Some Time Serial Properties of the Swedish Real Estate Stock Market, 1939-1998

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Abstract

This paper investigates the information in monthly nominal Swedish real estate stock market returns from 1939-1998. Thus we test the weak form efficient market hypothesis. Our results contradict previous findings from the general Swedish stock market as we find very little evidence of seasonal effects and time varying volatility. Further we find no evidence of mean reversion in the real estate stock market. The overall conclusion is that the nominal real estate stock market returns follow a random walk. Our result suggests in context of previous studies that the irregularities found in the Swedish stock market originate from other industries.

1 Introduction

One of the foundations in modern finance has been the efficient market hypothesis of Fama (1968). In an efficient market it should not be possible to profit from past information. Thus movements in asset prices are random and not predictable. Fama (1991) provides an excellent review of the extensive empirical literature that investigates the efficient market hypothesis. The research on stocks is mainly based upon general stock market portfolios and there is still very little academic research on industry specific portfolios.[1] This is odd as practitioners such as financial analysts pay such attention to the performance of industry portfolios as well as specific stocks. One plausible explanation to the minor academic interest can be the two-fund separation theorem. It stipulates that all assets along the security market line can be replicated as linear combinations of the risk-free asset and the market portfolio. Hence a sub-portfolio of the market portfolio ought to have similar time serial properties as the market portfolio and little would be gained by studying specific assets.

The question is weather or not this reasoning actually holds when studying time serial properties of a specific asset class: the Swedish real estate stock market. Sweden is a small open economy and the majority of the companies on the stock exchange conduct their business in the international arena. This makes the real estate industry an interesting asset class as it differs from the others by representing a large fraction of real capital and this capital along with the services provided is, with a few exemptions, domestic. Further we have access to a unique newly constructed data set of 60 years of monthly returns from 1939-1998.

The contribution of this paper is that we study a specific industry in a specific country, a Swedish real estate stock market portfolio. Our results, in support of the weak form efficient market hypothesis, contradict the previous findings from the general Swedish stock market returns as well as the two-fund separation theorem. And in context of previous studies of the Swedish stock market portfolio our result suggests that the irregularities, such as seasonal effects and mean reversion, found by Frennberg and Hansson (1993a, 1993b), originate from other industries. It also verifies the need to study specific asset classes.

The paper is organized as follows. Section 2 specifies martingales and random walk.

[1] The US stock market is studied by Ibotsson and Sinquefield (1976) and also by Schwertz (1990) using almost two centuries of monthly data. International comparisons between stock markets has been presented by Gultekin, M.N., and Gultekin (1986), Corhay, Hawawini and Michel (1987), just to mention a few in the vast literature that present international comparisons between stock markets.

Further the hypothesis to be tested and the econometric framework is presented in section 2. The data used in the study is presented in section 3 along with the results and the empirical evidence. Section 4 concludes the paper.

2 Theory and hypothesis

A cornerstone in modern finance has been the efficient market hypothesis.[2] It stipulates that if security prices reflect all relevant information in an efficient market the movements in asset prices are random and not predictable. Thus the returns is the expected value, μ, plus a random disturbance, ε_t. This random process is a martingale difference and the asset prices follow a martingale. Notice that the return process is white noise if and only if we have constant volatility.

$$r_t = \mu + \varepsilon_t \tag{1}$$

All white noise processes are martingale differences of which follows: all random walks are martingale processes. However the opposite is not true. Another feature of the general martingale differences is that we have not made any assumption regarding the higher moments. Thus, the process is able to carry information in the higher moments such as volatility. If we impose the restriction of uncorrelated disturbances the process is a weak form of white noise.

$$Cov\left[\varepsilon_t, \varepsilon_{t-k}\right] = 0, \quad \forall\ k \neq 0 \text{ and } Cov\left[\varepsilon_t^2, \varepsilon_{t-k}^2\right] \neq 0, \quad \forall\ k \neq 0 \tag{2}$$

However this process is not independent as information is carried via the autocorrelation of the squared increments. Next we impose the restriction of uncorrelated squared increments. Thus, the disturbances are assumed to be independent but not identically distributed, $INID$. This is a property that is useful when modelling time varying volatility models:

$$Cov\left[\varepsilon_t, \varepsilon_{t-k}\right] = 0,\ Cov\left[\varepsilon_t^2, \varepsilon_{t-k}^2\right] = 0, \quad \forall\ k \neq 0, \text{ and } \varepsilon_t \sim INID(0, \sigma_t^2) \tag{3}$$

If we impose the restriction of uncorrelated increments both in levels and squares in conjunction with disturbances being independently identically distributed, IID, we have white noise.

[2] See Fama (1991) for a survey of research on the efficient market hypothesis.

$$Cov\left[\varepsilon_t, \varepsilon_{t-k}\right] = 0,\ Cov\left[\varepsilon_t^2, \varepsilon_{t-k}^2\right] = 0, \quad \forall\, k \neq 0, \text{ and } \varepsilon_t \sim IID(0, \sigma^2) \tag{4}$$

If and only if we also condition the increments to be normally independently identically distributed, $NIID$, the martingale difference will be strict white noise.

$$Cov\left[\varepsilon_t, \varepsilon_{t-k}\right] = 0,\ Cov\left[\varepsilon_t^2, \varepsilon_{t-k}^2\right] = 0, \quad \forall\, k \neq 0, \text{ and } \varepsilon_t \sim NIID(0, \sigma^2) \tag{5}$$

The geometric monthly return is calculated by using month-end index values.

$$r_t = \frac{I_t}{I_{t-1}} - 1 = \mu + \varepsilon_t \tag{6}$$

This presents us with five testable hypotheses.

H_{01}: There are no monthly seasonal effects.

H_{02}: There are no four months seasonal effects.

H_{03}: Past month-to-month returns yield no information, i.e. there is no autocorrelation.

H_{04}: The returns have stable volatility.

H_{05}: Prices follow a random walk.

Hypothesis H_{01}- H_{03}, all test the serial independence in Eq. (3) as this is a necessary condition for martingale differences and weak form white noise. The last two hypotheses, H_{04}- H_{05}, test whether or not returns have stable volatility. If hypotheses H_{01}- H_{03}, are not rejected the last hypotheses H_{04}- H_{05}, serve as an indication of returns being INID and IID white noise.The reasoning behind the hypothesis and the methodology for conducting the tests are presented in the following sections.

2.1 Non-Seasonal effects

The seasonal effects that have been found in stock return series still remains a puzzle. The most frequent documented anomaly is the positive January effect first reported by Wachtel (1942) on US data. Later research by Rozeff and Kinney (1976), Dyl (1977) and Roll (1983) verified this effect. Blume and Stambaugh (1983), explains the seasonal effects by statistical biases. Jones, Lee and Apenbrink (1991) and Jones and Lee (1995) as an effect of the higher bid ask spreads for small priced stocks. Ball, Kothari and Shanken (1995). Banz (1981), Keim (1983) and Reinganum (1983) suggest that the January effect is the result of tax reduction and tax-loss selling. However the later does not explain a negative autumn effect in European stock market data first reported by Gultekin and Gultekin (1983) and an additional positive summer effect in the Swedish stock market found by Frennberg and Hansson (1993). Interesting is that they found seasonal effects in the Swedish stock market both on monthly and on four-month returns. Can this also be the case for the real estate stocks? Our null hypothesizes are that there is no statistical significant difference between the investigated periods. We utilize 11 dummies to capture the seasonal effects of the month-to-month returns. If there is no seasonal effect there are no statistical significant dummies in the regressions.

$$r_t = c_0 + \sum_{j=1}^{11} \gamma_j D_j + \varepsilon_t \tag{7}$$

Following Frennberg and Hansson (1992) we test December to March, April to July and August to November returns by the following regression:

$$r_t = c_0 + \sum_{i=1}^{2} \gamma_i D_i + \varepsilon_t \tag{8}$$

The methodology is to use an F-test on the regressions and test the null hypothesis of equal mean return. The F-test statistic is a test of the equality of the different regression dummy parameters γ.

$$\frac{(SSR/k)}{(SSE/(n-k-1))} \sim F_{k,n-k-1,\alpha} \tag{9}$$

The results of the tests are presented in the section 3.

2.2 Serial independence

Autocorrelation is a natural time series extension of ordinary correlation. Auto-covariance, ν_m, and autocorrelation coefficient, ρ_m, are expressed as

$$\nu_m = Cov\left[r_t, r_{t+m}\right] \tag{10}$$

$$\rho_m = \frac{Cov\left[r_t, r_{t+m}\right]}{Var\left[r_t\right]} = \frac{\nu_m}{\nu_0} \tag{11}$$

If ρ_m has a positive sign positive (negative) returns tend to be followed by positive (negative) returns. If ρ_m has a negative sign positive returns tend to be followed by negative returns and vice versa. We test the null hypothesis of serial independence with the portmanteau test of Ljung and Box (1978):

$$Q(m) = T(T-2)\left[\sum_{j=1}^{M} \frac{\rho_j^2}{T-j}\right] \sim \chi_m^2 \quad (12)$$

2.3 Stable volatility

Empirical evidence points to the fact that we tend to observe tranquil and volatile periods in asset returns. This is often referred to as volatility clustering or time varying volatility. A huge body of literature has during the last 15 years established a relationship between time-varying risk and return, for example ARCH/GARCH, stochastic volatility models and recently regime shifts models. These models all try to explain serial dependence in volatility.

This motivates a test of time varying volatility utilizing both Ljung-Box Q-statistics and Lagrange multiplier (LM) tests on the squared residuals.[3] These test are of interest as the difference between white noise and martingale differences is that the later can have serial dependence while the former can not.

2.4 Security prices follow random walk

IIf returns are white the noise the asset prices, or an index, is a random walk. The index I_{t+q} of a q year investment in a market portfolio at time t is the compounded return. Let r_q is the monthly return of the market portfolio. Compounded returns, I_{t+q}, in our case the real estate index, is a random walk under the assumption that the return is a martingale difference, a drift μ plus a white noise term ε_t.

$$r_q = q\mu + \varepsilon_t + \ldots + \varepsilon_{t+q} \quad (13)$$

$$r_q = \mu + r_{q-1} + \varepsilon_{t+q} \quad (14)$$

Hence, the expected q period return is equal to the monthly mean return, μ, times the holding period q and the variance of the expected q period return is q times the variance

[3]Engle (1982) proposes the Lagrange multiplier test for ARCH disturbances. With a large sample of, T, residuals, under the null hypothesis, the test statistic TR^2 converges to a χ_q^2 distribution. For further details see Enders, Walter, *Applied Econometric Time Series*, pp. 148-149 and Andrew C Harvey: *Time Series Models*.

of monthly returns.

$$\mathrm{E}\left[r\left(q\right)\right] = q\mu,\ \mathrm{Var}\left[r\left(q\right)\right] = q\sigma^2 \tag{15}$$

The random walk property can be tested with the variance ratio test, VR, of Cochrane (1988) also we test if this property changes with the investment horizon. Faust (1992) reports the VR-test is the optimal test for mean reversion.

$$\mathrm{VR}\left(q\right) = \frac{\mathrm{Var}\left[r\left(q\right)\right]}{q \cdot \mathrm{Var}\left[r\left(1\right)\right]}, \tag{16}$$

Which is unity under random walk. VR values below unity are an indication of mean reversion i.e. lower risk then expected. Subsequently values above unity are an indication of mean aversion. The variance ratio test statistic is asymptotically normal distributed (Cambell, Lo and MacKinley [1997]).

$$\sqrt{nq}\left(\mathrm{VR}\left(q\right)\right) \sim asymp\ N\left(0, 2\left(q-1\right)\right)$$

3 Results

In this paper we study the properties of a never before analyzed data set of monthly Swedish real estate stock market index returns from 1939 until 1998 (Graflund (2001)). The monthly risk-free rate of return is from the Frennberg and Hansson (1992) database.[4]

Figure1a presents the monthly nominal returns from the Swedish real estate stock market index and figure 1b the cumulative squared residuals, CSR, from the real estate index (top) and the Swedish general stock market index (bottom).[5] The two straight lines in figure 1b shows theoretical average cumulative squared residuals for the real estate (top) and the market portfolio (bottom). A property of using CSR is that the estimated volatility over a given time period is equal to the slope of the CSR. Notice the difference in volatility between real estate stocks and the general stock market index. The high volatility in the real estate stocks is due to the industry risk of the portfolio while the lower volatility in the Swedish market portfolio represents the combined idiosyncratic and country specific risk. Notice that the empirical CSR of the real estates are tight to the theoretical CSR (line). This is not the case for the Stock market portfolio, where the

[4] See also Frennberg and Hansson (1992). This database is regularly updated. We use data from 1999.

[5] The cumulative squared residuals are similar to the CUSUM test. The latter employs recursive squared residuals.

empirical CSR deviates from the theoretical, which according to figure 1b. This is in line with previous research that have found evidence of time varying volatility in the Swedish general stock market portfolio (Frennberg and Hansson (1993)).

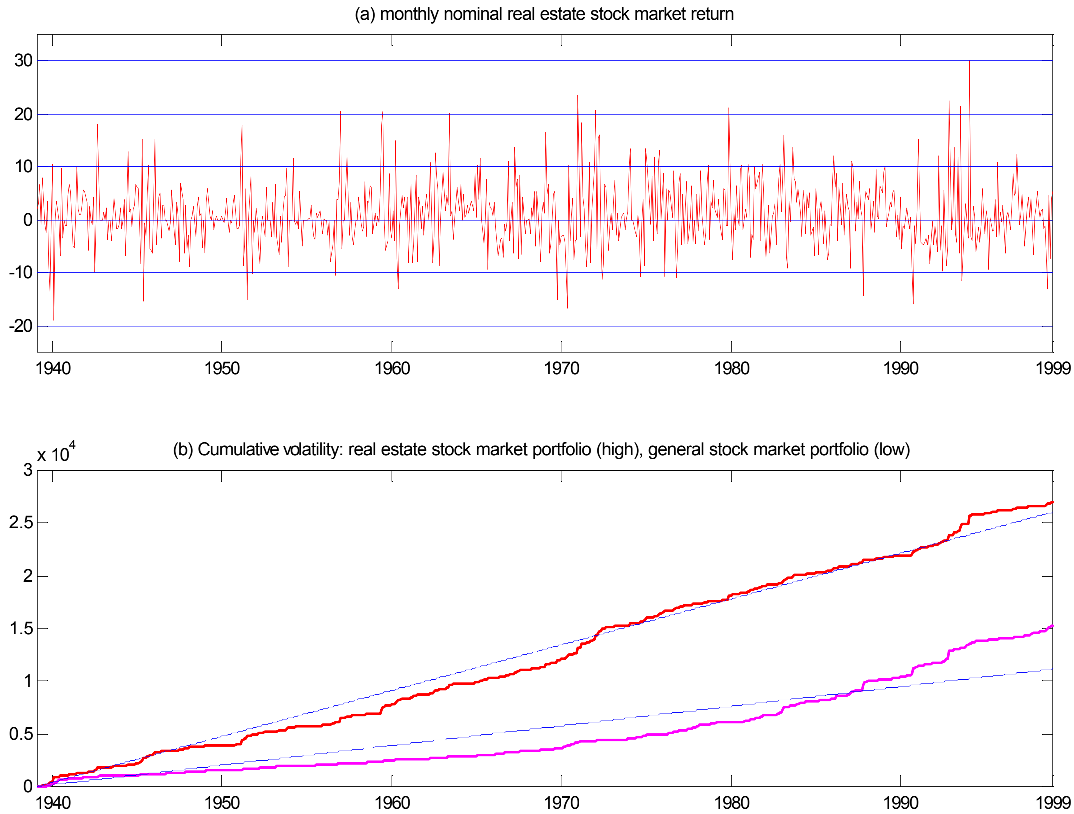

Figure 1: Nominal Returns of Real Estate Stocks Jan. 1939- Dec. 1998

3.1 Seasonal effects

Previous studies have found seasonal effects in the Swedish market portfolio. The question is whether there exists seasonal effects in the real estate data and if the effects exist, are they stronger or weaker in comparison to the ones found in the market portfolio. Table 1 presents the mean and the standard deviation of the month-by-month returns as well as the result of the F-test with the null hypothesis of no seasonal effect. As we can see in figure 2 the distribution of the month-by-month returns of the real estate index indicates a presence of seasonal effects with below average returns in June and September and above average returns in July and December.

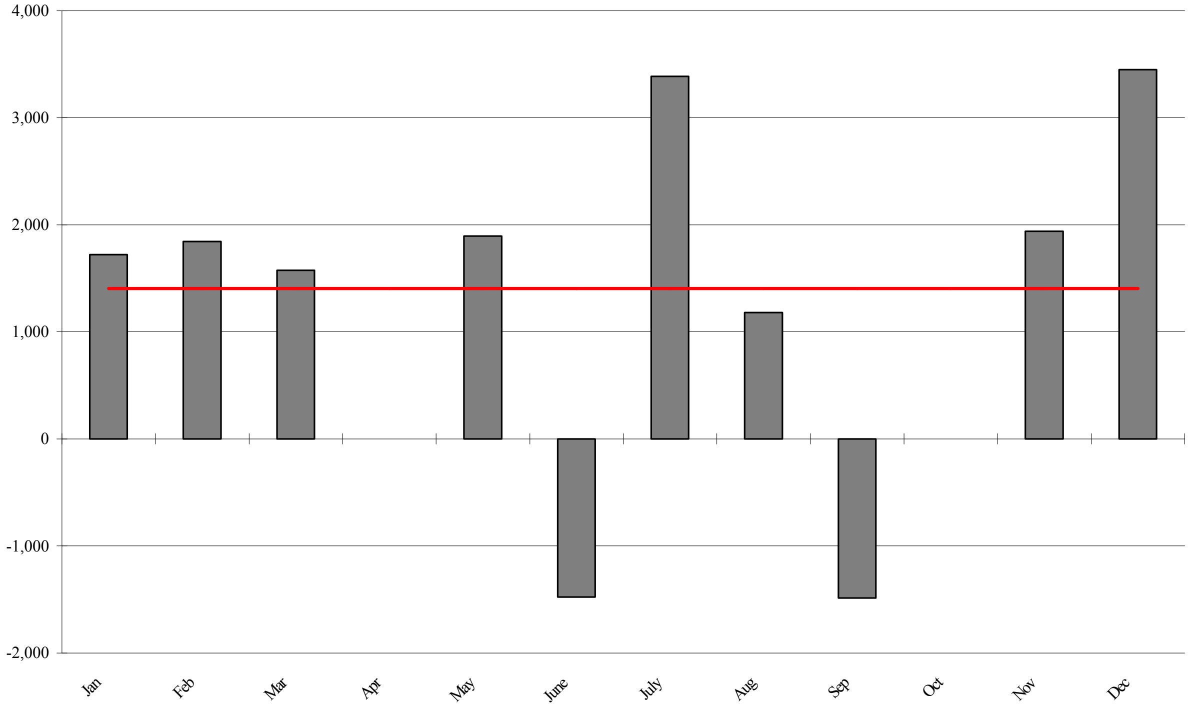

Figure 2: Distribution of nominal month-by-month returns from real estate stocks 1939:1 - 1998:12

However, from our result in table 1 we cannot find any support of a positive January effect as reported by other studies and with the exception of the period 1969-1978, (F-stat: 2.590 (0.006)), there is not any support of monthly seasonal effects. This is different to the results for the Swedish stock market as reported by Frennberg and Hansson (1993) but also to international evidence (see Gultekin and Gultekin (1983) and Corhay, Hawawini and Michel (1987)).

Table 2 reports the returns of four-month holding periods: December to March, April to July, August to November, and the F-test of equal returns for the holding periods. We find no statistical support for four-month seasonal returns and this contradicts the findings by Frennberg and Hansson (1993), see table 2. As the real estate stocks do not

Table 1: Mean and Standard Deviation of Month to Month Returns of Real Estate Stock Market, and Test of Equality of Mean Returns

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	F-stat
1939-98													
Mean	1.81	1.94	1.43	-0.80	1.35	-1.45	3.22	1.06	-1.25	0.49	1.59	3.38	0.46
S D	7.56	6.13	6.26	4.97	6.44	5.44	4.42	6.55	5.66	5.26	6.01	6.40	[0.84]
1939-48													
Mean	-2.51	-0.76	2.04	-1.26	2.25	-0.70	2.05	3.76	-1.66	-1.85	0.37	4.26	1.59
S D	7.48	3.55	6.17	5.86	6.40	5.74	3.31	6.05	3.80	5.48	4.26	6.20	[0.11]
1949-58													
Mean	1.01	3.79	-1.80	-0.43	0.65	-4.07	2.04	0.66	0.13	1.52	-1.43	2.68	1.80
S D	4.60	6.86	4.26	4.81	4.50	4.11	2.41	4.96	5.34	3.79	4.00	6.38	[0.06]
1959-68													
Mean	3.44	-0.19	4.76	0.04	3.11	-0.41	3.93	-1.24	0.50	1.12	2.82	-0.05	1.02
S D	3.48	3.76	8.15	4.52	10.86	8.07	5.36	5.44	4.42	4.72	4.47	4.54	[0.44]
1969-78													
Mean	1.56	5.94	2.40	-0.63	-1.39	-0.71	1.77	3.24	-4.74	1.22	0.01	9.12	2.59
S D	9.14	6.57	6.64	6.97	6.67	6.33	3.27	7.01	7.02	5.06	5.62	8.56	[0.01]
1979-88													
Mean	1.30	2.17	1.94	-1.27	2.39	-0.06	5.89	3.12	-0.33	2.15	4.40	4.32	1.26
S D	7.20	7.61	5.38	4.77	3.84	3.32	2.72	6.95	3.39	7.16	7.47	4.31	[0.25]
1989-98													
Mean	6.05	0.71	-0.74	-1.25	1.13	-2.75	3.60	-3.18	-1.37	-1.20	3.35	-0.03	1.75
S D	10.27	5.97	5.57	3.33	4.38	3.78	7.11	6.95	7.93	4.80	8.21	3.40	[0.07]

Note: Underlined F-values rejects null hypotheses of white noise at 95% level. P-values whitin brackets.

Table 2: Mean and Standard Deviation of Real Estate Stock Market Returns December to March, April to July and August to November, and Test of Equality of Mean Returns

Period	December to March	April to July	August to November	F-stat
1939-1998				
Mean	5.15	3.12	0.93	0.00
S D	10.79	10.14	10.88	[1.00]
1939-1958				
Mean	0.76	0.97	-1.30	0.21
S D	9.03	6.93	9.62	[0.82]
1959-1978				
Mean	9.15	3.16	0.49	0.30
S D	11.67	12.91	10.26	[0.75]
1979-1998				
Mean	5.55	5.22	3.58	0.03
S D	10.32	9.70	12.52	[0.97]

Note: We cannot reject the null hypothesis at 95 percent level. P-values in parentheses.

contribute to the anomalies, the seasonal effects found by Frennberg and Hansson (1993) and in Swedish stock market data must be explained by other industries.

3.2 Serial independence

This section investigates if the monthly returns are subject to serial independence both in levels and in volatility. If the returns have serial dependence in level we would be able to extract information from historical data. The test is the Ljung -Box statistic using twelve lags and a test of each specific lag being autocorrelated. The results are presented in table 3. The rejection of the null hypothesis at individual lags yields mixed conclusions. For the period 39-48 we cannot reject a negative one-month dependence. Both periods 59-68 and 69-78 have a significant past year return (lag 12). However the null hypothesis of no serial correlation is only rejected for the period 59-68. It is hard to find economic interpretation to the rejection of lag 5 (89-98), lag 6 (79-88) and lag 7 (59-68).

Table 3: Autocorrelation at lag 1-12 of Monthly Nominal Returns

Period	Autocorrelation ρ at lag												L-B
	1	2	3	4	5	6	7	8	9	10	11	12	
1939 - 1998	-0.04	-0.03	0.01	0.03	-0.03	0.03	-0.05	0.06	-0.00	-0.04	0.01	0.07	12.
1939 - 1948	-0.20*	-0.10	0.02	0.10	-0.06	0.04	0.02	-0.13	0.08	0.01	-0.05	0.04	11.
1949 - 1958	-0.02	-0.10	0.06	-0.14	0.13	0.01	-0.02	-0.07	-0.07	-0.04	-0.07	0.03	8.3
1959 - 1968	0.01	-0.03	-0.11	0.10	0.10	0.08	-0.20*	0.13	-0.05	0.18	-0.05	-0.20*	22.
1969 - 1978	-0.03	-0.03	-0.01	0.08	-0.08	-0.03	-0.04	0.03	-0.04	-0.04	0.03	0.26*	11.
1979 - 1988	0.06	-0.13	-0.01	-0.02	-0.01	-0.19*	-0.06	0.00	0.10	0.04	0.01	-0.01	8.8
1989 - 1998	-0.13	0.06	0.08	0.02	0.20	0.14	-0.10	0.19*	0.06	0.04	0.10	0.09	20.

Note: Astrix reject null hypotheses of WN at 95% level. Critical values for individual lags:
120 observations +/-0.18, and 720 observations +/-0.08.

Table 4: Test of Time - Varying Volatility

Period	LM-stat	Sign. level	L-B Q(12)	Sign. level
1939 - 1998	91.44*	0.08	21.73*	0.04*
1939 - 1948	6.37	0.90	5.32*	0.95
1949 - 1958	24.57*	0.02*	26.21*	0.01
1959 - 1968	12.58	0.40	11.84	0.46
1969 - 1978	16.54	0.17	16.77	0.16
1979 - 1988	9.34	0.67	4.26	0.98
1989 - 1998	17.82	0.12	20.15	0.06*

Note: Astrix reject null hypotheses of white noise at 95% level.
LB-Q(12) and LM(12) is χ^2_{12} . Critical value for the test statistic is 21.03.

3.3 Stable volatility

We perform two test of time varying volatility a Lagrange multiplier test and a Ljung-box test of serial independence between the squared residuals. The results are presented in table 4. An unexpected finding is the rejection of the serial independence during the period 1949-1958. The Ljung-Box statistic rejects the null at a 6 percent level for the last decade However it is not rejected by the LM test. This can be explained by extraordinary events during this period.[6] The explanation of the overall rejection of the null hypothesis by the Ljung -Box is the rejection of the null hypothesis during, 1949-1958 and near rejection during the last decade 1989-1998. 1989-1998.

[6]See Graflund (2001) for a detailed description of these events.

3.4 Random walk of the index

Mean reversion have been found in several stock markets including the Swedish. The overall conclusion of mean reversion has been that stocks are less risky in the long run. However Malliaropulos and Priestly (1999) and Kim, Nelson and Startz (1998) and Graflund (2000) have questioned the evidence of mean reversion. Risager (1998) finds a significant mean reversion effect in real return but not in the nominal returns from Danish stock market data. According to the author this reflects a slow adjustment to inflation by the stock market.

We use twenty different investment horizons from two months up to 120 months (10 years). Hence we are able to test the hypothesis both in the short-run and the long run. The variances and variance ratios are computed using overlapping month-to-month returns. The second column in table 5 refers to the actual in sample variance and the third column to the random walk implied variance. The variance ratios are presented in the fourth column and the last column presents the p-value. The actual variance is below the implied variance for investment horizons between two up to twelve months. This is also reflected by the variance ratios being below one. The VR-test has a minimum value at three months (0.931) and a maximum at 120 months (1.337). The random walk hypothesis cannot be rejected and the result is robust to the investment horizon. Thus, we cannot reject that the nominal returns of the real estate index follow a random walk. Recent literature reports that the variance ratio test to be sensitive to time-variation in volatility (Kim, Nelson and Starz [1991, 1998] and Malliaropulos and Priestly [1999]). Thus, the evidence of mean reversion in financial time series is controversial as it might be explained with the often-found time varying volatility. This should not present a problem in our case as we find very little evidence of time-varying volatility, with an exemption of the period 1949-1958 decade.

Table 5: Variance Ratio Test of Mean-Reversion

Horizon, q (months)	Actual variance	Random Walk implied variance	VR(q)	Prob.
2	0.007	0.007	0.965	0.508
3	0.010	0.011	0.937	0.463
4	0.013	0.014	0.931	0.538
5	0.017	0.018	0.940	0.653
6	0.020	0.022	0.936	0.674
7	0.024	0.025	0.941	0.728
8	0.027	0.029	0.934	0.720
9	0.030	0.032	0.940	0.764
10	0.034	0.036	0.947	0.805
11	0.038	0.040	0.959	0.857
12	0.042	0.043	0.972	0.907
24	0.088	0.086	1.014	0.969
36	0.132	0.130	1.015	0.972
48	0.182	0.173	1.054	0.917
60	0.248	0.216	1.149	0.801
72	0.321	0.259	1.240	0.714
84	0.395	0.302	1.308	0.668
96	0.459	0.345	1.330	0.671
108	0.527	0.389	1.355	0.669
120	0.577	0.432	1.337	0.704

Note: We cannot reject the null hypothesis of white noise at 95 percent level.

4 Conclusion

This paper studies a new time series of 60 years of monthly returns of real estate stocks from 1939 to present. Previous studies have found seasonal effects in the stock return data. However, no such strong conclusion can be made for the swedish real estate stock market. Further there is little evidence of serial correlation. The results of our test of stable volatility finds statistical evidence of time variation in volatility only in one subperiod during 1949-1958. Further stable volatility could not be rejected for the whole sample case. Given the result in Graflund (2001) we find that nominal returns from a value-weighted portfolio of Swedish real estate stocks can be characterized as strict white noise.

In context of previous studies of the Swedish stock market our result suggests that the irregularities, such as seasonal effects originates from other industries.

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