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INTRODUCTION

In Canada, there is a large market in home ownership. Real estate agents, residential appraisers, bank mortgagers, and residential construction business all rely on activity in the housing market. With so many people involved in the market it is important to develop a clear idea of industry price changes and what causes there variation. Therefore, for the purpose of this paper a thorough analysis of what causes price changes in the Canadian housing industry will be conducted.

By determining what causes residential property prices to change a large group of people will benefit. Homeowners looking to sell and people looking to buy will benefit by knowing the change is housing prices because it will affect the timeliness of there purchase so they can optimize returns. Banks benefit since they can better estimate the supply and demand of houses. They can then plan how to appropriately accommodate for change. Other people to also benefit from knowing changes in housing prices are real estate agents and residential appraisers because it helps them to better execute their jobs.

Policy makers also benefit from better understanding what affects the change in housing prices because it can help them to develop regulations. Therefore, various policy makers will be able to understand the effect of their policies, and this should help them make better decisions for the economy.

LITERATURE REVIEW

An important tool when designing a statistical model is to research what other people have used as a model in the past. By reading literary publications in journals, magazines, and books it helps to both understand and design a realistic model. For this particular paper, a large amount of logic and basic understanding of statistical theory and the housing industry was used.

One of the starting points for the research was to look at the *Appraisal Institute of Canada* book '*Basics of Real Estate Appraising: Second Edition'*. The main interest in this particular book was chapter one and the four main groups that affect housing prices in the Canadian market. These four main categories are: government, social, cultural, and economic conditions. From there the book further broke down all the factors that affect housing prices in each of the four categories. For the purpose of this paper, we will only use economic conditions because it readily available.

Another source of information came from the *Journal of Housing Economics* titled '*The Time-Series Behavior of House Prices: A Translation Divide?'*. This piece of literature was very useful because it looked at six models for the United States and the United Kingdom. It took into affect various macroeconomic factors that helped in the design of our model. A particular model of interest by *Malpezzi (1999)* looks at both real income and population when determining the log of nominal housing prices divided by nominal income. By referring to this model a useful insight that these two variables are important when determining housing prices was conceived. Another model by *Abraham and Henderson (1996)* attempted to test for housing 'bubbles', also known as the 'ripple effect'. Unfortunately the methodology behind the model is beyond the scope of our testing and modeling knowledge. However, the idea of bubbles with relation to housing is a realistic way to explain outliers in the model design process. Also the text describes short term shocks that cause the ripple effect vs. long term housing prices that are relatively steady with relation to inflation.

Aside from these two pieces of literature a third source by the *Canadian Mortgage and Housing Corporation (CMHC)* titled '*Demographic Changes and Real Housing Prices in Canada*' was used as a reference. This research report takes a look at the historical timeline and notes the extreme growth rate, approximately 25%, and falls of housing prices between 1975 to 1982 and 1986 to 1989. Thus, giving an indication of when the housing bubbles in Canada occurred.

THE MODEL

The model that will be used in this study includes ten independent variables as well as six dummy variables for seasonality and housing price bubbles. The coefficients of the model will be estimated using the OLS regression in order to achieve BLUE (Best Linear Unbiased Estimator). For a better interpretation of the model we will consider the functional form:

CPRICE = f(MRATE, URATE, RGDP, CBUILT, CMARRIAGE, CINCOME, CPDI, TSERETURN, CPOP, BUBBLE, BUBBLE2, SEASONS, CPRICELAG)

For the empirical, or statistical, model of this function refer to the section titled '*Results*'. For the variables, in the function, a detailed explanation and description of there relation to the dependent variable will be given in the following outlines.

Change in Housing Prices [$CPRICE_t$]

The change in housing prices is measured by the quarterly percentage change in the consumer price index of owned accommodations. This measure gives the average percentage change in prices of residential housing purchased in Canada. To obtain the percentage change in housing prices, we take the natural log of the current period take, subtract the natural log of the previous period, and multiply by one hundred. This calculation is multiplied by one hundred to make the data uncomplicated to understand. The mathematical form is: $(\ln(CPI_t) - \ln(CPI_{t-1}))*100$, where CPI is the consumer price index of owned accommodation and ln is the natural log.

This measure of the percentage change in housing prices was used because we are investigating the affects of prices when purchasing a home. The percentage is calculated by the natural log difference because we are assuming that change in prices happens continuously throughout the year and not strictly at the end of period t.

Lagged Change in Housing Prices [$CPRICE_{t-1}$]

In Appendix 2, the data indicates that the previous period, two periods ago, and four periods ago all have a significant affect on the current change in housing prices. Therefore, we can conclude that the current periods' expected change in housing prices should be affected by the past. We must note that the CPRICE two and four periods ago should be captured by the mortgage interest rate, or other independent variables. We only use the one period lag of the change in housing prices because the other lags should be modeled by the other variables. It is expected that the lagged change in the housing prices will have a positive affect on the dependent variable because of the rational expectation that last periods volatility will dictate this period's value.

Mortgage Rate [$MRATE_t$]

A rational assumption that we are making is that when people purchase homes they are usually obtaining a loan to pay for the home. Many people purchase their homes by obtaining a loan from a bank or near bank, and this is commonly called a mortgage. Loans are obviously not free and people must pay an interest rate on these loans. This interest rate is the published mortgage rate. When the mortgage rate increases, then it is relatively more expensive to purchase a home, if financing with a mortgage, all else the same. We would then infer that if the cost of obtaining a home increase then the demand will fall causing the housing prices to fall. Therefore, we assume that the mortgage rate will have a negative affect on the change in housing prices.

Unemployment Rate [$URATE_t$]

When people are unemployed they have less money to use for consumption purposes. When purchasing a house you need a lot of money and if you are unemployed then you will plan on obtaining a mortgage. However, to obtain a mortgage a person must have a secure income, assets, and good credit rating. Therefore, if a person applies for a mortgage to purchase a home and is not employed (i.e. they do not have a secure source of income) then they will be denied the loan because of their inability to periodically repay the debt. So if more people are unemployed, then there will be less demand for housing, and sellers will decrease the price of their homes to make the sale, all else the same. So we can expect that the unemployment rate will have a negative affect on the change in housing prices.

Change in Total Income [$CINCOME_t$]

The change in total income is measured by the percentage change in consumer's total income per quarter. In the housing industry people always have to make a down payment when purchasing a home. This down payment deters people from purchasing homes if there income is low.[1] When income rises in Canada this causes people to make

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[11] Meen, Geoffrey, The Time-Series Behavior of House Prices: A Transatlantic Divide?, Journal of Housing Economics, pg.17

it possible to make these down payments easily. Effectively this causes demand to increase, holding all else the same. Therefore, prices will increase and the quantity sold will also increase based on the basic economic theory of supply and demand. We can then expect that an increase in total income will cause a positive change in housing prices.

Change in Personal Disposable Income [$CPDI_t$]

The change in personal disposable income is the percentage change in consumers' total income less direct taxes, or income tax. We are including this variable to see which measure of income ($CPDI_t$ or $CINCOME_t$) will have a greater affect on the change in housing prices. We are unsure if banking institutions take direct taxes into consideration when deciding to give a mortgage so we need to consider the possibilities. If $CPDI_t$ has a greater affect then $CINCOME_t$, then we can conclude that tax does not have an affect on the change in housing prices. This is possibly due to banking institutions using direct tax income as the measure of creditworthiness. For the purpose of this study, creditworthiness is the likeliness that the consumer is able to pay the periodic payments on a loan. We expect that $CPDI_t$ will be highly correlated with $CINCOME_t$ and that it will have a positive affect on the change in housing prices.

Change in Houses Built [$CBUILT_t$]

When more houses are built, the supply of houses will increase, holding all else the same (i.e. the rate houses demolished in the same period). By using the basic economic model of supply and demand then with an increase in supply, prices will fall, all else the same. We must note that in the winter season fewer houses are built, and thus restricting the supply of new homes, causing prices to increase. This, again, is based on the simple economic theory of supply and demand. This relation of prices to the winter term indicates that there will likely be seasonal affects. We expect that changes in houses built will have seasonal variations and will have a negative affect on the change in housing prices.

Change in Marriages [$CMARRIAGES_t$]

When people get married we can logically infer that they tend to want to buy a house with their new spouse and start a family. Owning a home provides security to a family because of the collateral it provides for the future (this is particularly important when raising a family). This incentive to buy a home would in turn, increase the demand for housing thus causing prices to rise, (based the economic theory of supply and demand) all else the same. This study includes the marriage variable because it is an interesting relationship worth investigating. It is expected that the change in marriages will have a positive affect on the change in housing prices.

Stock Market Returns [$TSERETURN_t$]

This paper will use the TSE300 index returns as a proxy for stock market returns. With an increase in the TSE300 index returns this will likely increase consumers' income (given they have investments in the market), which would then increase their demand for housing as described in the above income section, all else the same. The TSE300 index's return represents the average quarterly percentage capital gains in the stock market and we assume that home buyers have some money in stock markets. A main problem with using stock market returns is that consumers' may not realize the capital gains because they are investing for a long term horizon and will let their money 'ride'. Therefore, their incomes may not increase in that quarter, but it is still worth investigating the affects for those who are affected by the change. It is expected that stock market returns will have a positive affect on the change in housing prices.

Growth in Nominal GDP [$RGDP_t$] [2]

The growth in nominal GDP is being used as a possible proxy for income. This theory is based on the literature reviewed. If there is a positive growth in the nominal GDP, then we expect that consumers are earning more income and perceiving that economic conditions are improving. Thus, $RGDP_t$ would cause a shift in the demand

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[2] The nominal growth variable is effectively referred to as RGDP due to a small error when developing the E-Views models

curve by affecting consumers' preferences, all else the same. It is expected that $RGDP_t$ will have a positive affect on the change in housing prices.

Change in Population [$CPOP_t$]

Based on the literature review, this paper will model the change in population as affecting the change in housing prices. It is argued that if the population increases then the demand for housing will rise. If the demand rises, then the prices of housing will rise, all else the same. It is expected that the change in population will have a positive affect on the change in housing prices.

Housing Bubbles Dummy [$BUBBLE_t$] and [$BUBBLE2_t$]

Canada has experienced two periods of large housing price increases that are not modeled by the other independent variables. This paper has referred to these periods as housing bubbles. The first bubble (BUBBLE) is from approximately 1975 to 1982 and the second bubble (BUBBLE2) is from about 1986 to 1989[3]. Unfortunately, we were unable to find exact quarters in which the bubble had began or finish, so estimates will be made by observing the data. The bubble dummies will be interacted with $CPRICE_t$ to observe the affect on slope during these periods. It is expected that the bubbles will have a positive affect on the change in housing prices and possibly they may have a lagged affect as well, also known as a 'ripple effect'.

Seasonality

Since this paper is based on quarterly data, we will investigate the seasonal affects. These seasonal affects may be on the dependent variable and/or interacted with an independent variable to show its seasonal affect on the change in housing prices. The seasonal affect will be generated by assigning a dummy where a value of one is given if the quarter is the proper season. For example, if we are looking at the winter dummy variable then if it is winter the variable is given a value of one, and zero otherwise.

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[3] Fortin, Mario and Anre Leclerc. Demographic Changes and Real Housing Prices in Canada, Canadian Mortgage and Housing Council. October 1999, pg.11

Missing Data

This study could have benefited from a measure of consumers confidence, but this data was not feasible to collect. This would have showed us how people felt about the future and if they felt that the future was stable then they would be more willing to invest into homes.

All of the above changes are calculated by taking the natural log of the current period, subtracted by the natural log of the previous period, and multiplied by one hundred. The multiplication is simply for easy interpretation purposes. Since most of the variables have been calculated with the natural log, we do not have to consider a log model. However, we are using the unemployment rate and the mortgage rate, so we can use a linear-log model with the $LnURATE_t$ and $LnMRATE_t$[4].

DATA ANALYSIS

All of the data was collected from Statistics Canada via the CANSIM II databases. The data was transformed into quarterly data from the first quarter of 1976 to the second quarter of 2003; thus there are 110 observations.

Change in Housing Prices

The CPI on housing was collected from *Statistics Canada* via *CANSIM II* in series V735401 (INDEX; CANADA; OWNED ACCOMMODATION). This is presented in monthly data and must be converted into quarterly data. This was done by taking the index level at the end of each quarter and taking the natural log of the current period, subtracting the natural log of the previous period, and then multiplying by 100. This method of calculation captures the change in housing prices. The graph and summary statistics for the change in housing prices from 1976:Q2 to 2003:Q2 are shown in *Figure 1* and *Figure 2* below.

[4] The final Linear-Log model is shown in Appendix 10

Figure 1: **Summary Statistics (prepared in E-Views)**

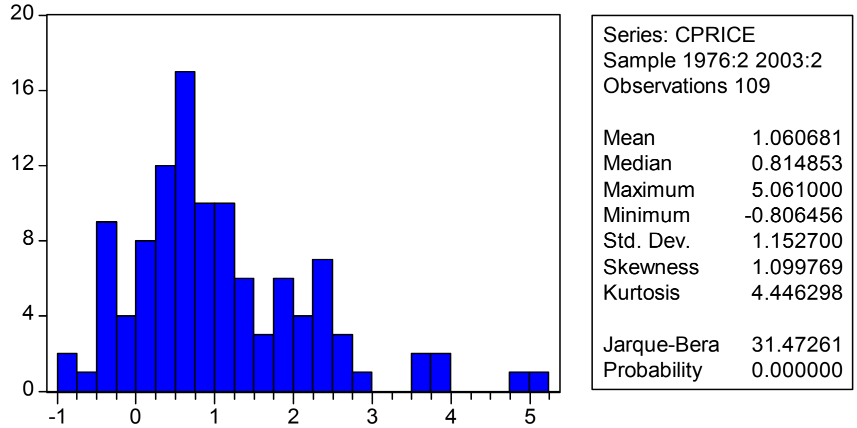
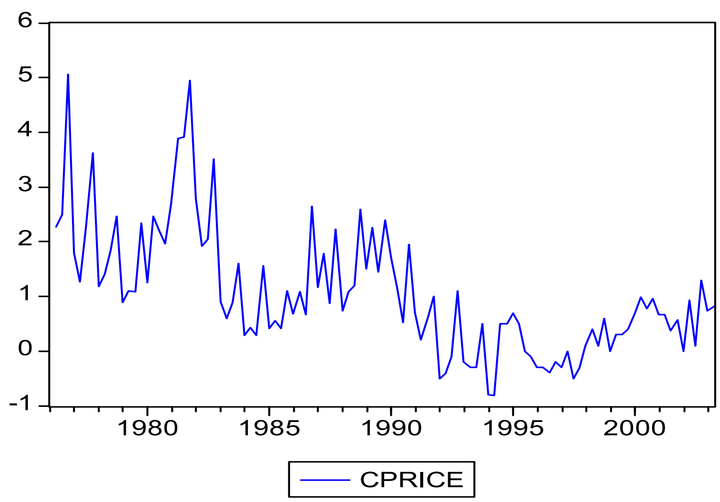


Figure 2: **Change in Housing Prices (prepared in E-Views)**



From *Figure 2* we can see the housing bubbles are in approximately 1975 to 1982 and 1986 to 1989. The first bubble is identified as beginning in the first quarter of 1976, to about the fourth quarter in 1982 (by refer to the data points). This may have been caused by the high inflation experienced during the periods and possibly the fact that the tail end of the baby boomers were increasing demand for housing (due to their demand for a first time home purchase). The second bubble is a little bit harder to notice and is from the second quarter in 1986 to the second quarter in 1989. This may have occurred due to the stability and steady growth of the economy during the late 1980's. It also could have been caused by an increase in the quality of housing during the bubble which caused sellers to demanding higher prices for newly built homes. The mean of $CPRICE_t$ is 1.06%, the minimum is -0.81%, and the maximum is 5.06%. This shows us that there were some periods of large price changes but on average the increase in housing prices is about 1%. In *Appendix 2*, we can see that the partial autocorrelation exists for the first two lags, which show us that there is likely at least on lagged period affect.

Mortgage Rate

The data for the mortgage rate was found at *Statistics Canada* via *CANSIM II* in series V122497 (CANADA; AVERAGE RESIDENTIAL MORTGAGE LENDING RATE: 5 YEAR). This is presented in monthly data and was converted into quarterly averages. In *Appendix 1*, we can see that since 1982 there has been a downward trend in mortgage rates until around 1996 when rates flatten out. The mean of mortgage rates is 10.75%, the minimum is 6.05%, the maximum was 20.55%, and the standard deviation is 3.11%. The large range of mortgage rates can be seen in the $MRATE_t$ graph in *Appendix 1*, which also shows evident downward trends in the mortgage rates. Due to these facts and the relation mortgage rates have to price changes this variable should be modeled in some way; the functional form will be discussed in the results section.

Unemployment Rate

The data for the unemployment rate was found at *Statistics Canada* via *CANSIM II* in series V2062815 (CANADA; UNEMPLOYMENT RATE; BOTH SEXES; 15 YEARS AND OVER; SEASONALLY ADJUSTED). It is presented as a seasonally adjusted monthly dataset and was converted into quarterly averages. In *Appendix 1*, it is evident that the unemployment rate from 1976 to 2002 had some cyclical behaviour. These high periods of unemployment in 1983 and 1993 were the after affect of the recessions occurring during the same time period. The average or mean rate of unemployment during this period is 8.92%, the minimum is 6.7%, the maximum is 12.87%, and the standard deviation is 1.61%. This shows us that the unemployment rate is less volatile due to the seasonal fluctuations being removed. The seasonally adjusted dataset was chosen to avoid modeling the seasonality of jobs (i.e. snow plow drivers, life guards etc.) in the unemployment rate.

Change in Total Income

The data for the total income was found at *Statistics Canada* via *CANSIM II* in series V498977 (CANADA; UNADJUSTED; INCOME). This data is presented in a quarterly dataset, and was converted to a quarterly percentage change. In *Appendix 1*, it is evident that the change in total income is effected by seasonality and that in recent years its' volatility has decreased. The mean of the change in total income is 1.71%, the minimum is -6.61%, the maximum is 12.78%, and the standard deviation is 4.55%. This indicates that the change in total income is very volatile. This is likely due to seasonal fluctuations which are evident by looking at the graph in *Appendix 1*. Thus we should model these fluctuations in some way; to be discussed later.

Change in Personal Disposable Income

The data for the personal disposable income was found at *Statistics Canada* via *CANSIM II* in series V498998 (CANADA; UNADJUSTED; DISPOSABLE INCOME). This data is presented in a quarterly dataset, and was converted to a quarterly percentage change. In *Appendix 1*, it is evident that the change in personal disposable income is effected by seasonality and that in recent years its' volatility has decreased. The mean of the change in personal disposable income 1.68%, the minimum is -7.15%, the maximum is 14.27%, and the standard deviation is 5.61%. We can tell that this data is volatile and is likely caused by seasonal fluctuations, which should be modeled in some way; to be discussed later.

Change in Houses Built

The data for the houses built is found at *Statistics Canada* via *CANSIM II* in series V13447 (DOLLARS; CANADA; TOTAL RESIDENTIAL INVESTMENT). This data is presented in a quarterly dataset, and was converted to a quarterly percentage change. In *Appendix 1*, we can see that the change in houses built has some seasonal affects. The mean of the change in houses built is 1.89%, the minimum is -49.2%, the maximum is 63.1%, and the standard deviation is 30.34%. This shows that there are very large seasonal affects (refer to graph in *Appendix 1*) which are concurrent with the theory explained in the model section.

Change in Marriages

The data for the number of marriages is found at *Statistics Canada* via *CANSIM II* in series V92 (NUMBER; CANADA; MARRIAGES). This is presented in monthly data and had to be converted into quarterly percentages by taking the sum of marriages in each quarter. In *Appendix 1*, we can see that the change in marriages has seasonal affects and has a constant variance. The mean of the change in marriages is 0.48%, the minimum is -101.12%, the maximum is 111.69%, and the standard deviation is 73.41%. We can tell from these summary statistics that there are seasonal affects in the data set.

Stock Market Returns

The data for the TSE300 index is found at *Statistics Canada* via *CANSIM II* in series V122620 (CANADA; COMPOSITE (300) CLOSING QUOTATIONS, CLOSE). This is presented in monthly data, which was converted into quarterly data by taking the index level at the end of each quarter and then converting into a quarterly percentage change. In *Appendix 1*, it is evident that the stock market returns are somewhat constant with regards to large variances. The mean of the stock market returns is 1.71%, the minimum is -26.42%, the maximum is 18.55%, and the standard deviation is 7.45%.

Growth in Nominal GDP

The data for the growth rate in nominal GDP is found at *Statistics Canada* via *CANSIM II* in series V1997736 (CANADA; CONTRIBUTIONS TO PERCENT CHANGE; SEASONALLY ADJUSTED; GROSS DOMESTIC PRODUCT (GDP) AT MARKET PRICES). This dataset is nicely presented in a quarterly dataset. In *Appendix 1*, we can clearly see that there is some seasonal, or cyclical, affects. The mean of growth in nominal GDP is 1.7%, the minimum -6.47%, the maximum 9.24%, and the standard deviation is 4.1%.

Change in Population

The data for the population is found at *Statistics Canada* via *CANSIM II* in series V1 (PERSONS; CANADA). This data is presented in a quarterly dataset and must be converted into a quarterly percentage change. In *Appendix 1*, we can see that there are some seasonal, or cyclical, affects. The mean of the change in population is 0.28%, the minimum is 0.09%, the maximum is 0.53%, and the standard deviation is 0.08%. This shows us that this dataset is very stable and consistent.

Housing Price Bubble Dummies

The first housing price bubble dummy, BUBBLE, holds a value of one from the first quarter in 1976 to the fourth quarter in 1982, otherwise it is zero. The second housing price bubble dummy, BUBBLE2, holds a value of one from the second quarter in 1986 to the second quarter in 1989, otherwise it is zero.

RESULTS

Stationarity

Before any regressions are run we must first make sure that all of our data is stationary. If the data is non-stationary then we will have a spurious regression and our model will mean nothing. To test for stationarity we will use is the Augmented Dickey Fuller (ADF) test. We must note that the ADF test is always biased towards a unit root, or non-stationarity regression.

The ADF test indicated that the change in housing prices, $CPRICE_t$, does not have a unit root, or is stationary at the 10% level with a trend and intercept, and four lags. The reason the ADF is biasing for unit root in $CPRICE_t$ is because there are two housing price bubbles in the early and mid 1980's. Putting in the trend will capture a majority of these bubbles, but for our model we will use the dummy variables to capture the affects.

The ADF test signified that $CBUILT_t$, $MRATE_t$, $CPOP_t$, $CMARRIAGE_t$, and $TSERETURN_t$ do not have a unit root, or are stationary at the 10% level with a trend and intercept, and four lags. The ADF test signified that $CPDI_t$, $CINCOME_t$, $RGDP_t$, and $URATE_t$ have a unit root, or are non-stationary at the 10% level with a trend and intercept, and four lags. In *Appendix 1*, it is clear that all four of these variables have quadratic trends. It was noted before that the ADF test is biased towards a unit root, and we know that it is not powerful enough to capture a quadratic trend. Since the variables are percentages and they have quadratic trends, we can conclude that they are non-stationary. We must keep in mind that we must capture the quadratic trends in these four variables.

Initial Regression

The first regression will be a very simple linear regression with change in housing price as the dependent variable and the unemployment rate, mortgage rate, change in marriages, change in population, change in houses built, change in real GDP, market returns, change in income, change in personal disposable income, and the lagged change in housing prices as well as interact dummies for the first housing bubble and second housing bubble as the independent variables. The model equation is as follows:

$$CPRICE_t = \beta_0 + \beta_1 MRATE_t + \beta_2 URATE_t + \beta_3 CMARRIAGE_t + \beta_4 CPOP_t + \beta_5 CBUILT_t$$
$$+ \beta_6 RGDP_t + \beta_7 TSERETURN_t + \beta_8 CINCOME_t + \beta_9 CPDI_t + \beta_{10} CPRICE_{t-1} +$$
$$\beta_{11} BUBBLE_t * CPRICE_t + \beta_{12} BUBBLE2_t * CPRICE_t + \varepsilon_t$$

The estimated regression is[5]:

$$CPRICE_t = 0.367 + 0.09MRATE_t - 0.117URATE_t - 0.002CMARRIAGE_t + 0.64CPOP_t$$
$$- 0.001CBUILT_t + 0.063RGDP_t - 0.005TSERETURN_t - 0.014CINCOME_t - 0.015CPDI_t$$
$$+ 0.16CPRICE_{t-1} + 0.501BUBBLE_t*CPRICE_t + 0.356BUBBLE2_t*CPRICE_t$$

$$R^2 = 0.878 \text{ and Adjusted } R^2 = 0.862 \quad \hat{\sigma}^2 = 0.428$$

With a t-test the critical value is 1.985[6] and we find the significant variables are $MRATE_t$, $URATE_t$, $RGDP_t$, $CPRICE_{t-1}$, $BUBBLE_t*CPRICE_t$, and $BUBBLE2_t*CPRICE_t$ at the 5% level. The model must be tested for a variety of statistical problems.

Multicollinearity

To check for multicollinearity we will review the correlation matrix (*Appendix 5*) of the independent variables. We notice that the change in houses built is highly correlated with the change in marriages and that the change in total income is highly correlated with the change in personal disposable income. Since we do not know which one will have more of an affect on the change in housing prices, we cannot decide which one to omit from the regression. However, we must not use both of them in the regression, only CPDI or CINCOME and CMARRIAGE or CBUILT. To decide on which one to use in the regression we must check for dynamic affects, and decide which one has more of an affect on the dependent variable. It may be that CINCOME, CPDI,

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[5] All regression results can be found in *Appendix 3*

[6] Critical values are calculated in E-Views 4.1

CMARRIAGE, and CBUILT, are all highly correlated with each other, about 0.74 for all. This may mean that the four abover variables may have multicollinearity and are measuring the same relation.

Dynamic affects

We cannot assume that the current period independent variables are the only variables to affect the change in housing prices. Previous period's independent variables must be checked to see if they have any long run affects on the change in housing prices. To do this we must find the correlations of the lagged independent variables with the current change in the housing prices. This correlation vector is shown in *Appendix 6*. We can see that CBUILT has a higher correlation with two and three lags, and that CBUILT is highly correlated with the dependent variable, compared to CMARRIAGE, with the same lag length. Therefore, CBUILT may have more of an affect on CPRICE, and this should be tested with the second or third lag. Also note that CINCOME with one lag has a higher correlation with the dependent variable, compared to CPDI, with the same lag length. Therefore, CINCOME may have more of an affect on CPRICE, and this should be tested with the current or lagged one period.

Appendix 6 also shows us that the MRATE may have a one period lag affect, RGDP may have a two and four period lag affect, CPOP may have a one period lag affect, TSERETURN probably has no dynamic affects, the first bubble interaction dummy may have a one or two period lag affect, the second interaction dummy probably has no dynamic affects, and URATE may have up to four lag affects. Each one of these possible dynamic effects will be used in the model as guides to help decide on the final dynamic effects. These tests will not be shown and only significant results will be indicated in all of the regressions. After testing each of the probable dynamic effects, we concluded in using the lagged one period of mortgage rate, unemployment rate, and CPOP. We decided to use the two lagged period of RGDP and CPDI. CINCOME and CBUILT will use the current period data.

Inclusion of Insignificant Variables

Appendix 5 and *Appendix 6* show the correlations of all variables and their lags with the dependent variable. We can see that TSERETURN has a low correlation, including lags, which shows us it may just be random and does not move with the dependent variable. This is also concurrent with our initial regression which signifies that TSERETURN is insignificant. CPOP and CBUILT may be insignificant in this study because they have a somewhat low correlation with the dependent variable, but will be tested in the models. As mentioned before only significant results will be presented in this paper.

Wrong Functional Form

In *Appendix 7*, we can see that the relationship between unemployment rate and the change in housing prices are clearly not linear. After testing from a fourth level polynomial, we concluded that the unemployment rate is a second power polynomial. We also notice that the relationship between CPDI and the change in housing prices are not linear. After some testing we discovered that the relation is a cubic and linear function. The relationship between the change in total income and the change in housing prices are not linear. After testing we discovered that the relationship of the change in total income and the change in housing prices is a quadratic, cubic, and linear function. The relationship between the growth rate in real GDP and the change in housing prices might not be linear. After testing we find that the relationship of these two variables is linear. After all equations are run, Ramsey Reset test was conducted in E-Views to ensure that we have the right functional form. *Figure 3* shows all of the significant regressions with the significant non-linear specifications.

Seasonality

We can see in *Figure 1* and *Figure 4* that many of our independent variables have seasonal affects. The change in housing prices has a seasonal affect only in autumn. We also notice that RGDP, CBUILT, and CMARRIAGE all have seasonality. This can be modeled using an interaction term with the independent variables. The relevant results are modeled in *Figure 3*.

Autocorrelation

Since we are using time series data, it is very important that we test for autocorrelation. If autocorrelation exists then the assumption that our error term is random is violated. To test for autocorrelation we will use is the Durbin-Watson test, but it can be inconclusive and this might be due to model misspecification. A better test for autocorrelation is the Lagrange Multiplier (LM) test because it will not have a result that is inconclusive. This test will be performed on the final model and if there is autocorrelation then we will have to regress a feasible generalized least squares model (FGLS). The problem with a FGLS is that it is consistent with a large sample size, but what is a large sample size? 200? 300? Since we do not have this many observations, we will want to avoid autocorrelation by taking into account dynamic effects.

Best Model After Testing

To choose the best model that explains the affects on the change in housing prices, we used the adjusted R^2, the standard error, and the sum of squared residuals. We want a high adjusted R^2, but not too high because of overfitting, a low standard error, and a low sum of squared errors. After conducting all of the above tests and running multiple regressions[7] we decided that model 6 is the best explanatory model. It is as follows:

$$CPRICE_t = \beta_0 + \beta_1 MRATE_{t-1} + \beta_2 MRATE^3{}_{t-1} + \beta_3 URATE_{t-1} + \beta_4 URATE^2{}_{t-1} + \beta_5 CPRICE_{t-1} + \beta_6 CPDI_{t-2} + \beta_7 CPDI^3{}_{t-2} + \beta_8 CBUILT_t + \beta_9 CBUILT_t * AUTUMN + \beta_{10} CBUILT_t * SPRING_t + \beta_{11} RGDP_t * SPRING_t + \beta_{12} BUBBLE_t * CPRICE_t + \beta_{13} BUBBLE_{t-1} * CPRICE_{t-1} + \beta_{14} BUBBLE2_t * CPRICE_t + \varepsilon_t$$

The estimated regression is:

$CPRICE_t$ = 3.1 + 0.16$MRATE_{t-1}$ – 0.0002$MRATE^3{}_{t-1}$ -0.825$URATE_{t-1}$ + 0.037$URATE^2{}_{t-1}$ + 0.294$CPRICE_{t-1}$ + 0.07$CPDI_{t-2}$ – 0.0004$CPDI^3{}_{t-2}$ + 0.014$CBUILT_t$ -

[7] All results shown in Appendix 3

$0.04CBUILT_t*AUTUMN_t - 0.016CBUILT_t*SPRING_t + 0.084RGDP_t*SPRING_t$
$+0.532BUBBLE_t*CPRICE_t - 0.148BUBBLE_{t-1}*CPRICE_{t-1} + 0.269BUBBLE2_t*CPRICE_t$

$$R^2 = 0.93 \text{ and Adjusted } R^2 = 0.919 \quad \hat{\sigma}^2 = 0.326$$

These results are concurrent with our theory from above. By taking the first derivatives we can obtain the marginal affects. When the mortgage rate rises, then the change in housing prices will fall in the next period, at an increasing marginal rate. When the unemployment rate rises then there will be a decrease in the change of housing prices in the next period, at a decreasing marginal rate. There are also some rational expectations that this period's change in housing prices is increased by 0.295 of last periods change in housing prices. The CPDI is fairly consistent with our theory. If CPDI two periods ago increases then CPRICE will increase as well, but at a increasing marginal rate. An interesting result is that the change in houses built in the winter and summer will increase the change in housing prices, but the change in houses built in the autumn and spring cause the change in housing prices to fall. This could be because it is more costly to build houses in the winter and higher prices are required. The growth in the nominal GDP only has an affect on the change in housing prices in the current period if it is in the spring. This is interesting result and could be because people are working more, growth rate in nominal GDP is highest in spring, *Appendix 4*. When people work more they perceive a stable economy and do not expect to lose their job and thus more willing to invest into a different or new home. The first bubble caused an increase in the change of housing prices, which is expected, and it also had a short-term ripple effect. This ripple effect is that if there was a shock last period that the change in housing prices this period would fall. This seems to be consumers reacting to previous shock in the change in housing prices. The second bubble did not have as large of an affect as the first bubble but did have a positive effect on the change in housing prices. We do notice as well that the second bubble does not have a short-term ripple effect. All of these effects are concurrent with the theory that was developed in the model section, with a few more interesting results.

For the purposes of this paper, the dynamic affects will be calculated by taking the first difference and the value for the independent variable will be the mean value.

The dynamic affects on the current change in housing prices are: mortgage rate is 0.13%, unemployment rate is -0.23%, and change in personal disposable income is 0.09%.

When we run OLS regressions we make the assumption that the error term in normally distributed, with a zero mean and a constant variance, not correlated with the dependent variables, and there is no autocorrelation of the error term. These assumptions must hold if wish to trust that the standard errors are correct. This model was tested for autocorrelation using the serial LM test in E-Views, see *Appendix 8*, and it is concluded that there is no presence of autocorrelation. To test for normality we can use the histogram of the error term do determine the probability of it being normally distributed and having a zero mean. In Figure 3, we can see that the mean is effectively zero and that there is a 55% chance that the error term is normally distributed. Figure 4, shows us that the error term has a relatively stable and constant variance. Based on these results we can conclude that the assumptions made about the error term have not been violated and we can trust that the standard errors that we calculated are correct.

Figure 3: Error term histogram (prepared in E-Views)

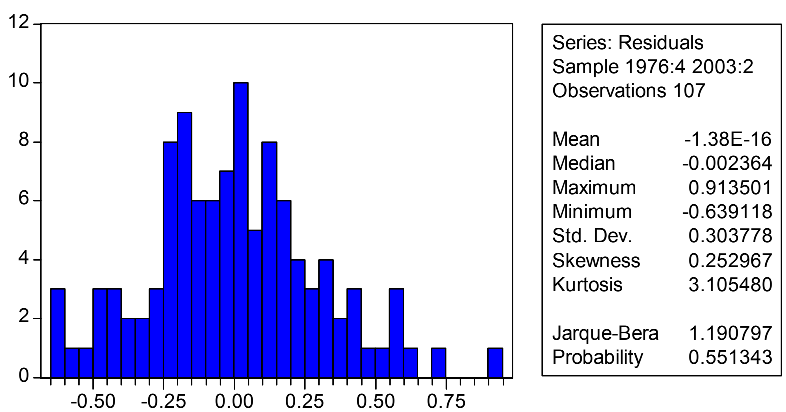
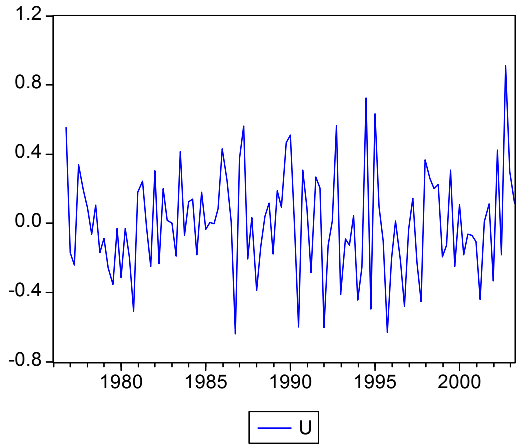


Figure 4: Error term over time



In *Appendix 9*, we can see that there is parameter stability and that there are no structural breaks in our model. We can compare model 6 to the linear-log model, in *Appendix 10*, and we can see that the two results are very much the same. So we can conclude that the linear-log model is just as good at explaining housing price changes as our linear model. In *Appendix 11*, we can see that the rational expectations model does not provide a better explanation of the changes in housing prices compared to model 6. Figure 5 shows us the Ramsey Reset test for our model, and it indicates that we do not have a wrong functional form.

Figure 5: Ramsey Reset Test (prepared in E-Views)

Ramsey RESET Test:

F-statistic	0.820642	Probability	0.485857
Log likelihood ratio	2.919646	Probability	0.404181

CONCLUSION

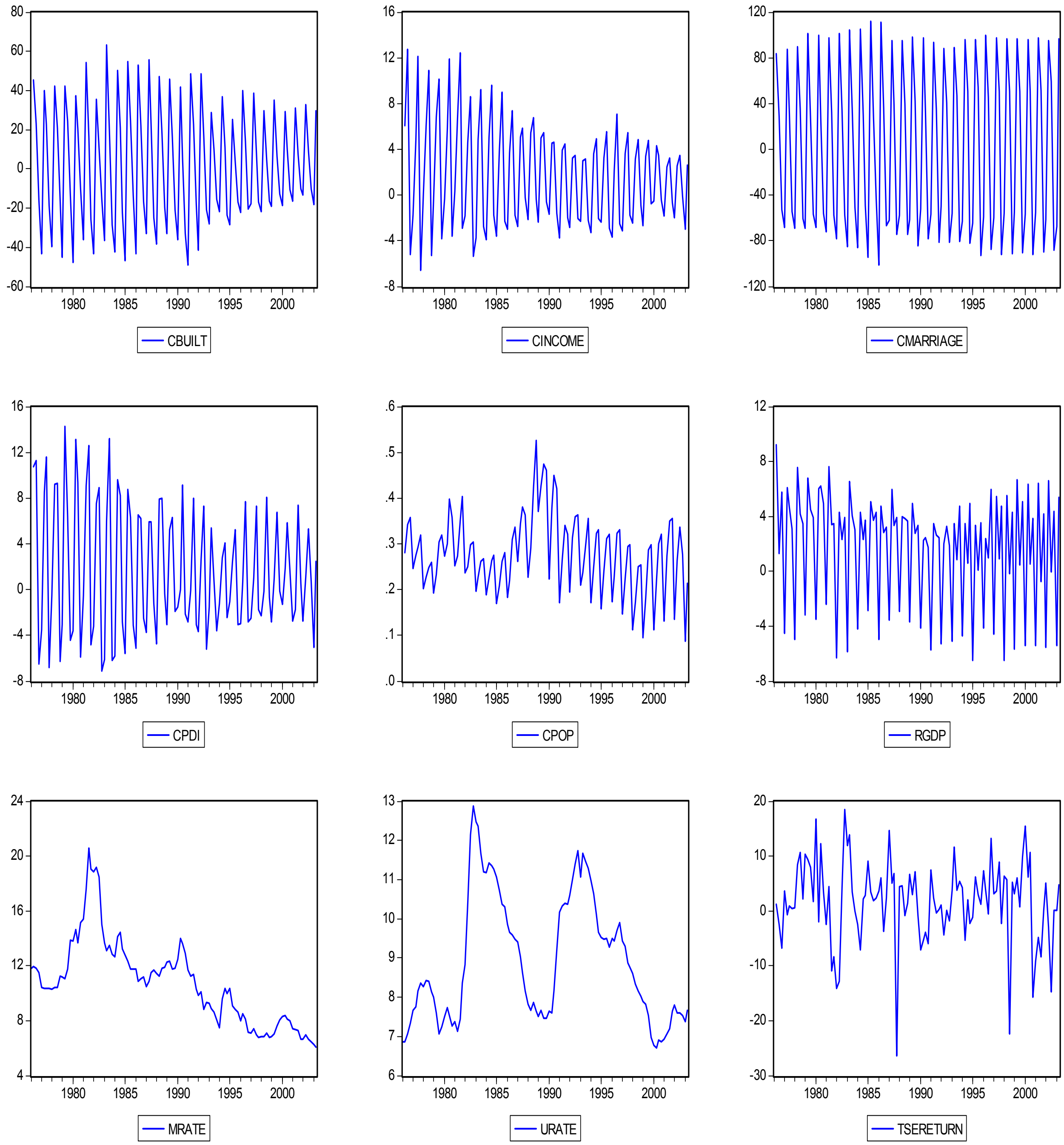
This study has examined many different models to determine the best explanatory model of the change in housing prices. Quarterly data from the first quarter in 1976 to the second quarter of 2003 was used in this study's regression analysis. We found that there are seasonal affects, that the first housing price bubble had a short term ripple affect, and there are rational expectations from the previous period's price change.

Dynamic affects or long term affect in the change of personal disposable income, the unemployment rate, and the mortgage rates were also discovered. It was interesting to discover that an increase in the supply of housing in the winter or summer would cause the price of homes to increase. However, an increase in the supply of housing in the autumn or spring caused the price of homes to decrease. The other interesting result was that only the percentage change in the nominal GDP in spring has an affect on the change in housing prices. This study believes that this is the case because people will perceive the economy to be stable and will be more willing to invest into a different or new home. This model can possibly be improved by obtaining a consumer confidence measure and using this in the regression.

This can benefit consumers wishing to purchase a different or new home by allowing them to understand why housing prices change. This study may also help developers make the decision as to when they want build new homes, based on the price changes. It is assumed that consumers will want to purchase a new home when the prices fall and developers or supplier wish to have the new home ready for sale when prices are expected to be higher. Policy makers will be able to better understand the policies that they intend to implement, which will help them make better decisions for society.

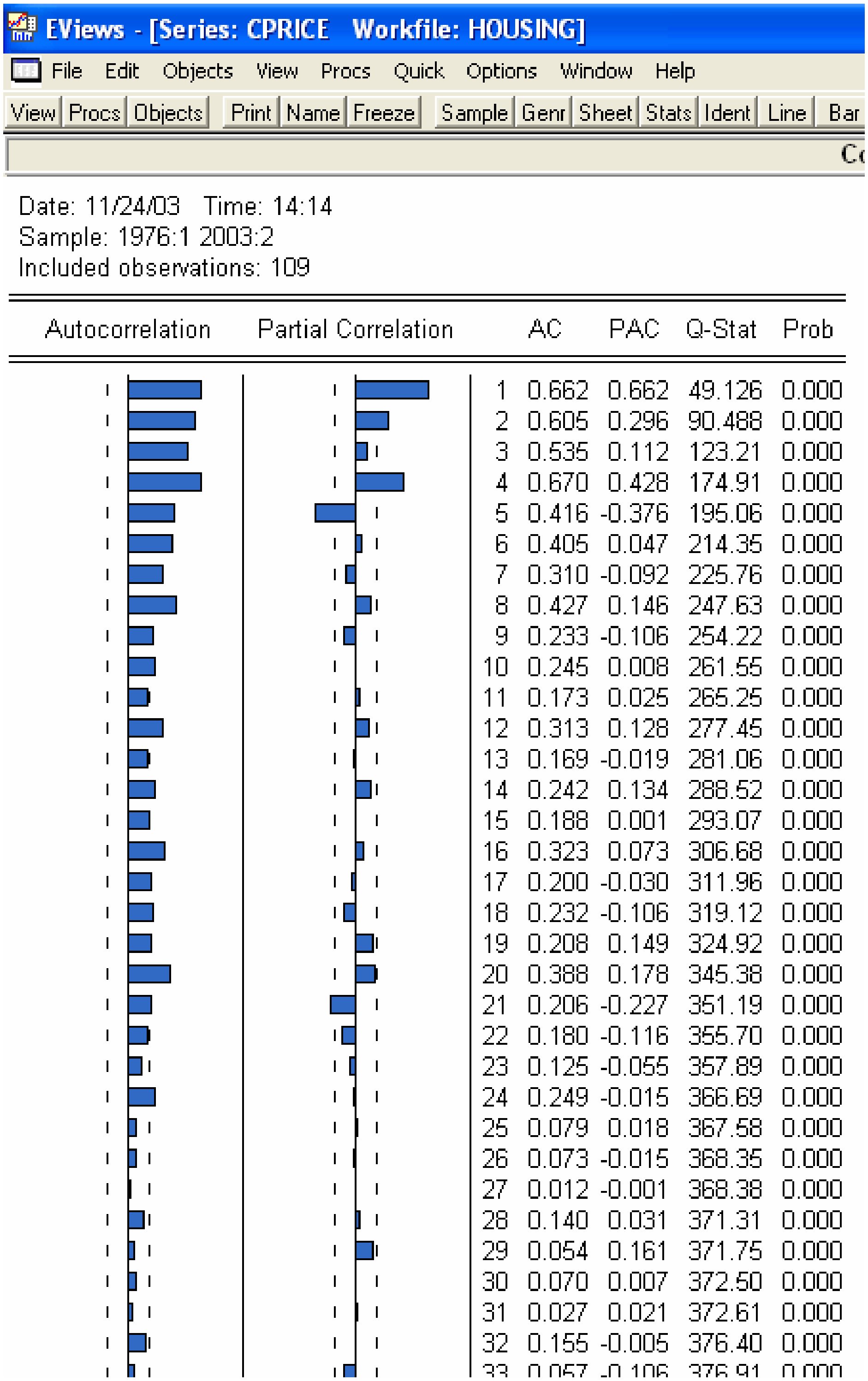
APPENDIX 1

Independent variables plotted against time



APPENDIX 2

Correlogram of CPRICE



Date: 11/24/03 Time: 14:14
Sample: 1976:1 2003:2
Included observations: 109

	AC	PAC	Q-Stat	Prob
1	0.662	0.662	49.126	0.000
2	0.605	0.296	90.488	0.000
3	0.535	0.112	123.21	0.000
4	0.670	0.428	174.91	0.000
5	0.416	-0.376	195.06	0.000
6	0.405	0.047	214.35	0.000
7	0.310	-0.092	225.76	0.000
8	0.427	0.146	247.63	0.000
9	0.233	-0.106	254.22	0.000
10	0.245	0.008	261.55	0.000
11	0.173	0.025	265.25	0.000
12	0.313	0.128	277.45	0.000
13	0.169	-0.019	281.06	0.000
14	0.242	0.134	288.52	0.000
15	0.188	0.001	293.07	0.000
16	0.323	0.073	306.68	0.000
17	0.200	-0.030	311.96	0.000
18	0.232	-0.106	319.12	0.000
19	0.208	0.149	324.92	0.000
20	0.388	0.178	345.38	0.000
21	0.206	-0.227	351.19	0.000
22	0.180	-0.116	355.70	0.000
23	0.125	-0.055	357.89	0.000
24	0.249	-0.015	366.69	0.000
25	0.079	0.018	367.58	0.000
26	0.073	-0.015	368.35	0.000
27	0.012	-0.001	368.38	0.000
28	0.140	0.031	371.31	0.000
29	0.054	0.161	371.75	0.000
30	0.070	0.007	372.50	0.000
31	0.027	0.021	372.61	0.000
32	0.155	-0.005	376.40	0.000
33	0.057	-0.106	376.91	0.000

APPENDIX 3

*Regression results

	Simple	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.367 (0.311)	0.540 (0.253)	4.384 (1.459)	4.496 (1.364)	5.646 (1.446)	3.1 (1.364)
$URATE_t$	-0.117 (0.034)					
$CPRICE_{t-1}$	0.16 (0.067)	0.327 (0.082)	0.272 (0.088)	0.314 (0.080)	0.221 (0.084)	0.294 (0.078)
$URATE_{t-1}$		-0.120 (0.031)	-1.002 (0.312)	-0.990 (0.292)	-1.08 (0.307)	-0.825 (0.286)
$URATE^2_{t-1}$			0.047 (0.016)	0.046 (0.015)	0.051 (0.016)	0.037 (0.015)
$MRATE_t$	0.090 (0.024)					
$MRATE_{t-1}$		0.086 (0.021)	0.093 (0.023)	0.077 (0.020)	0.097 (0.02)	0.16 (0.039)
$MRATE^3_{t-1}$						-0.0001 (0.00007)
$CPOP_t$	0.640 (0.725)					
$CPOP_{t-1}$					-6.022 (2.22)	
$CPOP^2_{t-1}$					9.27 (3.88)	
$CPDI_t$	-0.015 (0.019)					
$CPDI_{t-2}$				0.048 (0.017)		0.07 (0.019)
$CPDI^3_{t-2}$				-0.0003 (0.0001)		-0.0004 (0.0001)
$CINCOME_t$	-0.014 (0.024)		0.059 (0.023)			
$CINCOME^3$			-0.002 (0.001)			
$CINCOME^4$			0.0001 (0.00007			
$CMARRIAGE_t$	-0.002 (0.002)					
$CBUILT_t$	-0.001 (0.005)			0.009 (0.002)		0.014 (0.004)
$TSERETURN_t$	-0.005 (0.006)					

$RGDP_t$	0.065 (0.019)					
$RGDP_{t-2}$		0.044 (0.010)				
$BUBBLE_t$*$CPRICE_t$	0.539 (0.052)	0.510 (0.065)	0.547 (0.063)	0.563 (0.053)	0.603 (0.057)	0.532 (0.053)
$BUBBLE_{t-1}$*$CPRICE_{t-1}$		-0.214 (0.077)	-0.203 (0.076)	-0.188 (0.069)	-0.18 (0.077)	-0.148 (0.069)
$BUBBLE2_t$*$CPRICE_t$	0.419 (0.081)	0.341 (0.073	0.381 (0.074)	0.300 (0.071)	0.413 (0.073)	0.269 (0.07)
AUTUMN			0.698 (0.118)		0.619 (0.01)	
AUTUMN*$CBUILT_t$				-0.039 (0.005)		-0.04 (0.005)
SPRING*$CBUILT_t$						-0.016 (0.005)
SPRING*$RGDP_t$						0.084 (0.036)
R^2	0.878	0.885	0.907	0.921	0.908	0.930
Adjusted R^2	0.862	0.876	0.897	0.912	0.898	0.919
Standard Error	0.428	0.382	0.370	0.341	0.368	0.326
Sum Squared Residuals	17.371	14.16	13.168	11.038	13.114	9.782
Durbin-Watson stat	1.713	1.968	2.052	2.13	1.962	2.155

APPENDIX 4

	Seasonal-Cprice	Seasonal CBUILT	Seasonal RGDP	Seasonal CMARRIAGE
Constant	0.722 (0.212)	-32.573 (1.674)	-4.703 (0.283)	-66.1 (2.267)
SPRING	0.216 (0.297)	74.087 (2.347)	9.915 (0.397)	163.032 (3.177)
SUMMER	0.151 (0.300)	47.75 (2.368)	6.971 (0.400)	106.346 (3.205)
AUTUMN	0.993 (0.300)	14.562 (2.368)	8.611 (0.400)	-6.614 (3.205)
R^2	0.111	0.92	0.875	0.975
Adjusted R^2	0.086	0.918	0.872	0.974
Standard Error	1.102	8.7	1.471	11.777
Sum Square Residuals	127.465	7947.75	227.336	14564.23
Durbin-Watson Stat	0.383	1.92	1.948	3.327

APPENDIX 5

*Correlation Matrix, for Multicollinearity check

	CPRICE	CBUILT	CINCOME	CMARRIAGE	CPDI	TSERETURN	URATE	RGDP	MRATE	CPOP
CPRICE	1.000	-0.066	0.001	-0.115	-0.027	-0.157	-0.309	0.266	0.650	0.392
CBUILT	-0.066	1.000	0.743	0.928	0.744	0.006	-0.018	0.676	0.013	0.137
CINCOME	0.001	0.743	1.000	0.741	0.914	-0.031	-0.104	0.453	0.177	0.237
CMARRIAGE	-0.115	0.928	0.741	1.000	0.734	-0.004	-0.012	0.514	0.032	0.053
CPDI	-0.027	0.744	0.914	0.734	1.000	-0.078	-0.093	0.444	0.145	0.213
TSERETURN	-0.157	0.006	-0.031	-0.004	-0.078	1.000	0.165	-0.022	-0.114	-0.211
URATE	-0.309	-0.0180	-0.104	-0.012	-0.093	0.165	1.000	-0.078	0.160	-0.140
RGDP	0.266	0.676	0.453	0.514	0.444	-0.022	-0.078	1.000	0.100	0.495
MRATE	0.650	0.013	0.177	0.032	0.145	-0.114	0.160	0.100	1.000	0.287
CPOP	0.392	0.137	0.237	0.053	0.213	-0.211	-0.140	0.495	0.287	1.000

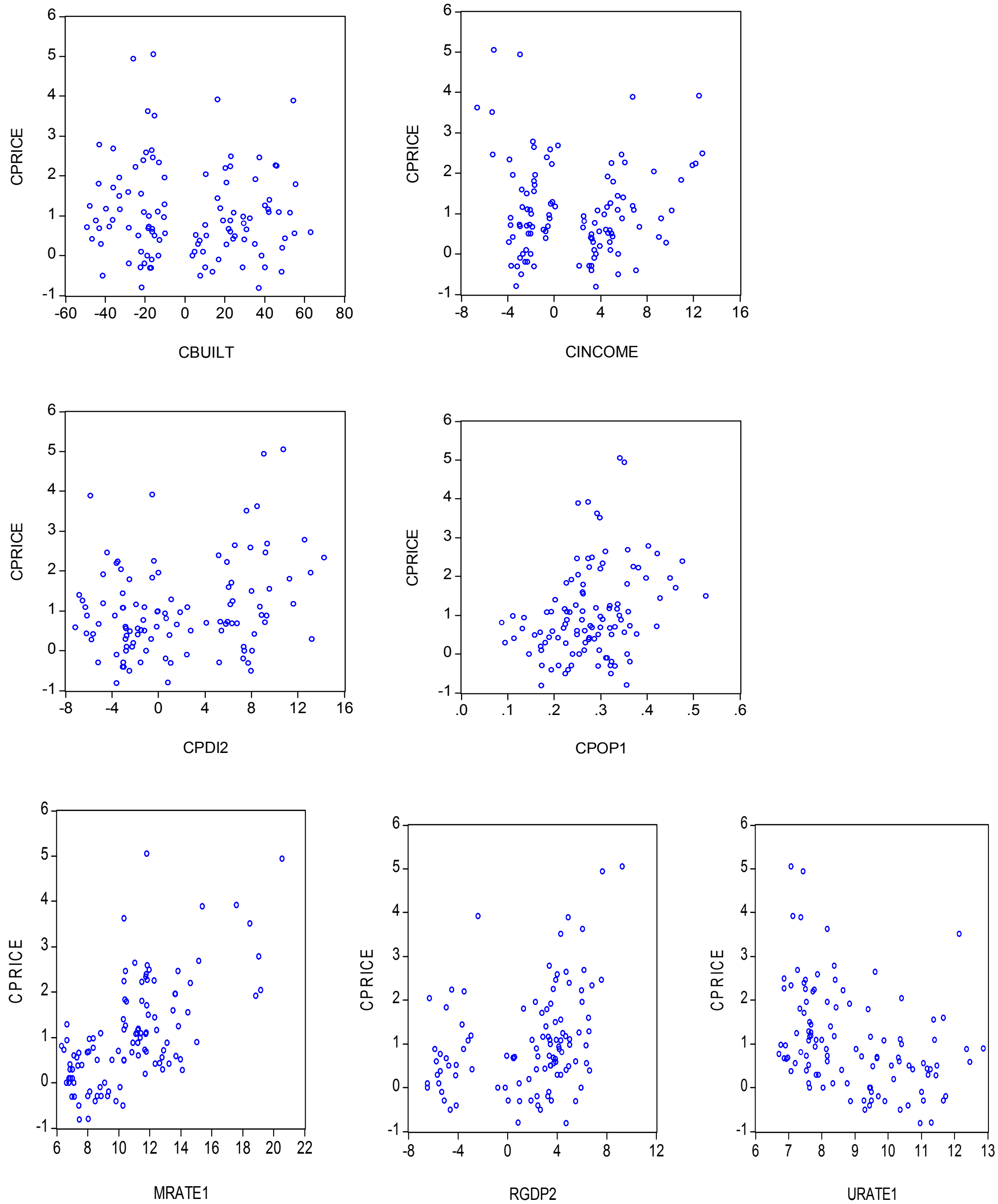
APPENDIX 6

*Correlation vector for check of dynamic affects

	CPRICE		CPRICE
CPRICE	1.000000	**URATE**	-0.269533
CBUILT	-0.066329	**URATE1**	-0.339841
CBUILT1	0.101820	**URATE2**	-0.398588
CBUILT2	0.241753	**URATE3**	-0.426900
CBUILT3	-0.243965	**URATE4**	-0.423669
CBUILT4	-0.036763	**TSERETURN**	-0.123908
CINCOME	0.018235	**TSERETURN1**	-0.071750
CINCOME1	0.420815	**TSERETURN2**	-0.030581
CINCOME2	0.221175	**TSERETURN3**	-0.003282
CINCOME3	-0.010435	**TSERETURN4**	-0.052265
CINCOME4	0.018496		
CMARRIAGE	-0.110976		
CMARRIAGE1	0.101347		
CMARRIAGE2	0.206882		
CMARRIAGE3	-0.192353		
CMARRIAGE4	-0.104763		
CPDI	-0.011182		
CPDI1	0.366023		
CPDI2	0.230468		
CPDI3	-0.061397		
CPDI4	-0.011078		
CPOP	0.384728		
CPOP1	0.299511		
CPOP2	0.209828		
CPOP3	0.077993		
CPOP4	0.336225		
D0	0.802700		
D1	0.632296		
D2	0.540472		
DD	0.261250		
DD1	0.141512		
DD2	0.249422		
DD3	0.160240		
MRATE	0.686728		
MRATE1	0.667438		
MRATE2	0.592732		
MRATE3	0.510110		
MRATE4	0.463232		
RGDP	0.251681		
RGDP1	0.139898		
RGDP2	0.282614		
RGDP3	-0.157530		
RGDP4	0.305996		

APPENDIX 7

Scatter plots of all variables



APPENDIX 8

Serial LM Test with 4 lags

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.836452	Probability	0.505650
Obs*R-squared	3.919188	Probability	0.417053

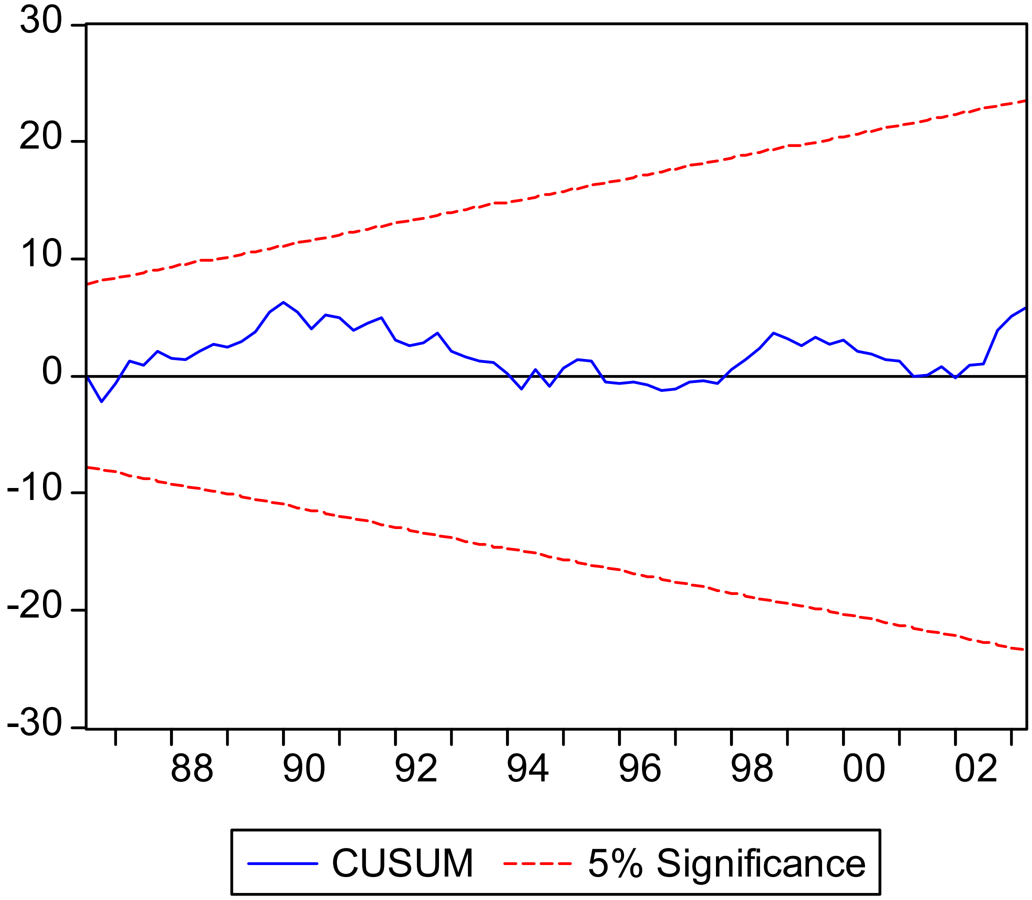
Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 11/26/03 Time: 14:34
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.453062	1.448649	-0.312748	0.7552
MRATE(-1)	-0.028780	0.042265	-0.680932	0.4977
MRATE(-1)^3	2.67E-05	7.08E-05	0.376745	0.7073
URATE(-1)	0.114999	0.304838	0.377247	0.7069
URATE(-1)^2	-0.004923	0.015774	-0.312095	0.7557
CPRICE(-1)	0.125238	0.119402	1.048879	0.2971
BUBBLE*CPRICE	0.011109	0.054046	0.205548	0.8376
BUBBLE(-1)*CPRICE(-1)	-0.073669	0.085687	-0.859743	0.3923
BUBBLE2*CPRICE	-0.028981	0.074766	-0.387631	0.6992
CPDI(-2)	0.000466	0.019606	0.023774	0.9811
CPDI(-2)^3	-1.47E-05	0.000128	-0.114917	0.9088
AUTUMN*CBUILT	-0.003217	0.005456	-0.589545	0.5570
CBUILT	0.001131	0.003825	0.295784	0.7681
SPRING*CBUILT	-0.000634	0.005534	-0.114626	0.9090
SPRING*RGDP	0.002671	0.036531	0.073125	0.9419
RESID(-1)	-0.227390	0.160340	-1.418170	0.1597
RESID(-2)	-0.100067	0.114780	-0.871818	0.3857
RESID(-3)	0.001405	0.116335	0.012081	0.9904
RESID(-4)	0.093990	0.116294	0.808204	0.4212

R-squared	0.036628	Mean dependent var	-1.38E-16
Adjusted R-squared	-0.160425	S.D. dependent var	0.303778
S.E. of regression	0.327239	Akaike info criterion	0.763399
Sum squared resid	9.423537	Schwarz criterion	1.238013
Log likelihood	-21.84184	F-statistic	0.185878
Durbin-Watson stat	1.992753	Prob(F-statistic)	0.999896

APPENDIX 9

CUSUM recursive residual test on Model 6



APPENDIX 10

Linear-Log Model

Dependent Variable: CPRICE
Method: Least Squares
Date: 11/26/03 Time: 16:20
Sample(adjusted): 1976:4 2003:2
Included observations: 107 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.71509	4.309550	3.182487	0.0020
LOG(MRATE)^-1	-5.001902	1.016305	-4.921657	0.0000
LOG(URATE(-2))	-7.181091	2.888329	-2.486244	0.0147
LOG(URATE(-2))^3	0.415365	0.195014	2.129931	0.0358
CPRICE(-1)	0.320752	0.075810	4.230968	0.0001
BUBBLE*CPRICE	0.517444	0.052766	9.806475	0.0000
BUBBLE(-1)*CPRICE(-1)	-0.159416	0.067713	-2.354290	0.0207
BUBBLE2*CPRICE	0.272833	0.070113	3.891319	0.0002
CPDI(-2)	0.073708	0.018842	3.911890	0.0002
CPDI(-2)^3	-0.000415	0.000125	-3.331670	0.0012
AUTUMN*CBUILT	-0.040749	0.004920	-8.282528	0.0000
CBUILT	0.014828	0.003552	4.174288	0.0001
SPRING*CBUILT	-0.017981	0.005419	-3.318334	0.0013
SPRING*RGDP	0.096378	0.036360	2.650673	0.0094

R-squared	0.928892	Mean dependent var	1.036057
Adjusted R-squared	0.918952	S.D. dependent var	1.148997
S.E. of regression	0.327108	Akaike info criterion	0.724399
Sum squared resid	9.950956	Schwarz criterion	1.074115
Log likelihood	-24.75535	F-statistic	93.45092
Durbin-Watson stat	2.088296	Prob(F-statistic)	0.000000

APPENDIX 11

Rational Expectations model

Dependent Variable: CPRICE
Method: Least Squares
Date: 11/26/03 Time: 17:18
Sample(adjusted): 1977:2 2003:2
Included observations: 105 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.834714	1.369757	2.799559	0.0063
MRATE(-1)	0.240058	0.072730	3.300661	0.0014
MRATE(-1)^2	-0.005510	0.002913	-1.891601	0.0618
URATE(-1)	-0.997426	0.277289	-3.597068	0.0005
URATE(-1)^2	0.043223	0.014741	2.932122	0.0043
BUBBLE*CPRICE	0.399295	0.050272	7.942665	0.0000
BUBBLE2*CPRICE	0.336396	0.067017	5.019539	0.0000
CPDI(-2)	0.074237	0.019572	3.793094	0.0003
CPDI(-2)^3	-0.000418	0.000124	-3.368549	0.0011
AUTUMN*CBUILT	-0.036565	0.005116	-7.147621	0.0000
CBUILT	0.017109	0.004629	3.695794	0.0004
CBUILT^2	0.000215	0.000109	1.962530	0.0528
SPRING*CBUILT	-0.030657	0.009244	-3.316611	0.0013
SPRING*RGDP	0.113840	0.037164	3.063192	0.0029
EXPECT^2	0.067875	0.021819	3.110776	0.0025

R-squared	0.923092	Mean dependent var	0.990431
Adjusted R-squared	0.911129	S.D. dependent var	1.087231
S.E. of regression	0.324117	Akaike info criterion	0.716142
Sum squared resid	9.454686	Schwarz criterion	1.095279
Log likelihood	-22.59743	F-statistic	77.15952
Durbin-Watson stat	1.755520	Prob(F-statistic)	0.000000

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