction tax rate	0.0020	0.0013	0.0021
	0.0025	0.0025	0.0025
Ave. local transaction tax rate	-0.0027	-0.0037	-0.0029
	0.0029	0.0029	0.0029
MSA 1 mil +, no heavy trans.	0.0307***	0.03***	0.0303***
	0.0098	0.0098	0.0098
MSA smaller than 1 mil	0.0429***		0.0433***
	0.0112	0.0112	0.0113
Not in MSA	0.0432***		0.0434***
	0.0119	0.0119	0.0119
Public transportation use	-0.0127	-0.0121	-0.0124
	0.0083	0.0082	0.0082
Ave. distance to work (in 10s of miles)	0.0075***		0.0075***
	0.0030	0.0030	0.0030
Driver Count	0.0688***	0.0687***	0.0687***
	0.0071	0.0071	0.0070
Number of observations	21,253	21,253	21,253
Pseudo R-squared	0.0596	0.0598	0.0595
Predicted probability	0.2531	0.2530	0.2531

Notes: Marginal effects that are statistically significantly different from zero at the 1, 5, and 10 percent levels are indicated with a ***, ** and * respectively.
  Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

The marginal effect of the ratio of tax liabilities is highly statistically significant in model 2. However, the small marginal effect results in an elasticity of only -0.10. Thus the model predicts that a one-percent increase in the ratio of tax liabilities would decrease the predicted probability that a vehicle is purchased by only 0.10 percent, all else constant. The marginal effect on the difference in tax liabilities is statistically significantly different from zero in model 3 when a one-tailed test is used. A $100 difference in wealth tax liabilities between new and used vehicles results in a very modest 0.17 percentage point decrease in the likelihood that a vehicle is purchased.

A majority of the marginal effects on the additional explanatory variables in these models are statistically significant and robust across the various specifications of the wealth tax. In most cases, the marginal effects of these explanatory variables are of the expected sign or are consistent with the trends presented in Table 1. For example, increasing a household's income would increase the probability that it purchases a vehicle, all else constant. Households with a youngest child between the ages of 16 and 21 are more likely to purchase a vehicle than are households in other stages of the life cycle. Homeowners are less likely to purchase a vehicle in 2001, which might reflect the effects of the liquidity constraints often faced by households with mortgage payments. Households that reside in an MSA with a population of at least one million and a heavy transit system are less likely to purchase a vehicle, perhaps due to a lack of need or availability of other transportation options. However, the marginal effect of the public transportation variable indicating whether a member of the household used some form of public transportation in the past two months is not statistically significant. Increasing the household size, worker count or average distance to work would increase the probability that a vehicle is purchased. Households with younger respondents and those with respondents without a college degree are less likely to purchase a vehicle.

Intuition would suggest that transaction taxes such as sales, use or excise taxes on motor vehicles would discourage households from purchasing a vehicle as they increase the overall cost of the purchase. However, neither state nor local transaction tax rates in the household's state of residence significantly affect the purchase decision in these models. These results are consistent with the findings of Beck and Bennett (2003) who suggest that a one-time charge such as a sales tax is less likely to affect a purchase decisions than is an annual cost such as a wealth tax.

The robustness of these results is tested by estimating several alternative specifications of the model. The findings suggests that the results of the baseline

model are robust to the exclusion of households with one or no vehicles who may be less sensitive to motor vehicle wealth taxes given their need for transportation. The baseline results are also robust to the use of motor vehicle wealth tax measures created using the Ford Taurus as the representative vehicle.[9]

However, slight changes in the results occur after controlling for the timing of the households' survey interview. Table 5 presents the results of models that include a dummy variable that indicates whether or not the household was interviewed in the fourth quarter of 2001. This variable serves two purposes. First, it captures the effects of special promotions, such as low interest rates and low down payments, that are frequently offered during this time of the year as auto-dealers attempt to clear their lots of current year models. Secondly, it serves as a control for the influence that the events of September 11th may have had on household vehicle purchase decisions. After controlling for the possibility of a fourth quarter purchase, the marginal effect on the wealth tax dummy variable is no longer statically significant. However, the marginal effect on the wealth tax ratio variable remains statistically significant and is of the same order of magnitude as in the baseline model.

Table 5: Marginal Effects for the 2001 Vehicle Purchase Decision After Controlling for a 4th Quarter Purchase			
	Model		
Variable	**1**	**2**	**3**
Wealth tax dummy	-0.0089		
	0.0062		
Wealth tax ratio		-0.0201***	
		0.0074	
Wealth tax difference (in $100s)			-0.0015
			0.0011
HH black	-0.0073	-0.0082	-0.0073
	0.0132	0.0131	0.0132
HH other	-0.0048	-0.0053	-0.0055
	0.0099	0.0098	0.0098
Household Income (in $1,000s)	0.0006***	0.0006***	0.0006***
	0.0001	0.0001	0.0001

Table 5: Marginal Effects for the 2001 Vehicle Purchase Decision After Controlling for a 4th Quarter Purchase			
	Model		
Variable	**1**	**2**	**3**
College degree	-0.0284***	-0.0284***	-0.0284***
	0.0067	0.0067	0.0067
Age of respondent	-0.0029***	-0.0029***	-0.0029***
	0.0003	0.0003	0.0003
Life cycle 1 - no kids	-0.0639***	-0.0642***	-0.064***
	0.0134	0.0134	0.0134
Life cycle 2 - youngest less than 16	-0.0609***	-0.061***	-0.0608***
	0.0145	0.0145	0.0145
Life cycle 4 - retired	-0.0293*	-0.0297*	-0.0295*
	0.0159	0.0159	0.0159
Home ownership	-0.0354***	-0.0354***	-0.0352***
	0.0091	0.0091	0.0090
Household size	0.0122***	0.0121***	0.0121***
	0.0048	0.0048	0.0048
Worker count	0.0146***	0.0148***	0.0147***
	0.0054	0.0054	0.0054
Ratio vehicles to drivers	0.0984***	0.0982***	0.0981***
	0.0064	0.0064	0.0064
State transaction tax rate	0.0031	0.0022	0.0030
	0.0025	0.0025	0.0025
Ave. local transaction tax rate	-0.0022	-0.0032	-0.0024
	0.0029	0.0029	0.0029
MSA 1 mil +, no heavy trans.	0.0269***	0.0264***	0.0267***
	0.0098	0.0098	0.0098
MSA smaller than 1 mil	0.0398***	0.0394***	0.0402***
	0.0112	0.0112	0.0112

Table 5: Marginal Effects for the 2001 Vehicle Purchase Decision After Controlling for a 4th Quarter Purchase

	Model		
Variable	**1**	**2**	**3**
Not in MSA	0.0416***	0.0414***	0.0418***
	0.0120	0.0119	0.0120
Public transportation use	-0.0103	-0.0099	-0.0101
	0.0083	0.0083	0.0083
Ave. distance to work (in 10s of miles)	0.0075***	0.0074***	0.0074***
	0.0030	0.0030	0.0030
Driver Count	0.0694***	0.0693***	0.0693***
	0.0070	0.0070	0.0070
4th Quarter Purchase	0.1800***	0.1801***	0.1801***
	0.0057	0.0057	0.0057
Number of observations	21,253	21,253	21,253
Pseudo R-squared	0.0948	0.0951	0.0948
Predicted probability	0.2438	0.2438	0.2439

Notes: Marginal effects that are statistically significantly different from zero at the 1, 5, and 10 percent levels are indicated with a ***, ** and * respectively.
Standard errors have been corrected for heteroskedasticity and are reported in parentheses.

These results suggest that after controlling for a fourth quarter interview households' vehicle purchase decisions are not affected by the mere presence of a motor vehicle wealth tax but are still responsive to the relative differences in tax liabilities for new versus used vehicles. The positive and statistically significant marginal effect on the fourth quarter dummy variable indicates that households interviewed during this time of the year are more likely to have purchased a vehicle. The significance patterns and the magnitudes of the effects of the remaining control variables are robust.[10]

EMPIRICAL ANALYSIS OF HOUSEHOLDS'
VEHICLE AGE DECISIONS

After analyzing households' vehicle purchase decisions, the next step is to examine the effects of motor vehicle wealth taxes on households' vehicle age decisions. The sample used to model vehicle age includes the 5,656 households that purchased at least one vehicle in 2001. Table 6 presents the results of multivariate OLS regression models of vehicle age. In each model, the dependent variable is the average age of vehicles purchased by the household in 2001; however, each model includes a different measure of the motor vehicle wealth tax as before.[11] The control variables again include measures of household demographics and composition, public transportation use and transaction tax rates.

Table 6: OLS Regression Results for Household's Vehicle Age Decisions			
	Model		
Variable	**1**	**2**	**3**
Wealth tax dummy	0.1458		
	0.1388		
Wealth tax ratio		0.1049	
		0.1621	
Wealth tax difference (in $100s)			0.0004
			0.0002
HH black	0.8463***	0.8533***	0.8401***
	0.3400	0.3398	0.3399
HH other	0.3903*	0.3970*	0.401*
	0.2143	0.2144	0.2144
Income (in $1,000s)	-0.0388***	-0.0387***	-0.0388***
	0.0025	0.0025	0.0025
College degree	-0.9649***	-0.9658***	-0.9668***
	0.1407	0.1407	0.1406
Age	-0.0249***	-0.025***	-0.0251***
	0.0060	0.0060	0.0060

Table 6: OLS Regression Results for Household's Vehicle Age Decisions			
	Model		
Variable	**1**	**2**	**3**
Life cycle 1 - no kids	-1.0593***	-1.058***	-1.0537***
	0.2650	0.2648	0.2650
Life cycle 2 - youngest less than 16	-1.0437***	-1.0454***	-1.0415***
	0.2790	0.2788	0.2791
Life cycle 4 - retired	-1.5253***	-1.5206***	-1.5123***
	0.3365	0.3366	0.3367
Own home	-1.5116***	-1.5108***	-1.511***
	0.2075	0.2075	0.2075
HH size	0.5969***	0.5981***	0.5984***
	0.0920	0.0920	0.0920
Worker count	-0.0133	-0.0134	-0.0143
	0.1046	0.1047	0.1047
Ratio vehicles to drivers	1.5661***	1.5679***	1.5703***
	0.1496	0.1496	0.1496
State transaction tax rate	0.0420	0.0376	0.0492
	0.0630	0.0631	0.0633
Ave. local transaction tax rate	0.0978	0.0990	0.1018
	0.0641	0.6475	0.0642
MSA 1 mil +, no heavy trans.	0.7677***	0.7807***	0.7696***
	0.1892	0.1880	0.1883
MSA smaller than 1 mil	1.3457***	1.3509***	1.3386***
	0.2151	0.2153	0.2153
Not in MSA	1.9501***	1.9606***	1.9454***
	0.2399	0.2398	0.2397
Public transportation	0.4567***	0.4511***	0.4576***
	0.1794	0.1792	0.1792

Table 6: OLS Regression Results for Household's Vehicle Age Decisions			
	Model		
Variable	**1**	**2**	**3**
Other than auto	-0.8078***	-0.8056***	-0.8095***
	0.1406	0.1406	0.1405
Ave. distance to work (in 10s of miles)	-0.1312**	-0.1308**	-0.1307**
	0.0627	0.0627	0.0626
Constant	6.4044***	6.346***	6.356***
	0.6525	0.7072	0.6534
Number of observations	5,656	5,656	5,656
R-squared	0.1706	0.1705	0.1707
Notes: Coefficients that are statistically significantly different from zero at the 1, 5, and 10 percent levels are indicated with a ***, ** and * respectively. Standard errors have been corrected for heteroskedasticity and are reported in parentheses.			

Households living in wealth tax states are expected to purchase older vehicles, all else constant, in order to avoid paying higher taxes. They are also expected to be more responsive to larger relative and absolute differences in tax liabilities for new and used vehicles. The positive coefficients on all three tax measures is consistent with this hypothesis; however, the coefficients fail to be statistically significantly different from zero, suggesting that wealth taxes do not affect households' vehicle age decisions. These results are perhaps unsurprising given the vehicle age distribution in Figure 2.

Instead, households' decisions are more likely to be affected by specific household characteristics and location. The remaining variables in the model are capable of explaining over 17 percent of the variation in average vehicle age, which is respectable considering that detailed information on the specifics of the vehicle transaction is not available. In fact a large majority of the coefficients are statistically significantly different from zero in each of the models and the results are robust across the various specifications of the wealth tax.

The largest effects on age in each of these models stem from the life cycle and MSA dummy variables. For example, households that have reached the retirement phase of life purchase vehicles that are roughly one and a half years

younger than the vehicles purchased by households whose youngest child is of driving age. Households with no children or with a youngest child below the age of 16 also purchase vehicles that are younger than those purchased by households with a youngest child between the ages of 16 and 21. Households not living in an MSA purchase vehicles that are approximately two years older than the vehicles purchased by households in the largest MSAs with a heavy transit system, all else constant. Households living in smaller MSAs also purchase older vehicles. Households that own their own homes, have higher incomes, drive further distances to work, do not use public transportation or have fewer members tend to purchase newer vehicles on average.

Intuitively, vehicle age decisions for households with more than one vehicle may be more sensitive to motor vehicle wealth taxes than those for households who own only one vehicle. Households with only one vehicle may rely solely on this vehicle for all of their transportation needs; therefore, they are probably more likely to purchase a more reliable, newer vehicle. Thus the status of motor vehicle wealth taxes in their state of residence may be less of a factor in their vehicle age decisions. This hypothesis was tested by estimating the vehicle age models using only the households that report owning more than one vehicle. The results of these models are similar to those of the baseline models, suggesting that vehicle ownership levels do not affect households' responses to wealth taxes.

The exclusion of households that failed to purchase a vehicle in 2001 in the vehicle age model may bias the coefficients of the ordinary least squares regression model. Specifically, households that failed to purchase a vehicle in 2001 may have been more likely to purchase vehicles in certain age groups. Potential sample selection bias in the vehicle age regression is investigated by estimating a Heckman selection model using the purchase decision as the selection equation.[12] The lack of statistical significance for the coefficient on the inverse mills ratio suggests that sample selection bias is not a concern in these models.

Figure 2 reveals that vehicles purchased by households in 2001 are more likely to be new in states without a wealth tax than in states with a tax. Households in non-wealth- tax states are 1.05 times more likely to purchase a new vehicle than households in wealth tax states; however, the remainder of the vehicle age distribution is very similar across wealth tax status. Thus the results of the linear regression model of vehicle age may fail to reveal the complete effects of motor vehicle wealth taxes on the decision to purchase a new vehicle. Therefore, the analysis estimates a probit model of households' decisions to purchase a new versus used vehicle. After controlling for the effects of the other explanatory variables, the

motor vehicle wealth tax measures fail to affect the probability that a household chooses to purchase a new vehicle versus a used vehicle. The results of a Heckman probit model suggest that these results are again robust to controls for sample selection bias.[13]

CONCLUSIONS

This analysis is perhaps the first to recognize the potential unintended consequences of motor vehicle wealth taxes as they are used in the United States on household vehicle purchases and age decisions that may lead to detrimental environmental effects. As hypothesized, motor vehicle wealth taxes have a statistically significant negative effect on the probability that a household purchases a vehicle in a given year. Marginal effects from probit models of households' 2001 vehicle purchase decisions indicate that households are not only responsive to the presence of a motor vehicle wealth tax but also respond to the relative tax treatments of new versus used vehicles. However, the hypothesis that households in motor vehicle wealth tax states purchase older vehicles to avoid higher tax liabilities is not supported by the results. All three wealth tax measures fail to be statistically significant in multivariate regression models of vehicle age. Thus, once a household has decided to purchase a vehicle neither the presence of a motor vehicle wealth tax nor the relative tax treatments of new versus used vehicles affects its choice of vehicle age.

Although the results presented in this analysis indicate that motor vehicle wealth taxes do not have a direct effect on household vehicle age decisions, these taxes may have an indirect effect on state vehicle age distributions as a result of their effect on household vehicle purchase decisions. Even modest delays in the purchase of a newer vehicle may impact average fleet age when summed over time and across households living in a state.

The potential unintended consequences of motor vehicle wealth taxes on fleet turnover, emissions and air quality certainly justify further research on household's responses to these taxes. Future research should test the robustness of the results reported in this analysis by examining household vehicle holdings over time and attempting to quantify the effects of the delay in vehicle purchase associated with motor vehicle wealth taxes on state vehicle age distributions. Efforts should also be made to translate any identified effects on vehicle age distributions into effects on emissions levels to determine whether adjustments to

the use and structure of motor vehicle wealth taxes could be used to improve air quality.

ENDNOTES

[1]   The impact of taxes on individual behavior has received much attention over the past several decades. Researchers have shown that individuals can be quite responsive to tax rates in deciding how much to work [Ziliak & Kniesner (1999), Feldstein (1995), and Hausman (1985)], how much to save [Pence (2002), Bernheim (2002), and Poterba et al. (1996)] and whether or not to purchase a house [Poterba (1992), Rosen & Rosen (1980), and Rosen (1979)], among many other decisions.

[2]   The EPA conducted this simulation by adjusted vehicle age distributions, increasing the fraction of vehicles with ages greater than 13 years old and subtracting the same fraction from vehicles that were younger than 13 years old.

[3]   For additional details on the probit model see chapter 2 of Long (1997).

[4]   Although the original NHTS sample included over 26,000, the state of residence could not be identified for households living in states with small populations to protect the confidentiality of survey participants. These households were dropped from this analysis because the corresponding state motor vehicle wealth tax data could not be matched to individual households' states of residence.

[5]   Definitions of the variables used in the analysis appear in the Appendix table.

[6]   Vehicles not owned by the household, such as leased or company vehicles, are excluded from this analysis as it is not clear whether the household is responsible for paying the wealth tax. Recreational vehicles, motorcycles and vehicles classified as something other than an automobile, van, SUV or truck are excluded because they are usually employed in leisure activities which represent a different choice decision facing the household. Finally, vehicles over the age of 39 are excluded as they are lumped into the same model year category and thus their actual age cannot be determined.

[7]   The calculation of these tax liabilities required the creation of a depreciation schedule for the Honda Accord to generate tax liabilities in states that use the blue book valuation method. This depreciation schedule that was generated by using the manufacturer's suggested retail price (MSRP) and resale value data for various model years of Accords. The first step in the calculation was to create a measure

that represented the total percentage change in value for vehicles of each age. The final step was to create annual depreciation rates over a thirteen year period by comparing the total percentage change in value for vehicles of consecutive ages. This analysis used a discount rate of five percent in the present value calculations.

[8]   Virginia and Rhode Island are excluded from the analysis due to a lack of sufficient detail on their wealth tax provisions. Motor vehicle wealth tax rates, which vary by jurisdiction in both states, are not available for 2001, thus prohibiting the calculation of wealth tax liabilities.

[9]   Although the Honda Accord has been one of the top selling vehicles over the past several years, its depreciation schedule may not be representative of the average vehicle since it tends to retain its value over a longer period time. The more rapid depreciation of the Taurus' value leads to larger relative and absolute differences between the tax liabilities of a new and used vehicle.

[10]   This analysis does not consider the supply side of this market, but a few features such as online sales and special ordering opportunities increase the scope of the market making this a less critical issue.

[11]   The analysis uses the average age of vehicles purchased by the household in 2001 as the dependent variable to account for the 13 percent of households that purchased more than one vehicle. However, results from models that use the vehicle as the unit of analysis and allow for possible heterogeneity across households were similar to those of the baseline model.

[12]   This analysis uses the count of drivers in the household was used to identify the selection model. This variable is expected to affect vehicle purchase decisions as a larger number of drivers leads to the need for more vehicles; however, it is unlikely to affect household vehicle age decisions after controlling for the age of drivers in the household. This variable proves to be a sufficient instrument as it is highly statistically significant in the probit model. The results from the Heckman selection model are available from the author upon request.

[13]   This analysis also estimated several other alternative specifications of the model were estimated to test the robustness of the baseline vehicle age results. Specifically, the results on the wealth tax measures were found to be robust to controls for a fourth quarter purchase, using vehicles as the unit of analysis and the use of wealth tax measures that were created using the Ford Taurus as an alternative representative vehicle.

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Table A.1: Variable Definitions	
Variable	**Definition**
Age of respondent	Age of the household respondent in years
Ave. distance to work	Average distance to work for household workers (in 10s of miles)
Ave. local transaction tax rate	Average value of the local transaction tax rates imposed on vehicles by local taxing jurisdictions in the household's state of residence
College degree	Dummy variable indicating that the household respondent received a college degree
Driver count	Count of drivers in the household
HH black	Dummy variable indicating that the household respondent is black
HH other	Dummy variable indicating that the household respondent is not black or white
Home ownership	Dummy variable indicating that the household owned its place of residence
Household size	Count of all household members
Household income	Income is reported in the NHTS files as a categorical variable. Households were assigned an income equal to the midpoint of their respective category
Life cycle 1	Dummy variable indicating that the household members are not retired and have no kids
Life cycle 2	Dummy variable indicating that the household has a youngest child younger than 16
Life cycle 3	Dummy variable indicating that the household has a youngest child between the ages of 16 and 21 (Used as the reference group in the multivariate analyses)
Life cycle 4	Dummy variable indicating that the household is retired
MSA 1mil +, heavy trans	Dummy variable indicating that the household lives in an MSA with a population greater than one million and a heavy transit system (such as a metro line) (Used as the reference group in the multivariate analyses)
MSA 1mil +, no heavy trans	Dummy variable indicating that the household lives in an MSA with a population greater than one million but without a heavy transit system

Table A.1: Variable Definitions	
Variable	**Definition**
MSA smaller than 1mil.	Dummy variable indicating that the household lives in an MSA with a population that is less than one million
Not in MSA	Dummy variable indicating that the household does not live in an MSA
Other than auto	Dummy variable indicating that at least one of the vehicles the household purchased in 2001 was something other than an automobile (such as a sports utility vehicle or truck)
Public transportation use	Dummy variable indicating that at least one member of the household used public transportation at least once in the the two months prior to the survey
Ratio vehicles to drivers	Ratio of vehicles owned or leased by the household to the number of drivers in the household
State transaction tax rate	2001 vehicle transaction tax rate in the household's state of residence (i.e. sales or excise tax rate on vehicles)
Wealth tax	Dummy variable indicating that the household lived in a state that imposed a wealth tax on motor vehicles in 2001
Wealth tax difference	Present value of the ten-year stream of tax liabilities for a new 2001 Accord minus the present value of the ten-year stream of tax liabilities for a used 1998 Accord (in $100s)
Wealth tax ratio	Present value of the ten-year stream of tax liabilities for a new 2001 Accord divided by the present value of the ten-year stream of tax liabilities for a used 1998 Accord
Worker count	Count of household members with jobs

ECONOMIC FREEDOM AND CONFLICT: AN EMPIRICAL NOTE

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ABSTRACT

This paper explores the relationship between economic freedom, political institutions, and conflict. We use a relatively new measure of peace that offers the unique advantage of capturing both internal and external conflicts, and we use a Freedom House measure of civil liberties for political liberties. According to our findings, countries with higher levels of economic freedom, other things equal, also have lower levels of external and internal conflict. In addition, we find a statistically significant relationship between the degree of civil liberty protection in a country and conflict. Our preliminary findings provide further evidence of the negative relationship between economic freedom and conflict (or positive relationship between economic freedom and peace).

INTRODUCTION

In pre-modern times, engaging in war and conflict with other nations was frequently viewed as a possible way to improve the economic well-being of a country. Thus it was sometimes viewed as being lucrative to engage in conflict, in particular when one was the aggressor, if the expected benefits of the conflict were greater than the expected costs. In the modern world, however, engaging in violent conflict is more appropriately viewed as something to be avoided. Yet, violent conflict continues to persist, both within countries as well as between countries. Determining the causes of violent conflict as well as possible solutions is one of the most important social science questions of our time.

In the academic literature, there are two primary factors that have been suggested as contributing to a reduction in conflict or an increase in peace, which can be viewed as both sides of the same question. First, free trade is said to reduce conflict between nations. According to the 19th century French economist, Frederic

Bastiat, if goods don't cross borders, armies will (Boudreaux, 2007). Bastiat's basic message is something that can be traced to Enlightenment philosophers of the 18th century and classical liberals of the 19th century. Immanuel Kant (1795), for example, argued that one of the keys to "perpetual peace" was economic interdependence. In his farewell address to the nation, President George Washington spoke positively of economic interdependence and warned against political interdependence. More recently, the economic interdependence hypothesis of the classical liberals has been more formally developed into the "trade-peace" hypothesis of international relations and trade theory (Mansfield and Pollins, 2001; Polachek, 2007; Schnabel, 2007).

According to another prominent line of inquiry, democracy and representative government lead to peace (Brawley 1993; Ray 1998; Russett and Oneal 2001). Russett and Oneal, in particular, have performed numerous tests on what they call "the Kantian tripod," and they have found that all three legs of Kant's tripod—democracy, economic interdependence, and affiliations with international organizations—matter. Among other things, the so-called 'democratic peace' observed in the data comes from democratic institutions, which make political leaders accountable for the costs of war.

Recently, the primacy of both theories has been challenged, in part, by empirical work showing the relationship between free-market capitalism and peace (Gartzke, 2007; Weede, 2007). In much of the empirical work, the degree to which a country's economic institutions are consistent with laissez-faire capitalism is measure by the Economic Freedom of the World index, produced annually by the Fraser Institute. While the freedom to trade is certainly a part of economic freedom, it is only a part, and other parts of economic freedom might contribute to both international and domestic peace (Hall and Lawson, 2009). For example, the ability to freely work in labor markets without belonging to a particular ethnic or racial group might lessen reasons for domestic conflict. Additionally, when governments consume a smaller share of overall output, they reduce opportunities for internal conflict over the distribution of public resources.

The relationship between increased democracy and conflict reduction has also been called into question by research focusing on the relationship between capitalism and peace. As Gartzke (2005a) has argued, "the 'democratic peace' is a mirage created by the overlap between economic and political freedom." The mirage is largely due to the fact that more economic freedom and increased democracy typically occur simultaneously. Thus if economic freedom causes peace, it would be easy to find democracy also contributing to peace, especially if economic

freedom was not taken into account. According to Gartzke, after controlling for economic freedom, there is no statistically significant relationship between democracy and peace (Gartzke 2005b). In fact, changes in economic freedom are fifty times more important in encouraging peace than changes in democracy (Gartzke 2005a). Tures (2003) also finds a positive relationship between economic freedom and conflict reduction.

This paper further explores the relationship between economic freedom, political institutions, and conflict. We do so in two ways. First, we use a relatively new measure of peace, which measures the degree to which a country is currently engaged in both internal and external conflicts. Second, most of the literature measures democracy using the standard Polity IV data. Here we look specifically at protection of civil liberties by the government. When governments are limited and protect civil liberties of their citizens, they should be less likely to go to war with other nations or to foster internal conflict. According to our findings, countries with higher levels of economic freedom, other things equal, also have lower levels of external and internal conflict. In addition, we find a statistically significant relationship between the degree of civil liberty protection in a country and conflict. Our preliminary findings provide further evidence of the negative relationship between economic freedom and conflict (or positive relationship between economic freedom and peace) as well as suggest some avenues for future research as more data becomes available.

DATA AND EMPIRICAL APPROACH

Our analysis of the relationship between economic freedom, civil liberties, and violent conflict uses cross-sectional data on 106 countries for 2006. We are limited to a cross-sectional analysis for two reasons. First, our measure of conflict comes from the *Global Peace Index* (Economics Intelligence Unit, 2007) which has only been collected and published since 2006. Second, our measure of the degree to which a country's economic institutions are consistent with free-market capitalism is measured with a two year lag. Thus, given our desire to use a measure of peace that captures both internal and external peace, a cross-section reflecting freedom and conflict in 2006 is the only methodological approach available.

As mentioned, our dependent variable *Conflict* is obtained from the *Global Peace Index* (Economic Intelligence Unit, 2007). The 2007 *Global Peace Index* reviews the state of peace across countries for the year 2006. The index takes into consideration twenty-four independent factors per nation including such aspects as:

ongoing domestic and international conflict, measures of societal safety and security, and measures of militarization. A score from one to five is assigned for each of the 24 indicators. Scores of one indicate greater peace and scores of five indicate areas of conflict. The scores are then weighted and summed to produce an overall score for the entire country. Thus the composite score for a country ranges from one to five, with a score of one representing a country with a high level of peace and five representing a country with a high level of conflict and turmoil. For 2006, the *Global Peace Index* ranked 121 countries, with Norway having the most peace at 1.357 and Iran having the most conflict at 3.437.

The variable *Economic Freedom* is obtained from the annual *Economic Freedom of the World* (EFW) report published by the Fraser Institute (Gwartney and Lawson, 2008). The cornerstones of economic freedom are personal choice, voluntary exchange, freedom to compete, and security of private property. The authors of the report then use 42 different variables to measure the degree to which a country's policies are economically free. Each variable is assigned a score on a 0-10 scale, with zero representing an extremely low level of economic freedom and 10 being a high level of economic freedom. The scores are then aggregated to create an economic freedom score for the country as a whole. The data used to compile the EFW index are all obtained from third-party sources, and therefore reflect a two-year time lag. Thus data from the *Economic Freedom of the World: 2008 Annual Report* was used to reflect the level of economic freedom for 141 countries in 2006. In 2006, Hong Kong had the highest level of economic freedom at 8.94 and Zimbabwe had the lowest level with a score of 2.67.

The variable *Military Expenditure* is the percentage of Gross Domestic Product (GDP) spent by a country on the military and defense in 2006 (measured in 2006 U.S. dollars) and was obtained from the Stockholm International Peace Research Institute (2008). Military and defense expenditures are expressed as a percentage of Gross Domestic Product in order to gain a realistic perspective of the amount a country is spending per its fiscal size. Theoretically, military expenditures have two possible effects. On the one hand, government can buy peace through might (i.e., "hard power") by spending on the military. However, countries currently engaged in international conflict are likely to have high military expenditures as a percentage of GDP. So theoretically, the sign on military expenditures will be ambiguous.

The degree to which government respect their citizens civil liberties is measured with *Civil Constraint*, which is obtained from Freedom House's (2007) annual *Freedom in the World Report*. The report evaluates the ability for individuals

to act spontaneously and independently of their government in two broad categories: political rights and civil liberties. Our interest here is not in political rights, which have been covered by previous research on democracy and conflict, but with civil liberties. As defined by Freedom House, civil liberties allow for the freedoms of expression and belief, associational and organizational rights, rule of law, and personal autonomy without interference from the state. The total number of points awarded to a country or territory is based on the evaluation of fifteen civil liberties measures. Each geopolitical area was then assigned a rating between one and seven, with one representing the highest level of civil liberties and seven the lowest level. By naming our variable *Civil Constraint*, a higher score means less liberty and more constraints. We expect a positive relationship between civil liberties and conflict: when countries do not respect civil liberties, they will be more likely to have both internal and external conflict. (For a full list of countries included in the study see the Appendix).

The final dependent variable is a binary variable, *Africa*. It takes the value of one if a country is located on the continent of Africa and zero otherwise. The *Africa* variable was used for the purpose of determining whether or not Africa represented a unique case study in the relationship between economic freedom and conflict as it is in many other cases, such as economic growth (see, for example, Barro, 1991). *A priori*, we expect a positive relationship between *Africa* and *Conflict*.

Table 1: Descriptive Statistics				
Variable	Mean	SD	Min	Max
Conflict	1.98	0.38	1.37	3.03
Economic Freedom	6.76	0.91	2.67	8.57
Military Expenditure	2.36	1.80	0.20	11.40
African	0.22	0.41	0	1
Civil Constraint	2.80	1.58	1	6

After excluding countries with missing data, our sample consists of 106 countries. Summary statistics for each of the variables are provided in Table 1. Although *Conflict* has a possible maximum score of 5, the average country's score is centered about 1.98 with a standard deviation of about .38. The average country has an *Economic Freedom* score of 6.78 (consistent with the level of Uganda or

Poland) with a standard deviation of .91. The mean of *Military Expenditure* is 2.36 with a standard deviation of 1.80. In terms of civil liberties, the mean country had a score of 2.80 on the 1-7 scale, which means countries are, on average, more likely to protect civil liberties than violate them.

EMPIRICAL APPROACH AND RESULTS

To determine empirically if there exists a relationship between economic freedom and conflict, we estimated the relationship between the independent variables described in Section 2 and our dependent variable *Conflict* using Ordinary Least Squares (OLS). Our results are presented in Table 2. Our specification does a fairly good job of explaining cross-country variation in *Conflict*, with an r-squared of 0.43. Both multicollinearity and heteroskedasticity were tested for and neither was found to be a problem. While the correlation coefficient of 0.59 between *Economic Freedom* and *Civil Liberties* is cause for concern, tests of the variable inflation factor show that each variable is well below the acceptable threshold of ten. Both the Breusch-Pagan test and the White test were used to test for heteroskedasticity and in both cases we failed to reject the null of homoskedasticity.

Table 2: Economic Freedom and Conflict: OLS Results		
Variable	Coefficient	Standard Error
Constant	2.8297***	0.3216
Economic Freedom	-0.1616***	0.4107
Military Expenditure (log)	0.0281	0.0405
African	-0.0556	0.0785
Civil Constraint	0.0864***	0.0232
N	106	
R-sq	0.4275	
* indicates significance at the 10% level, ** at 5% level and *** at the 1% level		

In terms of our primary variable of interest, *Economic Freedom*, we have the expected negative sign and the coefficient of -0.16 is statistically significant at the one percent level. Everything else being equal, a one unit increase in a country's

economic freedom score is expected to reduce *Conflict* by 0.16 units. Our secondary variable of interest, *Civil Constraint*, is also statistically significant at the one percent level and has the expect sign. Since higher values mean *less* protection of civil liberties, the positive sign on the coefficient is the sign we expected; civil liberties, as measured by Freedom House (2007), do have a positive impact on peace, holding constant the impact of economic freedom on peace. Our other independent variables, *Military Expenditure* and *Africa*, are not statistically or economically significant. (*Military Expenditures* were expressed in log form to make sure heteroskedasticity was not a problem in our regressions).

CONCLUSION

Our results indicate some further evidence of a relationship between economic freedom and conflict reduction. In addition, civil liberties continue to be important for peace, even after controlling for economic freedom. Like many other studies in the growth literature, African countries are at a disadvantage when it comes to conflict reduction. Our results are consistent with work being done in international relations, and they support the idea that constitutional liberalism is consistent with both peace and prosperity.

When more data become available, a particularly fruitful line of research would be to run panels and explore the effect of economic freedom on peace over time. While our findings indicate that freer countries are more prosperous, it would be interesting to explore the effect of changes in economic freedom on peace. With more data, it would also be useful to check causality to determine if there are any positive feedback loops: in particular, as countries become more peaceful because of economic freedom, do they then promote more economic freedom?

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APPENDIX
LIST OF COUNTRIES INCLUDED IN ANALYSIS

Algeria, Angola, Argentina, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belgium, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Cote d'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Gabon, Germany, Ghana, Greece, Guatemala, Honduras, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kuwait, Latvia, Lithuania, Macedonia, Madagascar, Malawi, Malaysia, Mexico, Moldova, Morocco, Mozambique, Namibia, Netherlands, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Senegal, Singapore, Slovakia, Slovenia, South Africa, South Korea, Spain, Sri Lanka, Sweden, Switzerland, Syria, Taiwan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Venezuela, Vietnam, Zambia, and Zimbabwe.

AUTHORS' NOTE

CAN CULTURE EXPLAIN ECONOMIC GROWTH? A NOTE ON THE ISSUES REGARDING CULTURE-GROWTH STUDIES

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ABSTRACT

The notion that culture affects economic development and therefore explains growth has pre-occupied social scientists for decades. Studies have shown mixed results, some supporting that economic growth is shaped (at least in part) by cultural factors while others conclude otherwise. Intuitively, culture should affect growth since culture defines the belief systems of the people making up the economy and thus would ultimately affect economic growth. But the question is how do we show that empirically?

This paper attempts to answer that question by reviewing literature and examining more recent studies on the culture-growth dilemma then proceeds with summarizing issues regarding such studies as how they can possibly be resolved.

INTRODUCTION

Intuition will tell us that economic growth is affected by culture. History supports us in this as it shows how civilization with distinct culture was able to develop and grow economically. The ruins in Machu Picchu of Peru, Pyramids in Egypt, and the Angkor Wat in Cambodia are just but some evidence that we can see. In this modern age, we are again challenged to show this empirically using data rather than ruins. This is a challenge for most researchers and this paper summarizes the issues and provides some resolutions moving forward regarding this significant phenomenon.

LITERATURE REVIEW

Traditionally, literature presents culture and its different constructs and economic determinants of growth as separate and distinct. Political economists and political sociologists, even social psychologists, view their respective methodologies as mutually exclusive perhaps primarily due to the level of analysis employed by each and the underlying assumptions about human behavior. After all, culture is all about behavior and how it *changes* over time – on a collective basis. Additionally, there is the issue of inadequate measures of cultural factors because until these factors enter into a quantitative analysis, the hypothesis that it affects growth (or vice versa) cannot be tested.

Previously, studies attempting to establish the role of culture either infer culture from economic performance or estimate cultural factors from impressionistic historical evidence such as the obvious results of the industrialization and the Protestant Ethics to growth. We can see from history that all cultures of virtually all pre-industrial societies are hostile to social mobility and individual economic accumulation. These cultures are mostly influenced by religious beliefs. Both medieval Christianity and traditional Confucian culture stigmatized profit-making and entrepreneurship. Hence, there is some degree of hostility to social mobility and indirectly, growth. That may be the case until a Protestant version of Christianity played a key role in the rise of capitalism and much later, a modernized version of Confucian society which encourages economic growth through its support of education and achievement. As constructs, these are represented by values on thrift (which affects investment and savings), achievement motivation and post-materialism.

Motivational literature stresses the role of culture on economic achievement. It grows out naturally of Weber's Protestant Ethic thesis which gave rise to historical research by Tawney (1926, 1955), case studies by Harrison (1992), empirical work by McClelland et all (1953) and achievement motivation by McClelland (1961). In the 1970s, this was expanded by Inglehart (1971, 1977, 1990) by examining the shift from materialist to post-materialist value priorities which illustrate how culture can change and can thus explain a more dynamic phenomena called economic growth.

In the preceding arguments, culture is viewed as a system of basic common values that help shape the behavior of the people in a given society. This value system in most pre-industrial times takes the form of a religion and thus changes very slowly. But with industrialization and accompanying processes of

modernization, these worldviews tend to become more secular, rational and open to change and thus dynamic and variable enough to be quantified.

VARIOUS CULTURAL MODELS

Extant literature shows that there are five important and significant models and concept of culture which are mostly cited in studies on culture and growth – Kluckhohn and Strodtbeck (1961), Hofstede (1980, 1983, 1993), Rokeach (1960), Bond (1988) and Trompanaar (1993).

Model 1: Kluckhohn and Strodbeck

The work of Kluckhohn and Strodtbeck (KS)(1961) is one of the earliest cultural comparative models designed where they hypothesized that people of different cultures tend to have different orientations toward the world and people who are different from themselves. Hence, people of different cultures can be compared and differentiated using their orientation towards such dimensions as people, nature, relationship, human activity and even concept of space. Table 1 summarizes the details of the KS model.

Table 1: Kluckhohn and Strodtbeck's Cultural Orientation Model	
Concerns / Orientation	Possible Responses
Human nature: What is the basic nature of people?	*Good.* Most people are basically good at heart; they are born well. *Evil.* Most people can't be trusted; they are basically bad and need to be controlled. *Mixed.* There are both eveil and good people in the world; you have to check people out to find out which they are; they can change with the right guidance.
Man-nature Relationship: What is the appropriate relationship to nature?	*Subordinate to nature.* People really can't change nature; life is largely determined by external forces, such as fate and genetics; fatalistic – what happens was meant to happen. *Harmony with nature.* Man should, in every way, live in harmony with nature. *Dominant over nature.* It is the great human human challenge to conquer and control nature; everything from air-conditioning to the "green revolution" has resulted from having met this challenge.

Table 1: Kluckhohn and Strodtbeck's Cultural Orientation Model	
Concerns / Orientation	Possible Responses
Time sense: How should we best think of time?	*Past.* People should learn from history, draw the values they live by from history and strive to feel life has been worthwhile. *Present.* The present moment is everything; let's make the most of it; don't worry about tomorrow, enjoy today. *Future.* Planning and goal setting make it possible for people to accomplish miracles, to change and grow; a little sacrifice today will bring a better tomorrow.
Activity: What is the best mode of activity?	*Being.* It is enough to just "be"; it is not necessary to accomplish great things to feel your life has been worthwhile. *Becoming.* The main purpose for being placed on this earth is for one's own inner development. *Doing.* If people work hard and apply themselves fully, their efforts will be rewarded; what a person accomplishes is a measure of his own.
Social relations: What is the best form of social organization?	*Hierarchical.* There is nature order to relations, some people are born to lead, other to follow; decisions should be made by those in charge. *Collateral.* The best way to be organized is as a group where everyone shares in the decision process; it is important to not to make important decisions alone. *Individual.* All people should have equal rights, and each should have complete control over one's own destiny; when we have to make a decision as a group, it should be "one person one vote"
Kluckhohn, C. and F.L. Strodtbeck (1961). *Variation in value orientations.* Evanston, Illinois. Row, Peterson.	

The KS model proposes that it is possible to distinguish cultures based on how they each address these five common human concerns but these are not an exhaustive list. Furthermore, it is the rank order of responses that gave a culture its character and uniqueness. These five concerns are often called "value orientation" or "core values".

It is relevant to note that from economic growth viewpoint a culture's concept of time (i.e. affects decisions relating to savings and delayed gratification), human activity, and social relations (political culture perspective).

Model 2: Hofstede

In the early 1980's, Gert Hofstede published a book, *Culture's Consequences,* which presents results of his study on values in many countries through his work at IBM. In the said work, Hofstede presented cultural indices developed from surveys of 72,215 IBM employees in 40 countries between 1967 and 1973. Further data were then obtained from 10 additional regions (Hofstede, 1983, Hofstede and Bond, 1988). Hofstede found four important cultural measures, two (individualism and masculinity) resulted from factor analysis, while the other two (power distance and uncertainty) were derived from theoretical concepts. All indices were based on responses to questions framed by Western social scientists. Later on in a further study (1993), he would add a fifth dimension which is time.

Interestingly, in his 1983 study Hofstede related his measures of national culture with economic growth but his study shows significance only for rich countries yielding a negative correlation for individualism and a positive one for uncertainty avoidance (Hofstede, 1980). However, in a related study (with economic data lacking for Iran; cf. Franke, Mento, and Brooks, 1985) building on these findings it was argued that subsequent rather than prior economic growth should be considered. This analysis showed that a quarter of the variance in 1979-80 economic growth could be explained by cultural variables for 39 of the 40 nations. Specifically, individualism (a non-collectivistic orientation) and political instability (an index of political deaths during 1968-72) were found to be negative factors, both indicators of low social cohesion which might inhibit effective economic enterprise.

Model 3: Rokeach

In his landmark work *The Nature of Human Values* (1973), Milton Rokeach emphasized that value is an enduring belief that a specific mode of conduct (or behavior) or end-state of existence is personally or socially preferable than an opposite or converse mode of conduct or end-state of existence. In addition, a value system is an enduring organization of beliefs concerning preferable modes of conduct or end-states of existence along a continuum of relative importance. He concludes that to say that a person has a value is to say that he has an enduring prescriptive or proscriptive belief that such specific mode of conduct or end-state of existence is preferred to an opposite mode of behavior or end-state. This belief, he further stressed, transcends attitudes toward objects and toward situations; it is a standard that guides and determines action, attitudes toward objects and situations,

ideology, presentations of self to others, evaluations, judgments, justifications, comparisons of self with others, and attempts to influence others. Instrumental values (which refers to the values associated with a mode of behavior) and terminal values (which relates to end-states), are related yet are separately organized into relatively enduring hierarchical organizations along a continuum of importance. Table 2 shows the result of his extensive study on human values and value categories.

Table 2: The Rokeach Value Survey - Terminal and Instrumental Values	
Terminal Values	Instrumental Values
A comfortable life *(a prosperous life)*	Ambitious *(hard-working, aspiring)*
An exciting life *(a stimulating, active life)*	Broadminded *(open-minded)*
A sense of accomplishment *(lasting contribution)*	Capable *(competent, effective)*
A world at peace *(free of war and conflict)*	Cheerful *(lighthearted, joyful)*
A world of beauty *(beauty of nature and the arts)*	Clean *(neat, tidy)*
Equality *(brotherhood; equal opportunity for all)*	Courageous *(standing up for your beliefs)*
Family security *(taking care of loved ones)*	Forgiving *(willing to pardon others)*
Freedom *(independence, free choice)*	Helpful *(working for welfare of others)*
Happiness *(contentedness)*	Honest *(sincere, truthful)*
Inner harmony *(freedom from inner conflict)*	Imaginative *(daring, creative)*
Mature love *(sexual and spiritual intimacy)*	Independent *(self-reliant, self-sufficient)*
National security *(protection from attack)*	Intellectual *(intelligent, reflective)*

Table 2: The Rokeach Value Survey - Terminal and Instrumental Values	
Terminal Values	Instrumental Values

Pleasure
    (an enjoyable, leisurely life)
	Logical
	    (consistent, rational)

Salvation
    (saved, eternal life)
	Loving
	    (affectionate, tender)

Self-respect
    (self-esteem)
	Obedient
	    (dutiful, respectful)

Social recognition
    (respect, admiration)
	Polite
	    (courteous, well-mannered)

True friendship
    (close companionship)
	Responsible
	    (dependable, reliable)

Wisdom
    (a mature understanding of life)
	Self-controlled
	    (restrained, self-discipline)

Rokeach (1973). *The Nature of Human Values*. New York. The Free Press. pp 359-361	

Using Rokeach's Value Survey (RVS), by rank ordering value importance to an individual, culture could be compared. Hofstede and Bond (1984), on the other hand, related the national RVS factor scores to the Hofstede's four cultural dimensions and found that each of the four RVS factors correlated significantly with Hofstede's measure. Thus, both appraisals of culture seem to tap similar cultural information in six Western and Eastern countries common to the studies (i.e. Australia, New Zealand, Hong Kong, India, Japan and Taiwan). From here we could infer that culture is indeed more rigid and unchanging.

Model 4: The Chinese Culture Connection (TCCC) by Bond

Another cross-cultural model, this time not based on Western social science was proposed by Bond (1988) as he worked with other Chinese social scientists which he called the "The Chinese Culture Connection" (TCCC) or more popularly referred to in literature as the Chinese Value Survey (CVS). Perhaps motivated by the phenomenal growths exhibited by Eastern countries mostly Asia, Bond's study focused on unique value structures (thus cultural dimensions) of Asian countries. His model lists 40 "fundamental and basic values for Chinese people" and yielded four cultural factors: Confucian work dynamism, Integration, Human-heartedness,

and Moral Discipline. A cross-sectional comparison of 20 nationals and regions in common with the Hofstede study showed significant correlations of three of the four CVS factors with three of the four Hofstede measures. Both Western uncertainty avoidance and Eastern Confucian dynamism were statistically independent of the two measures. Confucian dynamism was noted to be correlated with national economic growth and was suggested as an index of the social philosophy hypothesized to be responsible for the stunning economic development of Oriental cultures with a "Chinese" heritage.

Model 5: Trompenaar's Cultural Dimensions

A fifth, more recent cultural model and a deviation from a single-point of view models of culture, is the one proposed by Trompenaars (1994). He argued that culture can be examined on different levels: individual, organizational and national. On an individual level, culture can be viewed as the way people share and express their values. On an organizational level, it can be looked at as the way in which people within an organization express attitudes, and on a national level, it is as away in which attitudes are expressed in a particular country or geographical region.

Moreover, he asserts that every culture distinguishes itself from others by the specific solutions it chooses to certain problems which reveal themselves as dilemmas. It is convenient to look at such problems under three areas: those which arise from relationships with other people, those which come from the passage of time, and those which relate to the environment.

Trompenaars' cross-cultural dimensions allow us to further breakdown our unit of analysis for cultural variables into the individual, organization and nation. This allowed researchers to have a more flexible definition of a cultural unit other than an independent state. In the era of globalization or even localization, the concept of defining and measuring culture beyond the boundary of political economies becomes more significant.

Common elements of the cultural construct

The five models of culture present two elements which allowed culture to be compared or even related to growth. The first is that it defines culture into dimensions which not only describes a specific country's culture but provides a way to distinguish it from the other. This discriminatory aspect of measuring culture allowed more robust tests to be conducted to explain growth. Next is that culture as

presented by the five models are both descriptive (past and present) and predictive (future). This aspect of culture allows it to be tested against economic variables such as growth.

However, it is very curious to note how the models constructs culture using different components, dimensions or elements but does not provide a holistic measure of culture.

CULTURE-GROWTH STUDIES

With the development of cross-cultural models, studies relating culture to growth started to take off. Notable studies in this area are those of Franke, Hofstede and Bond (1991) and Granato, Ingelhart and Leblang (1996).

Franke, Hofstede and Bond (1991) linked culture and economy, suggesting that values fostered in a nation's families, organizations, and political life are reflected in its economic statistics. In the said study, they utilized cultural measures (predominantly Models 3 and 4) to evaluate differences in economic performance at the level of nations (3rd level according to Trompanaars). Cultural indices were derived from Western and Chinese investigations of people's values explained more than 50% of the international differences in economic growth rates for the period 1965-80 and 1980-87, employing samples of 18 and 20 nations. Empirical analysis further shows the potential of cultural measures in explaining the growth phenomenon. According to their regression equation, two cultural measures, whose sources and values are quite different, account for most of the variance in national economic growth rates. Confucian dynamism-a measure extracted from a questionnaire developed by Chinese scholars which stresses the dynamic rather than the static values traditionally found in Confucianism-has the most consistent explanatory power. This index appears to explain the relative success of East Asian economies over the past quarter century.

The second cultural variable with strong explanatory power, based on data collected within subsidiaries of IBM around the world, is individualism-a liability in a world in which group cohesion appears to be a key requirement for collective economic effectiveness. In addition, in multiple regressions for the period after 1980, economic growth seems to be aided by relative equality of power among people in organizations (lower power distance) and by a tendency toward competitiveness at the expense of friendship and harmony (lower integration).

Their finding that national differences in dominant cultural values exist and affect economic life is, of course, a common sense insight. Until now, however,

these differences had not been identified, measured and interpreted so that their relationships to economic performance could be better appreciated.

In a more recent study of Granato, Ingelhart and Leblang or GIL (1996), they used the two dimension of culture in their multivariate analysis and a more dynamic endogenous growth model of Levine and Renelt (1992). They build on their thesis on culture from motivational literature which stresses the role of cultural emphasis on economic achievement. This school of thought primarily grew out of Weber's (1904-1905) Protestant Ethic thesis. In trying to measure culture, GIL came up with an achievement motivational index using the World Values Survey (WVS) which sums up the percentage in each country emphasizing autonomy and economic achievement such as "thrift", "saving money and things", and "determination" minus the percentage emphasizing conformity to traditional social norms such as "obedience" and "religious faith". A given society's emphasis on thrift and determination **over** obedience and religious faith has a strong bivariate linkage with its rate of economic growth over the past three decades ($r = .66; p = .001$).

While GIL's cultural construct does not reflect an authoritarianism dimension of culture, it reflects the balance between emphasis on two types of values. One set of values thrift and determination-support economic achievement; while the other-obedience and religious faith-tend to discourage it, emphasizing conformity to traditional authority and group norms. These two types of values are not necessarily incompatible: some societies rank relatively high on both, while others rank relatively low on both. But, the relative *priority* given to them is strongly related to its growth rate.

In light of this data structure, GIL interestingly posits the question "Do cultural factors lead to economic growth, or does economic growth lead to cultural change?" They then argue that the causal flow can work in both directions. For example, there is strong evidence that post-materialist values emerges when a society attains relatively high levels of economic security. In this case, economic change reshapes culture. On the other hand, once these values become widespread, they are linked with relatively low subsequent rates of economic growth. Here, culture seems to be shaping economics - a parallel to the Weberian thesis, except that what is happening here is, in a sense, the rise of the Protestant Ethic in reverse.

They admit though that demonstrating causal connections is always difficult. In connection with the achievement motivation index, the obvious interpretation would be that emphasis on thrift and hard work, rather than on obedience and respect is conducive to economic growth. The two most sensitive indicators of this dimension are thrift, on the one hand, and obedience on the other.

For some time, economists have been aware that a nation's rate of gross domestic investment is a major influence on its long term growth rate. Investment, in turn, depends on savings. Thus, a society that emphasizes thrift produces savings, which leads to investment, and later to economic growth. We provide evidence below that this is probably the case. This does not rule out the possibility that economic growth might be conducive to thrift but this linkage is less obvious.

Emphasis on obedience is negatively linked with economic growth, for a converse reason. In pre-industrial societies, obedience means conformity to traditional norms, which de-emphasize and even stigmatize economic accumulation. Obedience, respect for others, and religious faith all emphasize obligations to share with and support one's relatives, friends and neighbors. Such communal obligations are strongly felt in pre-industrial societies. But from the perspective of a bureaucratized rational-legal society, these norms are antithetical to capital accumulation and conducive to nepotism. Furthermore, conformity to authority inhibits innovation and entrepreneurship which leads to increased economic activity and growth.

The motivational component was also tapped by materialist/postmaterialist values, with postmaterialism having a negative relationship with economic growth. The achievement motivation variable is only modestly correlated with the materialist/postmaterialist dimension *(r=-.39; p=*.0581). Though both dimensions have significant linkages with economic growth, they affect it in different ways. The achievement motivation dimension seems to tap the transition from pre-industrial to industrial values systems, linked with the modernization process.

The materialist/postmaterialist dimension reflects the transition to postindustrial society, linked with a shift away from emphasis on economic growth, toward increasing emphasis on protection of the environment and on the quality of life more generally. Previous research demonstrates that:

(1)   a gradual shift from materialist toward postmaterialist goals has been taking place throughout advanced industrial society;

(2)   this shift is strongly related to the emergence of democracy (r = .71); but

(3)   it has a tendency to be negatively linked with economic growth (Abramson and Inglehart 1995).

This brings GIL to consider more dynamic growth models such as *endogenous growth* models. At the heart of the endogenous growth literature is an emphasis on the productivity of the population (Lucas 1988; Romer 1990). Unlike the "old" neoclassical models, endogenous growth models show that reproducible capital need not have decreasing returns to scale. Growth can be sustained in endogenous growth models. In particular, they assume constant returns to scale to a broad range of reproducible inputs, including human capital.

The two leading schools of thought, however, differ in their emphasis. Romer (1990), argues that Research and Development (R&D) spending is the key to new technological developments, which result in increasing social returns to social knowledge. Alternatively, Lucas (1988) argues that expansion of human capital in terms of both education and "learning by doing," also plays a pivotal role in economic growth.

Empirical endogenous growth models invariably are of the following form:

$$Y_i = \beta I_{i,o} + \Pi X_i + \varepsilon_i \qquad [1]$$

where Y is output growth (per capita) for country i, $I_{i,o}$ is a set of economic variables measured at the beginning of the time period for country i. These variables include initial levels of wealth and investment in human capital, and are included because studies by Barro (1991), Helliwell (1994), Levine and Renelt (1992), and Mankiw, Romer, and Weil(1992) all find that they have a robust and positive partial correlation with economic growth. X, is a set of "other variables" including a constant, physical capital investment rates (as a percent of GDP usually), and whatever other variables the investigator is interested in exploring. Obviously, given the preceding discussion, variable X will include achievement motivation and post-materialism.

GIL used the model of Levine and Renelt (1992) because they found that in Levine and Renelt's model, the initial level of per capita income, the initial level of human capital investment, and the period share of investment to GDP have robust correlations with economic growth. They find that most other exogenous variables are fragile to alterations in the conditioning set of information. Thus, the conclusions of most empirical work rest on parameter estimates that fluctuate at a magnitude large enough to make scholars wary. Furthermore, Levine and Renelt's (1992) work is also informative in that they provide a straightforward way to evaluate the sensitivity of the cultural variables.

Following Equation [I], GIL then regressed a nation's rate of per capita economic growth i on its initial level of per capita income and human capital investment (education spending) as well as on its rate of physical capital accumulation. As expected, the results (shown as Table 3) are quite compatible with the expectations of endogenous growth theory. The results of Model 1 are summarized as follows:

(1)   the significant negative coefficient on the initial level of per capita income indicates that there is evidence of "conditional convergence." That is, controlling for human and physical capital investment, poorer nations grow faster than richer nations;

(2)   investment in human capital (education spending) has a positive and statistically significant effect on subsequent economic growth; and

(3)   increasing the rate of physical capital accumulation increases a nation's rate of economic growth.

Overall this baseline economic model performs well: it accounts for 55% of the variation in cross-national growth rates and is consistent with prior cross-national tests of the conditional convergence hypothesis (e.g., Barro 1991; Mankiw, Romer, and Weil 1992). Model 1 also passes all diagnostic tests, indicating that the residuals are not serially correlated5 (LM test), are normally distributed (Jarque-Bera test), and homoskedastic (White test).

GIL continued by regressing a 2-variable culture dimensions of Achievement motivation and postmaterialism which further increased explanatory power of the model to 59% (referred to as Model 2 in Table 3). Then they combined both the economic and cultural variables and came up with Model 3. After which, they performed a sensitivity analysis eliminating the three insignificant variables before finally coming up with a more robust model, Model 4.

Table 3: GIL's OLS Estimation of Economic Growth Models
Using Dependent Variable: Mean Rate of Per Capital Economic Growth (1960-89)

Model Variable	Model 1	Model 2	Model 3	Model 4
Constant	−0.70	7.29*	3.16	2.40*
	(1.08)	(1.49)	(1.94)	(0.77)
Per Capita GDP in 1960	−0.63*		−0.42*	−0.43*
	(0.14)		(0.14)	(0.10)
Primary Education in 1960	2.69*		2.19*	2.09*
	(1.22)		(1.06)	(0.96)
Secondary Education in 1960	3.27*		1.21	
	(1.01)		(1.08)	
Investment	8.69*		3.09	
	(4.90)		(4.40)	
Achievement Motivation		2.07*	1.44*	1.88*
		(0.37)	(0.48)	(0.35)
Postmaterialism		−2.24*	−1.07	
		(0.77)	(1.03)	
R^2 Adjusted	.55	.59	.69	.70
SEE	.86	.83	.72	.71
LM ($\chi^2(1)$)	.42	.65	.68	.87
Jarque-Bera ($\chi^2(2)$)	.05	.30	.18	.57
White ($\chi^2(1)$)	.28	.24	.37	.18
SC	.119	−.117	−.095	−.352

Notes: Mean of dependent variable: 3.04; *N* is 25 for all models; Standard errors in parentheses.
*t test: $p < .05$.

Granato, J., R. Inglehart and D. Leblang. (1996). The Effect of Cultural Values on Economic Development:Theory, Hypotheses, and Some Empirical Tests. *American Journal of Political Science*, 40(3). 607-631.

      In conclusion, GIL accepts that the idea that economic growth is partly shaped by cultural factors has encountered considerable resistance. One reason for this resistance, they claim is because cultural values have been widely perceived as diffuse and permanent features of given societies: if cultural values determine economic growth, then the outlook for economic development seems hopeless, because culture cannot be changed. Another reason for opposition is that standard economic arguments supposedly suffice for international differences in savings and

growth rates. For example, the standard life cycle model and not cultural arguments explains the difference in savings rates and growth rates between, say, Germany, Japan, and the United States.

However, they assert that when culture is approached as something to be measured on a quantitative empirical basis, the illusion of diffuseness and permanence disappears. We no longer deal with gross stereotypes, such as the idea that "Germans have always been militaristic," or "Hispanic culture is unfavorable to development." Thus, analysis now shifts to specific components of a given culture at a given time and place. Though these changes have been gradual, they demonstrate that central elements of culture can and do change.

Furthermore, GIL's study provides encouragement that empirical research can help identify specific components of culture that are relevant to economic development. One need not seek to change a society's entire way of life. The present findings suggest that one specific dimension-achievement motivation-is highly relevant to economic growth rates. In the short run, to change even a relatively narrow and well-defined cultural component such as this is not easy, but it should be far easier than attempting to change an entire culture. Furthermore, empirical research demonstrates that culture can and does change. Simply making parents, schools and other organizations aware of the potentially relevant factors, may be a step in the right direction.

Their study further finds that economic theory already is augmented with "social norms" and "cultural" factors (Cole, Malaith, and Postlewaite 1992; Elster 1989; Fershtman and Weiss 1993). Where would cultural values fit theoretically in growth models? The economics literature is replete with models of savings behavior that focus on the "life cycle" and, more specifically, the bequest motive. Cultural variables matter here. Since savings and investment behavior holds an important place in growth models, a determination of how cultural and motivational factors can be used to augment these existing economic models, it seems, is the next step to uncovering a better understanding of economic. In the end, however, these arguments can only be resolved on the empirical battlefield.

The results of GIL's study demonstrate that *both* cultural and economic arguments matter. Neither supplants the other. Future theoretical and empirical work is therefore better served by treating these "separate" explanations as complementary rather than mutually exclusive.

ISSUES AND RESOLUTIONS

The foregoing review highlights some important issues relating to factoring culture into growth economics. It seems that there are three main issues, one relating to the concept of culture, another to measures of cultural factors and third, appropriate operational models.

Concept of Culture

Hofstede defined culture as "the collective programming of the mind which distinguishes the members of one human group from another . . . culture, in this sense includes systems of values and values are among the building blocks of culture". As such, culture relies on structures of values of its members.

Kluckhohn (1951) defined value as "a conception, explicit or implicit . . . of the desirable which influences the selection from available modes, means and ends of action". Rokeach (1968) further refined this concept by stating that it refers to "abstract ideals, not tied to any specific object or situation, representing a person's belief about modes of conduct and ideal terminal modes". England (1967) views it as composing "a relatively permanent perceptual framework which shapes and influences the general nature of an individual's behavior". Williams (1968) further adds that the core phenomenon is that values serves as "criteria or standards of preference". Posner and Schmidt (1996) described it as lying "at the core of personality, influencing the choices individual makes . . . and the way individuals and organizations alike invest their time and energy". This implies the centrality of values in understanding and even predicting (or at least antecedents of) actual human behavior (Homer and Kahle, 1988; Connor and Becker, 1994).

Culling from the works of Aizen and Fishbein (1980) and Fazio (1986), Connor and Becker (2003) stressed that behavior is the most readily observable variable, with attitudes and values successively inferential. Furthermore, this relationship provided a major reason for the growth in scholars' interest in values: the pervasive and important influence of values on an individual's interpersonal, decision-making, ethical and performance behavior (England, 1967; England and Lee, 1974). Indeed, most researchers conclude that values are predictors or at least antecedents of actual behavior. Research has shown that the most important indicator of attitudes and behavior is value structure since values are the underlying structures that affect attitude and subsequently behavior (Ajzen, 1988; Kahle, 1985; Murphy and Anderson, 2003; Rokeach, 1979).

Rokeach further adds that values transcends attitudes toward objects and toward situations; it is a standard that guides and determines action, attitudes toward objects and situations, ideology, presentations of self to others, evaluations, judgments, justifications, comparisons of self with others, and attempts to influence others. Thus, extending it to how cultures are formed, cultures are both stable and universal concept.

Williams (1968) further attests to this enduring quality of value when he wrote, "It is the rare and limiting case if and when a person's behavior is guided over a considerable period of time by one and only one value . . . more often particular acts or sequences of acts are steered by multiple and changing clusters of values." After a value is learned it becomes integrated into an organized system of values wherein each value is ordered in priority with respect to other values. Such relative conception of values enables us to define change as a reordering of priorities and, at the same time, to see the total value system as relatively stable over time. It is stable enough to reflect the fact of sameness and continuity of a unique personality socialized within a given culture and society, and yet unstable enough to permit rearrangements of value priorities as a result of changes in culture, society and personal experiences.

While the universality of values, the essential building blocks of culture, allows researchers to compare similar value constructs across different countries, the enduring and stable aspects of values (and hence culture) makes it difficult to measure values or changes in values over a short time period to explain growth.

This leads to another issue regarding the appropriate period dimensions (i.e. annual, 5-year cycles, etc.) within which changes or variations in cultural measures could be correlated or regressed. This maybe addressed by using appropriate panel data analysis or other specialized econometric or statistic models.

Measurement

Culture, by definition, is a very qualitative concept. While we could use different operational constructs to measure each dimension of culture, the issue remains how do we measure culture as a whole.

Most studies in measuring culture use either a single or a set of dimensional variables (i.e. Confucian-work dynamism) separately and in a single time period. Few studies, like Hofstede's and Bond's, measures the same variables or dimension in two or more time periods. Comparable data across countries and time is not available or does not even exist.

Furthermore, there seems to be no consensus among scholars which cultural construct is superior or is at least widely accepted. I believe, this is perhaps due to the very dynamic and multi-faceted nature of culture per se.

Models and Methodologies

Most common models or methodologies in factoring in culture to explain growth includes regressions and multivariate analysis. While results of studies such as Granato, Ingelhart and Leblang has shown empirically that culture is an important explanatory variable to growth, using only a dimension (those quantifiable) of culture does not really do justice to the holistic concept to of culture which we intuitively, at least, accept as a key determinant of growth.

The need for a more robust regression model which can integrate both qualitative and quantitative dimensions of culture as a pattern or holistic measure of culture, and bootstrap sampling methods would thus be primordial in coming up with a more widely acceptable empirical basis if not an irrefutable proof of what we accept intuitively as true.

CONCLUSION

The question "Can culture explain economic growth?" should not be addressed with either an affirmative nor negative response. Instead, the above literature points to the intuitive and empirical basis that indeed culture at the very least, in part explains economic growth. I believe, the more pertinent question for researchers now is "how to measure the effect of culture in explaining economic growth using more robust modeling techniques" and of course, continuous sampling and data collection across different countries.

Significance-wise, studies on culture and its effect on economic growth is gaining momentum. With business becoming more and more international, profiles of national culture can become tools for strategic choices in corporate boardrooms. Sensitivity to cultural variables will be needed for decisions as to what to do in which country. However, national cultural differences often are treated at the level of gut feelings, sometimes even as cocktail-party joke but we should view human values as serious business. Indeed, studies now should be undertaken to determine whether organizations which differ in terms of these cultural characteristics also differ in economic performance.

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DIFFERENT PRICE INDICES AND THE IMPLICATION FOR THE FEDERAL RESERVE REACTION FUNCTION: AN EMPIRICAL STUDY

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ABSTRACT

This paper demonstrates the importance of properly measuring inflation when estimating Federal Reserve reaction functions. Based on static Taylor rule type reaction functions the median consumer price index (MCPI) is a better measure of information on monetary inflation than either the consumer price index (CPI) or the GDP chain-type price index (CTPI) or several other common measures of inflation. The issue is important when attempting to assess the stance of monetary policy; the Federal Reserve's goal of maintaining price stability must account for movements in the overall price-level and not changes in relative price.

INTRODUCTION

This paper examines the implications of using different price indices in the estimation of Federal Reserve reaction functions. The use of different indices generates different reactions by the Federal Reserve to inflation based on the time period being analyzed. Taking the two main goals of the Federal Reserve as given, which are to promote economic growth and maintain price stability, it is critical when attempting to determine the stance of monetary policy to understand the implications from the use of different measures of inflation. Mismeasuring price level changes may lead to faulty conclusions about the stance of monetary policy, in particular the Federal Reserve's stance on inflation. The price indices examined

in this paper include the Consumer Price Index (CPI), the consumer price index less food and energy (CPILF), the Gross Domestic Product chain-type price index (CTPI), the GDP deflator (DEF), the personal consumption expenditures index (PCE), the personal consumption expenditures index less food and energy (PCELF), and the Median Consumer Price Index (MCPI).

The first six indices are familiar to economists; the seventh may be somewhat less familiar. The MCPI is a measure of inflation calculated by the Cleveland Federal Reserve Bank. Bryan and Pike (1991) provide a brief explanation of the calculation of the MCPI and rationale for using the MCPI to estimate the rate of inflation.

"The median of a set of data is the value of the middle observation when all items are arranged in either ascending or descending order of magnitude. In effect the median consumer price change is the CPI less everything but the price change that lies in the middle of the continuum. Since only the order, not the values, of the various price changes is used in its calculation, the median is a central tendency statistic that is largely independent of the data's distribution. The median also has the intuitively appealing property of lying closer to the majority of price changes than does any alternative measure." (Bryan & Pike, 1991)

A more rigorous discussion of the median price index as a measure of monetary inflation, or a "trimmed means estimator of inflation" can be found in Bryan, Cecchetti, and Wiggins (1997). The authors find that the trimmed means estimators yield an efficient estimator of core inflation which is twenty-three percent more efficient than the standard mean CPI.

The Consumer Price Index (CPI) as the measure of inflation in the U.S. economy is probably one of the most often cited pieces of economic information. Everything from Social Security benefits to union contracts depend upon the consumer price index, through the use of cost of living adjustments. The case has been made that the CPI overstates the rate of inflation therefore it may not be the most appropriate measure of monetary inflation or the price level in the economy (The reasons why the CPI may overstate inflation are outside the scope of this paper, see Wynne and Sigalla (1993) or Shapiro and Wilcox (1996) for a detailed discussion of the issues). However, based on the underlying implications for the CPI, it remains an important measure of macroeconomic performance.

The GDP deflator index is often used as an alternative to the CPI when estimating the rate of inflation. The inflation rate as measured by the GDP chain-type price index tends to be lower than that measured by the CPI. In fact, the inflation rate as measured by the CPI exceeds that from the GDP chain-type price

index in 95 of the 133 quarters (or over seventy-percent of the time) from 1968 Q4 through 2001 Q4. The GDP chain-type price index is the broadest measure of the price level, in that, it includes goods and services not captured by the CPI, including investment goods. Both the CPI and the GDP chain-type price index appear as measures of inflation in the reaction function literature with varying degrees of significance, for example Judd and Rudebusch (1998). Figure 1 shows a plot of the CPI and GDP chain-type price indices from 1968 Q4 through 2001 Q4 using quarterly data.

Figure 1: Consumer Price Index and GDP chain-type price index, 1968.4 -2001.4
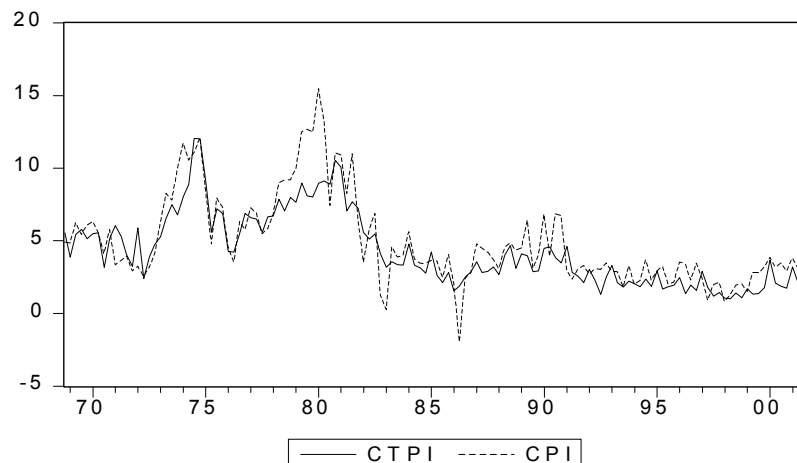
The use of the CPI as the measure of inflation is troublesome because in addition to measuring changes in the overall price level (inflation) the CPI also tends to measure changes in relative price movements. The issue addressed in this paper is whether or not there exists a measure of inflation that is "better" than either the CPI or CTPI, or other popular measures of inflation including the PCE, for determining the stance of monetary policy. The answer according to Bryan and Pike (1991) is yes. As demonstrated by Bryan and Pike, the MCPI is more closely related to changes in the money supply than the CPI, which indicates that it is a better measure of monetary inflation and is less affected by relative price changes.

"Distinguishing between inflation and relative price movements is also important for the conduct of monetary policy. Without a clear distinction between the two, policymakers may inadvertently react to relative price changes and thereby

complicate the economy's adjustment to a new set of prices. By not reacting to changes in the inflation rate, they might allow unnecessary price level fluctuations." (Bryan & Pike, 1991)

Figure 2 plots inflation measured form the CPI and the MCPI from 1968.4 through 2001.4. From the Figure we see that the MCPI is less volatile than the CPI particularly from the mid-1980s through 2001. Table 1 provides descriptive statistics for inflation based on the seven price indices being examined. The table indicates that for the entire sample inflation as measured by the CTPI or the PCELF are on average lower than either the CPI or MCPI and they both also have smaller standard deviations. Table 1 also shows that during both periods the CPI and CTPI have minimums which indicate deflation, whereas the minimum inflation rate based on the MCPI is approximately 2.3 percent.

Figure 2: Inflation measured by the MCPI and CPI, 1968.4 - 2001.4
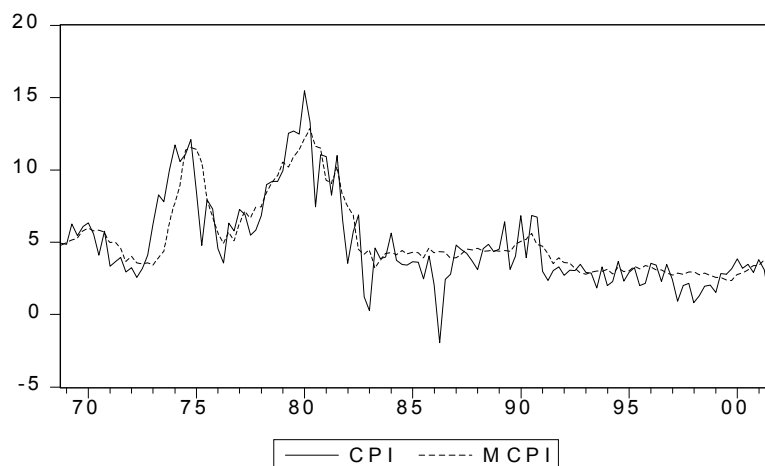
According to Brunner (1994) and Hetzel (2000) this latter period represents a regime shift at the Federal Reserve where inflation began to receive greater attention and the role of monetary growth was de-emphasized. This also represents a period where the federal funds rate became the primary tool of monetary policy. Table 2 provides the correlation matrix between the different price indices and the federal funds rate. The results indicate that over the whole sample the CPILF has the highest correlation with the federal funds rate and the CTPI has the lowest correlation with the federal funds rate. During the more recent time period the MCPI has the highest correlation with the federal funds rate followed by the GDP

deflator and the GDP chain-type price index, the latter two represent much broader measures of inflation than does the CPI. Interestingly, during this more recent time-period the CPI has the lowest correlation with the federal funds rate, (0.472), of the seven price indices.

Table 1A: Summary Statistics for inflation, based on price indices, 1969.1-2001.4							
	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
Mean	4.883	4.926	4.287	4.286	5.186	4.331	4.242
Median	3.859	4.224	3.561	3.575	4.372	3.758	3.947
Standard Dev.	3.117	2.728	2.529	2.531	2.569	2.621	2.210
Minimum	-1.952	1.372	-0.255	-0.255	2.362	0.241	0.840
Maximum	15.479	14.522	12.049	11.795	12.863	11.738	11.032
Count	133	133	133	133	133	133	133
Table 1B: Summary Statistics for inflation, based on price indices, 1982.1-2001.4							
	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
Mean	3.190	3.543	2.689	2.689	3.770	2.838	3.059
Median	3.147	3.414	2.604	2.636	3.744	2.674	3.034
Standard Dev.	1.546	1.204	1.143	1.146	0.938	1.327	1.370
Minimum	-1.952	1.372	-0.255	-0.255	2.362	0.241	0.840
Maximum	6.887	7.334	5.577	5.551	7.476	6.211	6.354
Count	80	80	80	80	80	80	80

Table 2A: Correlation Matrix, 1969.1-2001.4								
	FFR	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
FFR	1.0000							
CPI	0.6491	1.0000						
CPILF	0.7082	0.8876	1.0000					
CTPI	0.6128	0.8857	0.8575	1.0000				
DEF	0.6150	0.8836	0.8545	0.9949	1.0000			
MCPI	0.6521	0.8503	0.9139	0.8851	0.8813	1.0000		
PCE	0.6260	0.9445	0.8437	0.9336	0.9279	0.8596	1.0000	
PCELF	0.6529	0.8035	0.8814	0.9076	0.9004	0.8916	0.9073	1.0000

Table 2B: Correlation Matrix, 1982.1-2001.4							
	FFR	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
FFR	1.0000							
CPI	0.4724	1.0000						
CPILF	0.6793	0.6697	1.0000					
CTPI	0.7040	0.6556	0.7473	1.0000				
DEF	0.7032	0.6571	0.7511	0.9977	1.0000			
MCPI	0.7599	0.4300	0.7767	0.7087	0.7053	1.0000		
PCE	0.6223	0.8118	0.6782	0.8154	0.8103	0.6267	1.0000	
PCELF	0.6733	0.4056	0.7400	0.7690	0.7629	0.7695	0.8014	1.0000

DATA AND METHODOLOGY

All data are quarterly and cover 1968.4 through 2001.4. The starting point for the data represents the beginning of the median consumer price index series available from the Cleveland Federal Reserve Bank. The data covering real gross domestic product, the consumer price index, the gross domestic product chain-type price index, and the federal funds rate are from the St. Louis Federal Reserve Bank (The internet source for the St. Louis Federal Reserve Bank, Federal Reserve Economic Data is http://www.stls.frb.org/fred/index.html). Data for the median consumer price index are from the Cleveland Federal Reserve Bank, where the series is maintained (The internet source for the Median Consumer Price Index at the Cleveland Federal Reserve bank is http://www.clev.frb.org/Research/index.htm#data). Following convention annualized growth rates for inflation and GDP are calculated according to:

$$\pi_{i,t} = 400*(ln(P_t) - ln(P_{t-1}))$$
$$and$$
$$y_t = 400*(ln(GDP_t) - ln(GDP_{t-1}))$$

The quarterly data on the MCPI were provided by researchers at the Cleveland Federal Reserve Bank.

The reaction function to be estimated is given by the following:

$$FFR_t = c + \eta FFR_{t-1} + \alpha y_t + \beta \pi_{i,t}.$$

Where FFR_t is the current federal funds rate, FFR_{t-1} is the federal funds rate from the previous quarter, y_t is the growth rate of real GDP, $\pi_{i,t}$ is the inflation rate based on the three different indices, and c is a constant. The rationale for including the lagged federal funds rate is to capture potential interest rate smoothing by the Fed. The coefficients to be estimated are c, η, α, and β. This reaction function differs from the standard "Taylor rule" reaction function, estimated by Taylor (1993) in that rather than using output gaps and inflation gaps, the estimation is based on the growth rates of real GDP and inflation. This alternative estimation has the advantage of not having to determine the Federal Reserve's inflation target or possible issues with determining potential GDP and has been used in several empirical papers including McNees (1986) and Perez (2000). Federal Reserve reaction functions similar to the one above have been estimated in a variety of settings, for example Bernanke and Blinder (1992), Brunner (1994), Balke and Emery (1994), Christiano, Eichenbaum, and Evans (1996), and Rudebusch (1998).
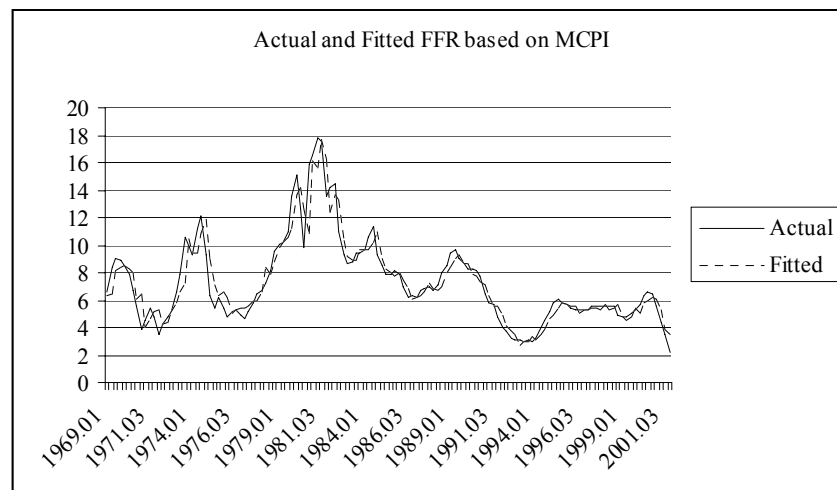
RESULTS

The reaction function above is estimated over two time periods, 1968.4, after accounting for the lagged federal funds rate, through 2001.4 and also the more recent time period 1982.1 through 2001.4, which represents a relatively stable period of monetary policy. Table 3 provides the results of the estimation from 1968.4 through 2001.4. Over the whole sample there are only minor differences between the estimations. Based on the results, the federal funds rate reacts least strongly to inflation measured from by the MCPI than from the other two measures of inflation. However, both inflation and real GDP growth have significant and positive effects on the FFR in all seven equations. In addition, the adjusted R-squared for the CPI equation and the standard error of regression from the CPI equation indicate that the CPI provides a slightly better fit than inflation measured by the other indices. There are very small differences in the response to the growth rate of GDP among the seven estimations. Therefore, the conclusion for the entire sample is that the choice of the price index is relatively unimportant and that the differences in the Federal Reserve reaction functions based on the indices are negligible. Figure 3 plots the actual federal funds rate over this time period against

the fitted federal funds rate from the MCPI regression, the plot appears to show a very good fit based on the MCPI.

Table 3: Reaction functions estimated over 1969.1 – 2001.4.							
Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].							
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-0.273 (0.282) [0.336]	-0.300 (0.286) [0.297]	-0.307 (0.295) [0.301]	-0.303 (0.295) [0.305]	-0.386 (0.305) [0.209]	-0.308 (0.289) [0.289]	-0.312 (0.300) [0.300]
FFR(t-1)	0.887 (0.037) [0.000]	0.874 (0.041) [0.000]	0.916 (0.038) [0.000]	0.915 (0.039) [0.000]	0.918 (0.041) [0.000]	0.903 (0.038) [0.000]	0.917 (0.041) [0.000]
GDP Growth	0.096 (0.027) [0.001]	0.097 (0.028) [0.001]	0.098 (0.028) [0.001]	0.098 (0.028) [0.001]	0.104 (0.029) [0.000]	0.096 (0.028) [0.001]	0.097 (0.029) [0.001]
CPI	0.160 (0.035) [0.000]						
CPILF		0.185 (0.044) [0.000]					
CTPI			0.140 (0.045) [0.002]				
DEF				0.141 (0.045) [0.002]			
MCPI					0.125 (0.048) [0.010]		
PCE						0.162 (0.042) [0.000]	

Table 3: Reaction functions estimated over 1969.1 – 2001.4.							
Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].							
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PCELF							0.142 (0.055) [0.011]
Adj. R-Square	0.894	0.891	0.885	0.885	0.883	0.889	0.883
SE of Reg.	1.019	1.031	1.060	1.060	1.072	1.041	1.072
AIC	2.906	2.930	2.984	2.983	3.006	2.949	3.007

Figure 3: Actual and fitted FFR based on inflation from the MCPI, 1969 Q1 – 2001

To determine whether or not the regression equations estimated are stationary, an augmented Dickey-Fuller test (ADF) is performed on the residuals for each equation. The results of the ADF tests are presented in Table 4. For each of the equations the null hypothesis of a unit root in the residuals is rejected at the 1-percent significance level. This implies that the relationships described in Table 3 are not spurious and perhaps there is a long-run cointegrating relationship among the FFR output and prices.

Table 4: Results of ADF tests on the residuals from the estimated equations, 1968.4 – 2001.4		
Equation	Test Statistic	1 Percent Critical Value
CPI	-4.037	-2.582
CPILF	-3.996	-2.582
CTPI	-3.909	-2.582
DEF	-3.895	-2.582
MCPI	-4.226	-2.582
PCE	-3.984	-2.582
PCELF	-3.925	-2.582

Based on the plot of the inflation rates from Figures 1 and 2, and also the descriptive statistics in Table 1, the period from 1982 through 2001 represents a period of more stable prices than the entire sample. The stability of this period may be attributable to a shift in the monetary policy targets, from monetary aggregates to the federal funds rate. To determine whether or not the Federal Reserve has reacted differently to inflation in the post 1982 regime, as suggested by Brunner (1994), the Federal Reserve reaction functions are re-estimated using the more stable sample period, 1982 Q1 through 2001 Q4. The results of these estimations are presented in Table 5.

| Table 5: Reaction functions estimated over 1982.1 – 2001.4.							
Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].							
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-0.201 (0.248) [0.421]	-0.243 (0.267) [0.366]	-0.208 (0.248) [0.405]	-0.205 (0.249) [0.411]	-0.827 (0.375) [0.030]	-0.137 (0.247) [0.582]	-0.067 (0.249) [0.788]
FFR(t-1)	0.920 (0.032) [0.000]	0.907 (0.039) [0.000]	0.890 (0.040) [0.000]	0.891 (0.040) [0.000]	0.858 (0.045) [0.000]	0.914 (0.037) [0.000]	0.944 (0.041) [0.000]

Table 5: Reaction functions estimated over 1982.1 – 2001.4.							
Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].							
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Growth	0.080 (0.028) [0.005]	0.082 (0.028) [0.004]	0.092 (0.028) [0.002]	0.092 (0.028) [0.002]	0.114 (0.030) [0.000]	0.083 (0.028) [0.004]	0.082 (0.028) [0.005]
CPI	0.108 (0.052) [0.040]						
CPILF		0.132 (0.081) [0.110]					
CTPI			0.191 (0.089) [0.034]				
DEF				0.188 (0.089) [0.039]			
MCPI					0.340 (0.129) [0.010]		
PCE						0.109 (0.069) [0.121]	
PCELF							0.015 (0.076) [0.845]
Adj. R-Square	0.931	0.930	0.932	0.931	0.933	0.930	0.927
SE of Reg.	0.639	0.647	0.638	0.639	0.629	0.647	0.647
AIC	1.992	2.014	1.989	1.990	1.961	2.016	2.048

The results of the estimation over the more recent time period indicate that the only statistically significant inflation rate at the 1-percent level in the Federal

Reserve reaction function is the rate of inflation as measured by the MCPI. The inflation variable is not significant at the ten-percent level in three of the regressions, including the CPILF, PCE, and PCELF. These results are interesting in that the CPILF and the PCELF have been touted as better measures of inflation that the CPI or the CTPI. The regression equation estimated with the MCPI as the measure of inflation has a highest adjusted R-squared value, the smallest standard error of regression, and the minimum AIC, indicating that the MCPI provides a better fit for the data. The MCPI regression is also the only equation where the intercept is statistically significant, therefore the response of the federal funds rate is smaller for both GPD growth and inflation. Figure 4 plots the actual federal funds rate with the fitted federal funds rate from the MCPI equation and inflation from the MCPI appears to give a very good fit for the data.

Figure 4: Actual and fitted FFR based on inflation from the MCPI, 1982 Q1 – 2001
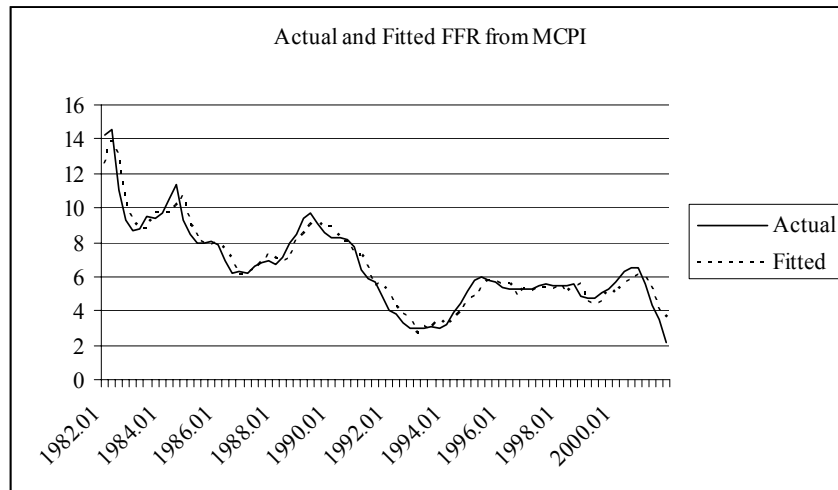
Results of augmented Dickey-Fuller tests are presented in Table 6. Based on the ADF tests, the null hypothesis of a unit root can be rejected for all three equations. These results imply that the estimated regression equations are stationary.

Table 6: Results of ADF tests on the residuals from the estimated equations, 1982.1 – 2001.4		
Equation	Test Statistic	1 Percent Critical Value
CPI	-3.942	-2.593
CPILF	-4.572	-2.593
CTPI	-4.768	-2.593
DEF	-4.789	-2.593
MCPI	-4.559	-2.593
PCE	-5.027	-2.593
PCELF	-4.917	-2.593

CONCLUDING REMARKS

This paper has demonstrated the importance of properly measuring inflation when estimating Federal Reserve reaction functions. The results indicate that the median consumer price index (MCPI) is a better measure of information on monetary inflation during the stable monetary regime from the early 1980s through the early 2000s, than either the consumer price index (CPI) or the GDP chain-type price index (CTPI), or several other measures of inflation including the CPI less food, the personal consumption expenditures index (PCE) and the PCE less food, based on estimated reaction functions. Over a longer period, from the late 1960s through the 2000s there appeared to be little difference in reaction functions based on inflation from the different price indices. The issue is important when attempting to assess the stance of monetary policy, because the Federal Reserve's goal of maintaining price stability must account for the fact that the CPI may be measuring relative price movements rather than overall price-level changes.

This paper suggests that the MCPI perhaps best represents the information being used by the Federal Reserve when setting monetary policy. This is likely due to the fact that the MCPI is less affected by relative price movements than the CPI or the CTPI and is more closely related to monetary inflation, or changes in the overall price-level. Further research should examine the MCPI in dynamic Taylor rules as the results presented in this paper are based on the estimation of static Federal Reserve reaction functions.

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