A DUPLICATION AND REPLICATION OF TWO ECONOMETRIC DEMAND MODELS EXPLAINING THE EFFECTS OF PROMOTION ON MILL-LEVEL DEMAND OF U.S. UPLAND COTTON

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Trent Alan Morton, son of Richard Morton and Denise Morton, was born in Cullman, Alabama, February 27, 1979. He graduated from Cullman High School in May 1997. In September of 1997 he enrolled in Wallace State Community College. In September of 1998, he transferred to Auburn University where he received the degree of Bachelor's of Science in Finance, May 2002. He entered Graduate School at Auburn University in August 2003 and began work towards a Master's of Science degree in Agricultural Economics.

THESIS ABSTRACT

A DUPLICATION AND REPLICATION OF TWO ECONOMETRIC DEMAND MODELS EXPLAINING THE EFFECTS OF PROMOTION ON MILL-LEVEL DEMAND OF U.S. UPLAND COTTON

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Many studies have been conducted to determine the effects of generic promotion on the demand for a certain commodity. Two studies examining the effects that cotton promotion expenditures by Cotton Incorporated has on the mill-level demand for U.S. upland cotton are examined in this paper. Researchers at the Research Triangle Institute conducted a study in collaboration with researchers from North Carolina State University (hereafter Murray *et al.*). They found long-run elasticity estimates of 0.02 for promotion and 0.35 for nonagricultural research. In addition, they found the long-run elasticity estimate for the own-price of cotton to be –0.4. With these estimates, they suggested that the U.S. Cotton Research and Promotion Program was effective in increasing the mill-level demand for U.S. Upland Cotton.

Ding and Kinnucan conducted a study that found the long-run elasticity estimate to be 0.06 for promotion. This estimate was somewhat larger than the Murray *et al*. estimation. They, furthermore, found the long-run elasticity estimate for the own-price of cotton to be –0.3. They, too, suggested that promotion expenditures expanded the mill-level demand for upland cotton.

Following William Tomek's guidelines for duplication and replication of research results, an attempt was made to duplicate the Murray *et al*. results and then, to replicate Ding and Kinnucan's results with Murray *et al*. data. Duplication is utilizing previous research and trying to retrieve the exact results by implementing the same methods used by the original researchers. Replication is defined as fitting the original specification of a model to new data. If there are no major errors in the results, then the work of the researcher is confirmed. Both duplication and replication are important to research because with alternative models being presented by researchers, different economical interpretations can be illustrated. Second, researchers learn from confirmation. Third, confirmation brings about a more robust model. Finally, honesty in publications is encouraged and careless work is deterred.

The Murray *et al*. OLS and GLS results were confirmed by duplication. The duplicated results exhibited only slight differences in parameter estimates and *t*-ratios. Problems did arise from the 2SLS results because of identification problems caused by collinear variables. However, after deletion of two variables (justified by a variable selection method utilized in SAS), regression analysis was continued (without correction for first-order autocorrelation because of unclear methods) and reasonable results were attained although exact duplication of Murray *et al*. results could not be accomplished.

One of the major problems that researchers run into in replication studies is locating missing data. This was the main problem that was incurred during this study. Replication was not perfect in that monthly, rather than quarterly, data were used and two proxy variables had to be used due to some missing data. This coupled with the fact that it was not known whether the researchers used unadjusted or seasonally adjusted advertising data, may have caused different regression results.

It was first suggested, using *unadjusted* advertising data with Model D (the model that compared directly with Ding and Kinnucan's), that the inferences made by the researchers were negated and their results were suggested to be very fragile. However, it was later suggested, using seasonally *adjusted* advertising data with Model D, that Ding and Kinnucan's inferences (advertising expands the demand for cotton) were robust, although many conclusions were altered and the model's fit was not ideal. When an interaction term was included in the model without the monthly dummy variables (Model C with seasonally adjusted advertising data), it became significant. This implied that advertising played the role of a "taste shifter" by rotating the demand curve and therefore changed Ding and Kinnucan's findings of no curve rotation.

With the regression results being severely altered using seasonally adjusted advertising data, it is suggested that the use of such data causes the inferences from these studies to be conditional upon whether advertising data are seasonally adjusted and on the particular model specification. Furthermore, questions about the robustness of the results are brought up when such dramatic changes occur from the use of modified data.

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The author would like to thank Dr. Henry Kinnucan for assistance with statistical analyses, economic theory, and data collection. Thanks are also due to family members Denise, Butch, Tanya, Allene, and U. L. Morton and Ruth Morgan for their support during the course of this research.

STYLE MANUAL AND COMPUTER SOFTWARE

Style Manual or Journal Used: The journal used for formatting the thesis was the *American Journal of Agricultural Economics*.

Computer Software Used: Microsoft Word was used for word processing, Microsoft Excel was used for data storage during research and SAS, Version 9.1, was used for all statistical regression analyses.

TABLE OF CONTENTS

LIST OF TABLES

I. INTRODUCTION

Since the 1800's and before, cotton was considered the dominant fiber for clothing in the U.S. It was also the country's number one agricultural export for 150 years thereafter. But, in the 1950's and 1960's, cotton began to lose its stronghold in the marketplace to man-made fibers such as polyester. Cotton's weakening in the market stimulated Congress to step in and take action. In 1966, the U.S. Cotton Research and Promotion Act was established to offset synthetic fiber's growth in the market and to restore cotton as the number one fiber.

The U.S. Cotton Research and Promotion Program is designated to aid in research for more cost efficient methods for cotton production therefore increasing the producer's profits. It also provides the necessary funding for promoting cotton and cotton products. The program is carried out by way of funds collected from both producers and importers of upland cotton via a mandatory check-off program established in 1990. The Cotton Program currently requires producers and importers to pay $1 per bale, plus an additional assessment of one-half of 1 percent of the value (Murray *et al.*, p.2.3). The funds collected are sent directly to the Cotton Board after the USDA retains enough to manage its expenses for the program. The Cotton Board then pays any in-house expenses and reimburses any governmental agencies, primarily the Customs Agency whom assists in the import program. The balance is then sent to Cotton Incorporated where the assessments are used to fund agricultural research, fiber research, textile research, global product marketing, and consumer marketing. The Program engages in promotion designed to increase retail demand, research into fiber and textile quality that is aimed at increasing mill-level demand directly (because of reductions in the costs of processing cotton), and agricultural research into methods of reducing production costs or increasing yields (Murray *et al*., p.4.9). The spending patterns of Cotton Inc. have been particularly stable over the years. From 1996 to 2000, agricultural research took a consistent 11 percent of the budget, fiber and textile research 16 percent, consumer marketing (primarily advertising) about 50 percent, and global product marketing about 16 percent (Murray *et al*., p.2.6). Every five years, the Secretary of Agriculture has the Cotton Program evaluated. The chief focus of the evaluation is to determine how well the Cotton Research and Promotion Program, primarily through promotion efforts, is expanding the demand for upland cotton and increasing the profitability of cotton growers and of cotton product importers.

The Research Triangle Institute (RTI), in collaboration with researchers from North Carolina State University (NCSU), conducted an evaluation of the Cotton Program for William Crawford of the Cotton Board in 2001. RTI consisted of Brian C. Murray, Robert H. Beach, William J. White, and Catherine Viator. NCSU consisted of Nick Piggott and Michael Wohlgenant. Their study objectives were to assess the effects of the program on the domestic demand for upland cotton, the return on investment (ROI) to domestic cotton producers, and the value to importers of cotton products. They furthermore estimated the overall ROI of the program and assessed the nonquantitative program benefits. Ultimately, Murray *et al*. were to determine if the benefits to producers outweighed the assessments collected from them.

By implementing an econometric demand model, Murray *et al*. concluded that the benefits from the Cotton Program outweighed the per-bale assessments collected from producers. They found the own-price elasticity of cotton to be approximately –0.4. In addition, they found the promotion elasticity to be approximately 0.02 and the long-run elasticity estimate for the sum of the current and lagged effects of nonagricultural research to be approximately 0.35. The promotion elasticity estimate presumes that a 10 percent increase in promotion expenditures would directly lead to a 0.2 percent increase in the domestic mill-level demand for cotton. Furthermore, a 10 percent increase in nonagricultural research expenditures would lead to a 3.5 percent increase in the domestic mill-level demand for cotton.

By only using a distributed lag with the research variable and specifying the other variables (cotton price and promotion) contemporaneously, the assumption of the researchers was that the promotion effects were felt instantaneously, i.e., promotion expenditures affect mill-level demand in the exact period that they are used. This assumption contradicts many past studies that have shown that promotion expenditures affect the domestic mill-level demand over a long time period. For example, a study by Ding and Kinnucan concluded that advertising did not take hold until the second quarter following the initial expenditure.

Ding and Kinnucan's study focused on making optimal allocation decisions for cotton promotion based on advertising elasticities in the domestic and export markets and the export market share. In the course of their research, Ding and Kinnucan devised an econometric model for the domestic mill use of upland cotton, with a different lag specification than Murray *et al*., to estimate the domestic advertising elasticity. They wanted to determine the effects that advertising expenditures had on the domestic mill-level demand for cotton. They furthermore wanted to determine if advertising expenditures caused a structural shift in the demand curve (is advertising a taste shifter?). They tested this with the inclusion of an interaction term.

Ding and Kinnucan obtained a larger estimate for the advertising elasticity than did Murray *et al*. Their estimate for advertising elasticity was approximately 0.06. This estimate implied that a 10 percent increase in cotton promotion would increase mill-level demand by 0.6 percent. In addition, they found the own-price elasticity of cotton to be approximately –0.30.

Ding and Kinnucan's model differs significantly from the Murray *et al*. model. First, Ding and Kinnucan used a different lag specification. Murray *et al*. used an Almon distributed lag specification only lagging nonagricultural research instead of the fiber prices or promotion. Ding and Kinnucan lagged advertising 6 months and the prices of cotton, rayon, and polyester 12 months while excluding nonagricultural research expenditures. Additionally, Ding and Kinnucan included a lagged dependent variable to account for any advertising carry-over effects. Also, Ding and Kinnucan's use of quarterly data differed from Murray *et al*.'s use of monthly data. Furthermore, Ding and Kinnucan specified the model as a double-log to allow advertising to display diminishing marginal returns.

Following the guidelines of William Tomek and prior duplication and replication studies, the first objective of my research is to duplicate Murray *et al*. regression results. I will be focusing on their econometric demand model for the domestic mill use of upland cotton. Duplication is utilizing previous research and trying to retrieve the exact results by implementing the same methods used by the original researchers. If the exact results are attained without any major errors, then the work of the researcher is confirmed. As stated by William Tomek (p.7), one of the potential benefits of confirmation research is an improved model. Duplicating and confirming the research of Murray *et al*. will ultimately validate the adequacy of the econometric model that they developed to explain the effects of promotion and research on the domestic mill-level demand for cotton.

The second objective of my research is to replicate Ding and Kinnucan's econometric results using Murray *et al*. updated data. Replication is defined as fitting the original specification of a model to new data. Murray *et al*. used data ranging from 1986-2000 whereas Ding and Kinnucan used data ranging from 1976-1993.

In general, the purposes of my research are to compare and contrast two different econometric demand models for the effects of promotion on the domestic mill use of cotton and to test whether or not the Ding and Kinnucan model holds its validity when estimated with updated data. Many researchers say that the strength of agricultural economics comes from researchers combining theories, quantitative methods, and data to do useful analyses of problems faced by society. Tomek (p.6) states that agricultural economists are not accomplishing this very well and that one component of the problem is that econometric results are often fragile. Many domestic cotton promotion studies have proven Tomek to be correct. Hopefully, with the successful duplication of Murray *et al*.'s results and the replication of Ding and Kinnucan's results, the robustness of their models explaining the relationship between promotion and the domestic mill-level demand for cotton will improve.

II. LITERATURE REVIEW

"The strength of agricultural economics rests on its capacity to combine theory, quantitative methods, and data to do useful analyses of problems faced by society" (Tomek, p.6). A major problem faced by economic researchers is that econometric results are often fragile. Large variation in results may be a major consequence of a small change in a model or data, which, in turn, reduces the robustness, or explanatory power, of the model. Nonetheless, there is no easy solution to improving upon unstable results because econometric models are just approximations.

One possible way to reduce the variation in the results and contradictory conclusions between researchers is to build upon prior research. The aim of the researcher should be to expand or improve upon the previous research, not to disprove others work. "Replication and confirmation, I shall argue, are often essential components in demonstrating such improvements" (Tomek, p.6). Confirmation may help in the explanation of how researchers arrive at different results given the same model or data. Different results may be a consequence of differences in models or data, but uses of alternative estimators or dissimilarities in how the results are analyzed or applied by the researcher can be other causes. For example, Murray *et al*. and previous researchers (Capps *et al*., 1997; Ding and Kinnucan, 1996) used different lag specifications for the econometric demand models. This led to different elasticity calculations. Murray *et al*. concluded that the own-price elasticity of demand for cotton was –0.4, which was significantly larger than Capps *et al*. estimate of –0.16 and Ding and Kinnucan's estimate of –0.3. The Murray *et al*. model implemented the Almon distributed lag on the nonagricultural research expenditure variable without any other lagged variables. Capps *et al*. lagged the price of cotton by 13 months. "When we included the 13-month lagged price variable in our model (in addition to current price), we found no statistically significant impact of lagged price. We take these results to strongly suggest that mill consumption and the raw fiber price are contemporaneously determined" (Murray *et al*., p.5.12). Ding and Kinnucan did not include nonagricultural research expenditures, but lagged the prices of cotton, rayon, and polyester by 12 months, as well as advertising by 6 months.

The scientific community is not a large supporter of confirmation and replication research. "Scientific and professional laurels are not awarded for replicating another scientist's findings. Further, a researcher undertaking a replication may be viewed as lacking imagination and creativity, or of being unable to allocate his time wisely among competing research projects. In addition, replications may be interpreted as reflecting a lack of trust in another scientist's integrity and ability, as a critique of the scientist's findings, or as a personal dispute between researchers. Finally, ambiguities and/or errors in the documentation of the original research may leave the researcher unable to distinguish between errors in the replication and in the original study" (Dewald *et al*., 1986). Dewald *et al*. (p.601) suggests that given these circumstances, replication may be considered a form of "professional head-hunting" instead of an important part of scientific research.

Although unpopular among a number of researchers, confirmation offers several benefits to the field of research. First, with alternative models being presented by researchers, different economical interpretations can be illustrated. Second, researchers learn from confirmation. "True scholarship arises from building in-depth expertise; confirmation provides greater understanding of the strengths and weaknesses of prior work; and it helps build the intellectual capital from which innovation can spring" (Tomek, p.8). Third, confirmation brings about a more robust model. If the model were being used for an important policy, one would want the model to be as error-free as possible. Furthermore, honesty in publications would be encouraged and careless work would be deterred.

Although many benefits arise from confirmation work, there exist some implicit difficulties. The number one difficulty in confirmation studies is that original data from previous studies may not be available or may be incomprehensive to researchers. Many times, data are lost or discarded once a paper has been published. Furthermore, errors may occur in data input, the sample period stated may be different from the vintage sample period, and data transformations may be unclear to the duplicating researcher.

The second most occurring difficulty in confirmation research comes from the duplicating researcher's poor comprehension of the original model. The structural form of the model, specification of variables, or definitions of variables may be unclear to the duplicating researcher.

A third difficulty may arise from differing minimization algorithms of different statistical computer programs that researchers prefer. One econometric program may present quite different results because of the methods that it employs in minimizing estimates of parameters. Tomek (p.10) gives an example of how Generalized Least Squares (GLS) functions of different econometric packages differ. He notes that Dewald, Thursby, and Anderson were unable to duplicate results from a previous study, though the exact data was used, because of differing econometric software amongst the researchers.

Tomek (p.10) illustrates two confirmation studies in which some problems arise for researchers. He demonstrates the difficulty of duplicating published results, the problems arising from using revised data, the sensitivity of results to data revisions, and the potential insights from attempted confirmations. He focuses on the importance of obtaining the original data set.

One confirmation study was from an unpublished MS thesis by Miller who attempted to confirm a paper by Braschler that focused on the structural change in meat demand. In the original research, Braschler used the sample period 1950–1982. Braschler concluded that the structural demand for beef changed between 1970 and 1971 causing a need for a break in the data. Applying the break in his data set minimized the total sum of squared errors resulting in an F statistic of 11.12 (the model was statistically significant).

Miller was able to confirm the results after acquiring the original data used by Braschler. Following the confirmation, Miller attempted replicating the study with revised data. The problem presented here was that the government had revised most of the data more than once and the revisions were inconsistent amongst all the variables used in the model (some variables were revised at different times). A second problem that Miller faced was that the Consumer Price Index (CPI) had shifted to a smaller scale.

Remedies for these problems were unclear; therefore, Miller estimated the model twice. By joining the revised data with the original data without adjustment, the first estimation was performed. The second estimation involved adjusting the original data by the revised CPI to be consistent with the more recent data. This caused the dependent variable (deflated price) to be larger, thus causing overestimation of the model parameters (this problem did not pose major concern for Miller because the paper focused on the structural change dates, not the scale of the estimates).

Miller found that using revised data shifted the structural change dates. After the first estimation, the structure changed between 1972 and 1973. Likewise, in the course of the second estimation, the structure changed between 1958 and 1959. Furthermore, both models had a smaller R^2 and autocorrelated residuals.

In general, instead of building upon previous results, the revised data that Miller used actually changed Braschler's results. The original research was duplicated but could not be replicated with the available revised data therefore; the model or the previous conclusions were not robust.

A further confirmation study discussed by Tomek was based on a Ziemer and White paper that suggested that the U.S. beef sector was best modeled in disequilibrium. Two researchers, Shonkwiler and Spreen, were the first to attempt to duplicate the research. They could not acquire the original data so they collected data independently. They failed to duplicate the original results because of significant differences in coefficients in the demand equation. Ferguson, on the other hand, accomplished duplication of the exact results because Ziemer and White's original data became available. Nevertheless, Ferguson ran into problems in the process. The trouble occurred with matching the per capita personal income data in Ziemer and White's data files with other published works. After further examination, two income observations were found to be approximately 20% too large with respect to the others. After correcting these errors, Ferguson's results were similar to Shonkwiler and Spreen's earlier results. Ferguson found that the residuals remained autocorrelated after the corrections, which would require further research as to why. It was also proven that the fed beef market was not in disequilibrium, which contradicted Ziemer and White's conclusions simply because of the errors in their data set.

Tomek (p.13) stated, "Published and anecdotal evidence on confirmation in economics suggests the disheartening conclusion that many published empirical studies contain errors and that some of these errors are serious in the sense that, if corrected, the stated conclusions of the study would change." Furthermore, confirmation helps in building upon the true scholarship of research and should be encouraged in the field of agricultural economics to supplement existing empirical research.

Perhaps the most noted replication study was from the Journal of Money, Credit and Banking (JMCB) *Data Storage and Evaluation Project* by Dewald, Thursby, and Anderson in 1986. They examined the importance of replication in empirical economic research by conducting a two-year study that focused on the collection of data and computer programs from various authors and attempting replications of their published results. They found that published errors are rather common in economic articles and, only if the replicating researcher makes the exact same errors while conducting research, the replication of published results becomes impossible. They wanted to find out the different causes for failures in replication research.

Dewald *et al*. suggest that the role of professional journals in attempting to deter published errors should be to require authors to make available the data and computer programs used for different economic analyses. They believed that there were two significant advantages to having data and programs being made available to article referees. First, it would greatly reduce the costs incurred by the researcher attempting to replicate original results. Second, readers of journals benefit from being assured that the probability of published errors is greatly diminished because referees have access to data and programs.

Referees primarily focus on methodology, theoretical specification, statistical estimators, and importance of results. The referee usually assumes that the authors' calculations, data, and computer programs are correct. It would take an extraordinary amount of time for referees of articles to be required to check the authors' data and computer programs. Dewald *et al*. argue that by simply requiring the compilation of data and computer programs for submission to the referee, ambiguities, oversights, and errors that were otherwise undetected to the researcher will be brought forth. These oversights can then be corrected before publication. Nevertheless, at the time Dewald *et al*. were published, the only economic journal that had editorial policies that requested data and programs from the author was the *JMCB*. Today, such requests are more common.

The first part of the project was to request data and computer programs from all authors of empirical articles during or after 1980. The authors were divided into two groups: authors of articles that were published before the start of the *JMCB Project* in 1982; and authors of articles after 1982 (either articles being accepted, but not yet sent for publication or articles under review by referees). In group one (published before *JMCB*

Project), 42 out of 62 authors responded and 22 of them sent data and programs. Approximately one-third never responded and one-third replied by saying that they could not supply the data and programs. In the first half of group two (accepted, but not yet published), 26 out of 27 responded. Only 5 authors failed to send data and programs and one author never responded. In the second half of the group two (authors under review), 49 out of 65 authors responded. Only 2 authors did not send data and programs and no more than 16 failed to reply.

Dewald *et al*. examined the first 54 submitted data sets to determine if the data was comprehensible enough for a replication. Only 8 or 15 percent of the data was determined to be usable in a replication and 14 or 26 percent was incomplete. They determined that the most prevalent problems with the data sets were that the author failed to identify the sources of the data exactly and incomplete data sets. More problems occurred from the authors' failures in identifying variable data sources and incomprehensible variable transformations.

Dewald *et al*. illustrated three examples of what they found from the first half of the project. First, they found a large number of transcription errors in the data set submitted by Canarella and Neil Garston. After correction of the errors, regression estimates and likelihood-ratio test statistics changed significantly, but conclusions remained the same. Second, in a data set submitted by Edward Gramlich, the sample period cited in the manuscript and the actual sample period of the data set were in contradiction. Before publication, the author found that one of the forecasts of the model had been coded incorrectly by six months. The correction of this error caused the conclusions to change considerably. The final example was from a coding error discovered in the ten-year government-bond-rate series in data submitted by Thomas Mayer and Harold Nathan. The conclusions were unchanged after the correction, but their equations came to be substantially different.

The next element of the Dewald *et al*. study consisted of an attempted replication of nine articles from the submitted data sets. Their goal was to obtain the same numerical results as the original authors without having to examine the data sets for errors.

They found that they could only replicate, completely, the results of two articles (James Johannes and Robert Rasche; and Robert Engle). They were almost able to reproduce the results from Roley and attained approximately the same results as Merrick. They replicated all of Roley's results from a three-equation model for the impact of weekly money stock announcements on Treasury bill yields except for the estimates of the third equation. Dewald *et al*. were able to obtain the same sign and statistical significance of the coefficients for Merrick's equation for the determinants of money growth, but failed in reproducing the exact regression estimates. They were unable to uncover the reasons for the differences in estimates.

Dewald *et al*. found that a number of computer program errors hindered their replications. Brian Maris cited in an article that 1952: III – 1977: III was the estimation period (101 observations) used while the original period used by the computer program started with 1950: III (110 observations). This caused the computer program that was used, FORTRAN, to compute errors. Dewald *et al*. found, after correction, that the specific time-series filters accepted by Maris were rejected by the data.

Dewald *et al*. discovered that they could not replicate two articles. The first article, submitted by Bala Batavia and Nicholas Lash, stated that generalized least squares (GLS) was used for estimation of both a single-equation and a simultaneous-equation model, but failed to report the estimator that they used. This coupled with the fact that the authors failed to provide the computer programs, caused Dewald *et al*. to fail to replicate the results of the article.

The second article, submitted by Woglom dealt with the role of stock prices as a determinant of consumption in the MIT-Penn-SSRC (MPS) macroeconometric model. The research contained in the original article had been completed several years before Dewald *et al*. had requested it and had also been updated since the article's publication. The vintage data set that corresponded to the original article could not be recovered, so Dewald *et al*. used revised data supplied by Woglom. Neither Dewald *et al*. or Woglom could replicate the results from the original article. "These results emphasize the importance of maintaining intact the vintage data sets used in published articles, especially when continuing research requires that active data sets be updated with revised observations" (Dewald *et al*., 1986).

Dewald *et al*. attempted replication of a submitted article by Goldberg and Saunders where the author claimed that the data had been lost but could easily be obtained from other published sources. They provided the general sources for the data, but failed to provide specific months, pages, or table numbers. Dewald *et al*. collected the most-recent published values for all missing variables and time periods. Their regression coefficients and standard errors were significantly different from the coefficients calculated by Goldberg and Saunders. Several of the insignificant coefficients became significant and vice versa.

The last replication attempt was from a large-scale macroeconometric model submitted by Benjamin Freidman. His model was based on a version of the MIT-Penn-SSRC (MPS) macroeconometric model that contained a large model for the market for U.S. government bonds. When Dewald *et al*. requested the programs and data used in the article, they were sent an 87-page manual describing the installation and usage of the MPS model on Harvard University's IBM VM/370 computer system and two tapes containing over 2,500 files of programs and data. Needless to say, Dewald *et al*. gave up any replication efforts because of limited time and resources.

Dewald *et al*. results suggest that published errors are a more common occurrence than not. Because of these findings, several authors suggested that replication of empirical research become an imperative preliminary step for new research. They strongly reiterated that to deter many of the published errors in economic research, authors should be required to submit all data and computer programs at the time the papers are submitted to referees of journal articles.

In the U.S., different organizations spend millions of dollars per year on promotion programs designed to increase consumer demand for a certain commodity. Since they are the ones funding such programs, producers of commodity goods often want to see empirical results on the effectiveness of these programs for increasing consumer demand and producers' profits. Two such studies were conducted focusing on the effectiveness of U.S. generic meat advertising but obtained contradictory results.

Coulibaly and Brorsen conducted a study as to why the two previous studies of Brester and Schroeder and Ward and Lambert reached conflicting conclusions about the effectiveness of U.S. generic meat advertising on consumer demand. One reason was thought to be because Brester and Schroeder used generic advertising expenditure data obtained from a media tracking service while Ward and Lambert used beef check-off expenditure data obtained from the promotion organization. Another possible reason was the differences in the econometric models used by the researchers. Brester and Schroeder used a Rotterdam demand system while Ward and Lambert used a single-equation price-dependent model. Coulibaly and Brorsen used both of the data sets with both previous models for re-estimation of parameters and misspecification testing.

Coulibaly and Brorsen learned from previous studies that increasing advertising for established products like beef would only show effects approximately one-third of the time, the demand elasticities for beef and pork with respect to advertising are small, and the money spent on beef advertising is relatively small compared to the total value of beef. They assumed that these facts combined might have led to statistical insignificance in the models.

Ward and Lambert illustrated the effects of U.S. beef check-off expenditures on meat demand with three different models. The live weight level, boxed beef market level, and retail market levels were used for the three models, respectively. Coulibaly and Brorsen only examined the retail market model because it was comparable to Brester and Schroeder's retail demand system. Ward and Lambert's model was specified as

$$\text{(1)} \quad \ln P_{bt} = \alpha_0 + \alpha_1 \ln Q_{bt} + \alpha_2 \ln Q_{kt} + \alpha_3 \ln Q_{pt} + \alpha_4 \ln I_t + \alpha_5 T_{1t} + \alpha_6 T_{2t} + \alpha_7 S_{1t} + \alpha_8 S_{2t} + \alpha_9 S_{3t} + \alpha_{10} FR_t + \delta_1 \ln[1 + \exp(-\beta/E_t)] + \delta_2 \ln[1 + \exp(-\beta/E_{t-1})] + \varepsilon_t,$$

Where P_{bt} is the real price of beef at the retail level, Q_{bt}, Q_{kt}, and Q_{pt} are the per capita disappearances of beef, pork, and poultry, respectively, I_t is the real per capita income, S_{it} are quarterly dummy variables, E_t and E_{t-1} are the current and lagged beef check-off expenditures (also used as proxies for current and lagged generic beef advertising expenditures), T_{1t} and T_{2t} are time trends, FR_t is the feeder steer ratio, and $\varepsilon_{t'}$ is the error term. T_1 increases one unit each quarter starting with $T_1 = 58$ in 1979:2. T_2 equals one before 1990:1 and increases in units of one thereafter.

Because Brester and Schroeder also determined the effectiveness of pork advertising with their model, Ward and Lambert's model had to be converted to a pork response function for comparison. The pork response model is specified as

$$(2) \qquad \ln P_{kt} = \alpha_0 + \alpha_1 \ln Q_{bt} + \alpha_2 \ln Q_{kt} + \alpha_3 \ln Q_{pt} + \alpha_4 \ln I_t + \alpha_5 T_{1t} + \alpha_6 S_{1t} + \alpha_7 S_{2t} + \alpha_8 S_{3t} + \delta_1 \ln[1 + \exp(-\beta/A_t)] + \delta_2 \ln[1 + \exp(-\beta/A_{t-1})] + \varepsilon_{t'}$$

where P_{kt} is the real price of pork, A_t and A_{t-1} are the current and one-period lagged per capita generic pork expenditures, and all other variables are the same as the beef model. T_1 starts at 1 in 1970:1 and increases in units of one until 1993:4. T_2 was not used in the pork model.

Brester and Schroeder studied the effects of generic and branded advertising on the consumer demand for beef, pork, and poultry. A different model, the Rotterdam demand system with scaling, was used to estimate advertising effects. The advertising variables were in the form of stock of investments and were obtained with a procedure proposed by Cox, which was supposed to account for advertising spillover effects better.

The Rotterdam system, with scaling, that Brester and Schroeder used was nonlinear in parameters. This would have made Coulibaly and Brorsen's misspecification tests rather challenging, thus the model was specified in linear form without scaling for the tests. The linear model yielded similar results to the nonlinear model, so the change did not affect the results a great deal. The Rotterdam model that Coulibaly and Brorsen used for the misspecification tests was specified as

$$(3) \qquad w_i d\ln q_i = \alpha_i d\ln Q + \Sigma_j \beta_{ij} d\ln p_j + \Sigma_j \gamma_{ij} d\ln A_j + \Sigma_j \Sigma^3_{m=1} \delta_{ijm} d\ln A_{jm} + \Sigma^3_{k=1} \phi_{ik} D_k + e_i$$

where w_i is the budget share of the i^{th} good, q_i is per capita consumption of good i, p_j is the nominal price of good j, A_j is the real advertising expenditures on good j, $d\ln Q = \Sigma_i w_i d\ln q_i$ is the Divisia volume index, A_{jm} is the m-period lagged advertising expenditures, the D_k's are quarterly dummy variables, and e_i is the error term.

Coulibaly and Brorsen used both generic and branded advertising variables in the model for misspecification tests. Because Brester and Schroeder only included lagged generic advertising expenditures with both generic and branded advertising expenditures in the equation, Coulibaly and Brorsen did the same.

Coulibaly and Brorsen attempted estimating, confirming, and performing misspecification testing on both the Ward and Lambert and the Rotterdam models. They wanted to determine whether it was different data, different variables, or different functional forms that caused the contradictory conclusions between the two studies.

To estimate Ward and Lambert's model, Coulibaly and Brorsen used price, quantity, and income data from Brester and Schroeder's data set because they only obtained the check-off expenditures and feeder steer ratio from Ward and Lambert. They estimated the model by OLS holding the check-off coefficient (β) constant (the value being the one for which the sum of squared errors was minimized). Next, Coulibaly and Brorsen estimated the model using data from 1970-1993 to detect how different sample periods affected the results. They obtained extra feeder steer ratio data from the USDA's

1990 cattle slaughter data because the sample period for Ward and Lambert's model only went through 1992. Finally, the misspecification test proposed by McGuirk *et al*. was used to find any problems with the model.

Coulibaly and Brorsen were able to confirm Ward and Lambert's results. The only differences in estimates came from income and the feeder steer ratio. Coulibaly and Brorsen also found the responses from the check-off program to be approximately the same, only differing slightly. The joint misspecification test for the beef model exhibited no problems, although the individual tests showed that the functional form of the model was misspecified. Furthermore, the tests for the pork model showed the major problem to be autocorrelation, which generally suggests a problem with the functional form of the model.

Coulibaly and Brorsen then estimated the linear Rotterdam model, the alternative for the Brester and Schroeder nonlinear model. They were able to use the exact sample period from 1970:1 to 1993:4 for the estimation. They added 100 to all observations of advertising (zero and nonzero expenditures) because a zero advertising expenditure would create problems in the model due to the logarithms of the parameters. Misspecification tests proposed by McGuirk *et al*. were used to test for problems.

After misspecification tests, the Rotterdam model was found to be severely misspecified. The only assumptions that held up in the model were the homoskedastic and independent error assumptions. Coulibaly and Brorsen then included women labor force participation and cholesterol information index as extra variables for respecification of the model. From previous studies, it was found that increases of women in the U.S.

labor force (McGuirk *et al*., 1995) and health information in the U.S. (McGuirk *et al*., 1995; Kinnucan *et al*., 1997) has caused significant structural changes to meat demand.

The inclusion of the extra variables to the original model did not cure the misspecification problem, so an alternate Rotterdam model was developed and tested for misspecification. Initially, the extra variables were not included in the alternate model. The joint test indicated that conditional mean and variances were misspecified (possibly caused by nonnormality, heteroskedasticity, parameter stability, or functional form). When they included the extra variables, women in the U.S. labor force and health information in the U.S., and tested for misspecification, more of the underlying assumptions held. The only problems found from the tests were unstable variances and covariances. The instability was possibly due to the fact that the advertising varied erratically over time.

In the alternate Roterdam model with the extra variables, most of Coulibaly and Brorsen's parameter estimates were statistically significant from zero, although some of the advertising coefficients in the beef and pork models were negative. They found that the advertising elasticities were insignificant, but were, at least, positive.

Coulibaly and Brorsen found that the major cause of the contradictory conclusions between the two studies was due to the fact that Ward and Lambert transformed the advertising variable. Because of the transformation, Ward and Lambert's model yielded very high advertising elasticities. When Coulibaly and Brorsen used more recent data with Ward and Lambert's model, the advertising coefficients for beef turned negative. Also, when they used Brester and Schroeder's data with Ward and Lambert's model, the results for advertising became insignificant.

The overall conclusion that Ward and Lambert's model was fragile was not changed. Both Ward and Lambert's and Brester and Schroeder's models were misspecified. Furthermore, after correctly respecifying Brester and Schroeder's Rotterdam model, Coulibaly and Brorsen found no differences in the results.

III. MURRAY *et al*. ESTIMATION PROCEDURES

To measure the net benefits to producers of upland cotton from the Cotton Program, Murray *et al*. carried out several tasks. First, a conceptual model of the cotton market was specified. Next, parameters for the model were estimated. Then, demand response (elasicities) to promotion and research were calculated. Finally, a simulation of the cotton market, minus the Program expenditures, and a cost/ benefit analysis were completed.

After careful consideration, Murray *et al*. adopted the following conceptual model for the mill-level demand for domestic cotton:

(4) $$Q^{d}_{fd} = D_{fd}\,(P_{cd}, P_{cf}, A_g, A_b, A_f, R_t, W_r, W_t, Z_r)$$

where Q^{d}_{fd} is the quantity demanded (d) for U.S. upland cotton at the farm level (f), P_{cd} is the domestic mill price of cotton, P_{cf} is foreign cotton fiber price, A_g is the generic promotion expenditures, A_b is branded advertising for cotton, A_f is advertising for man-made fibers, R_t is nonagricultural research expenditures, W_r is supply factors in the retail market, W_t is supply factors in the textile market, and Z_r is demand factors in the retail market.

With the conceptual model completed, Murray *et al*. began considering the appropriate variables to include in the model for estimation of parameters. They collected monthly data (ranging from January 1986 to December 2000) from the USDA, the National Cotton Council, Cotton Inc., the U.S. Census Bureau, the St. Louis Federal

Reserve Bank, and the U.S. Bureau of Labor Statistics. A total of 180 observations were gathered. They gathered data for the quantity of raw cotton consumed by domestic mills from various issues of the USDA's *Cotton and Wool Outlook*. The raw fiber equivalent prices of cotton, polyester, and rayon and the foreign cotton price (A Index) were obtained from the National Cotton Council (2001) website. Because the model was estimated using per capita information, U.S. population data was obtained from the U.S. Census Bureau (2001). The real wage rate in a U.S. textile manufacturing industry and the U.S. energy cost index were obtained from the U.S. Bureau of Labor Statistics (BLS, 2001). Data for income were obtained from monthly data on total personal income for the U.S. taken from the St. Louis Federal Reserve Bank's FRED database on their website (FRED, 2001). Foreign gross domestic product (GDP) was proxied by GDP for Organization for Economic Cooperation and Development (OECD) countries after subtracting the U.S. GDP from the total. These data were obtained from various issues of *Quarterly National Accounts of OECD Countries*. The data was quarterly and had to be converted to monthly data by using the EXPAND procedure by SAS statistical software. The seasonally adjusted promotional and nonagricultural research expenditures were obtained from Cotton Incorporated. All of the variables were deflated by the Consumer Price Index (CPI) where 1982-1984=100. CPI data was obtained from U.S. Bureau of Labor Statistics (2001).

One major concern for the researchers was the timing in which promotion and research affected the domestic mill-level demand of cotton. They explored the possibility that the impact of promotion and research did not affect the consumption of cotton contemporaneously, i.e., research and promotion would have long-term rather than short-term effects on cotton consumption. For that reason, a distributed lag model, where the effects of promotion and research were distributed over a certain period of months, had to be developed. If the model did not allow for the proper amount of lag time, the estimates would be biased because of omitted variables. Conversely, if the model allowed for too much lag time, the estimates would be inefficient due to over-specification of the model. They required a lagged model that was finite in nature because an infinite lagged model would allow the coefficient of the dependent variable to be unstable. Thus, they decided on an Almon distributed lag model because of its flexibility and finite nature. After deciding on the Almon model, they performed a grid search to study the elasticities, Akaike Information Criteria (AIC), Schwartz-Bayesian Criteria (SBC), and the adjusted R^2 of several different distributed lag models to decide on the best one. They found that a three-month lag on research, no lags on promotion, and no lags on cotton price would be sufficient for their estimation purposes. In addition to the research lags, monthly dummy variables were included to account for the seasonality of the cotton data.

Murray *et al.*'s econometric demand model for the domestic mill use of upland cotton was specified as

$$\text{Milluse}_t = \beta_0 + \beta_1\text{pcotton}_t + \beta_2\text{ppoly}_t + \beta_3\text{prayon}_t + \beta_4\text{dtexw}_t + \beta_5\text{wpcot}_t + \beta_6\text{deci}_t + \beta_7\text{dpi}_t + \beta_8\text{fgdp}_t + \beta_9\text{sagprom}_t + \beta_{10}\text{sagnares}_t + \beta_{11}\text{sagnares}_{t-1} + \beta_{12}\text{sagnares}_{t-2} + \beta_{13}\,\text{sagnares}_{t-3} + \beta_{14}M_1 + \beta_{15}M_2 + \beta_{16}M_3 + \beta_{17}M_4 + \beta_{18}M_5 + \beta_{19}M_6 + \beta_{20}M_7 + \beta_{21}M_8 + \beta_{22}M_9 + \beta_{23}M_{10} + \beta_{24}M_{11} + \varepsilon_t \quad (5)$$

where Milluse_t is the U.S. per capita raw cotton used by mills (pounds per person), pcotton_t is the real U.S. raw fiber equivalent price of cotton (cents per pound), ppoly_t

is the real U.S. raw fiber equivalent price of polyester (cents per pound), $prayon_t$ is the real U.S. raw fiber equivalent price of rayon (cents per pound), $dtexw_t$ is the real domestic wage rate in the U.S. textile manufacturing industry (dollars per hour), $wpcot_t$ is the real A Index of the world cotton price (cents per pound), $deci_t$ is the U.S. real energy cost index (1982-1984=100), dpi_t is the U.S. per capita real disposable income ($1,000's per person), $fgdp_t$ is the real GDP of OECD countries, excluding the U.S. (billions of dollars), $sagprom_t$ is the seasonally adjusted Cotton Inc. real promotional expenditures (dollar amounts), $sagnares_t$, $sagnares_{t-1}$, $sagnares_{t-2}$, and $sagnares_{t-3}$ are the current and lagged seasonally adjusted Cotton Inc. real nonagricultural research expenditures (dollar amounts), M_{it} are monthly dummy variables (M_i=1 for the i^{th} month, 0 otherwise) for i=1,…,11 where December is the reference month with its effect represented by the intercept, and ε_t is the error term.

With the formulation of the variables into an econometric demand model, linear regression analysis was the next step taken by Murray *et al*. The exact statistical software used by the researchers was unknown.

Murray *et al*. estimated the model with Ordinary Least Squares (OLS), OLS with correction for first-order autocorrelation, and Two-Stage Least Squares (2SLS) with correction for first-order autocorrelation. The three models showed exceptional similarities. All three models displayed a stable relationship between research and promotion and mill consumption. All models showed the promotion elasticity to be approximately 0.02 implying that a 10 percent increase in promotion expenditures would lead to a 0.2 percent increase in cotton demand at the mill level, ceteris paribus. The long run elasticity estimates of mill consumption with respect to research (the summation of the current and lagged effects) were 0.33 (model 1), 0.31 (model 2), and 0.35 (model 3). The 2SLS model (model 3) indicated that a 10 percent increase in nonagricultural research expenditures would directly lead to a 3.5 percent increase in cotton demand, ceteris paribus.

Because of the endogenous effects of the price of cotton, two-stage least squares (2SLS) was the preferred method for estimation by all researchers. A procedure developed by Hatanaka was implemented with the 2SLS method because first-order autocorrelation was detected in the OLS model. The Hatanaka procedure involves two steps. The method requires that one must; first, regress all endogenous variables on all predetermined and lagged predetermined models of the system to get a consistent estimate of rho. Then, use a quasi-differencing operator (1-rho*L, where L is a lagged operator) to transform the model into a form where the error term is uncorrelated. Next, regress each of the quasi-differenced endogenous variables ($w_{it}=z_{it}-rho*z_{it-1}$) on all of the predetermined and lagged predetermined variables of the model and use those values as instruments for the quasi-differenced endogenous variables. Finally, use the predicted values and quasi-differencing predetermined variables as instruments in instrumental variable estimation of the parameters.

"Overall, the results seem quite reasonable and suggest a strong and significant impact of promotion and research on mill consumption of cotton" (Murray *et al*., p.5-11). Mill consumption of cotton exhibited high seasonality supported by the extremely significant monthly dummy variables. The own-price elasticity of demand for cotton was -0.4, closely resembling estimates obtained from previous research [Wohlgenant (1986), Lowenstein (1952), Ding and Kinnucan (1996), and Waugh (1964) estimated elasticities of approximately –0.3]. The estimate was smaller than Shui, Behgin, and Wholgenant's estimate of –0.6. Nevertheless, as discussed earlier, the elasticity estimate differed from Capps *et al*. Capps *et al*. determined that the own-price elasticity for cotton was -0.16. The most significant difference between the Murray *et al*. study and the Capps *et al*. study was that Capps *et al*. stated that prices affect consumption after a 13-month lag. When Murray *et al*. included the 13-month lag of cotton price along with current price, they discovered that the lagged price had no statistical significance in the model. On the other hand, Murray *et al*. and Capps *et al*. corroborated in that polyester and cotton were complements and that rayon and cotton were substitutes. Capps *et al*. cross-price elasticity calculations were much larger than those calculated by Murray *et al*. Murray *et al*. calculated cross-price elasticities for polyester and rayon to be –0.13 and 0.14, respectively, while Capps *et al*. cross-price elasticities were –0.55 and 0.27 for polyester and rayon. The Murray *et al*. results verified that the mill consumption of cotton was less responsive to a price change in polyester or rayon than it was to a change in cotton price. Murray *et al*. found that their cross-price elasticity calculations were much more in accordance with traditional economic theory than was Capps *et al*.

The textile manufacturing industry wage rate and the U.S. energy costs proved to have a negative effect on the mill consumption of cotton, as expected. The foreign GDP had a positive effect on the mill consumption of cotton. The per capita disposable income had a negative effect, but was also statistically insignificant to the model. They thought that disposable income could be highly correlated with the textile wage rate therefore causing the insignificance. The world price of cotton had a highly significant effect on mill consumption. The higher the world price, the more expensive that it becomes to produce cotton in foreign markets. This causes the prices of cotton imported into the U.S. to rise and as a result domestic mill consumption is increased.

Murray *et al*. had originally included some extra variables in their model but had decided to exclude them on the grounds that they caused a substantial increase in multicollinearity, which, in turn, led to inconsistent estimates. Two of the variables omitted were foreign textile wages and the real exchange rate. Foreign textile wages and the real exchange rate were highly collinear with foreign GDP, causing the increase in multicollinearity.

In addition, monthly promotion expenditures made by Levi Strauss were initially included in estimations to represent the effects of branded advertising on mill consumption. By incorporating this variable into the equation, estimated returns from the Cotton Program promotion expenditures became larger, but the variable did not improve the fit of the model, so it was eliminated. Murray *et al*. found that branded advertising did not influence the Cotton Program noticeably.

Subsequent to evaluating the model, Murray *et al*. estimated the model with only the last five years of data (1996-2000), which was one of the periods when the check-off program was being evaluated for its effectiveness by the Secretary of Agriculture. They wanted to confirm that the structure of the model did not change in the last five years. Some coefficients of the model parameters changed slightly, but after implementing the Chow Test, they failed to reject the null hypothesis that the structure of the model had changed, therefore the model held its validity.

Murray *et al*. then re-estimated the model using the square roots of promotion and research to check if the linear model that was used sufficiently represented the effects of promotion and research on mill consumption. After estimation of the square roots of promotion and research, Murray *et al.* found that the linear model was sufficient for determining the effects of promotion and research on the domestic mill demand for cotton.

Overall, Murray *et al*. (p.5-24) concluded that the models "provide fairly good fits to the data and generate theoretically reasonable parameter estimates." Most of the coefficients had the correct signs and were highly significant. Only a few coefficients generated the wrong signs, but they proved to be statistically insignificant to the model. In general, they verified that the U.S. Cotton Research and Promotion Program did increase the domestic mill demand for cotton, which increased producers' profits

IV. DING AND KINNUCAN ESTIMATION PROCEDURES

The major objective of the Ding and Kinnucan study was to determine optimal allocation rules for a commodity that is traded in international markets but is protected in the domestic model by deficiency payments. In the process of their research, Ding and Kinnucan developed an econometric model to estimate advertising elasticities, which was expected to explain the effects of advertising on the domestic mill-level demand for cotton.

In order to determine how advertising affects the mill-level demand for cotton, long-run elasticity estimates for the advertising variable had to be calculated. Before calculating an advertising elasticity estimate, Ding and Kinnucan first established some basic guidelines to follow. Their assumptions for the domestic side of the market were as follows: there is competitive market clearing and a single price, quantity demanded is a decreasing function of price and an increasing function of promotion, production is an increasing function of the supply-inducing price, and the promoting country (in this case, the U.S.) has sufficient market presence to affect price.

Ding and Kinnucan's initial equilibrium model was

(6)	$Q_d = f(P, A_d)$	(domestic demand),
(7)	$Q_x = g(P, A_x)$	(export demand),
(8)	$Q_s = h(P_s)$	(domestic supply),
(9)	$Q_s = Q_d + Q_x$	(equilibrium quantity), and
(10)	$P_s = \phi P_T + (1 - \phi)P$	(supply-inducing price),

where Q_d is the quantity demanded in the domestic market; Q_x is the quantity demanded in the export market; Q_s is the promoting country's total supply; P is the market price of the promoted commodity; P_T is the target price; P_s is the supply-inducing price; A_d is advertising in the domestic market; and A_x is advertising in the export market.

Quarterly data ranging from the first quarter of 1976 to the last quarter of 1993 (72 observations) were collected for the model from various sources. The raw-fiber equivalent prices and quantities demanded for cotton, rayon, and polyester were collected from tables 15, 26, 7, 23, and 27 of the USDA's *Cotton and Wool: Situation and Outlook Report.* They adjusted the quantity data for polyester by its share in the noncellulosic category (Ding). This data was obtained from Table 5 of World Textile Trade and Production Trend in *Textile Outlook International*, January 1995. Prices for imported textiles were obtained from table 3 of the U.S. Department of Commerce's *Survey of Current Business.* Domestic advertising data, which pertained to the expenditures made by Cotton Inc., were collected from Leading National Advertisers (*AD $ Summary*). For per capita information, population data were collected from tables b-59 and b-22 from various issues of the *Economic Report of the President* (Council of Economic Advisors). The Consumer Price Index data were also obtained from tables b-59 and b-22 of issues of the *Economic Report to the President.*

Ding and Kinnucan then specified an econometric demand model to estimate the advertising elasticity. They specified the basic model as

$$(11)\quad \ln Q_{dt} = a_0 + a_1 \ln P_{t\text{-}4} + a_2 \ln P^R_{t\text{-}4} + a_3 \ln P^P_{t\text{-}4} + a_4 \ln P^I_t + a_5 \ln(E_t/P^*_t) + a_6 \ln A_{dt\text{-}2} + a_7 \ln Q_{dt\text{-}1} + \Sigma^3_{j=1} b_j D_{jt} + u_t$$

where t=5,6,…,72 (the first four observations were dropped due to the lag specification); Q_{dt} is per capita mill consumption of cotton in period t, $P_{t\text{-}4}$ is the domestic farm price of cotton in period t-4, $P^R_{t\text{-}4}$ is the wholesale price of rayon in period t-4, $P^P_{t\text{-}4}$ is the wholesale price of polyester in period t-4, P^I_t is the wholesale price of imported textiles in period t, E_t is the per capita total expenditures on cotton, rayon, polyester, and imported textiles in period t, P^*_t is the Stone's Price Index ($\ln P^*_t = w_1 \ln P_t + w_2 \ln P^R_t + w_3 \ln P^P_t + w_4 \ln P^I_t$, where w_j are expenditure weights such that $\Sigma^4_{j=1} w_j = 1$), $A_{dt\text{-}2}$ is the total expenditures on cotton promotion in the domestic market in period t-2, $Q_{dt\text{-}1}$ is the lagged dependent variable, D_{jt} are quarterly dummy variables where D = 1 in the specified quarter and zero otherwise, and u_t is the error term. All the variables were specified in real terms through deflation by the Consumer Price Index where1982-1984=100.

Ding and Kinnucan specified the equation with four-quarter lags on the prices of cotton, rayon, and polyester to account for forward contracts between mills and fiber suppliers. Imported textile price and total expenditures were specified contemporaneously. The advertising variable was lagged two quarters because of preliminary testing that indicated a delayed advertising response. In addition, Ding and Kinnucan specified the equation as a double-log to allow advertising to display diminishing marginal returns.

Ding and Kinnucan performed a preliminary test to determine if there was any correlation in the advertising variable (A_d) and equation (11)'s error term. They used the Hausman test for this procedure because the sample size was larger than 50 (72 observations). The procedure is completed by way of instrumental variable estimation where a one and two period lag is placed on the advertising variable and regressed with the dummy variables (to account for the seasonality of advertising). The first stage in the regression is specified as

$$(12) \quad \ln A_t = a_0 + a_1 \ln A_{t-1} + a_2 \ln A_{t-2} + a_3 D_1 + a_4 D_2 + a_5 D_3 + w_t$$

where w_t is the error term. The estimated values for w_t are kept for the second stage of regression. The second stage of the regression is the original regression including the variable w_t. The second equation is specified as

$$(13) \quad \ln Q_{dt} = a_0 + a_1 \ln P_{t-4} + a_2 \ln P^R_{t-4} + a_3 P^P_{t-4} + a_4 \ln P^I_t + a_5 \ln(E_t/P^*_t) + a_6 \ln A_{dt} + a_7 \ln Q_{dt-1} + cw_t$$

where the null hypothesis for the test is c=0. Ding and Kinnucan found that the coefficient for w_t was insignificant (*t*-value 0.452) so they failed to reject the null hypothesis and established that there was no evidence of measurement error in the advertising variable.

Furthermore, Ding and Kinnucan tested whether or not advertising played the role of a taste shifter that affected the marginal utility. They tested whether advertising rotated the demand curve by including an interaction term and specifying the own-price coefficient in (11) as a linear function of advertising. The own-price coefficient was specified as:

$$(14) \quad a_1 = c_1 + c_2 \ln A_{dt-2}$$

They substituted this interaction term into the original equation developing the equation

(15) $\ln Q_{dt} = c_0 + c_1 \ln P_{t\text{-}4} + c_2(\ln A_{dt\text{-}2} * \ln P_{t\text{-}4}) + c_3 \ln P^R_{t\text{-}4} + c_4 \ln P^P_{t\text{-}4} + c_5 \ln P^I_t$
$+ c_6 \ln(E_t/P^*_t) + c_7 \ln A_{dt\text{-}2} + c_8 \ln Q_{dt\text{-}1} + \Sigma^3_{j=1} d_j D_{jt} + v_t$

where c_2 was the interaction term between the own-price of cotton and advertising.

They formed the following hypothesis to test the validity of the structural change in the model:

(16a) $H_N: c_2 = 0$

(16b) $H_A: c_2 \neq 0$

where a *t*-test could be implemented for the test.

Ding and Kinnucan found from the *t*-test that the model without the interaction term was appropriate for estimation because the values from regression containing the interaction term were insignificant and close to zero. The *t*-value for the structural change was -1.367, not large enough to reject (16a) at the 5% level. They concluded that advertising did not cause a structural change to the price elasticity of demand because of changes in advertising expenditures so they used equation (11) for the regression.

Ding and Kinnucan then tested the model for first and fourth-order autocorrelation with the Durbin *m*-test (one of the preferred tests suitable for models with lagged dependent variables). From the test statistic, they found no first-order autocorrelation but fourth-order autocorrelation was present. Corrections for fourth-order autocorrelation were made using the Cochrane-Orcutt algorithm in Generalized Least Squares. This was accomplished by obtaining the residuals from the OLS regression first. Next, the residuals were regressed on themselves lagged four periods and a constant. Finally, the regression is transformed and adjusted by the estimate for the autocorrelation coefficient.

Ding and Kinnucan estimated equation (11) with (Model A) and without (Model B) the quarterly dummy variables to test whether or not the mill-level demand of cotton was seasonal. They obtained reasonable results from GLS estimation. Both of their models exhibited good explanatory power with an R^2 of approximately 0.95. Most of the parameter coefficients were significant and exhibited the correctly hypothesized signs (based on prior economic theory). They found that stability conditions were satisfied with the lagged dependent variable showing high significance to the model (*t*-ratio of 8.7). They estimated long-run own-price elasticities of -0.30 for Model A and -0.29 for Model B. These elasticities were calculated by dividing the estimate of the cotton price coefficient by one minus the estimate for the lagged dependent variable coefficient. With their long-run own-price elasticities corresponding to the results of previous studies, Ding and Kinnucan suggested that the derived demand for cotton was inelastic and stable over time.

The estimated elasticities for the textile price and total expenditures were positive suggesting that increases in prices of imported textiles or consumer income may increase the derived demand for U.S. cotton fiber. Furthermore, they concluded that polyester and cotton are complements because of the negative estimated coefficient of polyester. This was consistent with previous findings, which made sense because the two fabrics are often used together in mills for manufacturing. Rayon was found to be a substitute for cotton because of the positive estimated coefficient.

The major issue to Ding and Kinnucan's study was the long-run advertising elasticity. They found elasticities of 0.062 (Model A) and 0.066 (Model B). They conducted a one-tailed *t*-test and found that the advertising elasticity was significant at the 10% level in Model A and at the 0.005% level in Model B.

Because multicollinearity was thought to be present between cotton price and the quarterly dummy variables in Model A, Ding and Kinnucan performed an *F*-test between the full model (with dummy variables) and the reduced model (without dummy variables). They obtained an *F*-value of 2.08, which was not large enough to reject the null hypothesis of the dummy variables together equaling zero. Because of the *F*-test value and the higher *t*-ratios, Model B was the preferred model of Ding and Kinnucan.

They concluded from their preferred model (Model B) that the advertising elasticity of 0.066 meant that a 10 percent increase in advertising expenditures would lead to a 0.7 percent increase in the mill-level demand for cotton, ceteris paribus. Furthermore, advertising was found to be a simple shifter and not a structural shifter of the demand for cotton. Their results were consistent because they were comparable with the results of previous researchers. Results for Ding and Kinnucan's Models A and B are reported in Table 5.

V. DUPLICATION OF MURRAY *et al*. REGRESSION RESULTS

Before any duplication procedures could be started, the raw data supplied in the Murray *et al*. report to the Cotton Board had to be transformed to exactly match the transformations used on the variables for earlier regression analyses. Variable transformations for the duplication are documented in Table 1.

Transformations were completed fairly easily due to the in-depth explanations given by Murray *et al*. in their report. Most variables merely needed to be deflated by CPI to adjust for inflation. The only transformation that presented any sort of problem was disposable income (dpi_t). Murray *et al*. regression estimates for the disposable income variable were much larger than any estimates that the attempted transformed variables yielded after regression analyses. Murray *et al*. did not clearly explain how they devised their numbers and, as a result, transformation was practically impossible. However, the variable did not create much of a dilemma for the duplication because disposable income was found to be insignificant in all three models of both studies. After transformation of all variables, SAS was utilized for regression analyses.

The first regression results duplicated from the report by Murray *et al*. was from their Ordinary Least Squares (OLS) model. The first three observations were dropped because of the lag specification of nonagricultural research expenditures; therefore 177 observations were used instead of 180.

After regression, all parameter estimates, *t*-values, and standard errors matched the Murray *et al*. results nicely except for the parameter estimate for disposable income (dpi_t). This estimate proved to be quite different from the Murray *et al*. estimate (probably due to a different transformation of the variable). Three different variations of the variable were used in the regressions but none of them yielded a parameter estimate that even came close to the Murray *et al*. parameter estimate. Their estimate for disposable income was –15,866.9, which severely contradicted the duplicated estimate of –0.0000256. This problem brought up questions about possible errors made by the authors of the original report. Once more, this did not create a major threat to the duplication because the variable was insignificant with a *t*-value of –0.37 (*p*-value 0.7090) in the duplicated model and –0.23 in the Murray *et al*. model.

All the signs of the coefficients yielded the correct positive or negative signs (in accordance with economic theory). The own-price elasticity for cotton, the seasonally adjusted promotion elasticity, and the seasonally adjusted nonagricultural research elasticity (the sum of the current and lagged elasticities) were all calculated to be approximately the same as the Murray *et al*. estimated elasticitites. Furthermore, the duplicated OLS regression results showed signs of first-order autocorrelation just as did the Murray *et al*. results with Durbin Watson statistics of 1.4790 (duplicated) and 1.5199 (Murray *et al*.).

With only slight differences between the Murray *et al*. regression results and the duplicated regression results, the Murray *et al*. results were confirmed by the duplication. The differences were probably due to different statistical software packages used and the unknown steps taken to transform the disposable income variable.

The next regression results duplicated from the Murray *et al*. report were from their GLS model (correction for first-order autocorrelation). Again, SAS was utilized to carry out regression analysis. The first three observations were dropped because of the lag specification of the seasonally adjusted nonagricultural research expenditures (177 observations). Correction for first-order autocorrelation was done in SAS by implementing the AUTOREG procedure with the Yule-Walker algorithm. The Yule-Walker estimates coincide with Prais and Winsten estimates for rho.

Parameter estimates, *t*-values, the estimate for rho, and standard errors were approximately the same as the Murray *et al*. regression estimates. Again, the duplicated disposable income (dpi_t) parameter estimate exhibited significant differentiation from the Murray *et al*. estimate. Murray *et al*. came up with an estimate of -27,662.2 and the duplication yielded an estimate of –0.000032. Due to the insignificance of the variable (*t*-value of –0.44), there was no major reason for concern.

All signs of parameter estimates were the same as before, in accordance with economic theory. Furthermore, the own-price elasticity for cotton, the seasonally adjusted promotion elasticity, and the nonagricultural research elasticity (the sum of the current and lagged elasticities) were all calculated to be approximately the same as the Murray *et al*. estimated elasticitites. The first-order autocorrelation problem seemed to be corrected with the AUTOREG procedure in SAS (Durbin Watson statistics were 2.0671 for the duplication and 2.1243 for Murray *et al*.).

As a result of only yielding slight differentiation between the two studies, the GLS results of Murray *et al*. were confirmed by duplication. Yet again, the slight differentiation between the two studies was probably due to the different transformations used on the disposable income variable and differing statistical packages.

For the attempted duplication of the preferred model of Murray *et al.*, Two-Stage Least Squares (2SLS), SAS was used for regression analysis. The first three observations were dropped due to the lag specification of the seasonally adjusted nonagricultural research expenditures (177 observations were used). The endogenous variable in the equation was the price of cotton, thus predicted values of the variable had to be estimated to continue the 2SLS technique. First, the price of cotton variable was regressed on all independent variables in the equation and the predicted values were saved for the second regression. In the second regression, the mill use of cotton variable (dependent) was regressed on all independent variables and the predicted values of the price of cotton. The regression was completed without correction for first-order autocorrelation because the procedure that Murray *et al*. (Hatanaka estimator) used was unclear. Unclear regression techniques were major problems that previous duplication researchers encountered. The results were not duplicated because of the differences but, the equation was re-estimated and compared with the Murray *et al*. results.

After the first regression was finished, the model encountered a major problem. Identification problems of the model became evident due to highly collinear variables, which caused the parameter estimates to be imprecise. In order to solve the problem and continue regression analysis, the disposable income and foreign GDP variables were deleted from the equation and the equation was re-estimated. Justification for eliminating the two collinear variables came from the fact that they were insignificant in all three Murray *et al*. models and from the outcome of the variable selection technique (backward elimination) used in SAS. The technique eliminated both disposable income and foreign GDP from the equation.

After the equation was re-estimated without disposable income or foreign GDP, the results appeared reasonable. The model exhibited good explanatory power with an R^2 of 0.8363. All the signs of the parameters were in accordance with economic theory and the Murray *et al*. results. Most all variables exhibited significant *t*-values. All of the monthly dummy variables were found to be highly significant to the regression. The equation still exhibited problems with autocorrelation with a *Durbin Watson* statistic of 1.377. Elasticity estimates for seasonally adjusted promotion and nonagricultural research and the own-price of cotton were similar to the Murray *et al*. estimates. Seasonally adjusted promotion exhibited an elasticity of 0.026. The sum of the current and lagged elasticity estimates for seasonally adjusted nonagricultural research was 0.346. Lastly, the elasticity estimate for the own-price of cotton was -0.309. In general, the 2SLS re-estimation exhibited highly similar results when compared with the Murray *et al*. results, despite the differences in the specification of the two equations.

Overall, despite the differences in the 2SLS equation, the main argument of the researchers that promotion expands the demand for upland cotton was confirmed by the duplications of the three models. All duplicated regression results are documented in Table 2.

VI. ADDITIONAL TESTS AND REGRESSIONS PERFORMED ON THE MURRAY *et al*. MODEL

A series of tests were performed on Murray *et al*.'s Ordinary Least Squares model. Model adequacy tests, a test for any influencing observations or outliers, and a correlation test for multicollinearity were performed with SAS.

The following model adequacy tests for checking whether or not the underlying assumptions of the linear regression model held were performed with SAS by constructing residual plots: normality, linearity, independent errors (autocorrelation), and constant variance (heteroschedasticity). The residual plot for testing normality was constructed by plotting the normal quartile against the residuals. The plots for testing the constant variance and linearity assumption were both constructed by plotting the residuals against the predicted values. Finally, the plot for testing the independent errors assumption was constructed by plotting the residuals against time (observations).

The residual plots for testing normality, constant variance, and the linearity assumptions showed that the assumptions were not violated. However, after the test for the independent errors assumption, a pattern was detected in the residuals. The pattern showed signs of positive autocorrelation supporting Murray *et al*.'s previous findings.

Several residual plots testing for influencing observations or outliers were constructed. A leverage plot, the Cook's Distance Measure Plot, and the DFFITS plot were all constructed by plotting each one by the observations. After observing the plots, there were a small number of outliers but, with 180 observations, none were considered to have any influence on the regression.

Because of the fact that mulitcollinearity was thought to be present in the Murray *et al*. OLS model, a Pearson's correlation test was performed in SAS with the CORR procedure. The disposable income variable (dpi_t) was highly collinear with the foreign GDP ($fgdp_t$) with a correlation coefficient of 0.97. This may have led to the insignificance of the disposable income variable in all three original models. In addition, the A Index of the world cotton price was collinear with the domestic price of cotton, as expected, with a correlation coefficient of 0.92.

After performing a sequence of different model tests, a few variations to the original Murray *et al*. econometric demand model were completed with SAS. All variations were regressed as OLS without corrections for first-order autocorrelation and compared to the original Murray *et al*. OLS regression results.

For the first variation of the Murray *et al*. model, unadjusted promotion and nonagricultural research expenditure data were used instead of seasonally adjusted data. Because of the inclusion of the monthly dummy variables into the original model, the use of unadjusted promotion and research data were presumed to make the model less biased. The reason for using the seasonally adjusted data by the original researchers was unclear.

After regressing model (5) with unadjusted promotion and nonagricultural research data, the R^2_{Adj} decreased in value, the F-value decreased, and the sum of squared errors increased. Furthermore, the estimated coefficient for promotion became negative and insignificant thus suggesting that promotion is immaterial to increasing mill-level consumption. All other signs were the same as in the original OLS model. The long-run elasticity estimates for promotion, the own-price of cotton, and the sum of the current and lagged effects of research were –0.007, -0.133, and 0.217, respectively. In addition, autocorrelation was still present (*Durbin-Watson* 1.510). This variation certainly did nothing to improve the fit of the model when compared to the original. This suggested that the use of seasonally adjusted data was fitting for improvement of the model and that the inferences made by the researchers are conditional on whether or not the promotion data is seasonally adjusted.

Next, the square roots of promotion and nonagricultural research expenditures were used with the original model (5) to try and observe diminishing marginal returns. The linear model specification of the original model violates the law of diminishing returns.

The R^2_{Adj} and the *F*-value of the model decreased slightly and the sum of squared errors increased slightly. Most of the signs of the coefficient were the same except for the first nonagricultural research lag becoming negative. The significance of promotion and nonagricultural research expenditures increased slightly. Long-run elasticity estimates for both advertising and research were calculated from the equation: $q = a + bA^{1/2} + cR^{1/2}$, where $E_{q,A}$=½ $bA^{1/2}/q$ and $E_{q,R}$= ½ $cR^{1/2}/q$. These elasticities were evaluated at data means. In the equation, the values used for q and A are sample means for both promotion and research. The long-run elasticity estimate for promotion was 0.027. The long-run elasticity estimate for the sum of the current and lagged effects of nonagricultural research was 0.303. In addition, the long-run elasticity estimate for the own-price of cotton was –0.170. Furthermore, autocorrelation was still present (*Durbin-Watson* 1.440).

The third variation consisted of implementing a lagged dependent variable, to account for any advertising carry-over effects, while eliminating the nonagricultural research lags. The nonagricultural research expenditure variable was expressed contemporaneously. Only the first observation was dropped allowing the regression to contain 179 observations.

All parameter estimates exhibited correctly hypothesized signs after OLS was completed. The R^2_{Adj} of the model improved and the sum of squared errors decreased compared to the original specification of the model. The lagged dependent variable coefficient exhibited high significance to the model with a t-value of 4.60 (p-value $<.0001$). The long-run elasticity estimates for promotion and the own-price of cotton were 0.026 and –0.136, respectively. The long-run elasticity estimate for nonagricultural research was 0.245. The elasticity estimates were calculated by, first, calculating the short-run estimates and then, dividing the short-run estimate by one minus the coefficient for the lagged dependent variable.

A different tactic was implemented to test for first-order autocorrelation in the lagged dependent variable model. The Durbin h test statistic was used instead of the Durbin Watson because it is the preferred test for models with lagged dependent variables. The following hypothesis was formed to determine if autocorrelation was present:

(17a) H_N: No autocorrelation

(17b) H_A: Autocorrelation

The Durbin *h* statistic was –3.3253 (*p*-value 0.0004) so, hypothesis (17a) was rejected and autocorrelation was thought to be present in the model.

The lagged dependent variable model exhibited good properties of fit; however the lag structure of the model was still not specified correctly with respect to promotion.

Because of the collinear variables in the model, a variable selection method was performed with SAS. After applying the variable selection method, backward elimination, both the *dpi* and the *fgdp* variables were eliminated from the model. Backward elimination is particularly popular because it provides information for the analysts about the effect of including all the candidate predictors therefore no obvious predictor will be missed. The procedure consists of starting with the full equation and successively dropping one variable at a time. The first step is to start with the full equation with k predictors. Next, drop the predictor that has the smallest partial F statistic. The smallest F statistic is compared with the preselected F_{out} and if the F statistic is smaller than the F_{out}, the predictor is removed from the equation. Next, the model is fitted for k-1 predictors. Then the partial F statistics for the new model are found and the procedure is repeated. The final step is to stop when the smallest partial F value is not less than the F_{out} value.

Accordingly, after the backward elimination procedure results, the model was regressed without the two variables (*dpi* and *fgdp*). After regression, the R^2_{Adj} increased, supporting the fact that the deletion of the two variables actually improved the model.

Furthermore, the *F*-value of the model and the significance of all variables in the model increased although the elasticity estimates remained approximately the same as the original Murray *et al*. estimates. An *F* test was executed to examine if, together, the two variables equaled zero. The following hypothesis was developed:

(18a) H_N: $\beta_7 = \beta_8 = 0$

(18b) H_A: Full Model

The *F* value was 0.66708, which was not large enough to reject the null hypothesis (compared to the critical value of 3.00 at the .05% level).

After all variations to the original model were completed, it was discovered that the model without *dpi* and *fgdp* was the model that provided the best fit for estimation purposes. However, with the deletion of variables, biasness is sometimes introduced into an econometric model. In addition, with the unsuccessful attempts at transforming the disposable income variable exactly as did Murray *et al*., the model without the two variables may not be the most appropriate. Furthermore, autocorrelation presents problems for every model, as expected because of the time-series data. All additional regression results are documented in Table 3.

Table 1. Variables Used in the Duplication of the Murray *et al.* Study of Cotton Promotion, January 1986-December 2000

Variable	Definition
Per Capita Mill Use	(U.S. domestic mill use*1,000)(480lbs.)/(U.S. population*1,000)
Cotton Price	Fiber equivalent effective mill price of cotton/(CPI/100)
Polyester Price	Fiber equivalent polyester price/(CPI/100)
Rayon Price	Fiber equivalent rayon price/(CPI/100)
Domestic Textile Wages	Domestic textile wages/(CPI/100)
A Index of the World Cotton Price	Fiber equivalent A Index/(CPI/100)
Energy Cost Index	Energy Price Index/(CPI/100)
U.S. Disposable Income	[(Disposable income annual rate*1,000,000,000)/(CPI/100)]/(U.S. population*1,000)
Foreign Gross Domestic Product	OECD GDP annual rate/(CPI/100)
Seasonally Adjusted Promotion	CI seasonally adjusted promotional expenditures/(CPI/100)
Seasonally Adjusted Nonagricultural Research	CI seasonally adjusted nonagricultural research expenditures/(CPI/100)

Table 2. Duplication[1] of Regression Results for the Domestic Mill Demand Equation from the Murray *et al*. Study of Cotton Promotion, January 1986-December 2000

Independent Variable	OLS		GLS		2SLS	
	Murray *et al*.	Duplicated	Murray *et al*.	Duplicated[2]	Murray *et al*.	Re-estimation[3]
SAGPROM$_t$	2.04E-08	2.06E-08	1.57E-08	1.60E-08	2.12E-08	2.36E-08
	(1.93)	(1.94)	(1.58)	(1.62)	(2.00)	(2.22)
	[0.022]	[0.022]	[0.017]	[0.017]	[0.023]	[0.026]
SAGNARES$_t$	4.90E-07	4.50E-07	4.68E-07	4.41E-07	5.12E-07	4.77E-07
	(4.55)	(4.24)	(4.61)	(4.46)	(4.72)	(4.37)
	[0.145]	[0.134]	[0.139]	[0.131]	[0.152]	[0.143]
SAGNARES$_{t-1}$	4.29E-08	2.20E-08	2.91E-08	1.70E-08	7.30E-08	6.66E-08
	(0.42)	(0.21)	(0.28)	(0.17)	(0.68)	(0.66)
	[0.013]	[0.007]	[0.009]	[0.005]	[0.022]	[0.020]
SAGNARES$_{t-2}$	2.64E-07	2.39E-07	2.52E-07	2.36E-07	2.79E-07	2.70E-07
	(2.67)	(2.44)	(2.62)	(2.52)	(2.75)	(2.79)
	[0.078]	[0.071]	[0.075]	[0.070]	[0.083]	[0.080]
SAGNARES$_{t-3}$	3.21E-07	3.20E-07	2.97E-07	3.01E-07	3.16E-07	3.47E-07
	(3.10)	(3.05)	(3.06)	(3.06)	(3.06)	(3.32)
	[0.095]	[0.095]	[0.088]	[0.089]	[0.094]	[0.103]
PCOTTON$_t$	-0.00434	-0.00430	-0.00265	-0.00274	-0.01089	-0.00812
	(-2.52)	(-2.48)	(-1.35)	(-1.42)	(-3.21)	(-2.07)
	[-0.165]	[-0.164]	[-0.101]	[-0.104]	[-0.413]	[-0.309]
PPOLY$_t$	-0.00434	-0.00364	-0.00371	-0.00325	-0.00361	-0.00393
	(-2.43)	(-2.13)	(-1.64)	(-1.57)	(-1.65)	(-2.28)
PRAYON$_t$	0.00284	0.00172	0.00205	0.00134	0.00261	0.00215
	(1.99)	(1.48)	(1.15)	(1.07)	(1.50)	(1.95)
DTEXWAGE$_t$	-0.19959	-0.25961	-0.24807	-0.28480	-0.13169	-0.18608
	(-1.67)	(-2.31)	(-1.70)	(-2.15)	(-0.87)	(-1.60)
WPCOTTON$_t$	0.00710	0.00617	0.00548	0.00487	0.01264	0.00912
	(4.17)	(4.03)	(2.71)	(2.74)	(4.08)	(3.02)
DECI$_t$	-0.00683	-0.00725	-0.00713	-0.00737	-0.00723	-0.00548
	(-2.43)	(-2.58)	(-2.16)	(-2.26)	(-2.14)	(-2.20)
DPI$_t$	-15866.9	-2.56E-05	-27662.2	-3.20E-05	-67879.7	**
	(-0.23)	(-0.37)	(-0.37)	(-0.44)	(-0.87)	
FGDP$_t$	3.20E-05	4.85E-05	5.80E-05	6.61E-05	0.000061	**
	(0.47)	(0.71)	(0.76)	(0.90)	(0.79)	
CONSTANT$_t$	1.97714	2.41392	2.26220	2.52440	1.75181	1.93146
	(2.27)	(2.98)	(2.17)	(2.68)	(2.07)	(2.49)
M1$_t$	0.24005	0.24087	0.23910	0.23990	0.23720	0.24205
	(7.19)	(7.17)	(8.23)	(8.22)	(7.57)	(7.12)
M2$_t$	0.15837	0.15783	0.15725	0.15700	0.15811	0.16058
	(4.74)	(4.69)	(4.83)	(4.82)	(4.64)	(4.71)
M3$_t$	0.32105	0.32192	0.32054	0.32130	0.32788	0.32759
	(9.60)	(9.56)	(9.59)	(9.61)	(9.43)	(9.49)

Table 2. (Continued) Duplication[1] of Regression Results for the Domestic Mill Demand Equation from the Murray *et al.* Study of Cotton Promotion, January 1986-December 2000

Independent Variable	OLS		GLS		2SLS	
	Murray *et al.*	Duplicated	Murray *et al.*	Duplicated[2]	Murray *et al.*	Re-estimation[3]
$M4_t$	0.22697	0.22962	0.22504	0.22680	0.22650	0.23547
	(6.86)	(6.90)	(6.72)	(6.79)	(6.49)	(6.83)
$M5_t$	0.30343	0.29799	0.29989	0.29570	0.32037	0.30318
	(9.06)	(8.76)	(8.81)	(8.61)	(8.99)	(8.50)
$M6_t$	0.25450	0.25667	0.25163	0.25330	0.27420	0.26339
	(7.54)	(7.56)	(7.32)	(7.39)	(7.59)	(7.42)
$M7_t$	0.10311	0.10225	0.09812	0.09790	0.11965	0.11161
	(3.10)	(3.05)	(2.91)	(2.91)	(3.38)	(3.18)
$M8_t$	0.36200	0.36095	0.35981	0.35940	0.36604	0.36321
	(11.05)	(10.95)	(10.89)	(10.90)	(10.74)	(10.83)
$M9_t$	0.28302	0.28392	0.28263	0.28330	0.28398	0.28232
	(8.54)	(8.50)	(8.47)	(8.49)	(8.23)	(8.34)
$M10_t$	0.34242	0.34158	0.34239	0.34190	0.33890	0.33932
	(10.41)	(10.32)	(10.69)	(10.66)	(10.10)	(10.09)
$M11_t$	0.19263	0.19100	0.19252	0.19150	0.18853	0.18969
	(5.88)	(5.80)	(6.78)	(6.72)	(6.15)	(5.67)
rho	-	-	0.26845	-0.25753	0.19303	-
			(3.32)	(-3.28)	(2.62)	
N	177	177	177	177	176	177
R^2	0.8453	0.8432	0.8550	0.8546	0.7990	0.8363
Dw	1.5199	1.4790	2.1243	2.0671	2.0318	1.3770
SSE	1.2064	1.2234	1.3020	1.1342	1.2413	1.2771

Notes: Figures in parentheses are absolute values of *t*-ratios. Figures in brackets are long-run elasticities.
[1] All duplicated models were performed using the statistical software SAS.
[2] Duplicated GLS regressions were performed with correction for first-order autocorrelation using the Yule-Walker Method (Prais and Winsten) in SAS.
[3]2SLS results were computed without correction for first-order autocorrelation (Murray *et al*. used the Hatanaka Procedure for the correction); therefore the results are not an exact duplication.

**Disposable Income and Foreign GDP were eliminated from the regression because they were highly collinear (correlation coefficient of 0.97) causing identification problems in the model.

Table 3. Additional[1] Tests and Regressions Performed on the Domestic Mill Demand Equation from the Murray *et al*. Study of Cotton Promotion, January 1986 – December 2000

Independent Variable	Murray *et al*.	Unadjusted P&R[2]	Square Root P&R[3]	Lagged Response[4]	Exempting DPI & FGDP
$SAGPROM_t$	2.04E-08	-4.13E-09	6.55E-05	1.66E-08	2.26E-08
	(1.93)	(-0.59)	(2.03)	(1.59)	(2.17)
	[0.022]	[-0.007]	[0.027]	[0.026]	[0.024]
$SAGNARES_t$	4.90E-07	1.95E-07	6.27E-04	5.67E-07	4.60E-07
	(4.55)	(3.90)	(4.29)	(6.05)	(4.35)
	[0.145]	[0.085]	[0.142]	[0.245]	[0.137]
$SAGNARES_{t-1}$	4.29E-08	5.60E-08	-1.53E-05		5.28E-08
	(0.42)	(1.14)	(-0.11)	-	(0.53)
	[0.013]	[0.024]	[-0.003]		[0.016]
$SAGNARES_{t-2}$	2.64E-07	1.30E-07	3.05E-04		2.65E-07
	(2.67)	(2.71)	(2.28)	-	(2.79)
	[0.078]	[0.056]	[0.071]		[0.078]
$SAGNARES_{t-3}$	3.21E-07	1.25E-07	4.24E-04		3.43E-07
	(3.10)	(2.57)	(2.95)	-	(3.35)
	[0.095]	[0.052]	[0.093]		[0.101]
$PCOTTON_t$	-0.00434	-0.00350	-0.00446	-0.00247	-0.00495
	(-2.52)	(-1.86)	(-2.55)	(-1.49)	(-3.13)
	[-0.165]	[-0.133]	[-0.170]	[-0.136]	[-0.188]
$PPOLY_t$	-0.00434	-0.00384	-0.00317	-0.00244	-0.00481
	(-2.43)	(-2.08)	(-1.84)	(-1.44)	(-3.51)
$PRAYON_t$	0.00284	0.00104	0.00146	0.00089	0.00223
	(1.99)	(0.84)	(1.26)	(0.83)	(2.06)
$DTEXWAGE_t$	-0.19959	-0.43715	-0.25732	-0.21840	-0.22979
	(-1.67)	(-4.06)	(-2.24)	(-2.13)	(-2.22)
$WPCOTTON_t$	0.00710	0.00561	0.00643	0.00386	0.00677
	(4.17)	(3.38)	(4.16)	(2.53)	(4.75)
$DECI_t$	-0.00683	-0.00945	-0.00742	-0.00642	-0.00625
	(-2.43)	(-3.15)	(-2.63)	(-2.72)	(-2.72)
DPI_t	-15866.9	-2.35E-05	-2.52E-05	-5.60E-05	-
	(-0.23)	(-0.31)	(-0.37)	(-0.87)	
$FGDP_t$	3.20E-05	3.71E-05	4.63E-05	7.74E-05	-
	(0.47)	(0.48)	(0.68)	(1.24)	
$CONSTANT_t$	1.97714	3.55993	1.93547	2.13910	2.21079
	(2.27)	(4.57)	(2.20)	(3.07)	(3.17)
$M1_t$	0.24005	0.39625	0.24098	0.29860	0.24161
	(7.19)	(4.69)	(7.14)	(8.34)	(7.24)
$M2_t$	0.15837	0.22703	0.15751	0.14550	0.15909
	(4.74)	(2.70)	(4.66)	(4.49)	(4.75)
$M3_t$	0.32105	0.41786	0.32199	0.32640	0.32305
	(9.60)	(4.86)	(9.52)	(10.04)	(9.62)

Table 3. (Continued) Additional[1] Tests and Regressions Performed on the Domestic Mill Demand Equation from the Murray *et al*. Study of Cotton Promotion, January 1986 – December 2000

Independent Variable	RTI Results	Unadjusted P&R[2]	Square Root P&R[3]	Lagged Response[4]	Exempting DPI & FGDP
$M4_t$	0.22697	0.46505	0.22940	0.19170	0.22886
	(6.86)	(7.73)	(6.87)	(5.66)	(6.91)
$M5_t$	0.30343	0.49672	0.29843	0.29530	0.29394
	(9.06)	(8.32)	(8.75)	(8.89)	(8.76)
$M6_t$	0.25450	0.45722	0.25749	0.23260	0.25490
	(7.54)	(7.53)	(7.57)	(6.86)	(7.58)
$M7_t$	0.10311	0.27413	0.10280	0.08660	0.10354
	(3.10)	(4.59)	(3.06)	(2.64)	(3.11)
$M8_t$	0.36200	0.53156	0.36586	0.38550	0.36121
	(11.05)	(8.78)	(11.06)	(11.73)	(10.98)
$M9_t$	0.28302	0.47105	0.28547	0.23590	0.28267
	(8.54)	(7.57)	(8.53)	(6.72)	(8.49)
$M10_t$	0.34242	0.52281	0.34284	0.32600	0.34115
	(10.41)	(8.51)	(10.34)	(9.94)	(10.33)
$M11_t$	0.19263	0.37024	0.19366	0.14620	0.19147
	(5.88)	(6.28)	(5.86)	(4.34)	(5.83)
$MILLLAG_t$	-	-	-	0.31090	-
				(4.60)	
N	177	177	177	179	177
R^2	0.8453	0.8172	0.8421	0.8515	0.8418
Dw/Dh	1.5199	1.5100	1.4400	-3.3253**	1.4980
SSE	1.2064	1.4258	1.2317	1.2010	1.2342

Notes: Figures in parentheses are absolute values of *t*-ratios. Figures in brackets are long-run elasticities.
[1]All additional regressions were performed using the statistical software package SAS.
[2] Unadjusted promotion and research data were used instead of seasonally adjusted data.
[3] The seasonally adjusted promotion and research variables were the only variables transformed to square roots; the other variables remained the same as in the original Murray *et al*. model.
[4]Elasticities computed for the Lagged Response model are long-run, i.e., the short-run elasticity divided by one minus the coefficient of the lagged dependent variable.
**The Durbin *h* Statistic was used with the lagged response model as an autocorrelation test.

VII. REPLICATION OF DING AND KINNUCAN REGRESSION RESULTS

The replication was not exact for two reasons: first, the replication was completed with monthly, rather than quarterly, data and second, the textile price and expenditure variables had to be proxied. Despite these differences, the overall issue of whether the inferences (advertising shifts the demand curve for cotton) are robust to sample updating could still be tested.

Before any attempts at replicating the regression results could be started, the data for the variables had to be transformed to match Ding and Kinnucan's specification of their demand model for explaining the effects of advertising on the mill level demand of upland cotton. All of the data used for the replication was acquired directly from the Murray *et al*. study. The data for the domestic consumption of rayon, polyester, and imported textiles could not be obtained. This data was needed to form the total expenditure variable and the Stone's Price Index from the Ding and Kinnucan model. Furthermore, the prices of imported textiles could not be obtained. Sources of the data tables reported in the study were unclear therefore proxies for these variables were used to continue regression analyses. In place of the total expenditure variable, disposable income was used. In addition, the A Index of the world cotton price (raw-fiber equivalent) was used in place of imported textile prices. Both variables were also obtained from the Murray *et al*. study.

The mill use of cotton variable ($\ln Q_{dt}$), the raw fiber equivalent prices of cotton ($\ln P_{t\text{-}12}$), rayon ($\ln P^{R}_{t\text{-}12}$), and polyester ($\ln P^{P}_{t\text{-}12}$), the A index of the world cotton price ($\ln P^{wc}_{t}$), U.S. disposable income (DPI_t), and the advertising variable ($\ln A_{dt\text{-}6}$) were transformed by simply taking the natural log of the previous transformations used in the duplication of the Murray *et al*. regression results. Transformations for the replication are documented in Table 4.

The Ding and Kinnucan model was specified with quarterly data, but the replication was performed using monthly data. The raw fiber equivalent prices of cotton, rayon, and polyester were specified with 12-month lags to compare with the 4-quarter lags used in the Ding and Kinnucan model. The U.S. disposable income and A Index of the world cotton price variables were specified contemporaneously. The advertising variable was specified with a 6-month lag to compare with the 2-quarter lag used in the Ding and Kinnucan study. Furthermore, for consistency with the Ding and Kinnucan model, 11 monthly dummy variables were used instead of 3 quarterly dummy variables. The full model used for replication was specified as

$$(19) \qquad \ln Q_{dt} = a_0 + a_1 \ln P_{t\text{-}12} + a_2 \ln P^{R}_{t\text{-}12} + a_3 P^{P}_{t\text{-}12} + a_4 \ln P^{WC}_{t} + a_5 \ln DPI_t + a_6 \ln A_{dt\text{-}6} + a_7 \ln Q_{dt\text{-}1} + \Sigma^{11}_{j=1} b_j D_{jt} + u_t$$

where P^{WC}_{t} is the A index of the world cotton price and DPI_t is the U.S. disposable income. All other variables were the same as in the original Ding and Kinnucan model.

To test whether or not advertising rotated the demand curve in the replicated model, i.e., advertising plays the role of a "taste shifter", an interaction term was included with equation (19) and the model was specified as

$$(20) \quad \ln Q_{dt} = c_0 + c_1 \ln P_{t\text{-}12} + c_2(\ln A_{dt\text{-}6} * \ln P_{t\text{-}12}) + c_3 \ln P^R{}_{t\text{-}12} + c_4 \ln P^P{}_{t\text{-}12} + c_5 \ln P^{WC}{}_t + c_6 \ln DPI_t + c_7 \ln A_{dt\text{-}6} + c_8 \ln Q_{dt\text{-}1} + \Sigma^{11}{}_{j=1}\, d_j D_{jt} + v_t$$

where c_2 was the interaction term between the own-price of cotton and advertising.

The following hypothesis was formed to test the validity of the structural change in the replicated model:

$$(21a) \qquad H_N: c_2 = 0$$

$$(21b) \qquad H_A: c_2 \neq 0$$

where a t-test was implemented for the test.

After correctly specifying the models for replication and forming hypotheses to test the validity of the structural change, regression analyses were performed with SAS. Regressions were run for two different sets with four different model variations (Models A, B, C, and D) to each set. The first set of regressions was run with unadjusted advertising data while the second set was run with seasonally adjusted advertising data. Model A was the full model (with monthly dummy variables) including an interaction term. Model B was the full model (with monthly dummy variables) without the interaction term. Model C was the model with an interaction term and without the monthly dummy variables. Finally, Model D was the model without an interaction term or the monthly dummy variables. All models were regressed in GLS (the PROC AUTOREG procedure in SAS utilized the Yule-Walker algorithm for correction of autocorrelation).

Initially, the regressions were performed using the unadjusted advertising data. The first model replicated (Model A) with unadjusted advertising data was the full model including the interaction term. The first 12 observations were dropped due to the lag specification of the model (168 observations). The model showed fair explanatory power with an R^2 of 0.7892. Most variables exhibited the correct positive or negative signs according to economic theory, except the own-price coefficient of cotton, which was positive. The rayon price coefficient (positive) and the polyester price coefficient (negative) were in accordance with economic theory being that rayon is a substitute and polyester is a complement to cotton. The lagged dependent variable was highly significant (*t*-ratio of 14.63) implying that advertising has carry-over effects to domestic mill demand of cotton. The monthly dummy variables were also highly significant which implied that there is substantial seasonality in the data. The interaction term and all other variables displayed insignificant *t*-ratios. The long-run elasticity estimate for advertising was 0.098 and the long-run elasticity estimate for the own-price of cotton was –0.009. Because of the inclusion of the lagged dependent variable, the long-run elasticity estimates were calculated by dividing the short-run estimate[1] by one minus the estimate for the lagged dependent variable. Because of the insignificance of the advertising variable from data updating, one could not be confident that advertising shifted the demand curve, despite the positive demand elasticity.

The next model to be replicated (Model B) with unadjusted advertising data was the full model without an interaction term (This model could be directly compared to

[1] Short-run elasticities for Models A and C (with an interaction term) in both sets of regressions were calculated from the following example equation: $\ln q = a + b \ln P + c \ln A + d(\ln A * \ln P)$, where $E_{q,A} = c + d * \ln P$; and $E_{q,P} = b + d * \ln A$, where $\ln P$ and $\ln A$ are evaluated at data means.

Ding and Kinnucan's Model A). The interaction term was eliminated because of its insignificant *t*-ratio in the previous regression. The first 12 observations were dropped due to the lag specification of the model (168 observations). The model showed fair explanatory power with an R^2 of 0.7890, but Ding and Kinnucan's model had an R^2 of 0.9550. All variables exhibited the correct positive or negative signs. The lagged dependent variable (*t*-ratio of 15.03) and all monthly dummy variables were, again, highly significant. The high significance of the monthly dummy variables contradicted Ding and Kinnucan's results of insignificant dummy variables. The significance of the other variables increased slightly with the deletion of the interaction term, but the variables were still insignificant to the regression. The long-run elasticity estimate for advertising was 0.096. This estimate was somewhat higher than Ding and Kinnucan's estimate of 0.062. The estimated long-run elasticity for the own-price of cotton was –0.012. This estimate was extremely lower than Ding and Kinnucan's estimate of –0.30. The long-run elasticity estimates were calculated by dividing the short-run estimate for the elasticity by one minus the estimate for the lagged dependent variable.

Because of the insignificance of the advertising variable in Model B, one could not be certain that advertising shifts the demand for cotton, despite the positive demand elasticity. Furthermore, the conclusions of Ding and Kinnucan's model were found to be conditional on the time period in which the data was tested or on the particular model that they used which means that the inferences that they made are fragile.

The next model to be replicated (Model C) with unadjusted advertising data was the model with an interaction term and without the monthly dummy variables. The model showed very poor explanatory power with an R^2 of 0.3993. Most of the variables exhibited the correct positive or negative signs. The advertising variable became negative, implying that advertising would decrease mill level demand for cotton, but the variable was insignificant (t-ratio of –1.62). The lagged dependent variable was still highly significant to the regression (t-ratio of 6.39). The rayon variable became significant to the regression (t-ratio of 2.83). All other variables in the equation increased in significance from the previous regression, but were still insignificant. The long-run elasticity estimate for advertising was 0.012 and the estimated elasticity for the own-price of cotton was –0.011 (long-run elasticity estimates were calculated the same as in Model A). Because of the insignificance of the advertising variable, one could not make confident inferences as to whether advertising shifts the demand for cotton.

The final model replicated (Model D) with unadjusted promotion data was the model without the interaction term or the monthly dummy variables (This model could be directly compared to Ding and Kinnucan's Model B). The model exhibited very poor explanatory power with an R^2 of 0.3896 compared to 0.95 in Ding and Kinnucan's model. All signs were in accordance with economic theory. The lagged dependent variable was highly significant (t-ratio of 6.70). All other variables, except rayon, were insignificant to the regression. The long-run elasticity estimate for advertising was 0.016. This estimate was much smaller than Ding and Kinnucan's estimate of 0.066. In addition, the estimated elasticity for the own-price of cotton was –0.011, which was also much smaller than Ding and Kinnucan's estimated elasticity of –0.29.

Once more, because of the insignificance of the advertising variable in Model D, one could not be certain that advertising shifts the demand for cotton. Furthermore, the conclusions of Ding and Kinnucan's model were found to be conditional on the time period in which the data was tested or on the particular model that they used which means that their inferences are fragile.

After regressions were complete, and *F*-test was performed on Model B vs. D to observe if together the dummy variables equaled zero. The following hypothesis was constructed for the test:

(22a) H_N: a_8=a_9=,...,a_{18}=0

(22b) H_A: Full model

The *F*-value was 25.41, which was larger than the critical value of 1.645 (at the .05% level) so the null hypothesis was rejected and the monthly dummy variables were definitely needed in the equation.

When compared to Ding and Kinnucan's regression results, the results for Models B and D with unadjusted data did not show good properties of fit. The major difference may have been due to the use of the proxied variables in the replicated models and the use of monthly, rather than quarterly, data. The models with monthly dummy variables (A and B) contradicted Ding and Kinnucan's earlier finding for the need to eliminate these variables because of insignificance to the regression (the dummy variables were all highly significant in the replication). In fact, it was shown that the model shows severe seasonality because of the high significance of the monthly dummy variables (also supported by the *F*-test value of 25.41). Overall, with the use of unadjusted advertising data, the conclusions made by Ding and Kinnucan were found to be conditional on the time period in which they tested the data. Furthermore, their previous results were negated and their inferences were found to be fragile. All replicated regression results for unadjusted advertising data are documented in Table 6.

The next set of regressions was performed with seasonally adjusted advertising data to observe any differences between seasonally adjusted and unadjusted advertising data. In addition, regressions were compared with the Ding and Kinnucan results. All models (A, B, C, and D) were specified the same as with the unadjusted advertising data models.

The first model replicated (Model A) with seasonally adjusted advertising data was the full model including the interaction term. The first 12 observations were dropped due to the lag specification of the model (168 observations). The model showed fair explanatory power with an R^2 of 0.7894. Most variables exhibited the correct positive or negative signs according to economic theory, except advertising. The advertising coefficient was negative but was also insignificant. The rayon price coefficient (positive) and the polyester price coefficient (negative) were in accordance with economic theory being that rayon is a substitute and polyester is a complement to cotton. The lagged dependent variable was highly significant (*t*-ratio of 14.14) implying that advertising has carry-over effects to domestic mill demand of cotton. The monthly dummy variables were also highly significant which implied that there is substantial seasonality. The interaction term and all other variables displayed insignificant *t*-ratios. The long-run elasticity estimate for advertising was 0.085 and the long-run elasticity estimate for the own-price of cotton was –0.014. The long-run elasticity estimates were calculated by dividing the short-run estimate[2] by one minus the estimate for the lagged dependent variable. Because of the insignificance of the advertising variable from data updating, one could not be confident that advertising shifted the demand curve.

The next model to be replicated (Model B) with seasonally adjusted promotion data was the full model without an interaction term (This model could be directly compared to Ding and Kinnucan's Model A). The interaction term was eliminated because of its insignificant *t*-ratio in the previous regression. The first 12 observations were dropped due to the lag specification of the model (168 observations). The model showed fair explanatory power with an R^2 of 0.7890, but Ding and Kinnucan's model had an R^2 of 0.9550. All variables exhibited the correct positive or negative signs. The lagged dependent variable (*t*-ratio of 15.03) and all monthly dummy variables were, again, highly significant. The high significance of the monthly dummy variables contradicted Ding and Kinnucan's findings of insignificant dummy variables. The significance of the other variables increased slightly with the deletion of the interaction term, but the variables were still insignificant to the regression. The long-run elasticity estimate for advertising was 0.096. This estimate was only slightly higher than Ding and Kinnucan's estimate of 0.062. The estimated long-run elasticity for the own-price of cotton was –0.012. This estimate was extremely lower than Ding and Kinnucan's estimate of –0.30. The estimates from adjusted Model B were almost exactly the same as the unadjusted estimates for Model B (parameter estimates and *t*-ratios for dummy variables differed slightly). The long-run elasticity estimates were calculated by dividing

[2] Short-run elasticities for Models A and C (with an interaction term) in both sets of regressions were calculated from the following example equation: $\ln q = a + b \ln P + c \ln A + d(\ln A * \ln P)$, where $E_{q,A} = c + d * \ln P$; and $E_{q,P} = b + d * \ln A$, where $\ln P$ and $\ln A$ are evaluated at data means.

the short-run estimate for the elasticity by one minus the estimate for the lagged dependent variable.

Because of the insignificance of the advertising variable in Model B, one could not be certain that advertising shifts the demand for cotton. Furthermore, the conclusions of Ding and Kinnucan's model were found to be conditional on the time period in which the data was tested or on the particular model that they used which means that the inferences are fragile.

The next model to be replicated (Model C) with seasonally adjusted promotion data was the model with an interaction term and without the monthly dummy variables. The model showed very poor explanatory power with an R^2 of 0.4326. Most of the variables exhibited the correct positive or negative signs. The parameter estimate for the advertising variable became negative and was also significant (*t*-ratio of –2.47). The lagged dependent variable was still highly significant to the regression (*t*-ratio of 6.17). Most variables gained significance. The interaction term was significant to the regression (*t*-value of 2.60), which says that advertising does rotate the demand curve for cotton, i.e., advertising is a "taste shifter" in reference to the cotton market. This finding contradicted Ding and Kinnucan's earlier results of advertising not causing rotation in the demand curve with insignificant interaction terms in their regressions. The long-run elasticity estimate for advertising was 0.070, implying that a 10 percent increase in advertising would lead to a 0.7 percent increase in mill level consumption of cotton, ceteris paribus. The estimated elasticity for the own-price of cotton was 0.015. This calculation contradicts many past studies with its positive coefficient being that cotton price is usually inelastic.

From the results of Model C, Ding and Kinnucan's prior results were negated in the fact that the interaction term in the replicated model was significant. This finding led us to infer that, with the updated data, advertising may, in fact, play the role of a "taste shifter" by rotating the demand curve for cotton. The long-run elasticity estimate for advertising (because of its significance to the regression) in the replication did support Ding and Kinnucan's conclusion that advertising shifted the demand for cotton which made the inference more robust.

The final model replicated (Model D) with seasonally adjusted promotion data was the model without the interaction term or the monthly dummy variables (This model could be directly compared to Ding and Kinnucan's Model B). The model exhibited very poor explanatory power with an R^2 of 0.4081 compared to 0.95 in Ding and Kinnucan's model. Most signs were in accordance with economic theory, except for the own-price of cotton, which was positive (the *t*-ratio was 0.05, so the positive coefficient did not hold validity). The lagged dependent variable was highly significant (*t*-ratio of 6.70). Most of the variables were significant to the regression, except for the own-price of cotton and disposable income. The long-run elasticity estimate for advertising was 0.095, implying that a 10 percent increase in advertising would lead to a 0.95 percent increase in mill level consumption of cotton, ceteris paribus. This estimate was larger than Ding and Kinnucan's estimate of 0.066 and was significantly larger than the estimate that the unadjusted regression (Model D) yielded. In addition, the estimated elasticity for the own-price of cotton was 0.005, which very much contradicted economic theory (with the positive coefficient) and Ding and Kinnucan's estimated elasticity of –0.29. Again, the price of cotton is usually inelastic. Despite the differences in certain results, Ding and Kinnucan's results were affirmed.

The significance of the advertising variable increased with the use of the seasonally adjusted data. This proves that the use of seasonally adjusted data, compared to using unadjusted data, greatly increases the model's fit.

After regressions were complete, and *F*-test was performed on Model B vs. D to observe if together the dummy variables equaled zero. The following hypothesis was constructed for the test:

(23a) H_N: a_8=a_9=,...,a_{18}=0

(23b) H_A: Full model

The *F*-value was 24.28, which was larger than the critical value of 1.645 (at the .05% level) so the null hypothesis was rejected and the monthly dummy variables were definitely needed in the equation.

When compared to Ding and Kinnucan's regression results, Models B and D with seasonally adjusted advertising data did not show good properties of fit. Again, the major difference may have been due to the use of the proxied variables in the replicated models and the use of monthly, rather than quarterly, data. The models with monthly dummy variables (A and B) negated Ding and Kinnucan's earlier finding of the need to eliminate these variables because of insignificance in their regressions (again, the dummy variables were all highly significant). Furthermore, it was shown that the model shows severe seasonality because of the high significance of the monthly dummy variables (also supported by the *F*-test value of 24.28). Model C, the model without the monthly dummy variables but with the interaction term, suggested that advertising actually rotated the demand curve for cotton. This negated Ding and Kinnucan's earlier inferences of no rotation of the demand curve caused by advertising expenditures.

Overall, it can be deduced that Ding and Kinnucan's earlier inferences that advertising shifts the demand curve for cotton are fragile and are conditional on the sample period used and on the use of modified (seasonally adjusted) data. When using unadjusted advertising data, none of the inferences made by Ding and Kinnucan held up. However, after using seasonally adjusted advertising data, advertising showed a significant effect to the mill level demand of cotton, thus suggesting that Ding and Kinnucan's results were robust. It can not be positively suggested, from the replicated results, that advertising expands the demand for cotton. Replicated regression results for the seasonally adjusted advertising data are documented in Table 7.

Table 4. Variables Used for the Replication of the Ding and Kinnucan Study of U.S. Cotton Promotion, January 1986-December 2000

Variable	Definition
Per Capita Mill Use	ln [(U.S. Mill Use*1,000*480lbs.)/(U.S. population*1,000)]
Cotton Price	ln [Fiber equivalent effective mill price/(CPI/100)]
Rayon Price	ln [Fiber equivalent rayon price/(CPI/100)]
Polyester Price	ln [Fiber equivalent polyester price/(CPI/100)]
A Index if the World Cotton Price [1]	ln [Fiber equivalent A Index /(CPI/100)]
U.S. Disposable Income [2]	ln[[(Disposable income annual rate*1,000,000,000)/(CPI/100)]/(U.S. population*1,000)]
Advertising	ln [CI Seasonally Adjusted Promotional Expenditures/(CPI/100)] and ln [CI Unadjusted Promotional Expenditures/(CPI/100)]

[1] The A Index of the world cotton price was used as a proxy for Ding and Kinnucan's imported textile price variable.
[2] U.S. disposable income was used as a proxy for Ding and Kinnucan's expenditure variable.

Table 5. Ding and Kinnucan GLS Esimates (Corrected for Forth-Order Autocorrelation) of Domestic Mill Demand for Cotton, 1976-1993 Quarterly Data

Variable	Model A	Model B
Advertising	0.01967	0.02395
	(1.32)	(3.16)
	[0.062]	[0.066]
Cotton Price	-0.0952	-0.1055
	(2.51)	(2.77)
	[-0.30]	[-0.29]
Rayon Price	0.2236	0.2518
	(2.39)	(2.66)
Polyester Price	-0.2686	-0.3053
	(2.78)	(3.19)
Imported Textile Price	0.1372	0.1595
	(2.72)	(3.15)
Expenditure	0.1124	0.1295
	(2.11)	(2.41)
Lagged Dependent Variable	0.6843	0.6390
	(8.66)	(8.70)
Constant	0.23683	0.28003
	(0.97)	(1.14)
Spring	0.0311	-
	(1.94)	
Summer	-0.0009	-
	(0.051)	
Fall	0.00149	-
	(0.076)	
R^2	0.955	0.950
Durbin *m*-test for serial correlation:		
First order	0.778	0.218
Forth order	-2.232	-2.027
F-test: Model A vs. B	-	2.0832[a]

Notes: Figures in parentheses are absolute values of *t*-ratios. Figures in brackets are long-run elasticities.
[a] The probability for 3 and 57 degrees of freedom is 0.1125, which means that Models A and B are statistically equivalent.

Table 6. Replication of Ding and Kinnucan's Cotton Demand Model Using Seasonally *Unadjusted* Advertising Data[1], January 1986-December 2000

Variable	Model A[2]	Model B[3]	Model C[4]	Model D[5]
Advertising	0.0799	0.0182	-0.4160	0.007395
	(0.49)	(1.18)	(-1.62)	(0.44)
	[0.098]	[0.096]	[0.012]	[0.016]
Cotton price	0.2137	-0.002260	-1.4759	-0.003960
	(0.38)	(-0.07)	(-1.65)	(-0.07)
	[-0.009]	[-0.012]	[-0.011]	[-0.008]
Interaction	-0.0153	-	0.1045	-
	(-0.38)		(1.65)	
Rayon Price	0.1179	0.1183	0.3170	0.3191
	(1.75)	(1.76)	(2.83)	(2.84)
Polyester Price	-0.0504	-0.0511	-0.1798	-0.1733
	(-0.71)	(-0.72)	(-1.51)	(-1.45)
A Index Price	0.0334	0.0321	0.0918	0.1026
	(0.95)	(0.92)	(1.54)	(1.73)
Disposable Income	0.1292	0.1284	0.5067	0.5256
	(0.65)	(0.65)	(1.47)	(1.52)
Lagged Response	0.8168	0.8113	0.4932	0.5142
	(14.63)	(15.03)	(6.39)	(6.70)
January	0.3251	0.3235	-	-
	(10.27)	(10.34)		
February	0.1228	0.1221	-	-
	(4.65)	(4.65)		
March	0.2735	0.2736	-	-
	(9.87)	(9.90)		
April	0.1095	0.1098	-	-
	(3.96)	(3.99)		
May	0.2028	0.2028	-	-
	(7.30)	(7.32)		
June	0.1284	0.1273	-	-
	(4.16)	(4.16)		
July	0.0773	0.0781	-	-
	(2.44)	(2.48)		
August	0.3337	0.3318	-	-
	(11.71)	(11.86)		
September	0.1133	0.1137	-	-
	(4.03)	(4.06)		

Table 6. (Continued) Replication of Ding and Kinnucan's Cotton Demand Model Using Seasonally *Unadjusted* Advertising Data[1], January 1986-December 2000

Variable	Model A[2]	Model B[3]	Model C[4]	Model D[5]
October	0.2151	0.2147	-	-
	(8.28)	(8.29)		
November	0.0865	0.0862	-	-
	(2.74)	(2.75)		
Constant	-2.8885	-1.9997	0.2244	-6.0076
	(-0.95)	(-1.03)	(0.04)	(-1.72)
R^2	0.7892	0.7890	0.3993	0.3896
F-test: B vs. D	-	-	-	25.41

Notes: Figures in parentheses are absolute values of *t*-ratios. Figures in brackets are long-run elasticities.
[1] GLS estimates were obtained in SAS using the Yule-Walker algorithm for correction of first-order autocorrelation.
[2] Model A is the full model with an interaction term.
[3] Model B is the full model without an interaction term.
[4] Model C is the model with an interaction term and without the monthly dummy variables.
[5] Model D is the model without the interaction term or the monthly dummy variables.

Table 7. Replication of Ding and Kinnucan's Cotton Demand Model Using Seasonally *Adjusted* Advertising Data[1], January 1986-December 2000

Variable	Model A[2]	Model B[3]	Model C[4]	Model D[5]
Advertising	-0.1589	0.0182	-1.0014	0.0487
	(-0.59)	(1.18)	(-2.47)	(1.95)
	[0.085]	[0.096]	[0.070]	[0.095]
Cotton price	-0.6209	-0.002259	-3.6405	0.002785
	(-0.67)	(-0.07)	(-2.60)	(0.05)
	[-0.014]	[-0.012]	[0.015]	[0.005]
Interaction	0.0436	-	0.2574	-
	(0.66)		(2.60)	
Rayon Price	0.1200	0.1183	0.3161	0.3224
	(1.78)	(1.76)	(2.94)	(2.95)
Polyester Price	-0.0561	-0.0511	-0.2284	-0.1955
	(-0.78)	(-0.72)	(-1.99)	(-1.68)
A Index Price	0.0289	0.0321	0.0898	0.1111
	(0.82)	(0.92)	(1.57)	(1.92)
Disposable Income	0.1214	0.1284	0.2105	0.2889
	(0.61)	(0.65)	(0.61)	(0.82)
Lagged Response	0.7998	0.8113	0.4606	0.4855
	(14.14)	(15.03)	(6.17)	(6.44)
January	0.3150	0.3190	-	-
	(9.82)	(10.14)		
February	0.1164	0.1184	-	-
	(4.45)	(4.58)		
March	0.2701	0.2698	-	-
	(9.82)	(9.83)		
April	0.1139	0.1128	-	-
	(4.11)	(4.08)		
May	0.2020	0.2019	-	-
	(7.28)	(7.29)		
June	0.1453	0.1448	-	-
	(5.25)	(5.24)		
July	0.0603	0.0600	-	-
	(2.20)	(2.20)		
August	0.3165	0.3208	-	-
	(11.38)	(11.89)		
September	0.1144	0.1136	-	-
	(4.07)	(4.06)		

Table 7. (Continued) Replication of Ding and Kinnucan's Cotton Demand Model Using Seasonally *Adjusted* Advertising Data[1], January 1986-December 2000

Variable	Model A[2]	Model B[3]	Model C[4]	Model D[5]
October	0.2118	0.2130	-	-
	(8.18)	(8.26)		
November	0.0835	0.0843	-	-
	(2.67)	(2.69)		
Constant	0.6142	-1.9996	11.5544	-4.3187
	(0.14)	(-1.03)	(1.66)	(-1.25)
R^2	0.7894	0.7890	0.4326	0.4081
F-test: B vs. D	-	-	-	24.28

Notes: Figures in parentheses are absolute values of *t*-ratios. Figures in brackets are long-run elasticities.
[1] GLS estimates were obtained in SAS using the Yule-Walker algorithm for correction of first-order autocorrelation.
[2] Model A is the full model with an interaction term.
[3] Model B is the full model without an interaction term.
[4] Model C is the model with an interaction term and without the monthly dummy variables.
[5] Model D is the model without the interaction term or the monthly dummy variables.

VIII. SUMMARY AND CONCLUSIONS

Murray *et al*. suggested in the course of their research that the U.S. Cotton Research and Promotion Program was successful in expanding the U.S. mill level demand for upland cotton. To test whether advertising affects demand, the researchers implemented the use of regression analyses to estimate elasticities of demand with respect to nonagricultural research and promotion. Based on the regression analyses, Murray *et al*. suggested that the promotion and research expenditures made by Cotton Incorporated positively affected the mill level demand for upland cotton in the U.S., i.e. the demand curve was positively shifted by the expenditures. They concluded that for a 10 percent increase in promotional expenditures, the mill level demand for cotton increased by 0.2 percent, ceteris paribus. In addition, they found that for a 10 percent increase in nonagricultural research expenditures, the mill level demand for cotton would increase by 3.5 percent.

Ding and Kinnucan also found in their study that advertising expenditures made by Cotton Incorporated increased the mill level demand for upland cotton in the U.S. They concluded this from regression analyses that suggested the long-run elasticity estimates were posotive. They specified their econometric demand model a good deal differently than did Murray *et al*. Ding and Kinnucan found from preliminary tests that advertising effects did not set in until two quarters after the initial expenditures; therefore they specified the model with a 2-quarter lag on advertising. Murray *et al*. specified the promotion variable contemporaneously. In addition, Ding and Kinnucan specified the model with 4-quarter lags on the cotton, rayon, and polyester prices. Ding and Kinnucan calculated a long-run demand elasticity of 0.066 with respect to advertising. This implied that for a 10 percent increase in generic advertising expenditures, the mill level demand would increase by approximately 0.7 percent, ceteris paribus. Ding and Kinnucan also found that the seasonal dummy variables were insignificant to the regression whereas Murray *et al*. found the dummy variables to be highly significant.

William Tomek (p.6) stated, "The strength of agricultural economics rests on its capacity to combine theory, quantitative methods, and data to do useful analyses of problems faced by society." A major problem faced by economic researchers is that econometric results are often fragile. Large variations in results may be a major consequence of a small change in a model or data, which, in turn, reduces the robustness, or explanatory power, of the model. There is no easy solution to improving upon unstable results because econometric models are simply approximations. Tomek suggested that a possible way to reduce the variation in the results and contradictory conclusions between researchers is to build upon prior research with further caution.

By following closely the guidelines for duplication and replication of research results by William Tomek, the models of Murray *et al*. and Ding and Kinnucan were re-estimated and judged for consistency. The duplication of the Murray *et al*. results was considered a success with only slight differences in OLS, GLS and 2SLS parameter estimates. The research was confirmed by duplication.

By means of replication of Ding and Kinnucan's research results, it was suggested that their inferences (advertising expands the demand for cotton) were fragile.

The models (Models A, B, C, and D) were regressed with unadjusted advertising data and seasonally adjusted advertising data to observe any changes. Models B and D could be directly compared with Ding and Kinnucan's Models A and B. With the use of the unadjusted data, most all variables exhibited insignificant *t*-values, poor R^2's, and in some cases, the wrong signs. The results of the replication negated Ding and Kinnucan's earlier results because advertising was insignificant in all models. One could not be confident in saying that advertising expenditures expand the demand for cotton given the replication results. Furthermore, all dummy variables were significant to the replicated regressions whereas, Ding and Kinnucan found them to be insignificant (this suggests that there is high seasonality in the data). However, from the unadjusted advertising replication results, it was suggested that Ding and Kinnucan were correct in suggesting that there are carry-over effects from advertising with the highly significant lagged dependent variables. Overall, differing conclusions led us to believe that the original conclusions were conditional upon a specific time period or the model specification when using the unadjusted advertising data.

By using the seasonally adjusted data, regressions yielded somewhat improved results although they were not as ideal as the Ding and Kinnucan results. All monthly dummy variables and lagged dependent variables were highly significant in every model (A-D). All models, except for Models C and D, exhibited mostly insignificant *t*-values, poor R^2's, and some wrong signs. Model C did yield fair results, although it negated Ding and Kinnucan's inferences about curve rotation. From the results, it was suggested that advertising actually is a "taste shifter" by rotating the demand curve because of the significant interaction term.

When compared to Ding and Kinnucan's regression results, Models B and D with seasonally adjusted advertising data did not show good properties of fit. Again, the major difference may have been due to the use of the proxied variables in the replicated models and the use of monthly, rather than quarterly, data. Furthermore, it was shown that the model shows severe seasonality because of the high significance of the monthly dummy variables (also supported by the *F*-test value of 24.28).

Overall, despite the "less ideal" properties of fit exhibited by the model, from the results of Model D with seasonally adjusted advertising data, it can be deduced that Ding and Kinnucan's earlier inferences that advertising shifts the demand curve for cotton were robust. Furthermore, after observing the results of Model D, sample updating (using seasonally adjusted data) did not change the inferences of Ding and Kinnucan according to the elasticity estimates for the advertising variable.

By observing both sets of regressions, it could easily be demonstrated that the use of seasonally adjusted data will have a significant impact on the final results. By using the seasonally adjusted data, the advertising variable's *t*-ratio changed from 0.44 in the unadjusted advertising regression (Model D) to 1.95 in the seasonally adjusted advertising regression (Model D). This increases skepticism about how robust the models are when regressed with different data.

Cotton producers need to have hard evidence to support the U.S. Cotton Research and Promotion Program's importance. Because of the sensitivity of the results obtained from this study, cotton producers in the U.S. may not be willing to invest in the Program to any further extent. Further research is needed in finding an appropriate model for demonstrating the effects of generic advertising on the mill-level demand for upland cotton in the U.S. because of the sensitivity of the results from different time periods.

Tomek (p.13) stated, “Published and anecdotal evidence on confirmation in economics suggests the disheartening conclusion that many published empirical studies contain errors and that some of these errors are serious in the sense that, if corrected, the stated conclusions of the study would change.” Furthermore, confirmation helps in building upon the true scholarship of research and should be encouraged in the field of agricultural economics to supplement existing empirical research.

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APPENDIX A: DATA

A1. Variable Definitions and Source

1. qc -- (1,000 480lb. bales). U.S. Domestic mill consumption of cotton.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from various issues of the USDA's *Cotton and Wool Outlook*.

2. pc -- (cents / lb.). Fiber equivalent effective mill price of cotton.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from the National Cotton Council (2001) web site.

3. pp -- (cents / lb.). Fiber equivalent polyester price.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from the National Cotton Council (2001) web site.

4. pr -- (cents / lb.). Fiber equivalent rayon price.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from the National Cotton Council (2001) web site.

5. w -- ($ / hour). Domestic textile wages.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from the U.S. Bureau of Labor Statistics (BLS, 2001).

6. wpc -- (cents / lb.). A Index of the world cotton price.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from the National Cotton Council (2001) web site.

7. epi -- (1982-1984=100). U.S. Energy Price Index.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from the U.S. Bureau of Labor Statistics (BLS, 2001).

8. dpi -- (billions). U.S. disposable income annual rate.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from the St. Louis Federal Reserve Bank's FRED database on their web site (FRED, 2001).

9. fgdp -- (billions of $). OECD GDP annual rate excluding the U.S.

   Obtained from Murray *et al*. report to the Cotton Board who gathered data from various issues of *Quarterly National Accounts* and *National Accounts of OECD Countries*. The data was obtained in quarterly frequencies; therefore, by applying PROC EXPAND in the SAS statistical software package to quarterly data, they generated monthly estimates.

10. adjpro -- ($). Cotton Incorporated seasonally adjusted promotional expenditures.

    Obtained from Murray *et al*. report to the Cotton Board who gathered data from Cotton Inc.

11. unpro -- ($). Cotton Inc. unadjusted promotional expenditures.

    Obtained from Murray *et al*. report to the Cotton Board who gathered data from Cotton Inc.

12. adjres -- ($). Cotton Inc. seasonally adjusted nonagricultural research expenditures.

    Obtained from Murray *et al*. report to the Cotton Board who gathered data from Cotton Inc.

13. unres -- ($). Cotton Inc. unadjusted nonagricultural research expenditures.

    Obtained from Murray *et al*. report to the Cotton Board who gathered data from Cotton Inc.

14. cpi -- (1982-1984=100). Consumer Price Index.

    Obtained from Murray *et al*. report to the Cotton Board who gathered data from the U.S. Bureau of Labor Statistics (2001) web site.

15. pop -- (thousands). U.S. population.

    Obtained from Murray *et al*. report to the Cotton Board who gathered data from the U.S. Census Bureau (2001).

A2. Raw Data

Table A1: Raw Data used for Duplication and Replication of Murray *et al*. and Ding and Kinnucan Regression Results

date[1]	**qc**	**pc**	**pp**	**pr**	**w**	**wpc**	**epi**	**dpi**	**fgdp**	**adjpro**	**unpro**	**adjres**	**unres**	**cpi**	**pop**
1986.01	583	72.1	65.6	81.3	5.83	57.8	85.2	3193.2	6734.44	1348345	502663	359254	225486	109.9	239638
1986.02	523	73.4	65.6	81.3	5.8	60.7	76.5	3209.7	6769.32	686137	379914	315667	235478	109.7	239788
1986.03	542	75.6	65.6	81.3	5.82	58.5	67.3	3236.1	6766.88	505453	508991	308087	263356	109.1	239928
1986.04	572	76.4	65.6	78.1	5.83	53.8	62.9	3236.3	6766.62	1031919	951636	371230	306673	108.7	240094
1986.05	579	78.1	64.6	78.1	5.81	50.4	64.9	3246.5	6801.1	840396	762407	287445	271920	109	240271
1986.06	538	79.2	64.6	78.1	5.83	45.9	65.2	3257.7	6835.08	1085998	1097510	324060	292211	109.4	240459
1986.07	499	81.8	64.6	78.1	5.79	41.7	56.1	3273.7	6845.36	2280296	1805310	417824	407938	109.5	240651
1986.08	581	39.2	64.6	78.1	5.83	41.2	55.4	3282.4	6852.62	1108461	913372	274241	255006	109.6	240854
1986.09	603	49	64.6	78.1	5.9	48.5	57.3	3296.7	6877.51	930516	766094	311133	264444	110	241068
1986.10	660	58.5	64.6	78.1	5.86	57	54.9	3295.6	6890.73	554040	659474	319221	284260	110.2	241274
1986.11	554	61.1	64.6	78.1	5.87	58.5	55.1	3303.1	6906.72	694184	670512	306841	294601	110.4	241467
1986.12	556	68.7	64.6	78.1	5.9	66.5	55.2	3319.1	6940	1191169	3140041	328880	822643	110.8	241620
1987.01	621	72.7	64.6	83.3	5.94	73	58	3360.4	6999.18	1020351	380387	347082	217846	111.5	241784
1987.02	587	69.3	64.6	83.3	5.93	73.3	59.5	3393.8	7047.18	755425	418279	371331	277002	111.9	241930
1987.03	676	69.7	64.6	83.3	5.93	70.3	60.2	3411.4	7103.94	994920	1001884	358118	306123	112.3	242079
1987.04	661	73.7	64.6	83.3	5.93	73.2	61.7	3290.2	7172.62	1204838	1111102	394432	325840	112.8	242252
1987.05	642	83	64.6	83.3	5.87	84.5	61.6	3434.5	7226.92	1077736	977722	313676	296734	113.1	242423
1987.06	655	89.5	66.7	83.3	5.89	89	62.5	3446.7	7288.09	882409	891763	297650	268397	113.6	242608
1987.07	655	90.1	71.9	83.3	5.87	92.6	63.4	3465.6	7332.72	1521490	1204564	358669	350183	113.9	242804
1987.08	666	93.6	71.9	83.3	5.88	96.1	64.9	3495.1	7391.41	776443	639789	316535	294333	114.4	243012
1987.09	694	88.9	71.9	86.5	6	92.7	63.4	3508.3	7447.09	764560	629462	348876	296524	114.8	243223
1987.10	713	80.7	72.9	86.5	5.98	84.2	62.4	3544.7	7498.09	757020	901081	390726	347934	115.1	243446
1987.11	666	79.6	71.9	86.5	5.99	84.4	62.5	3564.1	7557.19	654307	631995	356049	341846	115.5	243639
1987.12	582	78.6	71.9	86.5	6.01	83.5	61.4	3598.9	7599.82	1070561	2822106	337259	843602	115.7	243809
1988.01	621	76.7	71.9	86.5	6.02	80.6	59.2	3617	7651.39	1066306	397519	315756	198184	116.1	243981
1988.02	649	73.5	71.9	86.5	6.03	75.1	58.5	3641	7675.87	1547174	856670	446600	333150	116.2	244131
1988.03	706	74.8	75	90.6	6.05	73.8	58.2	3668.9	7714.1	1090144	1097775	356500	304740	116.6	244279
1988.04	610	75.1	75	90.6	6.06	73.1	60.9	3688.6	7765.53	1808112	1667441	407778	336865	117.2	244445
1988.05	630	77.1	77.1	92.7	6.07	72.9	61.6	3707.3	7811.06	1317069	1194845	498739	471802	117.6	244610

Table A1 (continued).

date[1]	qc	pc	pp	pr	w	wpc	epi	dpi	fgdp	adjpro	unpro	ajdres	unres	cpi	pop
1988.06	603	79.1	77.1	92.7	6.1	76.7	60.3	3737.4	7875.25	827762	836536	318571	287262	118.1	244806
1988.07	477	72.9	79.2	94.8	6.03	71.1	61.3	3770	7946.25	1507111	1193180	339227	331201	118.6	245021
1988.08	692	67.1	79.2	94.8	6.08	64.2	61.1	3787.4	8009.12	684436	563975	385766	358708	119	245240
1988.09	634	64.8	79.2	94.8	6.21	62.9	58.8	3811.7	8077.02	782853	644523	426047	362114	119.6	245464
1988.10	603	66.1	79.2	100	6.22	64.3	58.7	3841.9	8126.77	2702257	3216496	363864	324014	120	245693
1988.11	597	67.8	79.2	100	6.26	65.2	60	3858.2	8177.94	805569	778099	385957	370561	120.4	245884
1988.12	512	70.2	79.2	109.4	6.29	68.3	59.2	3899.6	8234.24	886607	2337186	331245	828560	120.8	246056
1989.01	648	71.1	84.4	104.2	6.32	70.6	60.8	3930.2	8298.82	928466	346132	355172	222924	121.3	246224
1989.02	609	70.3	84.4	104.2	6.32	69.8	61.8	3947.3	8349.78	1209113	669486	442609	330173	121.7	246378
1989.03	722	72.8	84.4	104.2	6.34	73.2	62.3	3979.2	8405.51	1415481	1425389	362945	310249	122.3	246530
1989.04	650	76.1	84.4	114.6	6.32	81.6	68.4	3987.5	8478.49	1150892	1061353	245101	202478	123.2	246721
1989.05	771	79.9	84.4	114.6	6.32	85.9	71.8	3987.1	8535.3	1448787	1314340	432674	409305	123.8	246906
1989.06	731	80.7	92.7	114.6	6.33	87.6	70.2	4009	8581.33	2138745	2161416	433053	390493	124.1	247114
1989.07	613	84.8	92.7	114.6	6.28	91.9	68.4	4021.3	8647.13	1672453	1324081	281250	274596	124.6	247342
1989.08	831	87.8	92.7	114.6	6.32	92.1	63.6	4029.1	8677.2	1748495	1440760	305404	283983	124.6	247573
1989.09	753	85	92.7	114.6	6.4	90.7	65.9	4036.7	8721.49	1003464	826152	417452	354809	124.9	247816
1989.10	792	86.2	92.7	124	6.39	91.3	65.8	4060.4	8784.36	1112524	1324237	338982	301857	125.5	248067
1989.11	731	84.9	92.7	124	6.42	91.3	64.6	4095.2	8837.2	820258	792287	335350	321973	125.9	248281
1989.12	579	80.1	92.7	124	6.44	86.2	64.8	4112.6	8905.26	1058024	2789058	320966	802848	126.4	248479
1990.01	754	77.7	92.7	124	6.39	83.1	72.7	4176.2	9028.98	1118216	416871	455792	286078	127.6	248659
1990.02	690	80	92.7	124	6.44	85.6	69.2	4210.5	9102.6	3623283	2006212	457638	341384	128.1	248827
1990.03	757	84	92.7	124	6.51	88.2	67	4228.8	9172.35	1897792	1911077	427191	365167	128.6	249012
1990.04	711	87.2	92.7	124	6.55	92.3	68	4261.6	9229.28	1055901	973752	462397	381986	129	249306
1990.05	800	91.4	88.5	124	6.58	96.1	68.5	4263.1	9263.75	1713569	1554550	454456	429911	129.2	249513
1990.06	721	96.7	85.4	124	6.6	100.2	67.6	4290.5	9332.46	1022936	1033779	491284	443001	130	249743
1990.07	641	96.3	81.3	124	6.57	101.1	68.1	4318.9	9379.97	617495	488871	460236	449347	130.6	249973
1990.08	829	92.9	81.3	124	6.61	90.1	74.2	4328.1	9459.49	1514615	1248043	511936	476029	131.7	250226
1990.09	692	88	81.3	124	6.68	90.3	82	4355.3	9523.93	1463758	1205112	420445	357353	132.6	250484
1990.10	802	87	81.3	127.1	6.66	90.7	88.1	4351.1	9591.54	1646440	1959758	508465	452778	133.5	250737
1990.11	687	87.2	81.3	127.1	6.64	91.7	89.5	4360.4	9623.14	1663153	1606439	434061	416746	133.8	250969
1990.12	490	88.7	81.3	129.2	6.66	93.3	84.7	4378.9	9678.34	1321651	3484004	535353	1309089	134.3	251194

Table A1 (continued).

date[1]	qc	pc	pp	pr	w	wpc	epi	dpi	fgdp	adjpro	unpro	ajdres	unres	cpi	pop
1991.01	672	89.4	81.3	129.2	6.65	92.9	82.6	4386.1	9738.95	1159893	432408	495448	310968	134.8	251399
1991.02	661	96.4	81.3	129.2	6.62	94.6	78.4	4399.8	9768.35	1209460	669678	534646	398830	134.9	251588
1991.03	819	100.1	81.3	129.2	6.65	93.3	75.5	4411.5	9784.78	1532869	1543599	545949	466683	134.9	251772
1991.04	723	99.5	75	129.2	6.73	92.7	75.7	4434.2	9817.7	1351151	1246031	587827	485604	135.2	251986
1991.05	721	104	75	129.2	6.75	93.7	78	4453.8	9860.63	2762871	2506477	497906	471014	135.7	252200
1991.06	868	98.8	75	129.2	6.78	93.1	78.4	4484.6	9893.53	1341112	1355328	573752	517364	136.1	252436
1991.07	694	88.8	75	129.2	6.8	89.7	77.5	4481.8	9911.21	1124739	890456	583340	569538	136.3	252665
1991.08	876	83	75	129.2	6.82	81.1	78.8	4495.4	9945.15	1425864	1174912	541486	503506	136.7	252921
1991.09	739	78	75	129.2	6.88	77.9	79.1	4518.3	9983.31	1070155	881059	489629	416155	137.1	253181
1991.10	913	73.3	75	120.8	6.83	75.4	78.3	4516.6	10014.74	1297379	1544270	686193	611041	137.3	253433
1991.11	743	68.8	75	120.8	6.82	70.3	78.1	4534.3	10086.94	2439736	2356541	544674	522947	137.9	253662
1991.12	629	68	75	120.8	6.88	68.5	76.6	4581.5	10156.08	1626164	4286732	519905	1300464	138.3	253856
1992.01	850	66.1	75	120.8	6.84	65.8	74.3	4633.3	10202.62	1906242	710647	638032	400461	138.4	254051
1992.02	761	61.8	75	120.8	6.85	62.5	74.3	4668.5	10245.39	1636059	905886	737026	549799	138.7	254231
1992.03	825	62	76	120.8	6.88	61.6	74.4	4684.3	10276.94	2133717	2148653	580883	496545	139.2	254435
1992.04	824	66.2	77.1	120.8	6.98	65	75.4	4705.6	10277.17	3698201	3410481	681785	563223	139.5	254670
1992.05	820	67.7	77.1	118.8	6.95	67.4	77.8	4727.7	10277.91	1681997	1525908	584354	552793	139.8	254909
1992.06	811	72.5	77.1	118.8	6.97	71.4	81	4741.4	10299.11	1743255	1761734	579101	522187	140.2	255158
1992.07	822	71.4	77.1	117.7	6.94	72.4	80.4	4750.2	10330.71	1866380	1477613	800582	781640	140.6	255410
1992.08	849	69.2	77.1	117.7	6.97	66.2	80.2	4733.9	10357.37	1703242	1403471	592114	550583	140.9	255692
1992.09	871	65.5	77.1	117.7	7	62.5	80.8	4774.1	10380.21	5785111	4762882	778494	661673	141.2	255952
1992.10	911	60.1	77.1	117.7	6.98	58.8	80	4817.8	10421.49	1800796	2143487	762216	678738	141.8	256211
1992.11	825	62.3	77.1	117.7	6.98	58.6	78.4	4831.9	10446.61	2446959	2363518	701701	673710	142.2	256443
1992.12	752	64.2	76	116.7	7.04	60.3	76.4	4986.5	10457.46	2055194	5417698	841683	2105344	142.4	256655
1993.01	853	66.6	76	116.7	7.05	63.7	76.6	4820.2	10484.43	2016569	751777	814997	511533	142.8	256866
1993.02	828	68.5	76	116.7	7.04	67.3	76.9	4826	10513.56	1728497	957069	588407	438934	143.2	257051
1993.03	934	70	76	116.7	7.05	68.3	77.5	4819.1	10530.83	2457859	2475064	633643	541644	143.4	257235
1993.04	890	70.7	76	116.7	7.06	67.8	78.3	4908.8	10574.16	3120207	2877455	946066	781545	143.9	257441
1993.05	865	70.2	76	116.7	7.05	66.8	79.6	4933.8	10615.4	2413408	2189444	590217	558339	144.3	257654
1993.06	870	68.4	76	116.7	7.07	65	80.5	4930.1	10639.73	3504610	3541759	983057	886442	144.4	257882
1993.07	803	69.1	75	116.7	7.01	64.3	79.6	4931.6	10672.91	1344115	1064136	633920	618921	144.6	258119

Table A1 (continued).

date[1]	qc	pc	pp	pr	w	wpc	epi	dpi	fgdp	adjpro	unpro	ajdres	unres	cpi	pop
1993.08	919	62.9	75	116.7	7.07	61.6	79.1	4956.7	10710.27	1338297	1102757	672086	624946	144.9	258374
1993.09	881	64.5	75	116.7	7.15	61.3	79.5	4957.4	10733.71	2711383	2232282	728561	619233	145.1	258619
1993.10	864	64	75	116.7	7.14	60.9	78.8	4980.7	10784	1974146	2349826	776264	691248	145.7	258861
1993.11	836	65.2	75	116.7	7.18	61.3	76.2	5002.6	10814.86	2575261	2487445	741150	711586	146	259067
1993.12	744	69.8	75	109.4	7.25	66.1	73.3	5157.1	10859.84	2826956	7452140	877703	2195443	146.4	259261
1994.01	811	77.2	75	108.3	7.22	76.9	73.6	4961.1	10880.86	1880030	700875	732580	459804	146.4	259450
1994.02	818	87.4	74	108.3	7.22	89.6	74.9	5032.1	10933.26	2689834	1489361	828553	618076	146.8	259598
1994.03	955	88.1	74	107.3	7.25	90.9	74.7	5061.6	10985.88	5355230	5392717	748198	639567	147.2	259777
1994.04	880	90.4	75	107.3	7.28	93.3	75.5	5070.8	11016.85	2058896	1898714	840323	694191	147.3	259998
1994.05	949	94.9	79.2	106.3	7.28	95.7	76.2	5153.1	11064.19	2067630	1875754	848531	802702	147.6	260190
1994.06	945	91.7	79.2	106.3	7.33	95	78.3	5162	11120.93	2386567	2411865	949623	856294	148	260408
1994.07	817	84.4	79.2	106.3	7.31	91	79.6	5183.5	11185.85	1606161	1271598	662777	647096	148.5	260637
1994.08	1042	83.8	79.2	106.3	7.36	85.1	81.4	5209	11257.54	1723447	1420120	1111961	1033968	149.1	260868
1994.09	978	84.1	79.2	106.3	7.45	83.4	79.6	5240.6	11303.09	3294274	2712176	865008	735205	149.4	261104
1994.10	952	79.8	81.3	108.3	7.44	82.3	77.1	5290.4	11328.84	1922335	2288155	667197	594126	149.5	261332
1994.11	954	82.2	81.3	108.3	7.46	86.2	77.7	5298	11371.26	3077444	2972503	1196133	1148419	149.9	261533
1994.12	798	96.7	81.3	108.3	7.48	96.9	75.9	5323.2	11399.7	2380831	6276109	699033	1748527	150.2	261722
1995.01	978	105.7	85.4	108.3	7.55	106.2	76.6	5346.8	11432.61	4383270	1634083	983489	617287	150.6	261906
1995.02	912	111.2	89.6	108.3	7.49	112.2	76.6	5357.4	11466.53	2734573	1514133	793358	591821	151	262075
1995.03	1048	124.3	89.6	108.3	7.53	122.8	76.8	5370.1	11497.41	2807309	2826960	1008339	861938	151.3	262247
1995.04	879	125.7	89.6	108.3	7.62	126.4	78.2	5339	11557.19	2902756	2676922	802813	663204	151.9	262450
1995.05	1006	126.6	89.6	198.3	7.57	128.6	80.4	5395.6	11600.59	2794264	2534956	1063103	1005685	152.2	262637
1995.06	909	130.7	95.8	124	7.62	132.2	81.4	5413.8	11649.15	2279745	2303910	817677	737316	152.5	262852
1995.07	743	111.2	95.8	130.2	7.64	111.1	79.9	5427.7	11689.37	2409789	1907830	802974	783976	152.7	263082
1995.08	1000	99.7	95.8	130.2	7.68	94.5	79.4	5442.3	11729.28	2789023	2298155	981698	912842	153	263310
1995.09	887	107	95.8	130.2	7.72	101.3	79	5463.1	11750.58	2126926	1751098	818904	696019	153.2	263559
1995.10	908	100.9	95.8	130.2	7.73	101.6	77.2	5484.5	11797.04	2347367	2794071	730777	650742	153.7	263807
1995.11	861	100.6	95.8	130.2	7.77	99.1	75.2	5504.7	11832.29	3821360	3691052	890329	854814	153.8	264008
1995.12	669	99.7	91.7	130.2	7.83	97.7	76.7	5526	11911.51	3726789	9824189	995846	2490960	154.1	264180
1996.01	894	98.7	91.7	130.2	7.87	95.8	78.5	5533.1	12033.57	3347991	1248131	905976	568636	154.8	264331
1996.02	869	99.7	91.7	130.2	7.82	94.5	77.8	5580.6	12106.68	2871994	1590223	695515	518833	155.1	264486

Table A1 (continued).

date[1]	qc	Pc	pp	pr	w	wpc	epi	dpi	fgdp	adjpro	unpro	ajdres	unres	cpi	pop
1996.03	911	98.6	91.7	130.2	7.86	92.5	80.1	5609.5	12164.46	2829331	2849136	1022051	873659	155.6	264662
1996.04	931	102.3	87.5	125	7.95	92	83.3	5575.6	12211.36	2505274	2310364	750054	619620	156.2	264861
1996.05	991	100.2	83.3	119.8	7.94	92.2	84.6	5651.5	12237.28	2867084	2601019	790321	747636	156.5	265059
1996.06	860	95.5	81.3	119.8	7.99	92.2	84.7	5683.8	12281.72	4116608	4160244	712255	642255	156.8	265278
1996.07	867	91.3	81.3	119.8	7.95	88.6	84.2	5694.8	12339.81	2908856	2302941	920897	899109	157.1	265502
1996.08	998	91.8	81.3	119.8	7.94	84.8	84.6	5718.5	12392.15	11207131	9234676	793316	737673	157.3	265750
1996.09	900	92.2	79.2	119.8	7.99	83.7	85.3	5746.1	12460.84	2293205	1887996	797697	677995	157.8	265998
1996.10	1002	87.7	76	119.8	8.02	83.9	84.8	5753.3	12526.57	2304178	2742663	767984	683874	158.3	266237
1996.11	901	85.4	75	119.8	8.01	84.5	84.9	5778.4	12596.78	3288545	3176406	953667	915625	158.8	266475
1996.12	766	87.9	75	119.8	8.14	88	85.7	5807.5	12667.13	3132238	8256892	744086	1861220	159.2	266664
1997.01	996	86.6	72.9	119.8	8.12	88.8	86.5	5828.7	12729.4	4319812	1610426	713938	448103	159.5	266840
1997.02	867	86.3	72.9	119.8	8.18	89.4	85.2	5856	12785.22	2409446	1334110	777081	579679	159.9	267007
1997.03	907	86.6	72.9	119.8	8.23	89.6	83	5887.3	12790.25	2997221	3018202	889223	760117	159.9	267190
1997.04	975	83.5	70.8	119.8	8.21	87.6	81.8	5903.4	12796.44	2748692	2534844	907460	749653	160	267396
1997.05	979	83.9	70.8	119.8	8.22	88.2	82.2	5922.7	12814.25	2977232	2700945	935568	885038	160.1	267599
1997.06	905	85.7	70.8	119.8	8.25	89.5	83.6	5946.5	12863.49	4694590	4744353	771364	695554	160.3	267818
1997.07	931	86.7	70.8	119.8	8.19	90.4	83.1	5967.8	12926.62	2972970	2353700	996616	973036	160.5	268048
1997.08	966	84.4	70.8	119.8	8.23	90.2	84.2	6002.3	12995.3	2272329	1872399	789839	734440	160.8	268311
1997.09	1008	83.7	71.9	119.8	8.33	88.4	85.3	6029	13064.1	4346978	3578867	867245	737106	161.3	268563
1997.10	1040	81.4	70.8	119.8	8.33	86.2	83.2	6062	13104.03	3684517	4385681	820077	730262	161.6	268799
1997.11	881	81.3	70.8	119.8	8.33	85.8	81.9	6094.9	13130.7	2949774	2840187	756213	726048	161.8	269009
1997.12	882	78.3	70.8	119.8	8.42	82.7	80.2	6117.9	13149.07	4059495	10701235	826625	2067679	161.9	269189
1998.01	979	75	69.8	119.8	8.42	79.2	77.5	6158.2	13172.6	3704168	1380914	987348	619709	162.1	268379
1998.02	897	72.4	67.7	119.8	8.38	76.4	75.9	6195.3	13179.58	3877114	2146758	823887	614595	162.2	269536
1998.03	973	75	67.7	119.8	8.43	76.1	74.2	6231.1	13169.38	2269385	2285271	797226	681477	162.2	269699
1998.04	956	71.6	67.7	119.8	8.48	72.3	74.7	6254.5	13178.75	2492124	2298237	911742	753190	162.4	269886
1998.05	934	71.9	67.7	119.8	8.47	71.6	76.3	6286.3	13217.17	3402938	3087145	648849	613805	162.7	270078
1998.06	919	78.7	66.7	119.8	8.5	74.4	77.2	6308.5	13274.68	2717559	2746365	768332	692820	162.9	270287
1998.07	915	79.8	64.6	119.8	8.48	77.1	76.9	6337.2	13340.82	3491226	2764004	766305	748174	163.2	270509
1998.08	929	80.6	60.4	114.6	8.54	75.6	75.4	6364.6	13369.19	2449341	2018257	794550	738820	163.5	270763
1998.09	919	77.5	60.4	109.4	8.63	73.2	75.4	6381.5	13320.77	2809910	2313399	655303	556969	163.5	271007

Table A1 (continued).

date[1]	qc	pc	pp	pr	w	wpc	epi	dpi	fgdp	adjpro	unpro	ajdres	unres	cpi	pop
1998.10	957	72.1	55.2	105.2	8.65	67.6	74.6	6410	13309.32	6654223	7920522	793853	706910	163.9	271240
1998.11	806	65.3	55.2	105.2	8.64	63	72.8	6466.7	13372.21	4711629	4550962	694047	666361	164.2	271459
1998.12	722	66.1	55.2	105.2	8.71	62.3	70.8	6446.7	13562.11	3463125	9129145	695269	1739110	164.5	271644
1999.01	882	71.6	53.1	105.2	8.68	62	71.3	6488.4	13816.43	4756293	1773146	820913	515246	164.8	271841
1999.02	824	70.4	53.1	105.2	8.64	62.4	70.1	6515.6	13996.74	3824136	2117424	803662	599508	164.8	271987
1999.03	940	73.7	53.1	105.2	8.78	63	71.2	6540.8	14091.15	3217180	3239700	826122	706177	165	272142
1999.04	888	71.9	52.1	105.2	8.83	64.3	75.9	6569	14184.11	3163253	2917152	658400	543904	166	272317
1999.05	864	70.2	52.1	104.2	8.81	66.5	77.5	6583.1	14183.64	2868781	2602558	636664	601966	166	272508
1999.06	885	67.6	53.1	105.2	8.89	65.1	78.6	6636.9	14231.69	3228069	3262287	666921	601376	166.1	272718
1999.07	785	62.5	54.2	99	8.83	60.5	80.7	6638.3	14349.49	3514762	2782637	976554	953449	166.7	272945
1999.08	883	63.5	54.2	102.1	8.88	56.6	83.5	6686.8	14443.68	2817107	2321296	709541	659774	167.1	273197
1999.09	878	62.2	55.2	101	9.01	54.8	85.8	6668.3	14532.76	3055541	2515627	774852	658578	167.8	273439
1999.10	872	55.6	55.2	101	8.99	52.7	83.5	6760	14578.48	3200839	3809959	719103	640347	168.2	273672
1999.11	873	53.9	55.2	101	8.98	51.3	83.6	6781.6	14622.24	3231144	3120962	540278	518726	168.5	273891
1999.12	762	52.3	55.2	101	9.04	49.1	83.6	6783.4	14698.05	3297063	8691388	825078	2063808	168.9	274076
2000.01	810	55	55.2	101	9.03	52.9	83.8	6830.6	14799.41	3001376	1118913	748261	469646	169.4	274271
2000.02	849	61	57.3	101	9.03	59.7	87.5	6858.5	14925.01	1692413	937089	938624	700185	170.2	274423
2000.03	935	64.8	57.3	101	9.05	63.8	90.9	6910.4	15058.49	5090250	5125882	967787	827274	171.2	274583
2000.04	811	63.3	57.3	101	9.05	65.3	89.2	6939.7	15088.79	2257552	2081914	879246	726345	171.1	274765
2000.05	931	64.6	60.4	101	9.05	67.2	90.9	6963.5	15143.76	3382576	3068673	736684	696896	171.3	274952
2000.06	907	63.1	60.4	102.1	9.07	66.1	97.7	6991.5	15264.07	4380625	4427060	830643	749007	172.2	275155
2000.07	730	63.9	60.4	102.1	9.06	64.9	97.3	7006.4	15351.89	3232409	2559098	888081	867069	172.7	275372
2000.08	920	66.1	60.4	102.1	9.09	67.6	95.9	7017.8	15405.1	3425244	2822401	828558	770443	172.8	275619
2000.09	804	68.1	60.4	102.1	9.16	68.5	100.6	7098.6	15517.8	3479602	2864756	596663	507128	173.6	275857
2000.10	846	68.8	61.5	102.1	9.16	67.7	99.7	7071.8	15581.04	1958749	2331499	758397	675337	173.9	276083
2000.11	749	71.2	61.5	102.1	9.16	71.1	99.3	7079.2	15645.89	4207158	4063694	786201	754839	174.3	276298
2000.12	640	74.6	61.5	102.1	9.21	73.2	97.9	7109.8	15691.72	3367223	8876336	602415	1506851	174.6	276513

[1] Date is given by Year.Month.