

**Testing Weak-form Efficiency in Greater Toronto Area
Residential Real Estate**

by

James Brox, Emanuel Carvalho and Matthew Duckett
Department of Economics
University of Waterloo

ABSTRACT

This paper examines the question of whether the market for residential real estate is informationally efficient, using the efficient market hypothesis paradigm. Utilizing housing prices, rents and property taxes in seven sub-markets within the Greater-Toronto Area (GTA), a measure for excess returns is first constructed. Through an examination of the distribution and autocorrelations of the excess-return data, it is determined that the market is not weak-form efficient. The next section of the paper proceeds to fit an ARIMA model to the excess-return data using the Box-Jenkins method. The ARIMA models are then used to predict excess returns over a short-term time horizon. When compared to a naïve model, the ARIMA models are found to be superior. The paper concludes that it is, in fact, possible to exploit the historical time-series patterns in the data to the investor's advantage, possibly earning excess returns over greater time horizons.

Testing Weak-form Efficiency in Greater Toronto Area Residential Real Estate

INTRODUCTION

Over the past decade, a great deal of literature has been devoted to investigating the informational efficiencies of markets. While the studies vary greatly in terms of content and methodology, the underlying motivation remains quite consistent: if markets are inefficient, the possibility for agents to earn excess returns exists. This analysis, under the efficient market hypothesis (EMH) paradigm (Fama, 1970), has principally been confined to capital markets. Only recently has such research begun to be undertaken in a real estate context (Rayburn, Devaney and Evans, 1987).

Real estate markets have long been assumed inefficient in economic and financial literature. These presumed inefficiencies are attributable to a number of factors, including:

1. *Barriers to Entry* – In the context of residential real estate high-cost indivisible assets (properties) may limit market participation in an investment context. Also, the potential for restrictive monetary policy to “dry up” mortgage funds may limit access to markets, producing inefficiencies (Gau, 1987).
2. *Heterogeneous Information* – The localized nature and high cost of information may result in disparate information sets among market participants. This is likely to produce heterogeneous forecasts with regards to expected returns. Valuations (for

example, expected house appreciation) formed on heterogeneous expectations can produce inefficiencies.

These presumed inefficiencies do not preclude weak-form efficiency, however. So long as investors are compensated for the additional costs in the form of higher returns, the market can still be efficient (Gau, 1987). However, the cost of time, combined with the difficulty of gathering information, may exceed the resources of individual investors. Conversely, it is likely that large institutional scale investors could overcome these potential entry barriers and high information costs through scale. Because of their size, large investment firms possess deep capital pools and the resources necessary to undertake detailed evaluation of potential investments. The ability to assimilate and utilize market information better may afford large-scale investors clearer insights than that of the individual investor, producing abnormally high returns, even over the long-term horizon. Furthermore, large-scale investors have the funds available to purchase properties outright, without engaging in any form of financing. This allows them to avoid the costs associated with financing, such as interest and the writing of mortgage contracts. This study will proceed under the assumption that the availability of financing and cost of borrowing is not contained in the investment analysis undertaken by investors. Rather, investors are in search of profitable ventures and will select properties in markets which, they suspect, will earn excess returns.

The residential real estate market in the Greater Toronto Area (GTA) will be the focal point in this study of market efficiency. The GTA is Canada's most concentrated urban

centre, with 5.1 million inhabitants, representing approximately 17 percent of the country's population (Wade, 2001). In recent years, low interest rates and strong job growth have attracted thousands to the GTA, which has had perennially low vacancy rates and high housing costs.

THEORY AND HYPOTHESIS

The Efficient Market Hypothesis

Generally, the efficient market hypothesis states that markets are efficient if prices fully reflect all available information (Gau, 1987). Markets can therefore be categorized according to their degree of efficiency which reflects the type and timeliness of the information that is utilized in the formation of asset prices. Markets are said to be weak-form efficient if the information set implied by the asset price reflects only historical prices. Semi-strong market efficiency capitalizes all past and current prices, as well as publicly available information into the asset price. Strong-form efficiency requires that all information, including "insider" knowledge, be incorporated into the asset price. It is possible to test both weak and semi-strong forms of this hypothesis; however, this paper will confine the analysis to the weak-form variety.

Weak-form efficiency requires that all past market prices (or in this case, historical excess returns) be known to market participants and be fully capitalized immediately into the asset price. An efficient market will quickly capitalize on available information, such that it is impossible to earn excess returns by trading on that information. For example, when new information becomes available, such as the returns

earned last period, this information is immediately valued and incorporated into the asset price, so that no investor acting on that information can profit by trading on it. Similarly, since all past prices and returns have already been valued and capitalized into the current asset price, no investor can earn profits by analyzing and trading on this information. If it becomes possible to exploit the time-series properties of the price history to earn excess returns, then the market cannot be efficient.

This paper will test the hypothesis that the residential real estate market in the GTA is weak-form efficient by analyzing the time series of the excess returns available to investors. Excess returns (in the next period) are defined as follows (Clayton, 1998):

$$r_{t+1} = \frac{P_{t+1} - P_t + R_t}{P_t} - PT_t - i_t$$

where r_{t+1} is the excess return next period,

P is the house price,

R is rental income,

PT is property taxes (as a percentage of house price), and

i is the risk-free rate (Canadian government bonds)

Under the assumption of weak-form efficiency, the information set (I_t) consists solely of the historical excess returns in the market. If the market conforms to weak-form efficiency, then the expected excess return in any market conditional on I_t is zero:

$$E_t[r_{t+1} | I_t] = 0.$$

Agents will, therefore, on the basis of historical excess returns, not be able to predict future excess returns. The time series of excess returns is thus a mean zero, serially uncorrelated random variable, where future excess returns are not correlated with the time series of past excess returns (Clayton, 1998). Thus, if the market were indeed weak-

form efficient, we would expect that the excess returns, r_t , would follow a random-walk process and produce a normal distribution. Furthermore, in examining the autocorrelation and partial autocorrelation functions of the excess-return series, we would expect to find no statistically significant lags under the weak-form efficiency hypothesis.

This paper will begin by examining the distribution of the excess returns for normality, a necessary condition for a random-walk model. An analysis of the autocorrelation functions will then be undertaken in an attempt to detect significant relationships among past and present values of the time series. Using Box-Jenkins ARIMA methodology, the data will then be modeled according to its time-series properties. If the series can be modeled in such a manner, then trading strategies could be developed that exploit serial dependence in the data, potentially earning excess returns for investors, proving that the market is not efficient (Cho, 1996).

DATA DESCRIPTION

The data in this study is derived from the Royal LePage Survey of Canadian Housing Prices.¹ The survey, released quarterly, provides an appraisal-based estimate of house prices, rental rates (actual or imputed) and property taxes for a variety of property types and geographic locations across Canada. This study will focus exclusively on detached bungalows in the GTA. This specific property type has been selected because no other study has examined the efficiency of the market for “starter homes”. Royal LePage defines a detached bungalow in the following manner:

¹ Available online at <http://www.royallepage.ca/schp/query.asp>

“A detached, three-bedroom single storey home with 1 ½ bathrooms and a one-car garage. It has a full basement but no recreation room, fireplace or appliances. Using outside dimensions (excluding garage), the total area of the house is 111 sq. metres (1,200 sq. ft.) and it is situated on a full-serviced, 511 sq. metre (5,500 sq. ft.) lot. Depending on the area, the construction style may be brick, wood, siding or stucco.”²

The following sub-markets of the GTA have been included in the study: Burlington, Don Mills (central), Etobicoke (Islington/Kingsway), Markham, Richmond Hill, Scarborough (central), and Willowdale.³ While a variety of sub-markets was available within the GTA, the above have been selected because consistent data was available.⁴ The sample period begins in the third quarter of 1982 and terminates in the first quarter of 2002, resulting in approximately 78 observations per sub-market. The Box-Jenkins ARIMA methodology requires a minimum of 50 observations and thus the sample is adequate to perform the necessary analysis (Tse, 1997).

The rate of return available on alternative investments, denoted i , represents the one-year interest rate on Canadian government treasury bills. Risk-neutrality implies that agents wish to earn a rate of return similar to that available on other assets. The rates of return on government bonds proxies the opportunity cost of money, and net returns above this rate correspond to excess returns.

DATA CONSTRAINTS AND CONCERNS

A significant constraint in performing analysis of real estate market efficiency is the lack of time-series data. This is due to the relative infrequency of individual

² <http://www.royalpage.ca/schp/query.asp>

³ As defined by Royal LePage

properties being transacted, as well as possible changes to the quality of the specific property (maintenance issues or additions to the dwelling). For example, a residential property may change hands only once every few decades, resulting in a broken and unusable series of data. Furthermore, a property's value can be influenced by factors such as additions or standard of maintenance and landscaping which may render intertemporal comparisons impossible. In an effort to circumvent such difficulties, attempts to generate constant-quality indices have been undertaken by various authors using a variety of approaches such as hedonic or repeat-sales methods. These approaches are expensive and time-consuming endeavors, for which the appropriate underlying data is difficult to obtain (Pollakowski, 1995).

In an attempt to avoid the aforementioned difficulties, this study will rely on appraisal-based data, recognizing that this may introduce a source of bias into the study. This bias is usually referred to as "appraisal smoothing". In performing a residential valuation, the estimated values of the homes may be subject to two types of errors: a random error and a systematic error. Since the accuracy of an appraisal is dependent upon the skill of the individual appraiser, one would expect a random error to occur with each property valuation. These random errors on the part of the appraiser should cancel out in the aggregation process. However, because appraisers are thought to incorporate both past and present information into their current evaluation of property value, appraisal-based returns often lag real returns (Clayton, 1998). In other words, it is believed that appraisers "partially adjust" appraisals over time, a practice resulting in a systematic valuation error which would not diversify away in the aggregation process (Geltner,

⁴Some markets were redefined over time and have been excluded from the study.

1993). This systematic component could bias the excess returns, and introduce positive autocorrelations in the property-value data series.

Clayton (1998) used a similar Royal LePage data set in examining the efficiency of the Vancouver condominium market. Having recognized the potential bias in using appraisal-based data, an existing transactions-based price series was used as a comparison to determine the accuracy of the Royal LePage data. After both data sets had been indexed, they were found to have a correlation coefficient of 0.98. This lends confidence to the fact that there is no systematic bias running through the Vancouver data. Since property valuations are supposed to be conducted in a similar manner in all cities, a comparable pattern would likely emerge if a transactions-based index (which is not available for the GTA) were to be compared to the appraisal-based data. This study will proceed under the assumption that the Toronto appraisals are similarly devoid of appraisal bias.

DISTRIBUTIONAL ANALYSIS

One of the fundamental assumptions of the random-walk model, and thus weak-form efficiency, is that the data conforms to a normal distribution. A variety of statistical tests have been performed to examine whether the return data is consistent with a normal distribution, including descriptive statistics (skewness and kurtosis), runs tests and an examination of the autocorrelation properties of the data.

Descriptive Statistics

Table 1 provides a descriptive overview of the excess returns from each sub-market, as well as the aggregate.

Table 1: Descriptive Statistics							
				SKEWNESS		KURTOSIS	
MARKET	N	MEAN	MEDIAN	Stat	Std. Err.	Stat	Std. Err.
Burlington	77	1.34	0.36	2.223	0.274	9.159	0.542
Don Mills	77	0.86	-0.25	4.028	0.273	25.912	0.541
Etobicoke	77	1.06	0.55	1.301	0.274	5.321	0.542
Markham	77	0.91	0.16	0.810	0.274	2.458	0.542
Richmond Hill	77	0.87	0.23	0.814	0.274	2.839	0.542
Scarborough	77	0.74	0.11	1.048	0.274	2.267	0.542
Willowdale	77	1.09	0.25	0.412	0.274	2.962	0.542

In the case of a normal distribution, we would expect to find the mean and median approximately equal, a feature the data clearly does not exhibit. Furthermore, the skewness and kurtosis statistics are expected not to be significantly different from zero. Clearly, the above statistics are not consistent with a data set that is normally distributed, violating a fundamental assumption of a random-walk model.

Runs Test

A further test used to examine statistical dependencies is the runs test. The primary advantage to this non-parametric test is that it ignores the distribution of the data (Mobarek and Keasey, 2000). A run is defined as *a succession of identical signs (+, -, 0) running through the data*. If an abnormally high (or low) number of runs are present, then there is evidence against the null hypothesis of a random series. Table 2 presents the results of the runs test for the seven sub-markets.

Table 2: Runs Test Overview				
MARKET	TOTAL CASES	# OF RUNS	Z	ASYMP. SIG. (2-tailed)
Burlington	77	25	-2.972	0.003
Don Mills	77	24	-2.939	0.003
Etobicoke	77	28	-2.323	0.028
Markham	77	30	-1.647	0.103
Richmond Hill	77	27	-2.168	0.039
Scarborough	77	21	-3.800	0.000
Willowdale	77	26	-2.639	0.013

With the exception of Markham, all markets produce significantly negative Z-statistics, which imply a rejection of the null hypothesis of a random walk at a five per cent level of significance. In each case, there are fewer runs than would be expected in a series that follows a random walk. Poshokwale (1996) provides a more intuitive explanation:

*“...a lower than expected number of runs indicates a market’s overreaction to information, subsequently reversed, while a higher number of runs reflects a lagged response to information. Either situation would suggest an opportunity to make excess returns.”*⁵

The runs test provides further evidence against weak-form market efficiency by indicating that the data is not consistent with a random series.

⁵ Poshakwale S. “Evidence on the weak-form efficiency and the day of the week effect in the Indian stock market”, *Finance India*, Volume 10(3), September.

AUTOCORRELATION EXAMINATION

The autocorrelation function summarizes the pattern of autocorrelations present in a particular set of time-series data. An examination of the autocorrelation function illustrates to what degree current values of the series are related to various lags of the past data. In an efficient market, no such autocorrelation pattern should exist, since it would be immediately exploited to the point where the pattern vanishes. Table 3 summarizes the autocorrelation function (ACF) for each market.⁶

Table 3: Autocorrelation Evaluation								
	Autocorrelation at lag							
Area	1	2	3	4	5	6	7	8
Burlington	0.22 (0.061)	0.26 (0.013)	0.33 (0.001)	0.14 (0.001)	0.29 (0.000)	0.14 (0.000)	0.01 (0.000)	0.12 (0.000)
Don Mills	0.18 (0.126)	0.30 (0.011)	0.19 (0.008)	0.18 (0.006)	0.16 (0.005)	0.10 (0.008)	0.05 (0.014)	0.20 (0.008)
Etobicoke	0.11 (0.346)	0.07 (0.516)	0.15 (0.396)	0.14 (0.347)	-0.11 (0.366)	0.23 (0.141)	0.07 (0.187)	-0.03 (0.256)
Markham	0.20 (0.076)	0.35 (0.002)	0.30 (0.000)	0.21 (0.000)	0.01 (0.000)	0.06 (0.001)	0.10 (0.001)	-0.04 (0.002)
Richmond Hill	0.44 (0.000)	0.34 (0.000)	0.27 (0.000)	0.21 (0.000)	0.13 (0.000)	0.05 (0.000)	0.05 (0.000)	0.10 (0.000)
Scarborough	0.40 (0.000)	0.18 (0.001)	0.37 (0.000)	0.21 (0.000)	0.25 (0.000)	0.22 (0.000)	0.09 (0.000)	0.06 (0.000)
Willowdale	0.37 (0.001)	0.23 (0.001)	0.21 (0.000)	0.31 (0.000)	0.03 (0.000)	0.14 (0.000)	0.10 (0.000)	0.09 (0.000)

Note: Figures in parentheses are the marginal significance levels associated with the Q-statistics for tests of joint significance in the autocorrelations up to and including that lag.

With the exception of Etobicoke, each market displays a significant autocorrelation pattern that is not consistent with weak-form efficiency. There exists a relationship between past and present excess returns which implies the possibility of

⁶ The format of this table is derived from: Clayton, Jim. "Further Evidence on Real Estate Market Efficiency". *Journal of Real Estate Research*, Volume 15, Numbers 1&2, 1998.

earning excess returns in future periods based on historical returns. In an efficient market, this is not possible.

In aggregate, the results from the distributional and autocorrelation analysis are not consistent with a random series, implying that the residential real estate market in the GTA is not weak-form efficient. With the abundance of evidence that has so far been provided against market efficiency, it may be possible to exploit the serial dependence in the excess returns to earn consistently above-average returns in these markets. The next section details the development of a predictive model that will forecast future excess returns based on historical returns.

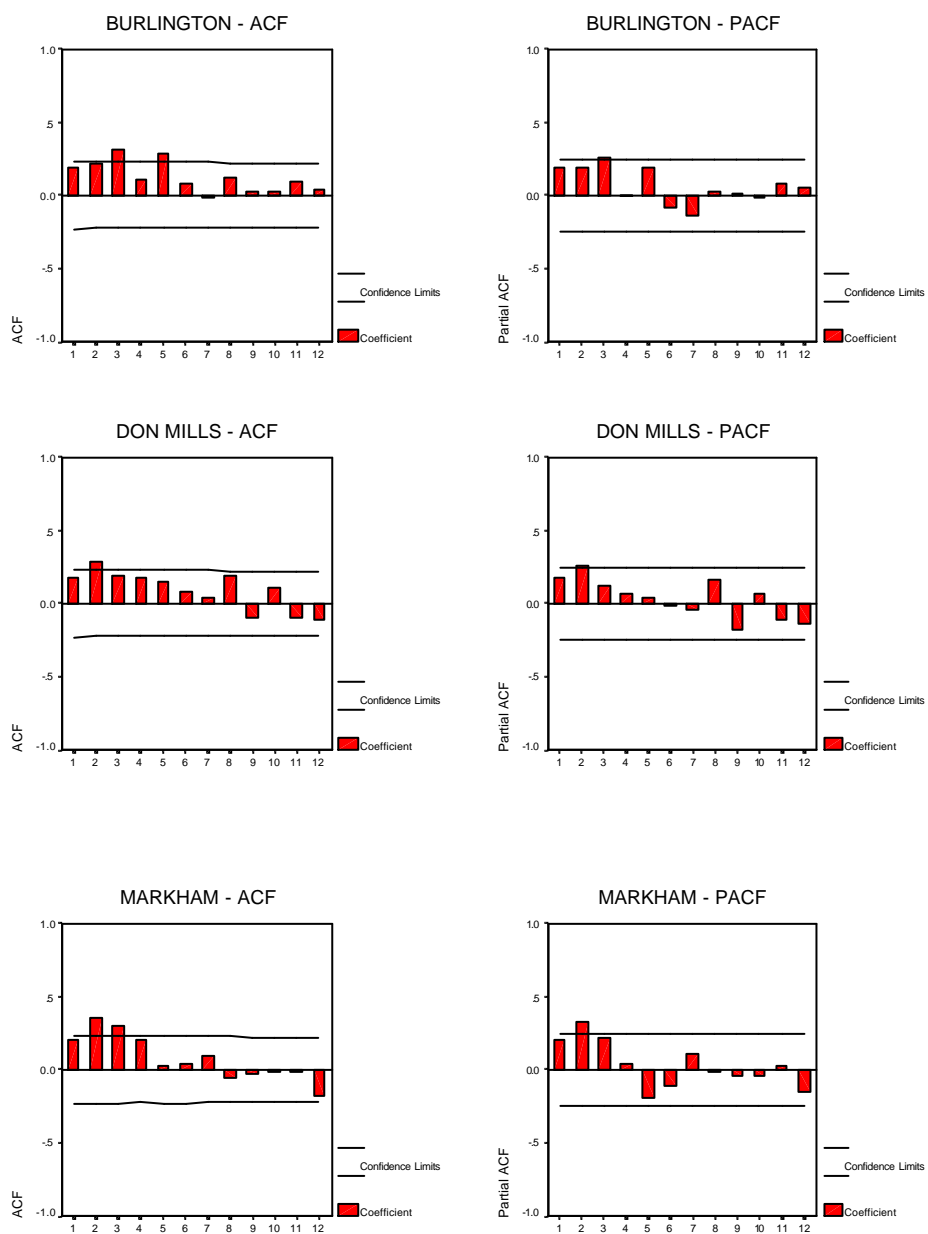
BUILDING THE PREDICTIVE MODEL

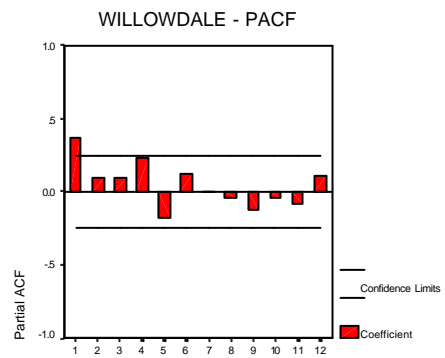
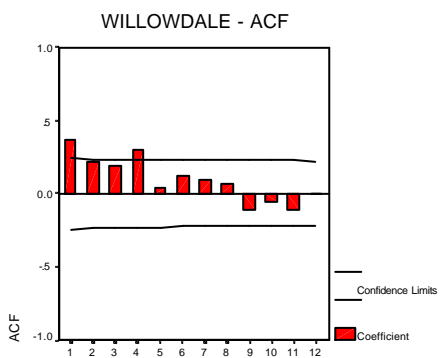
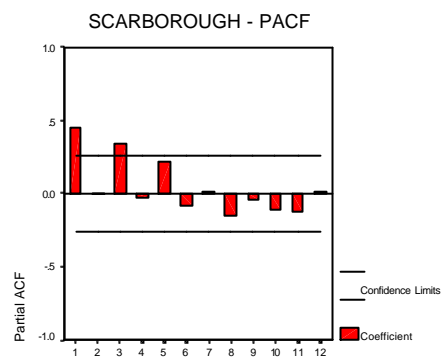
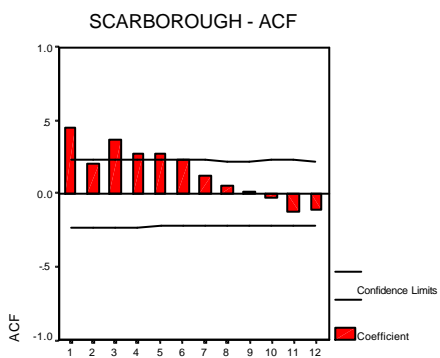
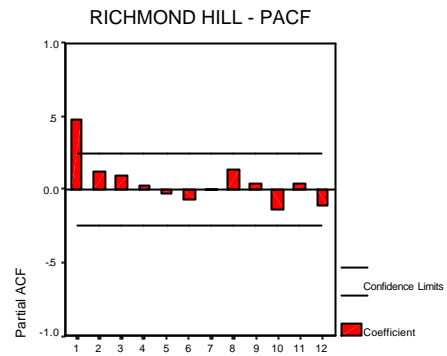
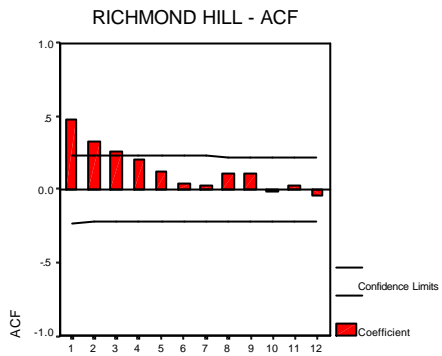
In order for investors to exploit what has been determined to be an inefficient market, a model that predicts excess returns in future periods needs to be developed. The process begins by first dividing the data into two distinct sets. The first will be a “modeling” set which will include all data from the fourth quarter of 1982 until the fourth quarter of 1999, a total of 73 observations. It is with this set that statistical tests will be run in an effort to discover relationships in the data. The second will be a holdout set, in this case the last four observations in the series (first quarter of 2000 until the first quarter of 2001), to test the accuracy of the predictions and to determine the adequacy of the models. The Box-Jenkins methodology for ARIMA models will be used to analyze the data series and to select the appropriate model. The Etobicoke data will be omitted from

this section as it was found to be a white-noise series (see table 3), and thus not possible to model according to the Box-Jenkins method.

The Box-Jenkins ARIMA Method

The first step in the Box-Jenkins methodology is to examine the autocorrelation and partial autocorrelation properties of the time series at hand. The following histograms summarize this analysis:





Confidence bands are set at the five per cent level of significance. As illustrated in the above histograms, each of the markets displays significant time-series correlations. In other words, observations of past excess returns are correlated with one another. Since the series appear to be stationary, no differencing is required. Furthermore, no seasonal component is evident from the above analysis. Thus, we will be pursuing an ARIMA model of the form $(p,0,q)$, where p is the order of the autoregressive process and q is the order of the moving-average process.

The graphs point to various plausible ARIMA models, none of which can be presumed superior without further study. Thus, a variety of models have been examined for each market to identify potential specifications. Akaike's information criterion (AIC) is used to identify the most appropriate models. The most appropriate combination of moving average and autoregressive processes (p and q) can be found by minimizing the AIC value (Makridakis et al., 1998):

$$\text{AIC} = -2\log L + 2m$$

where m equals $p + q$, the sum of the orders of the autoregressive and moving average processes. The AIC penalizes the inclusion of additional parameters, and will yield higher values if each parameter added does not contribute more to the likelihood (L) than the amount penalized. This is consistent with parsimony, a basic premise of the Box-Jenkins ARIMA methodology which states that as few parameters as possible should be used in fitting time-series models (Makridakis et al., 1998).

The AIC is only useful for comparing models fitted on the same data set and cannot be compared across data sets. Table 4 displays the results of fitting the data to various ARIMA models.

MODEL?	(1,0,0)	(2,0,0)	(0,0,1)	(0,0,2)	(1,0,1)	(1,0,2)	(2,0,1)	(3,0,0)
Burlington	2.8769	2.8659	2.8907	2.8974	2.8257	2.8437	2.8506	2.8299
Don Mills	3.7320	3.6899	3.7444	3.7213	3.6946	3.7121	3.7108	3.7175
Markham	3.0499	2.9720	3.0678	3.0283	2.9951	2.9282	2.9802	2.9644
Richmond Hill	2.9743	2.9887	3.0567	3.0497	2.9781	3.0199	3.0199	3.0169
Scarborough	3.0123	3.0529	2.9879	3.0144	3.0204	3.0235	3.0556	2.9654
Willowdale	3.6720	3.7049	3.7136	3.7207	3.6915	3.7281	3.7294	3.7365

Note: Highlighted cells represent the best model, as per AIC, where all coefficients are significant at the 5% level. Etobicoke was judged to be a white-noise series using Ljung-Box test (Q-stat), and is thus not included.

From the above table, it is obvious that rather than a uniform model, two distinct models emerge from the analysis. The selection criterion employed involves selecting the model with the lowest AIC for which all coefficients are significant at the five per cent level. If these models were, in fact, adequate representations of the individual markets, we would expect to find the residuals to be white noise series, with no discernable time-series pattern embedded. The following table shows the results of the residual diagnostic test, using the marginal significance of the Q-statistic at various lags:

Model	LAG?	4	8	12
(1,0,1)	Burlington	0.104	0.276	0.402
(2,0,0)	Don Mills	0.587	0.614	0.640
(1,0,2)	Markham	0.281	0.524	0.740
(1,0,0)	Richmond Hill	0.393	0.835	0.751
(3,0,0)	Scarborough	0.229	0.512	0.881
(1,0,0)	Willowdale	0.133	0.258	0.258

A lack of any significant Q-statistics is indicative of a properly specified model. The interpretation of the above results is that no autocorrelation pattern remains in the residuals after the model is imposed on the data. Therefore, all of the above models can be considered adequate representations of the data.

Forecasting with the Models

The following parameters have been generated for each of the markets, using Shazam and the previously specified ARIMA models (with standard errors in parentheses):

$$\text{Burlington ARIMA (1,0,1): } ERBUR_t = 0.149 + 0.875ERBUR_{t-1} + \epsilon_t + 0.687\epsilon_{t-1}$$

$$(0.200) \quad (0.124) \quad (0.185)$$

$$\text{Don Mills ARIMA (2,0,0): } ERDM_t = 0.409 + 0.132ERDM_{t-1} + 0.284ERDM_{t-2} + \epsilon_t$$

$$(0.709) \quad (0.113) \quad (0.113)$$

$$\text{Markham ARIMA (1,0,2): } ERMA_t = 0.282 + 0.657ERMA_{t-1} + \epsilon_t + 0.658\epsilon_{t-1} - 0.438\epsilon_{t-2}$$

$$(0.386) \quad (0.154) \quad (0.159) \quad (0.112)$$

$$\text{Richmond Hill ARIMA (1,0,0): } ERRH_t = 0.358 + 0.486ERRH_{t-1} + \epsilon_t$$

$$(0.508) \quad (0.098)$$

$$\text{Scarborough ARIMA (3,0,0): } ERSC_t = 0.183 + 0.389ERSC_{t-1} - 0.105ERSC_{t-2}$$

$$(0.476) \quad (0.111) \quad (0.121)$$

$$+ 0.351ERSC_{t-3} + \epsilon_t$$

$$(0.112)$$

$$\text{Willowdale ARIMA (1,0,0): } ERWI_t = 0.650 + 0.402ERWI_{t-1} + \epsilon_t$$

$$(0.716) \quad (0.109)$$

These ARIMA models were used to produce forecasts for the next four periods.

If the markets for residential real estate in the GTA follow a random-walk model, then we would expect that no model would outperform a naïve, no-change model. In the case of a random walk, the best prediction is the last available data point. This naïve forecast will be compared to the forecasts provided by the respective ARIMA models to determine if the ARIMA models are capable of outperforming the naïve forecasts.

ASSESSING THE ADEQUACY OF THE ARIMA FORECASTS

The method of evaluating the out-of-sample forecasting performance of the ARIMA models is the Theil's U-statistic. The Theil's U-statistic is normally defined as:

$$U = \sqrt{\frac{\sum (E_t - AF_t)^2}{\sum (E_t - NF_t)^2}}$$

where E_t is the observed excess return, AF_t is the ARIMA forecast of excess returns, and NF_t is the naïve forecast of excess returns. The Theil's U-statistic is thus comparing the ratios of the root mean square errors (RMSE) of the ARIMA forecasts and the naïve forecasts. The statistic implies that (Tse, 1997):

- (1) $U = 1$, i.e., the model's forecasts match, on average, the naïve forecasts;
- (2) $U < 1$, i.e., the model's forecasts outperform the naïve forecasts;
- (3) $U > 1$, i.e., the naïve forecasts outperforms the model forecasts.

The intent in this study is to compare the performance of the ARIMA forecasting model across four time periods. A truly naïve forecaster would merely take the last available observation and forecast it infinitely into the future. If the series were truly random, it would be expected that no model would systematically outperform such a no-change forecast. Previous sections have proven that the series is not random, which

provides the basis for an objective evaluation of the performance of the ARIMA models to be used for forecasting purposes. The following discusses the methodology employed in developing the Theil's U-statistic.

Most simply defined, the Theil's U-statistic can be represented by the following:

$$U = \sqrt{\frac{\text{Sum of RMSE for ARIMA Forecast}}{\text{Sum of RMSE for Naïve Forecast}}}$$

The results of this application are shown in Table 7.

Market	ARIMA Model	Theil's U
Burlington	(1,0,1)	0.925
Don Mills	(2,0,0)	0.859
Markham	(1,0,2)	0.287
Richmond Hill	(1,0,0)	0.706
Scarborough	(3,0,0)	0.807
Willowdale	(1,0,0)	0.756

In each market, the ARIMA model generated forecasts that outperformed the naïve forecasts.

SUMMARY AND CONCLUSIONS

The overall results of this study lead to the conclusion that the market for residential real estate in the Greater Toronto Area is not weak-form efficient. Weak-form efficiency implies a random-walk process that is premised on certain necessary

conditions, such as a normal distribution. It has been demonstrated that excess returns in every market (with the exception of Etobicoke) do not conform to a normal distribution, and hence cannot be expected to follow a random walk. Furthermore, the technical analysis, provided in this paper, demonstrates that excess returns in residential real estate can be fitted to an ARIMA model that predicts future returns, based on the pattern of historical returns.

All of the above suggests that an institutional investor, unconcerned with the availability of financing and possessing the resources to collect adequate and timely information, could use similar models to predict excess returns in future periods, and to base investment decisions on those predictions. However, the results obtained in this study, and those similar to it, must be interpreted and utilized with caution. The benchmark for assessing the adequacy of the predictive model is an extremely simple naïve model. While the models presented in this paper outperform the naïve model, this does not mean to suggest that superior forecasting models do not exist. For example, regression models with ARIMA errors have proven quite successful in applications similar to this (Tse, 1997).

Furthermore, point forecasts are subject to great uncertainty, and should be interpreted with care. Prediction intervals are important in assessing the dependability of the forecasts. In this study, although the models outperformed the naïve models, the wide prediction intervals make any forecast of excess returns extremely suspect. Large

prediction intervals also may make predicting turning points difficult, as the interval may encompass both positive and negative values.

While the specific forecasts obtained in this study may be subject to scrutiny, the underlying conclusion is not. The residential real estate market in the GTA is not informationally efficient. This is consistent with many contemporary studies of other real estate markets, including Tse(1997), Rayburn, Devaney and Evans (1987), Brown and Chau (1997) and Clayton (1998).⁷ More specifically, future excess returns may be partly predictable using currently available information such as past excess returns.

An implication of the analysis is that housing prices, and hence returns, may not always be based on market fundamentals, but instead on speculation, trends or fads (Clayton, 1998). In an environment such as this, ruled by emotion and momentum, it is possible that investors can potentially earn excess profits through careful analysis and timing. When this is possible, efficiency, by any definition, can be ruled out.

⁷ See Cho (1996) for a comprehensive review of articles

REFERENCES

- Brown, Gerald R. and K.W. Chau “Excess Returns in the Hong Kong Commercial Real Estate Market.” *Journal of Real Estate Research*, Volume 14, Number 1, 1997.
- Cho, Man. “House Price Dynamics: A Survey of Theoretical and Empirical Issues.” *Journal of Housing Research*, Volume 7, Issue 2, 1996.
- Clayton, Jim. “Further Evidence on Real Estate Market Efficiency.” *Journal of Real Estate Research*, Volume 15, Number 1, 1998.
- Darrat, Ali F. and Maosen Zhong. “On Testing the Random-Walk Hypothesis: A Model Comparison Approach.” Social Science Research Network Electronic Library, Available online at:
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=285715
- Fama, Eugene F. “Efficient Capital Markets: A Review of Theory and Empirical Work”, *Journal of Finance*, Volume 25, 383-420.
- Fu, Yuming and Lilian K. Ng. “Market Efficiency and Return Statistics: Evidence from Real Estate and Stock Markets Using a Present-Value Approach.” 2000. Available online at:
<http://www.bus.wisc.edu/realestate/culer/paper.htm>
- Gau, George W. “Efficient Real Estate Markets: Paradox or Paradigm.” *AREUEA Journal*, Volume 15, Number 2, 1987.
- Geltner, David. “Estimating Market Values from Appraised Values without Assuming an Efficient Market.” *The Journal of Real Estate Research*, Volume 8, Number 3, 1993.
- Graflund, Andreas. “Some Time Serial Properties of the Swedish Real Estate Stock Market, 1939-1998.” Lund University, 2001.
- Makridakis, Spyros et al. Forecasting: Methods and Application. Third Edition. John Wiley and Sons, Inc. New York, 1998.
- Mobarek, Asma and Keavin Keasey. “Weak-form Market Efficiency of an Emerging Market: Evidence from Dhaka Stock Market of Bangladesh” Presented at ENBS Conference, Oslo, 2000. Available online at:
<http://www.bath.ac.uk/cds/enbs-papers-pdfs/mobarek-new.pdf>

- Moore, David S. and George P. McCabe. *Introduction to the Practice of Statistics, 2nd Ed.* W.H. Freeman and Company, New York. 1993.
- Pollakowski, Henry O. "Data Sources for Measuring House Price Changes." *Journal of Housing Research*, Volume 6, Issue 3, 1995.
- Poshakwale S. "Evidence on the weak-form efficiency and the day of the week effect in the Indian stock market", *Finance India*, Volume 10(3), 1996.
- Rayburn, William, Michael Devaney and Richard Evans. "A Test of Weak-Form Efficiency in Residential Real Estate Returns." *AREUEA Journal*, Volume 15, Number3, 1987.
- Tse, Raymond Y.C. "An Application of the ARIMA model to Real-Estate Prices in Hong Kong." *Journal of Property Finance*, Volume 8, Number 2, 1997.
- Wade, P.J. "GTA Land Supply Dwindles". *Realty Times*, September 11, 2001. Available online at: http://realtytimes.com/rtnews/rtcpages/20010911_cagta.htm
- Wheaton, William C. et al. "Evaluating Risk in Real Estate." Torto Wheaton Research, July 1999.