THE DEMAND FOR CONSUMER CREDIT (CD_t)

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(ABSTRACT)

The demand for consumer credit is an area of economics that is of great interest to those in the lending community. While much research has been performed on this topic in the financial industry, the findings have been very closely guarded for competitive reasons. In this study, reduced form equations were derived to form the basis of a 2SLS regression model. This model was used to estimate the demand for consumer credit in the United States over the period 1973 – 2002. Six independent variables were included in the analysis: monetary base, unemployment rate, consumer confidence index, disposable personal income, federal funds interest rate and the price/barrel of oil.

The model results concluded that only two of these variables significantly affect the demand for consumer credit – disposable personal income (DPI_t) and the unemployment rate (ue_t). The error terms were compared against those derived from two alternative models using the same data sets – a trend model and an autoregressive model – AR(1). The root mean square error (RMSE) for the reduced form model was significantly lower then that of the trend model, but slightly higher then the AR(1) model. The objectives of this study are to: (1) produce an accurate model that defines the drivers behind the demand for consumer credit, while (2) producing results consistent with econometric theory. Based on this set of objectives, the reduced form model is the superior of the three models included in this study.

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- Consumer Confidence Board
- Department of Commerce (DoC) Bureau of Economic Analysis
- Department of Energy (DoE)
- Department of Labor (DoL) Bureau of Labor Statistics
- The Federal Reserve

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Section I - Introduction

"CHARGE IT." These two words have been ingrained in the American psyche over the past couple of decades. A recent story on the nightly news reported that the average American household now carries $8,000 in credit card debt.[1] Everywhere one turns, merchants are vying for their business by offering enticing credit schemes – 0% interest for 12 months, buy now, and make no payments until 2003, etc. Even medical providers, such as dentists, plastic surgeons and ophthalmologists are offering cosmetic services payable via a monthly payment plan. Have these schemes become just too attractive for consumers to refuse? Considering that the U.S. Congress is currently debating legislation to make it tougher for consumers to file for bankruptcy protection, the answer may seem quite obvious.

What is consumer credit (CD), and why is it important?

Consumer credit (CD_t) is defined as any type of purchases for goods or services in which the consumer makes payment for the product in the form of an extended payment plan. Consumer credit can be used to purchase a new home, a small business, durable goods such as automobiles and appliances, or services, such as construction or legal advice/representation. Consumer credit can be divided into two categories – (1) revolving credit, and (2) non-revolving credit. Revolving lines of credit allow the consumer access to the amount of debt that has been paid back, which can be charged again and again in the form of new purchases. The Federal Reserve Bank of St. Louis has tracked the level of total revolving consumer credit outstanding from the end of the Second World War to the present. Non-revolving credit relates to new home purchases, purchases of durable goods, etc. For purposes of this study, we will be focusing on revolving credit. "The determinants and effects of growth in consumer credit have not been a major focus of research

[1] "NBC Nightly News with Tom Brokaw, " WCAU-TV – Philadelphia, PA, 01 December 2001.

economists, so there has been relatively little research to evaluate the role of consumer credit in the economy."[2]

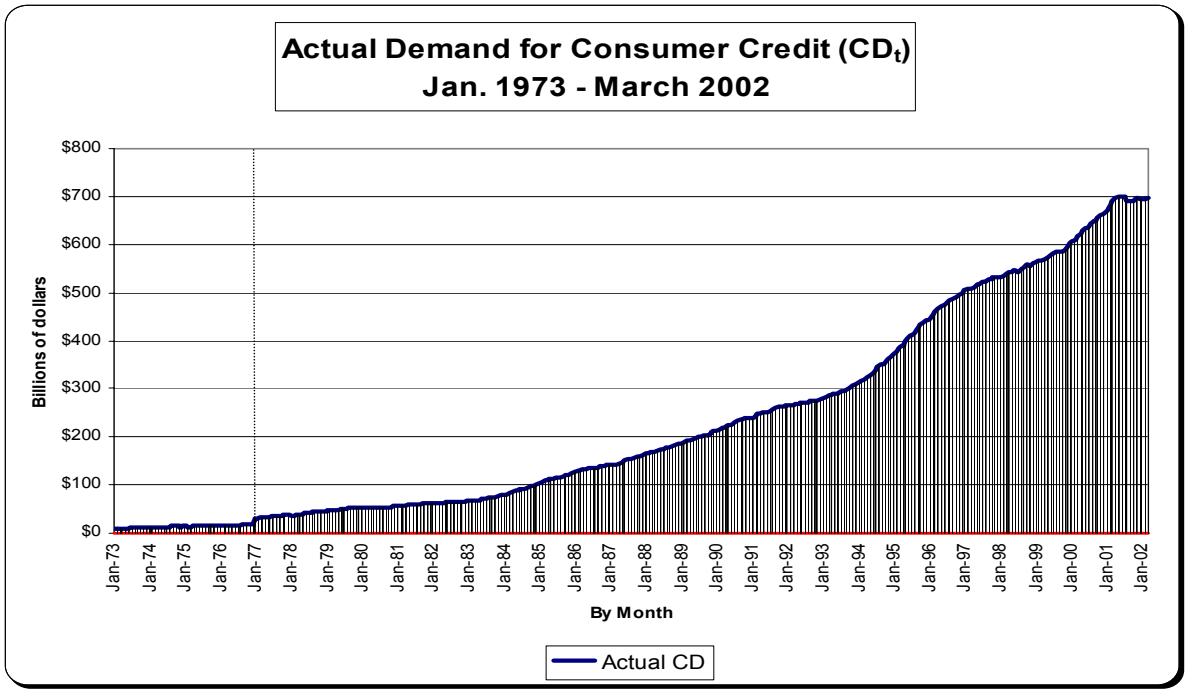
The study of consumer credit is important for a variety of macroeconomic reasons. To begin, consumer-spending accounts for two-thirds of the economy, and consumer credit makes up a majority of consumer spending.[3] In fact, students are graduating from college carrying an average of $2,800 on their credit cards. This is a 50% increase from just ten years ago. While it is true that major credit card issuers have devoted countless hours to the study of determinants of consumer credit, that information is not readily shared with competitors or the public for competitive market reasons. Information is power, and provides a supplier with a competitive advantage in the marketplace. As such, the need to better understand the demand for consumer credit for those outside the financial arena prompted this study.

Credit cards are by far the primary component of revolving consumer credit, with home equity loans and signature lines of credit making up the difference. Since credit cards also make up the majority of consumer spending, the determinants of credit card spending will be the focus of this study. According to data supplied by the Federal Reserve, the level of outstanding consumer credit has increased in an exponential fashion over the past 30 years or so. From 1973 to present, the level of revolving credit outstanding has increased from $9.4B in January 1973 to $697B in March 2002. See Graph 1:

[2] The Growth of Consumer Credit and the Household Debt Service Burden, Board of Governors of the Federal Reserve System, Dean M. Maki, 3-4 November, 1999, page 1.

[3] "Confidence Report Intensifies Urge To Sell," The Washington Times, Wednesday, 28 November 2001, page C10.

Graph 1 – Actual Level of Consumer Credit Outstanding in the US



Source: Federal Reserve Bank of St. Louis, MO

The spike from 12/76 to 01/77 is due to a change in the method for measuring CD_t by the Federal Reserve (previously only included major credit card issuers, such as VISA and MasterCard; now includes department store and gasoline charge cards.[4]) This data has been seasonally adjusted and indexed for inflation over this 32-year period. Utilizing the latest population figure, this equates to a credit card debt load of $2,425 PER PERSON in the US today.[5] Now, let us turn to the factors that have been chosen as inputs in the 2SLS econometric model used to estimate the demand for consumer credit (CD_t) in this study.

[4] "Total Revolving Credit Outstanding, Seasonally Adjusted, Billions of Dollars," Federal Reserve Monthly Statistical Release G.19 REVOLSL, http://stls.frb.org/fred/data/loans/revolsl, Release Date: April 5, 2002, pages 1-7.

[5] Population figure provided by "Civilian Noninstitutional Population," Current Population Survey; U.S. Department of Labor, Bureau of Labor Statistics, http://data.bls.gov/servlet/SurveyOutputServlet, Release Date: May 1, 2002. Estimate derived by dividing consumer credit outstanding as of March 2002 by current population figure for same month ($696.5B/287M = 2,425.)

Section II - Model Inputs

FACTORS DETERMINING DEMAND FOR CONSUMER CREDIT (CD_t) IN US

The following variables are hypothesized to directly or indirectly influence the level of outstanding consumer credit in the US:

- Adjusted Monetary Base (MB_t)
- Unemployment Rate (u_t)
- Consumer Confidence Index (CCI_t)
- Disposable Personal Income (DPI_t)
- Federal Funds Interest Rate (r_t)
- Price/Barrel Crude Oil (Oil_t)

} t = Period of time

Monthly data from January 1973 – March 2002 (last month in which data is available) was collected on these variables. This data will be used to estimate a demand model for CD_t in Section IV. What exactly are these variables, and why were they included in this analysis?

Adjusted Monetary Base (MB_t)

The monetary base is made up of currency and bank reserve deposits at the Federal Reserve (the Fed), and serves to provide the foundation of the nation's money supply. Given the required reserve ratios set by the Fed, it is the main determinant of the supply of loanable funds. The depository institution's demand for base money can be expressed as follows[6]:

[6] Richard G. Anderson and Robert H. Rasche, Eighty Years of Observations on the Adjusted Monetary Base: 1918-1997 January/February 1999 Review, (St. Louis: Federal Reserve Bank, 1999), pages 3-5.

(1) $MB_t = f({}_t d_t, rr_t, e_{mbdt})$

where,

MB_t = Demand for Monetary Base

d_t = Deposit liabilities of institution

rr_t = Required reserve ratio

e_{mbdt} = error term that contains all other determinants of MB_t

MB_t is utilized in the 2nd stage of the 2SLS model as an independent variable to partially determine the demand for consumer credit. The hypothesis is that as the demand for consumer credit increases, the supply of loanable funds increases in an attempt to maximize profit by meeting that demand. Therefore, one would expect a positive sign on the MB_t coefficient when the 2nd stage model is completed. The Federal Reserve Bank of St. Louis, is the source of this data.[7]

Unemployment Rate (ue_t)

The unemployment rate measures the percentage of the labor force that is looking for employment but is not gainfully employed in period t. The relationship of the unemployment rate to consumer credit might be explained in the following manner: as unemployment (ue_t) decreases, consumers become more optimistic about the future and are less concerned with taking on additional debt loads, so their level of consumer credit outstanding increases. As such, the expectation is that sign of the unemployment rate coefficient will be negative. The unemployment rate is calculated on a monthly basis by the U.S. Department of Labor (DoL) Bureau of Labor Statistics for the civilian labor force age 16 years and older. [8]

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[7] "Board of Governors' Adjusted Monetary Base, Seasonally Adjusted, Billions of Dollars," Federal Reserve Weekly Statistical Release H.3 BOGAMBSL, http://stls.frb.org/fred/data/reserves/bogambsl, Release Date: April 25, 2002, pages 1-9.

[8] "Unemployment Rate – Civilian Labor Force, Series ID: LFS21000000" Labor Force Statistics from the Current Population Survey, U.S. Department of Labor, Bureau of Labor Statistics, http://data.bls.gov/cgi-bin/surveymost, Release Date: May 1, 2002, pages 1-2.

Consumer Confidence Index (CCI_t)

The Consumer Confidence Index (CCI) measures the level of confidence individuals have in the performance of the economy. Survey questionnaires are mailed to a representative sample of 5,000 households on a monthly basis. Households are asked five questions that include (1) a rating of current business conditions in the local area, (2) a rating of expected business conditions in six months, (3) perceived current job availability in the local area, (4) expected job availability in 6 months, and (5) expected family income in 6 months. The responses are seasonally adjusted, i.e. expect more jobs in the summer due to the farming season, and indexes are created based on the responses.

Two other indices are taken into account, including one for assessing the present situation and one for the future. Future expectations account for approximately 60% of the index, while the current situation accounts for the remaining 40%. The Conference Board has been tracking the CCI since the late 1960s, and the CCI has become an important instrument used by economists to measure consumer expectations about the economy.[9] Changes in the CCI from t to t + 1 vary with such things as: unemployment, inflation, income growth and consumer spending. If consumers were confident about the future of the economy, one would expect they would be more inclined to increase their current debt levels, thereby increasing the demand for consumer credit. Conversely, if consumers were more cautious about the future, they could be inclined to slow down their spending and decrease the demand for consumer credit. The hypothesis is that the sign on the CCI_t coefficient will be positive.

Disposable Personal Income (DPI_t)

Disposable Personal Income (DPI_t) measures the level of income received by persons from all sources after taxes have been deducted in period t. DPI_t can be written as follows:

[9] "Consumer Confidence Index," The Conference Board, http://sub1.economagic.com/em-cgi/data.exe/bci97/a0m122, Release Date: April 30, 2002, pages 1-25.

(2) $\mathbf{DPI_t = Y_t - T_t = C_t + S_t}$

where,

$\mathbf{Y_t}$ **= Personal Income**

$\mathbf{T_t}$ **= Taxes**

$\mathbf{C_t}$ **= Consumption**

$\mathbf{S_t}$ **= Savings**

The hypothesis is that as DPI_t increases, consumers have less of a need to borrow funds to finance current spending habits, thereby resulting in a decrease in the demand for consumer credit. This would indicate a negative sign on the DPI_t coefficient. The level of Disposable Personal Income (DPI_t) is tracked by the U.S. Department of Commerce (DoC) on a monthly basis.[10]

Federal Funds Rate (r_t)

The federal funds rate is the interest rate charged on loans from one bank to another. Banks are required to have reserves on hand as mandated by the Fed, and they often make overnight loans in order to meet this reserve requirement. The federal funds rate, r_t, is a short-term interest rate to which many lines of credit, including credit cards, are often tied. Typically, banks use the federal funds rate as a basis upon which to add a fixed percentage rate to charge their credit card customers. For obvious reasons, the demand for consumer credit (CDt) would be determined partially by the rate of interest charged on the credit card balances. The lower the interest rate, the lower the cost of borrowing to the consumer and the more enticing it is to carry balances on their credit cards. Consequently, the sign of the

[10] "Disposable Personal Income, Seasonally Adjusted, Billions, State Personal Income 1929-2002 (CD ROM RCN-0284). U.S. Department of Commerce, Bureau of Economic Analysis, http://www.bea.gov/bea/uguide.htm#subj, pages 1-5.

r_t coefficient is expected to be negative. The Federal Reserve reports the federal funds rate on a monthly basis.[11]

Price/Barrel Crude Oil (Oil_t)

The United States is a very mobile society, and automobile ownership has greatly contributed to this mobility. American citizens routinely travel long distances for work, vacations, etc., especially when compared to other industrialized countries. Due to our continual evolving dependence on automobiles, the price of automobile gasoline fuel plays an important role in our economy. Fluctuations in gasoline prices influence our work and recreational activities. Since the price of gasoline is based largely on the price/barrel of crude oil, this variable was included as a factor in this analysis. Due to our dependence on this fuel, the hypothesis is that an increase in the price of Oil_t/barrel results in an increase in the demand for consumer credit, i.e. the coefficient of the Oil_t variable is positive. The Department of Energy (DoE) reports the price of a barrel of crude oil on a monthly basis.[12]

[11] "Federal Funds Rate," Federal Reserve Monthly Statistical Release H.15 FEDFUND, http://www.federalreserve.gov/releases/H15/data/m/fedfund.txt, Release Date: April 1, 2002, pages 1-10.

[12] "Crude Oil Price Summary, Dollars per Barrel," Petroleum Marketing Monthly March 2002, U.S. Department of Energy, Energy Information Administration, http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_marketing_monthly/current/pdf/pmmtab1.pdf, Release Date: April 7, 2002, pages 4-6.

Section III - Regression Analysis

Ordinary Least Squares (OLS)

A commonly used econometric tool, ordinary least-squares (OLS) regression, can be used to estimate the parameters characterizing the demand for outstanding consumer credit (CD_t) in the United States. Five assumptions underlying the OLS regression model are as follows[13]:

1. Dependent variable is a linear function of a specific set of independent variables plus a disturbance term;
2. Expected value of the disturbance term is zero;
3. Disturbances have uniform variance and are uncorrelated;
4. Observations on independent variables can be considered fixed in repeated samples; and
5. No exact linear relationships exist between the independent variables.

While OLS is a commonly used tool for conducting econometric analysis, it is only valid if all of the five conditions identified above have been met. For purposes of estimating the demand for consumer credit outstanding, OLS is not an appropriate econometric tool in its own right. This is because the variables previously listed to be included in an estimation model are not independent of each other, so assumption five (5) above cannot be met. For example, consumers take on credit to purchase goods and services. These purchases result in an increase in economic growth, which can lead to a decrease in unemployment, increased disposable personal income (DPI_t). The problem of reverse causation is readily apparent.

Two-Stage Least Squares (2SLS)

2SLS is a method of extending OLS regression to cover models that violate the OLS regression assumption that there is no reverse causation. 2SLS is used when the residual is

[13] Peter Kennedy, A Guide to Econometrics, (Cambridge: The MIT Press, 1998), pages 43-46.

correlated with one or more of the independent variables resulting in simultaneity bias. This bias occurs when one of the independent variables is not truly independent, and, instead is a function of one or more of the independent variables. When this occurs, as is the case with the CCI_t, ue_t and DPI_t variables, the effects of changes in each variable independent of changes in the other variables cannot be identified. Structural equations are formulated to replicate the demand and supply equations for the dependent variable in question. These structural equations are used to derive reduced form equations in which the endogenous variables are expressed as linear functions of the exogenous variables.

2SLS regression analysis can be further explained as follows:

1. 1st stage – An estimate of an endogenous variable is created for the original variable and expressed as a linear function of the exogenous variables. This is to eliminate correlation between the exogenous variables and the error terms;

2. 2nd stage – OLS regression is run using this estimated variable as a proxy for the original variable.

In using 2SLS, the new variable will be uncorrelated with the disturbance term of the endogenous variable. When similar replacements are done for all problematic causal variables, the recursivity assumption will no longer be violated.[14]

[14] Dr. Thomas Garson, "Two-Stage Least Squares (2SLS) Regression Analysis," On-line Lecture Notes, North Carolina State University, College of Humanities and Social Sciences, Raleigh, NC, http://www2.chass.ncsu.edu/garson/paa765/2sls.htm, 11 November 1998, pages 1-5.

Section IV - 2SLS Econometric Model

Before attempting to develop an econometric model, the econometric theory behind the model must be examined in order to ensure that the model is consistent with the relevant theories at hand. To begin, because our variables tend to grow exponentially, we take the natural logs of the variables to ensure they are in linear form. "Estimation is often facilitated by performing a logarithmic transformation of variables to create a linear estimating equation."[15] The initial demand/supply equations are as follows:

(3) $\mathbf{CD_t = f(ue_t, CCI_t, DPI_t, MB_t, r_t, Oil_t, k_t)}$

where

CD_t = Demand for Consumer Credit

r = Federal Funds Interest Rate (proxy for credit card interest rates)

ue = Unemployment Rate

CCI = Consumer Confidence Index

DPI = Disposable Personal Income

MB = Monetary Base

Oil = Price/Barrel of Crude Oil (proxy for gasoline prices)

k = Error Term

(4) $\mathbf{CS_t = g(r_t, MB_t, v_t)}$

where

CS_t = Supply for Consumer Credit

r = Federal Funds Interest Rate (proxy for credit card interest rates)

MB = Monetary Base

v = Error Term

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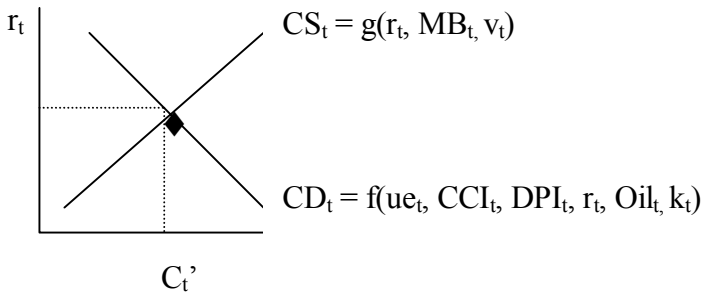
[15] Peter Kennedy, A Guide to Econometrics, (Cambridge: The MIT Press, 1998), page 115.

For simplicity, suppose demand and supply are linear functions and equilibrium is reached when the demand for consumer credit = the supply for consumer credit, or $CD_t = CS_t$ for any time period. We are assuming no disequilibrium during this period. Graphically, this can be seen as follows:



Adding an intercept, and coefficients α_i to equation (3) results in the following structural equation:

(5) $$\mathbf{CD_t = \alpha_0 + \alpha_1 * ue_t + \alpha_2 * CCI_t + \alpha_3 * DPI_t + \alpha_4 * r_t + \alpha_5 * MB_t + \alpha_6 * Oil_t + k_t}$$

Likewise, adding an intercept and coefficients β_i to equation (4) results in the following structural equation:

(6) $$\mathbf{CS_t = \beta_0 + \beta_1 * r_t + \beta_2 * MB_t + v_t,}$$

Rearranging equation (6) to isolate r_t, we arrive at:

(7) $$\mathbf{r_t = 1/\beta_1 * CS_t * -\beta_0/\beta_1 - \beta_2/\beta_1 * MB_t - v_t/\beta_1}$$

Rearranging equation (5) to isolate r_t, we arrive at:

(8) $$\mathbf{r_t = 1/\alpha_4 * CD_t * -\alpha_0/\alpha_4 - \alpha_1/\alpha_4 * ue_t - \alpha_2/\alpha_4 * CCI_t - \alpha_3/\alpha_4 * DPI_t - \alpha_5/\alpha_4 * MB_t - \alpha_6/\alpha_4 * Oil_t - k_t/\alpha_4}$$

Subtracting equation (7) from equation (8), we have

(9) $$0 = [1/\alpha_4*CD_t*-\alpha_0/\alpha_4 - \alpha_1/\alpha_4*ue_t - \alpha_2/\alpha_4*CCI_t - \alpha_3/\alpha_4*DPI_t - \alpha_5/\alpha_4*MB_t - \alpha_6/\alpha_4*Oil_t] - [1/\beta_1*CS_t*-\beta_0/\beta_1 - \beta_2/\beta_1*MB_t] - [k_t/\alpha_1 - v_t/\beta_1]$$

Moving CS_t and CD_t to the left side, we arrive at

(9a) $$[1/\beta_1*CS_t - 1/\alpha_4*CD_t] = [-\alpha_0/\alpha_4 - \alpha_1/\alpha_4*ue_t - \alpha_2/\alpha_4*CCI_t - \alpha_3/\alpha_4*DPI_t - \alpha_5/\alpha_4*MB_t - \alpha_6/\alpha_4*Oil_t] + [\beta_0/\beta_1 + \beta_2/\beta_1*MB_t] - [k_t/\alpha_1 - v_t/\beta_1]$$

Rearranging terms, we can now see the market clearance with the error terms added to the equations. $CS_t = CD_t = C_t$' is a function of the ue_t, MB_t, CCI_t, DPI_t and Oil_t variables, and can be expressed as

(9b) $$C_t' = \{[+\beta_0/\beta_1 - \alpha_0/\alpha_1] - [\alpha_1/\alpha_4*ue_t - \alpha_2/\alpha_4*CCI_t - \alpha_3/\alpha_4*DPI_t - \alpha_5/\alpha_4*MB_t - \alpha_6/\alpha_4*Oil_t + \beta_2/\beta_1*MB_t] - [k_t/\alpha_1 - v_t/\beta_1]\}/[1/\beta_{1t} - 1/\alpha_{1t}]$$

Now that the parameters/conditions to force equilibrium have been established, the reduced form equations for C_t' and r_t can be seen as follows:

(10) $$Ct' = \delta_o + \delta_1*ue_t + \delta_2*CCI_t + \delta_3*DPI_t + \delta_4*r_t + \delta_5*MB_t + \delta_6*Oil_t + ed_t$$

(11) $$r_t = \phi_o + \phi_1*ue_t + \phi_2*CCI_t + \phi_3*DPI_t + \phi_4*MB_t + \phi_5*Oil_t + es_t,$$

We estimate equation (11) by OLS. We use the OLS estimates of $\phi_o,\ldots,\phi_5$ and the independent variables in (11) to generate $rfit_t$, the fitted values of r_t. This is the first stage of the 2SLS procedure. The values of $rfit_t$ are then substituted for r_t in equation (10). $Rfit_t$ is not

correlated with the error term ed_t in (10), like r_t is, and therefore we can estimate (10) by OLS. This is the second stage of 2SLS.

We estimated equation (11) to arrive at the results shown in Table 1 on page 15. Then, we took the estimates of $\phi_o,\ldots,\phi_5$ and plugged them back into equation (11) to generate $rfit_t$ from the independent variables on the right side of the equation. This can be seen in equation (12) as follows:

(12) $\mathbf{rfit_t = \beta_o + \beta_1 * ue_t + \beta_2 * CCI_t + \beta_3 * DPI_t + \beta_4 * MB_t + \beta_5 * Oil_t}$

where

$rfit_t$ = the estimated value for the Federal Funds variable r_t

The resulting coefficients, $\beta_o \ldots \beta_5$, in equation (12) are the estimates of $\phi_o \ldots \phi_5$ in equation (11). For the **2nd stage of 2SLS**, we estimate (10) replacing r_t with $rfit_t$ to get:

(13) $\mathbf{CD_t = \alpha_o + \alpha_1 * ue_t + \alpha_2 * CCI_t + \alpha_3 * DPI_t + \alpha_4 * MB_t + \alpha_5 * rfit_t + \alpha_6 * Oil_t}$

where

$\alpha_0,\ldots,\alpha_6$ are the OLS estimates of $\delta_o,\ldots, \delta_6$

Since the focus of this paper is on the determinants of the demand for consumer credit outstanding, CD_t, equation (13) will be evaluated in this analysis.

1st Stage of 2SLS - Testing for Autocorrelation

Before running the first regression to estimate $rfit_t$, we need to ensure that autocorrelation is not present in this model. If autocorrelation is positive, standard errors of regression coefficients will be biased downward; if negative, errors will be biased upward. The Durbin-Watson (DW) test statistic for autocorrelation is always between 0 and 4. If it equals 2, then the null hypothesis stating there is no first order autocorrelation among the error terms can be

rejected. If positive autocorrelation is present, the DW statistic will be closer to 0; if negative autocorrelation exists, it will be closer to 4. The DW statistic on the 1st stage of this model was 0.07, indicating the presence of positive autocorrelation.

1st Stage of 2SLS - Correcting for Autocorrelation

Using the Hildreth-Lu procedure to correct for autocorrelation, we re-estimated the 1st stage of 2SLS. This resulted in a DW statistic of 2.08 (details of performing this procedure are provided in the 2nd Stage Model Analysis, beginning on page 18).

Running the regression for the 1st Stage of the model resulted in the following:

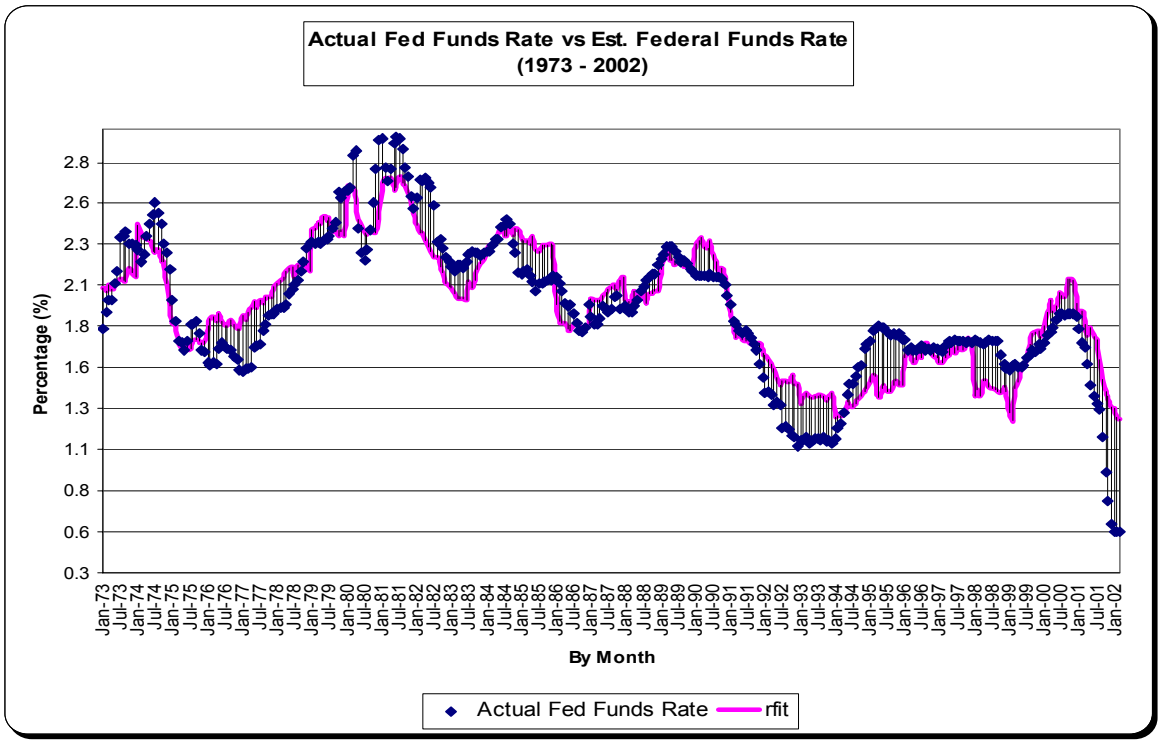
Table 1 – Equation (11) Regression Results (1973 - 2002)

Multiple R		0.88958586			
R Square		0.79136301			
Adjusted R Square		0.7882675			
Standard Error		0.18636996			
Observations		350			
ANOVA	***df***	***SS***	***MS***	***F***	***Significance F***
Regression	6	44.39828356	8.879657	255.6491	2.4383E-112
Residual	343	11.70527841	0.034734		
Total	349	56.10356198			
	Coefficients	***Standard Error***	***T-Stat***		
Intercept	4.19355386	0.533765337	7.85655		
ue_t	-1.3900101	0.080604955	-17.2447		
CCI_t	-0.1382481	0.054982078	-2.51442		
DPI_t	1.25693272	0.171043097	7.348632		
MB_t	-2.0272862	0.162845723	-12.4491		
Oil_t	0.655185	0.033922233	19.31432		
Rho	0.1				

Our observation period is January 1973 – March 2002, which represents 29.2 years, or 350 months. Using these coefficients to run the 1st stage model, we can derive r_{fit}, which will be used in place of r_t in the 2nd stage of the model analysis. When the regression is run, the

estimates derived for $rfit_t$ (estimated Federal Funds rate) are then compared to r_t (actual Federal Funds rate.) The results can be seen in Graph 2.

Graph 2 - $rfit_t$



What do these regression results mean?

The acceptance of regression results hinges on diagnostic checking for the breakdown of the five classical assumptions, as listed in Section III.[16] We have corrected for the breakdown of assumption 5 by incorporating the use of a 2SLS regression as opposed to an OLS regression. In order to further validate the integrity of the model, we need to examine the results of the regression analysis.

[16]Vijay Gupta, Regression Explained, (Washington, DC: VJBooks, Inc., 2000), page 2.

Step 1 – Significance of the model

To begin, one should always review the model fit, or analysis of variance (ANOVA) first. The "Significance of the model (last column of ANOVA section in Table 1)" answers the question: *Did the model explain the deviations in the dependent variable?* The significance level of the F statistic for the overall fit in Table 1 is 2.438E-112, less then 1%. Therefore, we can conclude the overall model is significant with 99% confidence.

Step 2 – R^2 results

R^2 measures the proportion of variation in the endogenous (dependent) variable explained by the variation in the exogenous (independent) variables, and can be expressed as (1-Sum of Squared Residuals)/Sum of Squared Deviations. The closer to 1, the higher the measured fit of the model.

In this regression shown in Table 1, both R^2 and the adjusted R^2 are at 78-79%. This indicates that approximately 79% of the changes in the estimated federal funds interest rate, $rfit_t$, are explained by the five independent variables – ue_t, CCI_t, DPI_t, MB_t and Oil_t.

Step 3 - Standard Error of Estimate

The standard error measures the dispersion of the dependent variables around its mean. In Table 1, the standard error is 0.1863, or about 19%.

Step 4 – Individual Coefficients

The T-stats indicate that the null hypothesis (H_0: $\beta_i = 0$) can be rejected for all of the independent variables. With T-stats ranging from –17 to 19, the coefficients indicate that all of the independent variables are statistically significant.

2nd Stage of 2SLS

The next step is to take the reduced form value derived in the 1st Stage of 2SLS, $rfit_t$, insert it in place of the actual federal funds rate, r_t, as shown in equation (13), and run the OLS regression to estimate consumer demand for credit outstanding, CD_t, using the newly created instrumental variable. This can be seen in equation (13). Again, the natural logs of the variables have been taken to ensure all variables are in linear form. This methodology will form the basis for estimating the demand for consumer credit (CD_t) over the past 30 years (January 1973 – March 2002) in the United States.

2SLS - Testing for Autocorrelation

Just as we did in for the 1st stage of 2SLS, we need to ensure that autocorrelation is not present in this model. The DW statistic on the 2nd stage of this model was 0.101, indicating the presence of positive autocorrelation.

2SLS - Correction for Autocorrelation

Using the Hildreth-Lu procedure to correct for autocorrelation, we re-estimated the 2nd stage of 2SLS. This resulted in a DW statistic of 2.02. How did we do this? Consider the following two equations (14) and (15):

(14) $\mathbf{CD_t = \alpha_0 + (\alpha_1 * ue_t + \alpha_2 * CCI_t + \alpha_3 * DPI_t + \alpha_4 * MB_t + \alpha_5 * rfit_t + \alpha_6 * Oil_t) + s_t,}$

where

CD_t = Consumer credit outstanding in period t

α_0 = Intercept

s_t = error term in period of time t

(15) $CD_{t-1} = \alpha_0 + (\alpha_1 * ue_{t-1} + \alpha_2 * CCI_{t-1} + \alpha_3 * DPI_{t-1} + \alpha_4 * MB_{t-1} + \alpha_5 * rfit_{t-1} + \alpha_6 * Oil_{t-1}) + s_{t-1}$

where t-1 = error term in previous period of time

Multiplying Equation (15) by ρ, we have

(16) $\rho CD_{t-1} = \rho\alpha_0 + (\alpha_1 * \rho ue_{t-1} + \alpha_2 * \rho CCI_{t-1} + \alpha_3 * \rho DPI_{t-1} + \alpha_4 * \rho MB_{t-1} + \alpha_5 * \rho rfit_{t-1} + \alpha_6 * \rho Oil_{t-1}) + \rho s_{t-1}$

Next, subtract (16) from (14), and the result is

(16') $CD - \rho CD_{t-1} = \alpha_0(1-\rho) + [(\alpha_1 * ue_t + \alpha_2 * CCI_t + \alpha_3 * DPI_t + \alpha_4 * MB_t + \alpha_5 * rfit_t + \alpha_6 * Oil_t) - (\alpha_1 * \rho ue_{t-1} + \alpha_2 * \rho CCI_{t-1} + \alpha_3 * \rho DPI_{t-1} + \alpha_4 * \rho MB_{t-1} + \alpha_5 * \rho rfit_{t-1} + \alpha_6 * \rho Oil_{t-1})] + (s_t - \rho s_{t-1})$

The end result is the equation we used to perform the Hildreth-Lu Procedure

(17) $CD_t' = [(\alpha_1 * ue_t + \alpha_2 * CCI_t + \alpha_3 * DPI_t + \alpha_4 * MB_t + \alpha_5 * rfit_t + \alpha_6 * Oil_t) - (\alpha_1 * \rho ue_{t-1} + \alpha_2 * \rho CCI_{t-1} + \alpha_3 * \rho DPI_{t-1} + \alpha_4 * \rho MB_{t-1} + \alpha_5 * \rho rfit_{t-1} + \alpha_6 * \rho Oil_{t-1}] * \rho + h_t$

Inputting values ranging from –1 to 1 in Equation 17, the value of ρ that resulted in the highest R^2 was:

ρ	R^2	DW statistic
0.1	0.9955	2.02

The highest R^2 was computed by subtracting the Residual Sum of Squares (RSS) from 1, and then dividing by the Sum of Squares of the Dependent Variable (SSY). This can be expressed as: (1-RSS/SSY.)

The regression results for equation (13), the 2nd stage of 2SLS, are shown in Table 2:

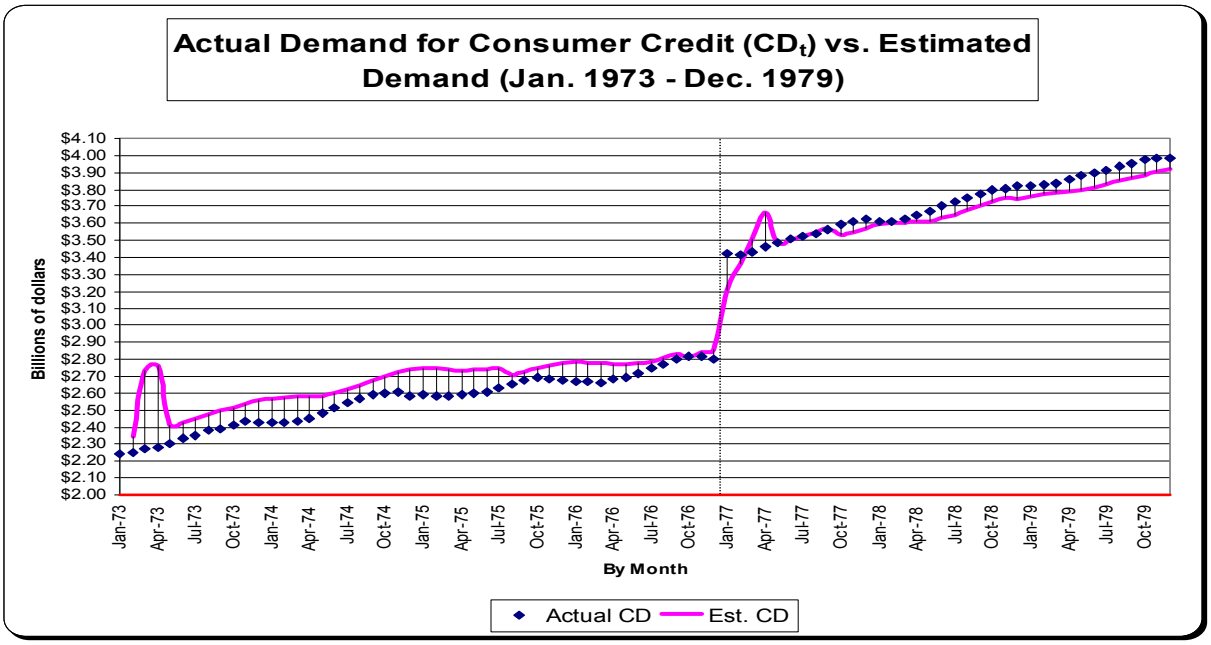
Table 2 – CD_t Regression Results Post Autocorrelation Correction Summary

Multiple R		0.9955			
R Square		0.9912			
Adjusted R Square		0.9910			
Standard Error		0.1311			
Observations		350			
ANOVA	***df***	***SS***	***MS***	***F***	***Significance***
Regression	6	665.17	110.86	6440.55	0
Residual	343	5.9040	0.01722		
Total	349	671.07			
	Coefficients	***Standard Error***	***T-Stat***		
Intercept	-1.4027	1.4623	-0.9592		
ue_t	-3.6913	0.6059	-6.0926		
CCI_t	-0.3325	0.5335	-0.6233		
DPI_t	5.3646	0.4486	11.9570		
MB_t	-5.2431	6.9690	-0.7523		
$rfit_t$	-2.4929	3.0493	-0.8175		
Oil_t	1.6177	1.7743	0.91174		
Rho	0.1				

Using these estimated coefficients in equation (13), the estimates derived for CD_t are compared to the actual levels of CD_t. Due to the volume of data, the regression results were graphed in three separate sections:

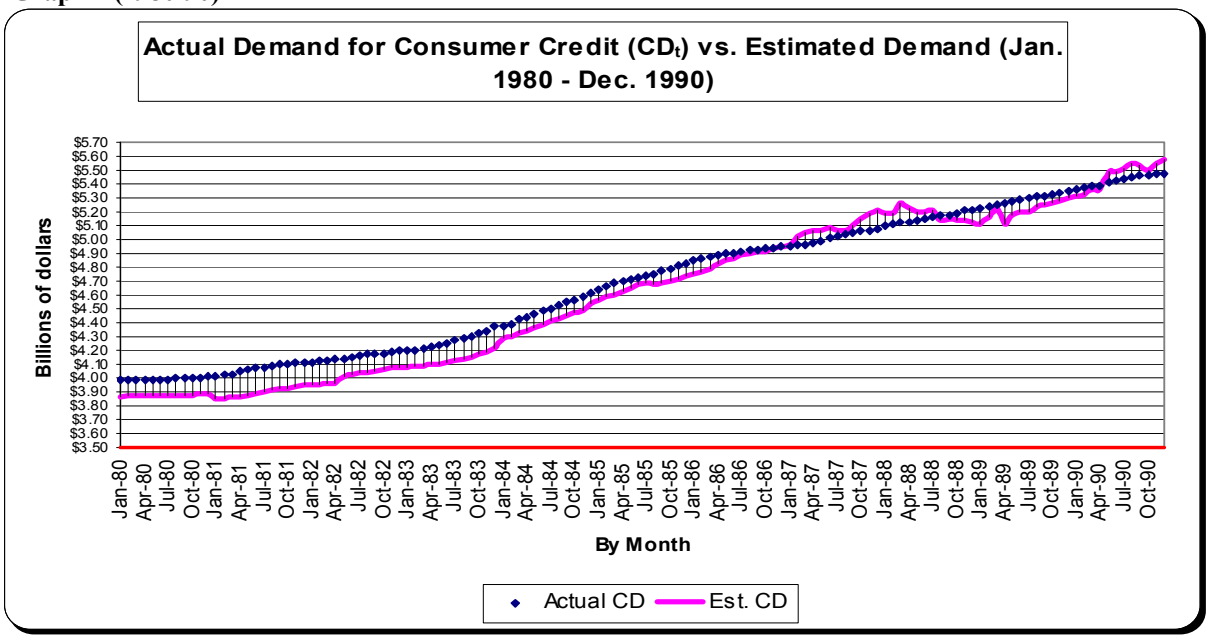
- 1973-79
- 1980-90
- 1991 to 1997 (In Section V, an Out-of-Sample Analysis from 1998 – 2002 is performed)

Graph 3 (1973-79)



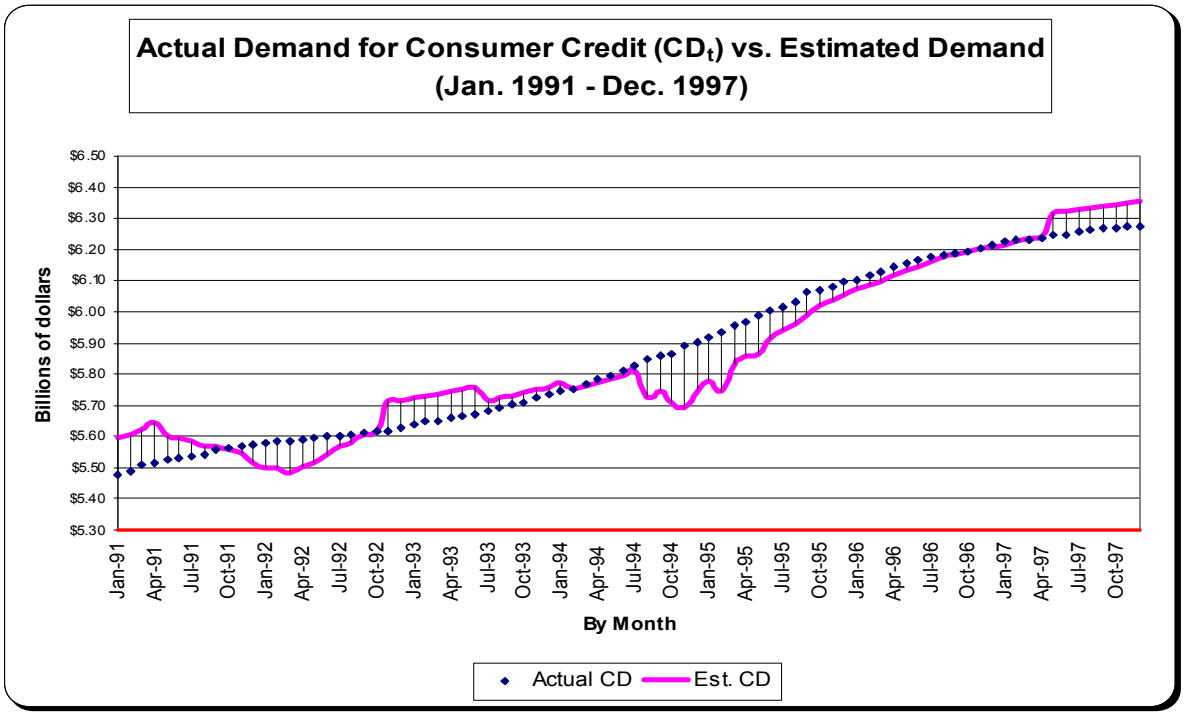
Please note the spike from 12/76 to 01/77 is due to a change in the method for measuring CD_t by the Federal Reserve (previously only included major credit card issuers, such as VISA and MasterCard; now includes department store and gasoline charge cards.[17])

Graph 4 (1980-90)



[17] The Growth of Consumer Credit and the Household Debt Service Burden, Board of Governors of the Federal Reserve System, Dean M. Maki, 3-4 November, 1999, page 4.

Graph 5 (1991 – 1997)



What do these regression results mean?

The acceptance of regression results hinges on diagnostic checking for the breakdown of the five classical assumptions, as listed in Section III.[18] We have corrected for the breakdown of the last assumption by the use of a 2SLS regression as opposed to an OLS regression. In order to further validate the integrity of the model, we need to examine the results of the regression analysis.

Step 1 – Significance of the model

The "Significance" of the model, last column of the analysis of variance (ANOVA) in Table 2, serves to answer the question: *Did the model explain the deviations in the dependent*

[18] Vijay Gupta, Regression Explained, (Washington, DC: VJBooks, Inc., 2000), page 2.

variable? The lower the significance, the greater the overall fit. Significance implies that we can accept the model results. Since our significance in Table 2 is 0, it is less then 0.01, or 1%. Therefore, we can conclude the overall model is significant with 99% confidence.

Step 2 – R^2 results

R^2 measures the proportion of variation in the endogenous (dependent) variable explained by the variation in the exogenous (independent) variables, and can be expressed as (1-Sum of Squared Residuals)/Sum of Squared Deviations. The closer to 1, the higher the measured fit of the model. In this regression shown in Table 2, both R^2 and the adjusted R^2 are at 99%. This indicates that approximately 99% of the changes in the demand for consumer credit (CD_t) are explained by the six independent variables – ue_t, CCI_t, DPI_t, MB_t, $rfit_t$ and Oil_t.

Step 3 - Standard Error of Estimate

The standard error measures the dispersion of the dependent variables around its mean. In Table 2, the standard error is 0.1311.

Step 4 – Individual Coefficients

We hypothesized the signs of the coefficients for the explanatory variables in Section II. How close were we after the regression for the 2nd stage was completed?

Table 3

Variable	Hypothesized Sign	Actual Sign	Hypothesis Correct?	Significant?
ue_t	Negative	Negative	Yes	Yes
CCI_t	Positive	Negative	No	No
DPI_t	Negative	Positive	No	Yes
MB_t	Positive	Negative	No	No
$rfit_t$	Negative	Negative	Yes	No
Oil_t	Positive	Positive	Yes	No

According to the t-stats in Table 2, CCI_t, MB_t, $rfit_t$ and Oil_t are not statistically significant at a 10% level. The signs of those coefficients are of little importance since they have no influence on CD_t. It's worth noting that the dependent variable from the 1st Stage of 2SLS, $rfit_t$, is not statistically significant in the 2nd Stage of 2SLS. The t-stats for ue_t and DPI_t, -6.09 and 11.95 respectively, indicate these variables are statistically significant. In essence, these two variables are the primary drivers behind changes in CD_t. As ue_t increases, consumers decrease their demand for credit presumably due to the increased uncertainty of future income levels needed to support the debt loads in question. Similarly, as DPI_t increases, consumers increase their demand for consumer credit debt presumably because they feel better able to manage their debt loads due to increased expectations of future income. Likewise, credit limits tend to increase as income levels increase, thereby allowing consumers the ability to take on more debt as their income rises.

Since the data sets have been transformed into natural logs, we can also focus on the elasticities of the dependent variables. The ue_t coefficient of –3.69 in Table 2 indicates a 1% increase in unemployment results in a 3.69% decrease in the demand for consumer credit. Conversely, a 1% increase in DPI_t would result in a corresponding 5.36% increase in CD_t. We can argue on the basis of these estimates that two variables are the primary drivers behind

changes in the demand for consumer credit. CD_t exhibits a high degree of sensitivity to changes in ue_t and DPI_t. The other variables are statistically insignificant.

Section V – Comparison of Reduced Form 2SLS Model to Other Models

In the field of econometrics, it is common practice when assessing the validity of a model to compare the results to those produced by other models using the same data sets. For purposes of this analysis, two other models were created to use for comparison purposes:

- Trend Model
- Auto-Regressive Model - AR(1)

Trend Model

In this model, the log of Time (T) is taken and used as the explanatory variable to estimate CD_t:

(18) $\mathbf{CD_t = \beta_0 + \beta_1 T + x_t}$

where

T = Observation number, from 1 – 299

x_t = error term

The regression results from running this model are shown on the next page.

Table 4 – Trend Model Post-Autocorrelation Regression Summary (1973-1997)

Multiple R		**0.923872792**			
R Square		**0.853540936**			
Adjusted R Square		**0.853049462**			
Standard Error		**0.445655867**			
Observations		**300**			
ANOVA					
	df	***SS***	***MS***	***F***	***Significance F***
Regression	**1**	**344.9242**	**344.9241639**	**1736.698**	**2.5E-126**
Residual	**298**	**59.18553**	**0.198609152**		
Total	**299**	**404.1097**			
	Coefficients	***Standard Error***	***t Stat***		
β_o	**-0.689800526**	**0.128497**	**-5.368223503**		
T	**1.112404951**	**0.026693**	**41.67371159**		

NOTE: The DW statistic for the initial trend model, (0.029), indicated a strong possibility for the presence of positive autocorrelation. As such, the Hildreth-Lieu procedure was performed to correct for the autocorrelation, and the results were as follows:

ρ	R^2	**DW statistic**
0.5	0.88	1.93

Table 4 shows the regression results AFTER correcting for autocorrelation.

Auto-Regressive Model - AR(1)

The AR(1) model used in this study can be expressed as:

(19) $\mathbf{CD_t = \delta_0 + \delta_1 CD_{t-1} + \xi,}$

where

$\mathbf{CD_{t-1}}$ **= Dependent variable in previous period**

ξ **= error term**

The regression results are as follows:

Table 5 – AR(1) Model Regression Summary (1993-1997)

Multiple R		**0.9996**			
R Square		**0.9992**			
Adjusted R Square		**0.9993**			
Standard Error		**0.0335**			
Observations		**300**			
ANOVA					
	df	***SS***	***MS***	***F***	***Significance F***
Regression	**1**	**549.07**	**549.07**	**489125.8**	**0**
Residual	**298**	**0.3906**	**0.0011**		
Total	**299**	**549.46**			
	Coefficients	***Standard Error***	***t Stat***		
δ_0	**0.0303**	**0.0071**	**4.2797**		
MA	**0.9963**	**0.0014**	**699.37**		

Now that the models have been introduced, a comparison of their results can be made. The most common method used to compare model results is to compute the Root Mean Square Errors (RMSE). This comparison will be made on two fronts: (1) within sample (1973 – 1997); and (2) out of sample (1998- 2002.)

Within Sample Model Comparison (1973 – 1997)

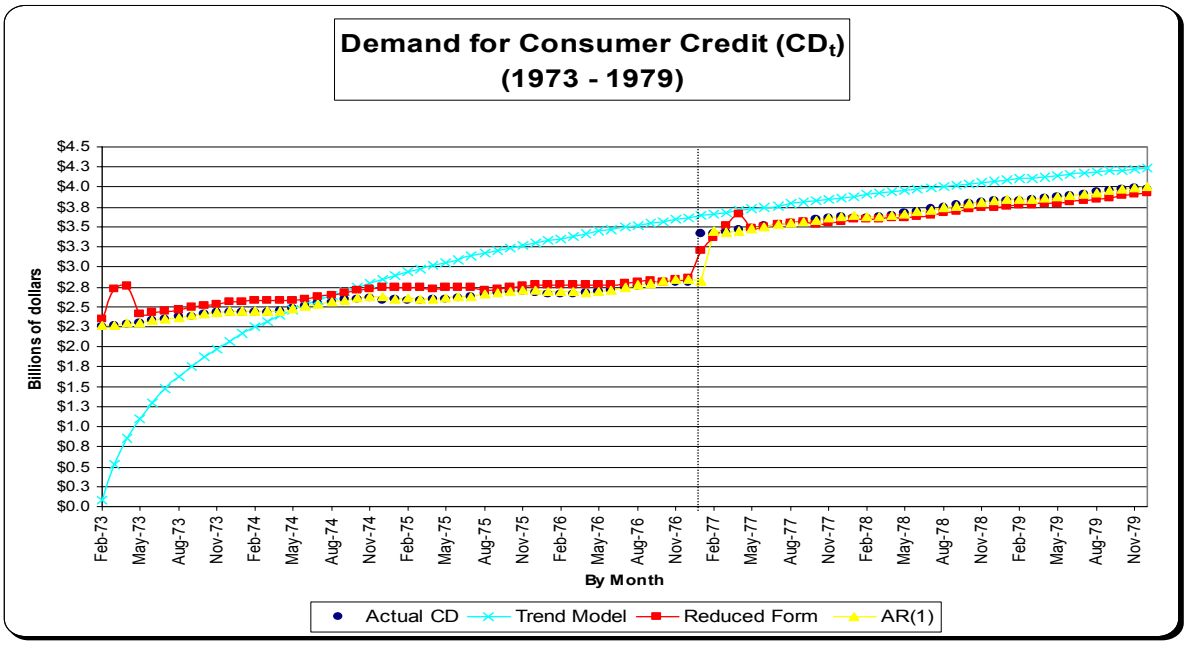
First, sum up the error terms squared for each model. This is the Sum of Squared Error (SSE) terms. Next, divide SSE by the number of observations to calculate Mean Square Error (MSE.) Finally, take the square root of the MSE to determine the RMSE. In computing the RMSE for each of the three models, the results are as follows:

Table 6 – Model Comparison Results (Within Sample)

	Model #1 Reduced Form	**Model #2 Trend**	**Model #3 AR(1)**
R^2	**0.99**	**0.88**	**0.99**
DW statistic	**2.02**	**1.93**	**N/A**
RMSE	**0.0908**	**0.4131**	**0.0389**
rho	**0.1**	**0.5**	**N/A**

The reduced form model equaled the AR (1) model in terms of highest R^2 (0.99) and had the second lowest RMSE (0.09) of the three models during this period. The trend model had the lowest R^2 (0.88) and highest RMSE (0.4131) of the group. Even though the AR(1) model had the lowest RMSE, it bases the estimates solely on the demand for consumer credit realized in prior periods. This methodology provides no insight into the actual drivers behind the demand for consumer credit, i.e. what factors influence the demand for consumer credit? How do changes in key macroeconomic variables such as: the unemployment rate, interest rate, disposable personal income, etc. impact the demand for consumer credit? The goal of this analysis was to identify a set of variables that determine consumer credit, so changes in these variables could be used to estimate future levels of the demand for consumer credit. This is simply not possible when using an AR(1) model, because the only input variable is the level of demand for consumer credit of prior periods. The model comparison results can be seen in graphs 6-8.

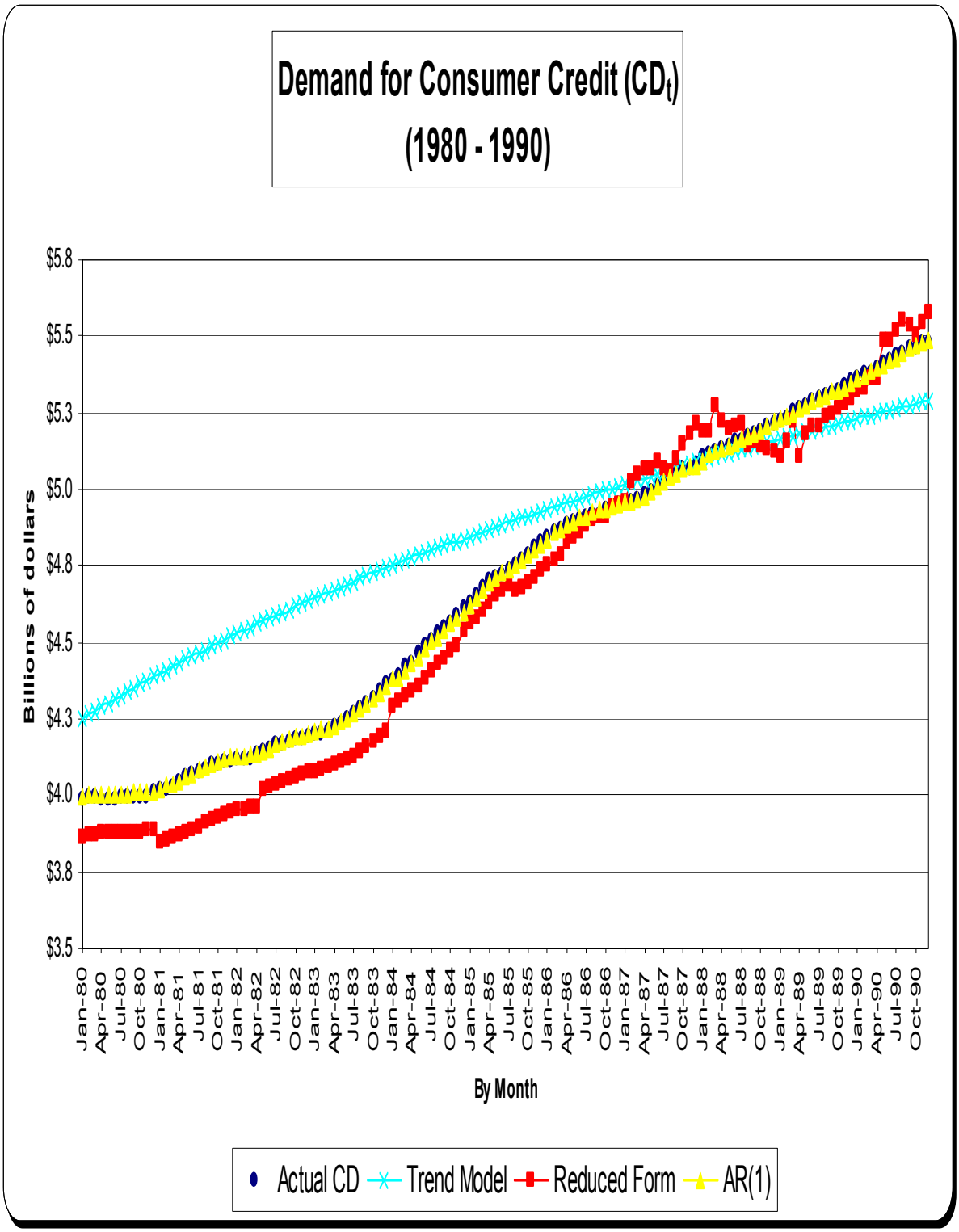
Graph 6 – Within Sample Model Comparison (1973 – 1979)



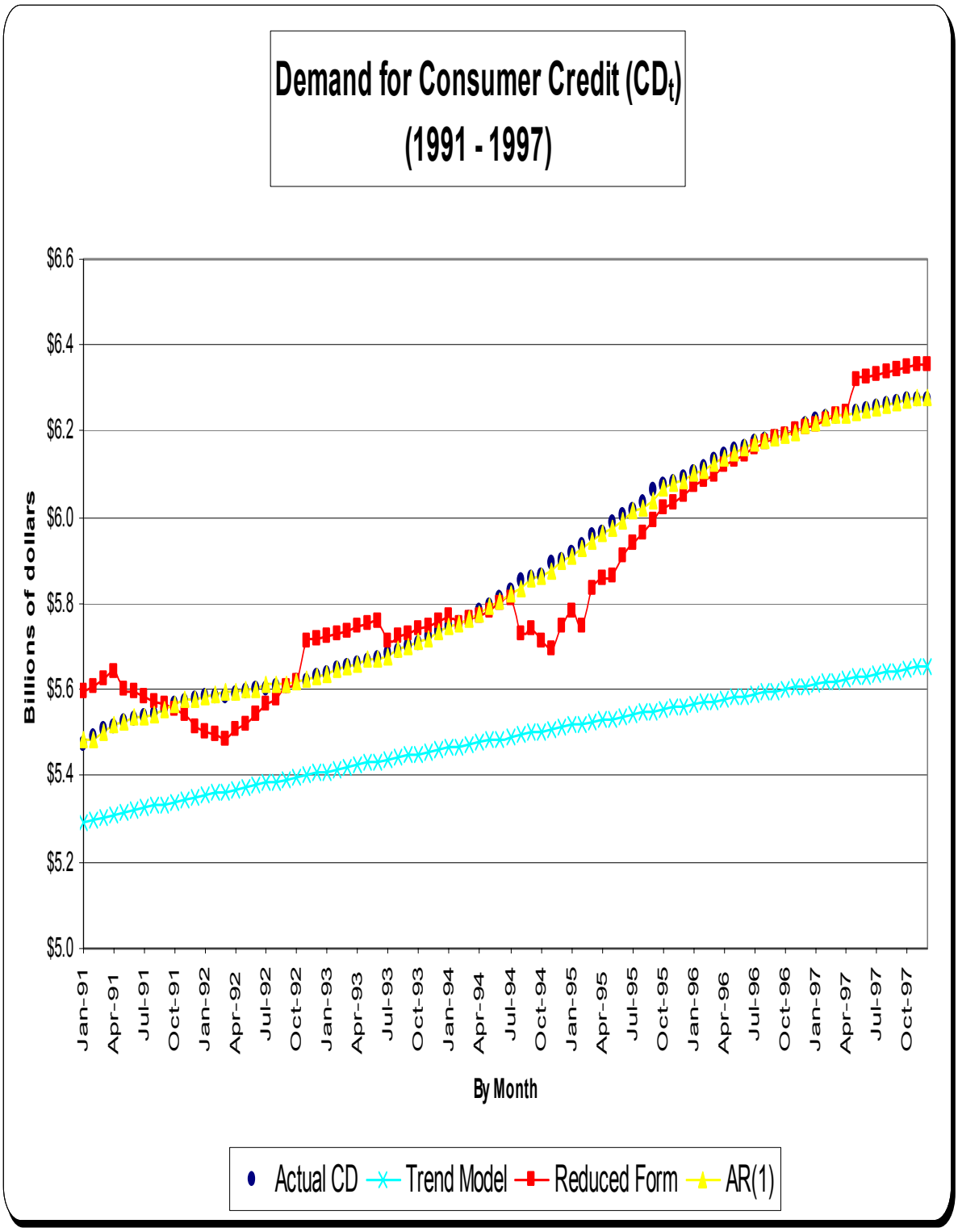
Please note the spike from 12/76 to 01/77 is due to a change in the method for measuring CD_t by the Federal Reserve (previously only included major credit card issuers, such as VISA and MasterCard; now includes department store and gasoline charge cards.[19])

[19] The Growth of Consumer Credit and the Household Debt Service Burden, Board of Governors of the Federal Reserve System, Dean M. Maki, 3-4 November 1999, page 4.

Graph 7 – Within Sample Model Comparison (1980 – 1990)



Graph 8 – Within Sample Model Comparison (1991 – 1997)



Out-of-Sample Comparison (1998 – 2002)

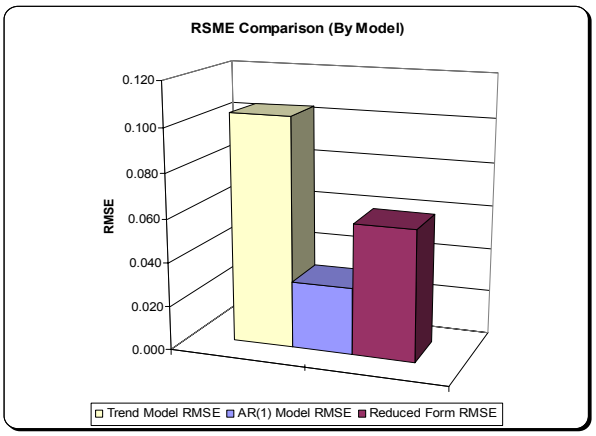
It is also common practice in the field of econometrics when assessing the validity of a model to estimate it over a given period of time (1973 - 1997) and then use it to predict the dependent variable over a period of time not used to estimate the model (1998 – 2002). Since we have the actuals values for CD_t from 1998 – 2002, a comparison can be made with the forecasted values given by the out-of-sample forecasts made with the models. This allows us to see how closely the model forecasts of CD_t are to the actual values of CD_t.

Table 7– Model Comparison Results (Out-of-Sample)

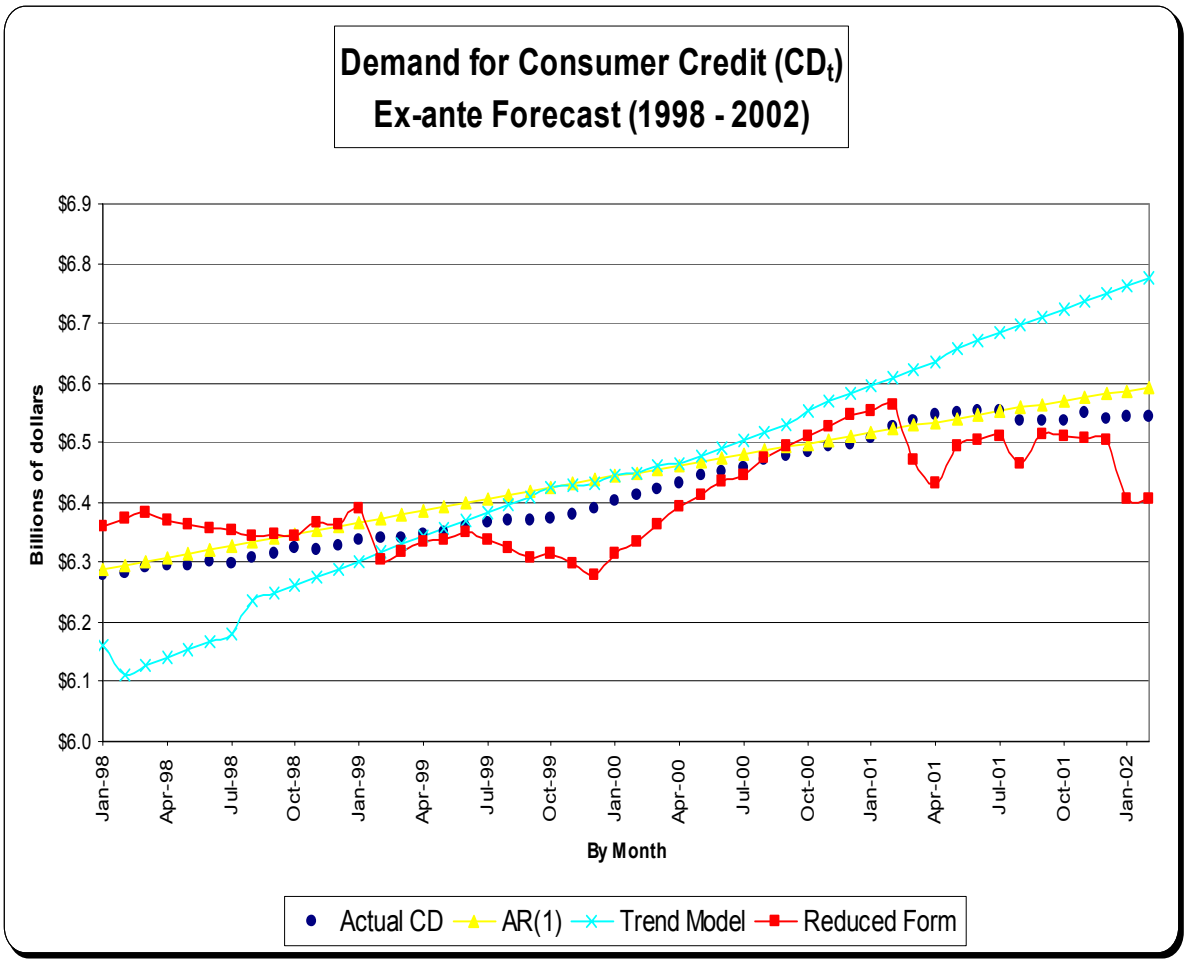
	Model #1 Reduced Form	Model #2 Trend	Model #3 AR(1)
SSE	**0.181**	**0.553**	**0.068**
MSE	**0.004**	**0.011**	**0.001**
RMSE	**0.060**	**0.104**	**0.037**

As shown in Table 7, the AR(1) model arrived at the lowest RMSE (0.037). Identical to the Within Sample Comparison, the AR(1) model resulted in the lowest RMSE. This comparison can also be seen in graphs 9 and 10. Once again, the AR(1) model may have resulted in a lower RMSE then the reduced form model (0.060), but it does not report the drivers behind the changes in the demand for consumer credit (as explained with the Within Sample model comparison on pages 28-29). The reduced form model was not that far behind the AR(1) model, and provided some insight into the macroeconomic variables influencing consumer demand for credit.

Graph 9 – RMSE Model Comparison



Graph 10 – Out-of-Sample Comparison of Model Results (1998 – 2002)



Section VI - Conclusion

Throughout the past 30 years or so, the demand for consumer credit in the United States has continued to increase at an alarming rate. The study indicates there are two main drivers behind this demand – the level of disposable personal income (DPI_t) and the unemployment rate (ue_t). However, these variables affect the demand for consumer credit in opposite ways – increases in disposable income entice consumers to fuel consumer spending by way of credit cards, while increases in the unemployment rate result in consumers pulling back from their credit card habits.

Simultaneous equation bias, heteroskedasticity and autocorrelation are recognized potential hazard areas and have been addressed by various means in developing the reduced form 2SLS model. In addition, the results of the reduced form model were compared to that of two completely separate models, trend and AR(1), using the same data sets. Standard econometric tests were applied to assess the validity of the model at various stages of the analysis. Even though the AR(1) model resulted in the highest R^2 and the lowest root mean square error (RMSE) when compared against the trend and reduced form models, the reduced form model provides some insight into the macroeconomic drivers behind the demand for consumer credit.

Section VII - BIBLIOGRAPHY

Anderson, Richard G., and Robert H. Rasche. Eighty Years of Observations on the Adjusted Monetary Base: 1918-1997. January/February 1999 Review. St. Louis: Federal Reserve, 1999.

"Board of Governors' Adjusted Monetary Base, Seasonally Adjusted, Billions of Dollars." Federal Reserve Weekly Statistical Release H.3 BOGAMBSL. Washington, DC: Federal Reserve, Release Date: 25 April 2002. http://stls.frb.org/fred/data/reserves/bogambsl.

"Civilian Noninstitutional Population." Current Population Survey. Monthly labor force data gathered by the Bureau of the Census for the Bureau of Labor Statistics. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, Release Date: 1 May 2002. http://data.bls.gov/servlet/Survey/SurveyOutputServlet.

"Confidence Report Intensifies Urge To Sell." The Washington Times, 28 November 2001, C10.

"Consumer Confidence Index," Consumer Confidence Survey. New York: The Conference Board, Release Date: 30 April 2002. http://sub1.economagic.com/em-cgi/data.exe/bci97/a0m122.

"Crude Oil Price Summary, Dollars per Barrel." Petroleum Marketing Monthly March 2002. Washington, DC: U.S. Department of Energy, Energy Information Administration, Release Date: 7 April 2002. http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/petroleum_marketing_monthly/current/pdf/pmmtab1.pdf

"Disposable Personal Income, Seasonally Adjusted, Billions." State Personal Income 1929-2002. CDROM RCN-0284. Washington, DC: U.S. Department of Commerce, Bureau of Economic Analysis, 2002. http://www.bea.gov/bea/uguide.htm#subj.

"Federal Funds Rate." Federal Reserve Monthly Statistical Release H.15 FEDFUND. Washington, DC: Federal Reserve. Release Date: 1 April 2002. http://www.federalreserve.gov/releases/H15/data/m/fedfund.txt.

Garson, Thomas, Dr. "Two-Stage Least Squares (2SLS) Regression Analysis." On-line Lecture Notes. College of Humanities and Social Sciences. Raleigh: North Carolina State University, 11 November 1998. http://www2.chass.ncsu.edu/garson/paa765/2sls.htm

Gupta, Vijay. Regression Explained. Washington, DC: VJBooks, Inc., 2000.

Kennedy, Peter. A Guide to Econometrics. Fourth Edition. Cambridge: The MIT Press, 1998.

Maki, Dean M. The Growth of Consumer Credit and the Household Debt Service Burden. Washington, D.C.: Board of Governors of the Federal Reserve System, 1999. Presentation at the Credit Research Center's 25th Anniversary Conference, Arlington, VA, 3-4 November 1999.

NBC Nightly News with Tom Brokaw. WCAU-TV, Channel 10, Philadelphia, PA, 01 December 2001.

"Total Revolving Credit Outstanding, Seasonally Adjusted, Billions of Dollars." Federal Reserve Monthly Statistical Release G.19 REVOLSL. Washington, DC: Federal Reserve, Release Date: 5 April 2002. http://stls.frb.org/fred/data/loans/revolsl.

"Unemployment Rate – Civilian Labor Force, Series ID: LFS21000000." Labor Force Statistics from the Current Population Survey. Washington, DC: U.S. Department of Labor, Bureau of Labor Statistics, Release Date: 1 May 2002. http://data.bls.gov/cgi-bin/surveymost.

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