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Post-Acquisition Performance in the Short and Long Run: Evidence from the Copenhagen Stock Exchange

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Post-Acquisition Performance in the Short and Long Run

Evidence from the Copenhagen Stock Exchange 1993-1997

by

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Abstract:

This paper investigates the short-run price adjustment around the acquisition announcement and the long-run upward bias of the cross-sectional average buy-and-hold returns. We apply the geometric Brownian motion model to decompose the cross-sectional average long-run returns into mean components and volatility components. The decomposition is necessary in order to interpret security performance correctly using the measure of wealth relatives. This procedure is useful for any studies of long-run security performance. The most surprising finding is that the long-horizon abnormal return after three years is not significantly different from zero. This implies that the acquiring firms do not under perform significantly compared to the market. That result stands in contrast to findings of other studies, and it may reflect that earlier studies do not adjust for the volatility component. This indicates that the market efficiency hypothesis is intact in the long run. It is only in the very short run, i.e. a few days around the acquisition announcements, that the market makes a significant adjustment to uphold the efficiency hypothesis.

Keywords: Event-study methods; wealth relatives; long-run returns; acquisitions
JEL classification: G14, G34

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I. Introduction

This paper investigates both short-run price adjustments around acquisitions and long-run security performances following acquisitions. In the short run, the event-study methodology provides correct and testable measurements of abnormal returns. For the long-run returns, the problem of right-skewed buy-and-hold returns distorting the inference of security performance.

The results of the short-run analysis show that the information content from an acquisition announcement is concentrated around a small event window. The cumulative average market model abnormal return from –15:-1 days is positive 1.5 percent and it is asymptotically significant with a t-value of *2.57*. For the event period +1:+15 days the cumulative market model abnormal return is negative 1.2 percent and it is asymptotically significant with a t value of -2.20. The size of the abnormal return is relatively small and for the event time –15:+15, days the cumulative market model abnormal return is not significant *(t=0.29)*.

For the long run, recent studies show inference problems of long-horizon security performance and test statistics. One particular problem is the right-skewed distribution of long-run returns. Barber & Lyon (1997) and Kothari & Warner (1997) point out severe problems that relate to the fact that the abnormal returns after a period of time become right skewed, which implies that the long-run returns are non-normally distributed. Fama (1998) argues that these problems are more serious with long-term returns because the errors in expected returns grow faster with time than volatility. An explanation of the right-skewed distribution of buy-and-hold returns is that if the periodic returns are symmetric and independently distributed, right skewness and autocorrelation will arise in the distribution of the accumulated buy-and-hold returns. The contribution of this paper is to adjust the problem of right-skewed distribution of long-run returns. We apply the geometric Brownian motion model to decompose the average buy-and-hold return into its mean and noise component. Applying this method shows that the noise-adjusted abnormal buy-and-hold return is insignificantly different from zero.

Long-horizon event studies, using the conventional method of arithmetic means of long-run returns, report an abnormal price adjustment that continues several years after a corporate announcement.[1] For US data, Agrawal, Jaffe & Mandelker (1992) find that mergers experience an average abnormal return of negative 10 percent over a five-year period using a size portfolio adjusted benchmark. However, Franks, Harris & Titman (1991) find no average abnormal return over a three-year period. However, Loughran & Vijh (1997) find, using a buy-and-hold strategy, a negative average abnormal return compared to matching firms over a five-year post-event period. When we apply the conventional measure of the arithmetic means on wealth relatives, the market out performs acquisitions firms by 25 percent after three years. However, the volatility-adjusted out performance is merely 10 percent and insignificant after three years. In addition, we investigate for cross-sectional changes due to acquisitions by comparing beta estimates from the market model before and after the announcement. There is no evidence of cross-sectional struc-

[1] Loughran & Ritter (1995) for initial public offerings, Agrawal, Jaffe & Mandelker (1992) for mergers and acquisition firms, Ikenberry, Lakonishok & Vermaelen (1995) for share repurchases, Michaeley, Thaler & Womach (1995) for dividend initiations and omissions, Speiss & Affleck-Graves (1995) for seasoned equity offerings, Loughran & Vijh (1997) for corporate acquisition firms, and Jakobsen & Sørensen (1998) for initial public offerings.

tural changes in the long-horizon performance following an acquisition. In general, our results support Fama's (1998) argument that the market efficiency hypothesis is intact because anomalies from acquisition firms disappear with a change in the model used to estimate the expected returns. The estimation methodology may be the cause of the long-horizon anomalies.

The structure of the paper is as follows: Section II provides descriptive statistics on acquiring firms, their returns, and market returns. Section III describes the standard methodology used in short-horizon event studies and shows features of the share price movements surrounding acquisition announcements. Section IV provides the proposed methodology for testing long-horizon buy-and-hold returns from wealth relatives and shows evidence of non-significant long-horizon security performance. Section V tests for structural changes before and after firms' acquisition announcements and Section VI states concluding comments.

II. Description of data

The data used in this study contains acquisition announcements when the acquiring firm is from Denmark.[2] The acquisitions are gathered form the monthly reports of the Copenhagen Stock Exchange that include acquisitions when Danish firms acquire domestic as well as foreign firms. The announcement dates from the Copenhagen Stock Exchange are double checked against announcement dates reported in Reuters Business Briefing. For each acquiring firm, the daily returns are gathered from Datastream and monthly returns are gathered from Account Data.[3] The mean returns, market-adjusted returns, and market model returns for the portfolio of firms in our sample is described in Table I.

[INSERT TABLE I]

The first line shows the number of acquisitions. The number rose from 11 in 1993 to 40 in 1997, the last year in our sample. Our sample includes a total number of 138 acquisitions. Table I presents the averages of monthly returns 6 months before and 6 months after the event month. The acquiring firms' average return decreases after an acquisition announcement. The 6-months average return before an acquisition is 1.73 percent, while after the acquisition the 6-months average return decreases to 1.55 percent. Applying a second method, the market-adjusted model, the 6-months average monthly abnormal return is calculated as $\overline{AR_t} = \overline{R}_t - \overline{R}_{m,t}$ where $\overline{R}_{m,t}$ is the 6-months average of the monthly returns of the Danish Total Market Index. $\overline{R}_t$ is the 6-months equally weighted average monthly returns of the acquiring firms. The 6-months average abnormal return before acquisition announcements is positive whereas after the announcements the 6-months average abnormal return is negative and the standard deviations are very high compared to the means. A third method, the market model, calculates the abnormal return as $MAR_t = R_t - (a + b \cdot R_{mt})$, where the parameters (α, β) are estimated using the returns in a period of 48 months before the event window. The 6-months average market model ab-

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[2] The data used in this study are an extension of the data gathered by Leyvsohn (1998). He presented us with the list of takeover announcements. We have expanded the data to include monthly returns.

[3] Account Data is a database that contains information about all firms that are listed on the Copenhagen Stock Exchange. It contains annual reports and market information about each security.

normal return is overall positive before and after the acquisition announcements, with the exceptions of 1994 and 1995; however the standard deviations are still very high. The results of Table I show that it is not possible to determine differences in the 6-months average abnormal returns before and after the acquisition announcements. Therefore, we change the horizon for the calculation of the average by looking at the short-run, i.e. the event window of 30 days and the long run of 36 months. The short-run effects are analyzed in section III and the long-run effects are analyzed in section IV.

III. Price movements around announcement

Empirical findings show several characteristics for acquisition firms, e.g. the shareholders of the acquired firms earn positive average abnormal returns while the shareholders of the acquiring firms experience negative average abnormal returns (Loughran & Vijh, 1997 and Agrawal, Jaffe & Mandelker, 1992). Also, empirical evidence demonstrates that a transfer of wealth occurs from acquiring shareholders to acquired shareholders (Jarrell, Brickley & Netter, 1988). The positive abnormal return of the shareholders of the acquired firms, or equivalently the negative abnormal return of the shareholders of the acquiring firms, depends on the size of the wealth transfer and the choice of the benchmark (reference) portfolio. The choice of the benchmark will always influence the magnitude of the abnormal returns. However, in the short run, the choice of benchmark is not so important for the measurement of the abnormal returns.

A. Event study methodology

The methodology used to estimate the short-horizon abnormal returns is standard and follows the method in Campbell, Lo, & MacKinlay (1997). After the announcement date is identified for an acquisition, the returns are aligned in event time, t, relative to the announcement date, $t=0$. The market model abnormal returns in the event-window around the event date are calculated using the expected returns of a market model.[4] The estimation of the parameter vector, q_i, is obtained by the ordinary least square method for the estimation window $L_1=T_{1*} – T_0$, where T_0 is the first observation in the estimation window and $T_{1*}=T_1-1$ is the last observation in the estimation window. The market model abnormal return vector for the event window is: $e^{\circ}_i = \boldsymbol{R}^{\circ}_i - \boldsymbol{X}^{\circ}_i q$, where ° denotes that the vector is from the event window $L_2=T_2 – T_1$, where T_2 is the last observation in the event window. Assuming N observations (events) in the event window, the Average Market-model Abnormal Returns (*AMAR*) is defined as:[5]

$$AMAR = \frac{1}{N} \cdot \sum_{i=1}^{N} e_i^{\circ} \ . \qquad [1]$$

Given *AMAR*, consider a period in the event window in the range t_1 to t_2, where $T_1 < t_1 £ t_2 £ T_2$. The Cumulative Average Market-model Abnormal Return (*CAMAR*) from time t_1 to t_2 is defined as:

[4] The market model is: $\boldsymbol{R}_i = \boldsymbol{X}_i q_i + e_i$, where $R_i = [R_{iTo+1} \ .. \ R_{iT1}]'$ is a $(L_1 x\ 1)$ vector of returns for firm i in the estimation window between T_0 and T_{1*}, i.e. $L_1 ° T_{1*}-T_0$. $X_i = [i, \boldsymbol{R}_m]$ is an $(L_1\ x\ 2)$ matrix between T_0 and T_{1*} with a vector of ones in the first column and the value-weighted market return vector $\boldsymbol{R}_m = [R_{mTo+1} \ .. \ R_{mT1}]'$ in the second column. $q_i = [a_i\ b_i]$ is the (2x1) parameter vector. $e_i = \boldsymbol{R}_i - \boldsymbol{X}_i q_i$ is the $(L_1\ x\ 1)$ vector of abnormal returns in the estimation window.

[5] The average abnormal return is a cross-sectional mean that has the advantages that it is taken across many observations. Therefore, potential influences from other simultaneously construed information, either firm specific or the result of market effects, are minimized.

$$CAMAR\,(t_1,t_2) \equiv \sum_{t=t_1}^{t_2} AMAR_t \qquad [2]$$

An advantage of using cumulative average market model abnormal returns is that the accumulated *AMARs* may describe systematic deviations. Moreover, if the *AMARs* are normally distributed, the *CAMAR* is also normally distributed which allows for standard tests. The asymptotic test statistic of the cumulative average market model abnormal return (*CAMAR*) over the period t_1 to t_2 is standard normal distributed:

$$J_1 = \frac{CAMAR(t_1,t_2)}{\sqrt{\operatorname{var}(CAMAR(t_1,t_2))}} \quad \sim \quad N(0,1) \qquad [3]$$

where

$$\operatorname{var}(CAMAR(t_1,t_2)) = g'\left(\frac{1}{N^2}\sum_{i=1}^{N}\hat{s}_{e_i}^2\left(I + X_i^*\left(X_i'X_i\right)^{-1}X_i^{*'}\right)\right)g \qquad [4]$$

and g is a vector with ones in position t_1 to t_2 and zeros in position t_1 to T_1 and t_2 to T_2. $\hat{s}_{e_i}^2$ is the variance estimate of the error in the ordinary least squares and I is the identity matrix with the dimension of $(T_2-T_1)'(T_2-T_1)$ and X_i^* is the market return vector between T_1 and T_2. Using this parametric test, it can be tested whether or not the event has any impact or effect on the returns or the variance.[6]

B. Results on price movements

Table II presents the market model responses to the announcements. The cumulative abnormal returns are calculated over different event periods surrounding the announcement

[6] Assuming identical, independently distributed (IID) returns involve some implications. Brown & Warner (1985) point out that using daily stock returns imposes several important problems concerning non-normality, non-synchronous trading, and variance estimation. However, using cross-sectional daily excess returns, the mean return will converge to the normal distribution. The variance estimation adjusts for serial

dates using the standard methodology of the market model. For a firm *i*, the cumulative average market model abnormal return (*CAMAR*) is calculated from 15 days before an announcement to 15 days after.

[INSERT TABLE II]

We find that the information content of acquisition announcements is concentrated around a small event window. The *CAMAR* for event period (–15:-1) is positive 1.5 percent and significant with a t-value of *2.57*, however, the *CAMAR* for event period (+1:+5) is not significant. The *CAMAR* for event period (+1:+15) is negative 1.2 percent and significant with a t-value of *-2.20*. The size of the average market model abnormal return is relatively small and for the event period (–15:+15) the *CAMAR* is not significant *(t=0.29)*. Overall, we identify a positive and significant cumulative average market model abnormal return (*CAMAR*) before an announcement and a negative and significant *CAMAR* after the announcement. The results indicate that the marketplace is positively anticipating acquisitions, however, shortly after the announcement the market participants realign the stock price of the acquiring firm to its magnitude of return. In line with empirical findings[7], the short-run post-event return is negative though not significant. The common interpretation is that the price of an acquisition is an expense to the acquiring shareholders. Using a generalized sign z-test shows that the percentage of positive *AMARs* before an announcement is significant at a critical level of 10 percent. At the announcement date, the *AMARs* are positive and significant at a 5 percent critical level. This may indicate optimism in the marketplace about the acquisitions but the optimism is sub-

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dependence, cross-sectional dependence, and stationarity in the event-window (Campbell et al. 1997).

[7] See Asquith (1983), Jarrell, Brickley & Netter (1988), or Agrawal, Jaffe & Mandelker (1992)

sequently followed by a mean-reverting security performance, which is a pattern that is often observed for acquisition firms (see e.g. DeBondt and Thaler (1987), Fama (1998)). However, that pattern is not significant at any level in our sample. The next section investigates the long-run security performance of acquiring firms for up to three years.

IV. Long-horizon security performance

Several recent papers investigate problems with the design of the benchmark portfolio and the test procedures of long-run returns.[8] The problems of measuring long-run returns can be dealt with in at least two different ways. The first approach focuses on the design of the benchmark portfolio and the mis-specifications that arise from re-balancing biases and new listings. The second approach focuses on the test problems due to the right-skewed distribution of long-run returns regardless of the choice of the benchmark. The majority of studies do not distinguish between those ways of approaching the problems but rather treat them as one issue. For instance, the studies of Barber & Lyon (1997a and 1997b) and Kothari & Warner (1997) investigate re-balancing the benchmark portfolio to adjust for the problems with the right-skewed distribution of the long-run returns. Barber & Lyon (1997) argue that the mis-specification of the benchmark design causes the inference of long-horizon returns to be incorrect. Barber & Lyon (1997) also argue that it is possible to achieve well-specified test statistics of the buy-and-hold abnormal returns (BHAR), without adjusting for right skewness, if the benchmark consists of firms of

[8] See Conrad & Kaul (1993), Barber & Lyon (1997), Canina, Michaely, Thaler, & Womack (1997), Kothari & Warner (1997), Cowan & Sergeant (1997), Lyon, Barber & Tsai (1999).

similar size and book-to-market ratio.[9] Kothari & Warner (1997) also treats the problems as one issue and suggest a test statistic that is derived from a bootstrapping technique using simulated generated pseudo-portfolio distributions of long-run returns. Lyon, Barber & Tsai (1999) investigate both the re-balancing of the benchmark portfolio and the power of different t-tests of the long-run returns. Lyon, Barber & Tsai (1999) suggest a skewness-adjusted t-statistic based on the findings of Neyman and Pearson (1928) and Pearson (1928, 1929). The suggested test statistic partly adjusts for the third moment of a skewed distribution, and it is similar to parts of the standard asymptotic normality test of Jarque & Bera (1980).

We focus on second approach: the issue of the right skewness problem. We treat the problem of the long-run return performance from a statistical point of view by identifying the distribution properties of the long-run returns of the included variables, i.e. the acquiring firms and the Danish Total Market Index. We apply a two-step procedure. First, we test the long-run returns of each of the variables for log-normality. If the long-run returns of the variables do not follow log-normal distributions, we seek to form transformations of the variables that will exhibit log-normally distributed long-run returns, e.g. wealth relatives. Secondly, we apply the geometric Brownian motion to model the long-run returns of the accepted combinations of variables, e.g. wealth relatives. The advantages of using the Brownian motion model is that the model allows a decomposition of the average long-run returns into mean components and volatility components.

[9] Fama (1998) argues that corrections of expected returns using a matching approach based on size and BE/ME does not limit bad-model problems. Abnormal returns vary whether matching is based on size or size and BE/ME. Fama (1998) argues that this matching approach does not capture the cross-sectional variation in expected returns. Therefore, a matching approach for expected returns is not a panacea for bad-model problems in long-horizon event studies because the standard error in abnormal return increases with

A. Buy-and-hold returns

The main purpose of this paper is to investigate buy-and-hold returns over a long horizon. The investigation focuses on the issue of the right-skewed distribution of long-run returns that follow a post-event period of up to three years. The problems with the design of benchmark, e.g. re-balancing, survivalship, delisting and new listings, still exists and are not addressed in this study. However, these problems are not essential for the contribution of this paper because the right-skewed distribution of long-run returns will still be present regardless of the design of the benchmark.

The buy-and-hold return calculated for each acquisition, *i*, uses a rolling survival method beginning the month following an acquisition. Firms are included in the sample until they are delisted on the Copenhagen Stock Exchange or until they reach the last month that is included in our sample.[10] If an investor initially invests an amount $W_{i,0}$, the investor will have accumulated after T months the value $W_{i,T}$:

$$W_{i,T} = W_{i,0} \cdot \prod_{t=1}^{T} (1 + r_{i,t}) \qquad [5]$$

where $r_{i,t}$ is the stochastic monthly returns of security i at the end of month t. Without loss of generality, the initial value $W_{i,0}$ can be set equal to one and the buy-and-hold return then becomes

the number of months.
[10] The last month in the sample is the last month where we could gather available returns from Copenhagen Stock Exchange.

$$\prod_{t=1}^{T}\left(1+r_{i,T}\right)-1\,. \qquad [6]$$

We calculated cross-sectional average long-run returns in three different ways. First, we calculated a simple arithmetic mean of [6] for all of the acquisition firms and the corresponding market index. Secondly, we calculated average buy-and-hold returns of wealth relatives, where a wealth relative is defined as the ratio between two accumulated values. Assuming that the initial wealth relative is one, i.e. $\left(W_{A,0}/W_{M,0}\right)=1$, the wealth relative after T months for $i=\{1,\ldots,138\}$ and $T=\{1,\ldots,36\}$ is:

$$\frac{W_{A,T}}{W_{M,T}} \equiv \frac{W_{A,0}}{W_{M,0}} \cdot \frac{\prod_{t=1}^{T}\left(1+r_{A,t}\right)}{\prod_{t=1}^{T}\left(1+r_{M,t}\right)} = \prod_{t=1}^{T}\frac{\left(1+r_{A,t}\right)}{\left(1+r_{M,t}\right)} \qquad [7]$$

Finally, we calculated, what refer to as the "transformed buy-and-hold returns" (*T-BHAR*) using abnormal returns from the market model. To determine the expected returns of the market, we applied an estimation window of 48 months to estimate the necessary parameters of the market model. We defined the "transformed buy-and-hold abnormal return" as, where $ar_t = r_{i,t} - r_{m,t}$,.:[11]

$$T\!-\!BHAR_{i-m,T} \equiv \prod_{t=1}^{T}\left(1+ar_t\right)-1 \qquad [8]$$

[11] The T-BHAR definition is different from the commonly used buy-and-hold abnormal return defined as $BHAR_{i-m,T} \equiv \prod_{t=1}^{T}(1+r_{i,t}) - \prod_{t=1}^{T}(1+r_{m,t})$ -1.

The advantage of the *T-BHAR* is that it is more likely to be log-normally distributed than the *BHAR*. The *BHAR* at best consists of a difference between two log-normal distributions, which is not a well-defined distribution.

[INSERT TABLE III]

Table III shows the results of the long-horizon performance using all three methods. The results using the first method (arithmetic cross-sectional buy-and-hold returns) shows that the average buy-and-hold returns for acquiring firms and the market index is 52.7 percent and 53.3 percent, respectively after three years. The average buy-and-hold return for acquiring firms and the market index shows a different development compared to empirical studies using data from the United States. In our sample the acquiring firms are constantly under performing compared to the market index, but the under performance is much smaller. For example, after six months the acquiring firms under-perform with 2.9 percent (1.106/1.075-1) relative to the market and after two years the under-performance is 1.6 percent (1.458/1.435-1). In general, the standard deviations of the buy-and-hold returns of acquisition firms are larger than the standard deviations of the market index. For the second method (buy-and-hold returns of the wealth relatives), the three-year average buy-and-hold return of the wealth relative between the acquisition firms and the market return is 2.4 percent. However, when the wealth relative is the market against acquisition, the buy-and-hold return is 25 percent. The difference is due to Jensen's inequality (see section 3.C). For the third method (T-BHAR), the average three years transformed buy-and-hold abnormal return is –9.3 percent for $r_{it} - (a + b \cdot r_{mt})$, while the opposite relationship $(a + b \cdot r_{mt}) - r_{it}$ is 7 percent.

From table III it is evident that the average buy-and-hold returns are different depending upon the method used to calculate the abnormal returns. We investigates this further in the next section. After comparing the realized post-acquisition cross-sectional security performance with the findings in Ruback (1988), Magenheim & Mueller (1988), and Agrawal, Jaffe & Mandelker (1992), we also identify negative long-horizon abnormal returns. We test the mean of the negative average buy-and-hold return in section C.

B. The distribution of buy-and-hold returns

The results in table III can easy be mis-interpreted because the buy-and-hold returns of the three different methods do not share common distribution properties. We test the distribution of the buy-and-hold returns of each method to identify log-normal distribution properties. We find that the wealth-relative method in the spirit of Ritter (1991) and Loughran & Ritter (1995) is the method that most likely exhibits log-normally distributed long-run returns. In other words, the monthly returns are normally distributed and the accumulated value of wealth relatives are log-normally distributed and therefore right-skewed. Thus the logarithm of the wealth relative is:

$$Log\left(\frac{W_{A,T}}{W_{M,T}}\right)=\sum_{t=1}^{T}Log\left(1+r_{A,t}\right)-\sum_{t=1}^{T}Log\left(1+r_{M,t}\right) \qquad [9]$$

The logarithmic expression [9] is transformed back to level by applying the exponential function. This is shown in the following equations for the discrete time representation, and for the continuous time representation applying the geometric Brownian motion model.

Trans-formation	**The wealth relative**	**Discrete time**	**Continuous time**	
T1:	$\left(\frac{W_{i,T}^{M}}{W_{i,T}^{A}}\right)$	$e^{\sum_{t=1}^{T} Log(1+r_{M,t})-Log(1+r_{A,t})}$	$e^{m_{M/A}\cdot T + s\cdot Z_T}$	[10]
T2:	$\left(\frac{W_{i,T}^{A}}{W_{i,T}^{M}}\right)$	$e^{\sum_{t=1}^{T} Log(1+r_{A,t})-Log(1+r_{M,t})}$	$e^{m_{A/M}\cdot T + s\cdot Z_T}$	[11]

The T2-transformations are the reverse of the T1-transformations.[12] The expressions in continuous time enforce an explicit structure on the wealth relative measure that is described by a geometric Brownian motion in which m and s are constants, and dZ_t is a Wiener process with $dZ_t \sim N(0,dt)$.

C. Buy-and-Hold Returns From the Wealth Relative

Due to Jensen's inequality, it is not possible to directly test the level of the average buy-and-hold return, which implies that the expected level of the buy-and-hold return is not exactly log-normally distributed. The expected average buy-and-hold return is in levels given by the expression:[13]

[12] The test statistics for log-normality (not reported) are based on Doornik & Hansen (1994) that adjust for sample size. The problem is severe for the market model's estimates of buy-and-hold returns while the buy-and-hold returns of wealth relatives are acceptable log-normally distributed. Summarizing the probability level of normality and corresponding chi-squared statistics for wealth relatives shows that only 8 percent of the cross-sectional returns are rejected as log-normal distributed on a 5% critical level of significance. Test statistics for distribution properties from the buy-and-hold abnormal returns are available from the authors.

[13] The variance of the expected average buy-and-hold return in level is:

$$E\left(\frac{W_T^{\ M}}{W_T^{\ A}}\right) = e^{\left(m+½\cdot s^{\ 2}\right)T}, \qquad T = \{1,\ldots,36\} \qquad [13]$$

From expression (10) it is observed that the volatility implies an upward bias on the average wealth relative in levels. Thus, the reason for the differences in the buy-and-hold return of the wealth relatives observed in table III is caused by the volatility component. As the volatility component inflicts an upward bias on the average buy-and-hold return we decompose the wealth relative into its mean component and its volatility component. This decomposition allows us to capture the feature that periodic returns (i.e. monthly) may be symmetric and independently distributed while the buy-and-hold returns of the wealth relatives exhibit right skewness. The geometric Brownian motion explicitly models the mean and volatility components:

$$dLog\left(\frac{W_{i,T}^{M}}{W_{i,T}^{A}}\right) = m_{M/A,T}\,dt + s_{M/A,T}\,dZ_{i,t} \quad , \qquad [14]$$

where $i = \{1,\ldots,138\}$ and $T = \{1,\ldots,36\}$. $m_{M/A,T}$ is the constant mean parameter, $s_{M/A,T}$ is the constant standard deviation parameter, and $dZ_{i,t}$ is the volatility component that follows a Wiener process. The expected change in the logarithmic relationship over the time span dt is given by $m_{M/A,T}\,dt$ and the unexpected change is given by $s_{M/A,T}\,dZ_t$. The loga-

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$Var\left(\frac{W_T^M}{W_T^A}\right) = e^{2m\cdot T}\cdot\left(e^{s^2\cdot T}-1\right) = e^{\left(2m+s^2\right)T}\cdot\left(e^{s^2\cdot T}-1\right)$, where $T = \{1,\ldots,36\}$.

rithmic wealth relative, $Log\left(W_T^M / W_T^A\right)$, is normally distributed with mean $m_{M/A,T} \cdot T$ and standard deviation $s_{M/A,T} \cdot \sqrt{T}$.

D. Results of the decomposition of wealth relatives

Figure 1, panel A and panel C, show the developments in the average buy-and-hold returns of the wealth relatives. Figure 1, panel B and panel D, show the decomposition of the average buy-and-hold returns of the wealth relatives into mean components and volatility components. The mean component (normalized to zero) over the time horizon T is shown as $e^{m_{J,T} \cdot T}-1$, and the volatility component (also normalized to zero) over the time horizon T is shown as $e^{½ s_J^2 \cdot T}-1$, where $J = \{M/A, A/M\}$ and $T = \{1,\ldots,36\}$.

[INSERT FIGURE 1]

Panel A in figure 1 provides the average buy-and-hold returns of the wealth relatives $\left(W_{M,T}/W_{A,T}\right)$ and in panel B the decomposition into the mean component and the noise component shown as $e^{m_{J,T} \cdot T}-1$ and $e^{½ s_J^2 \cdot T}-1$, respectively. The product of the non-normalized components equals the non-normalized average buy-and-hold returns of the wealth relatives in panel A. Panel C and panel D in figure 1 show the components of the wealth relative, $\left(W_{A,T}/W_{M,T}\right)$. Comparing panel B and panel D in figure 1 shows that the volatility components are identical for wealth relatives $\left(W_{M,T}/W_{A,T}\right)$ and $\left(W_{A,T}/W_{M,T}\right)$. The correct inference of the abnormal buy-and-hold return is that the volatility component must be accounted for in the reported returns. In other words, the average cross-sectional buy-and-hold returns tend to under-estimate the under performance of acquisition firms.

The results show that the mean under performance of the acquiring firms relative to the market after three years is negative 9.3 percent. Or equivalently, the results show that the market out performs acquisition firms after three years with a positive 10.4 percent. This out performance of 10.4 percent is very different from the 25 percent out performance reported in table III. The difference is due to the volatility component and the difference is exactly the upward bias. The out performance of 10.4 percent is the correct measure while interpreting the 25 percent to be the out performance is inappropriate. The misinterpretation is even more pronounced when the under performance of 9.4 percent is considered because table III shows that the acquisition firms out perform the market by 2.4 percent. Next, we test the mean components to evaluate whether the under performance or over performance is significant.

E. Test of Expected Mean and Volatility Component

To test the estimates of the volatility-adjusted long-horizon security performance, we use a test statistic that evaluates the buy-and-hold returns using the logarithmic of the wealth relatives. We test the maximum likelihood estimate $m_{j,T}{}^{x}T$:

$$H_0: m_{j,T}{}^{x}T = 0, \qquad H_1: m_{j,T}{}^{x}T \; ^1 \; 0$$

where $j = \{M/A, A/M\}$ and $T = \{1,\ldots 36\}$. The tests of the maximum likelihood estimate $m_{j,T}{}^{x}T$ are shown in figure 2 as 95-percent marginal confidence intervals. The tests are marginal tests at any time horizon T, which means that the tests and confidence intervals are calculated cross-sectionally at any point in time. The mean component is t-distributed with $N-1$ degrees of freedom. The marginal confidence intervals for the volatility component are also included in figure 2.

[INSERT FIGURE 2]

The tests in figure 2, panel A and panel B, show that the mean component $m_{j,T}{}^{x}T$ is not significantly different from zero at a 95% level of significance. The development in the mean component implies that the acquiring firms do not significantly under perform when the long-horizon security performance is corrected for the upward bias from the volatility component. Evaluating long-horizon security performance necessitates a correction for the implied upward bias that is due to the volatility component.

V. Structural changes

This section tests the market-model abnormal returns for structural changes. If a firm acquires another firm it may change its risk exposure relative to the market for its existing shareholders. Therefore, the estimates of the market-model parameters, especially the beta coefficient, i.e. the correlation between the market and the acquiring firm, may change. To test whether an acquiring firm exposes its shareholders to a change of risk, we perform a simple Chow test for structural changes. The Chow test is performed by dividing the sample of monthly returns into two groups, i.e. before and after the acquisition announcements. The sum of squared residuals of the unrestricted group (the whole period) and sum of squared residuals of the restricted group (the period before the announcements) are compared in an ordinary F statistic with *2* and *n-4* degrees of freedom. A simple Chow test is performed because it is appropriate in a linear framework as provided by the market model.

[INSERT FIGURE 3]

Figure 3 shows the results of testing the beta coefficient of the market model for structural changes for the alternative estimation windows. Three different estimation windows are used and tested: 12 months, 24 months, and 48 months, respectively. The results in panel A (12 months) and panel B (24 months) provide no indication of any structural changes for the acquiring firms. When an estimation window of 48 months (panel C) is applied a total of 20 acquiring firms actually experience a structural changes. However, overall acquisitions made by firms listed on the Copenhagen Stock Exchange between 1993 and 1997 do not change the risk exposure for their shareholders.

VI. Conclusion

Event-study methods are commonly used to measure long-horizon security performance. However, the right-skewed distribution of long-run buy-and-hold returns invalidates the direct application of event study methods because of the upward bias, due to the volatility component, inherent in stochastic buy-and-hold returns. The right-skewed distribution of buy-and-hold returns obscures the inference and testing of arithmetic averages of cross-sectional long-run returns. However, if cross-sectional buy-and-hold returns can be constructed to be log-normally distributed, e.g. by the measure of wealth relatives, the model of the geometric Brownian motion can be applied to the long-run returns. The geometric Brownian motion model allows for a decomposition of any average long-run return into two distinct effects: a mean component and a volatility component. This decomposition is necessary for interpreting security performance when applying the wealth-relative measure. This procedure is especially useful for any studies of long-run security performance.

Using this technique we find that the market out performs the acquiring firms by 10.4 percent after three years, or equivalently, that the acquiring firms under perform the market by 9.4 percent after three years. Our most surprising finding is that the long-horizon abnormal return after three years is not significantly different from zero. This implies that acquiring firms do not under perform significantly compared to the market. That result stands in contrast to findings reported in earlier studies, and it may reflect that earlier studies do not adjust for the volatility effect. A simple test for structural change shows that firms listed on the Copenhagen Stock Exchange are not exposing their shareholders to additional risk when acquiring other firms.

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Table I. Monthly Security Performance, Average Market Adjusted Returns and Average Market Model Returns

A total number of 138 acquisition firms are included in our sample. The sampling frequency is monthly. The announcements are gathered from the monthly reports from Copenhagen Stock Exchange. The cross-sectional average return of the raw returns are calculated around the event time, i.e. for each acquisition the average return is calculated as $R_t = \frac{1}{N}\sum_{i=1}^{N} R_{it}$, where N is the number of acquisition firms for each year, R_{it} is the monthly return for acquisition at time t, and the average monthly return is defined as $\overline{R}_t = \frac{1}{6}\cdot\sum_{t=1}^{6} R_t$. The before averages are the last 6 observation prior to the announcement and the after averages are the 6 observations subsequent to the announcement. The monthly abnormal returns across acquisition firms are calculated by weighting each acquisition equally. $AAR = \frac{1}{6}\sum_{t=1}^{6} AR_t$, where AR_t is the average abnormal return measured as $AR_t = R_t - R_{mt}$. The average monthly abnormal return from the market model is $AMAR = \frac{1}{6}\sum_{t=1}^{6} MAR_t$, where $MAR_t = R_t - (a + b \cdot R_{mt})$ and the parameters (α,β) are estimated using the 48 monthly returns prior to the event window. Both the market adjusted and market model uses the total market index on the Copenhagen Stock Exchange. The standard deviations are shown in parentheses.

		1993	1994	1995	1996	1997	All
	Number of Acquisition firms (N)	11	18	40	29	40	138
Average Raw Returns ($\overline{R}_t$)	Before	0.0177 (0.0970)	0.0392 (0.1225)	-0.0035 (0.0691)	0.0219 (0.0595)	0.0247 (0.0655)	0.0173 (0.0793)
	After	0.0251 (0.0804)	-0.0042 (0.1192)	0.0135 (0.0891)	0.0226 (0.0644)	0.0189 (0.0861)	0.0155 (0.0882)
Average Market adjusted Returns (AAR_t)	Before	0.0028 (0.1087)	0.0261 (0.1350)	-0.0048 (0.0790)	0.0061 (0.0640)	-0.0086 (0.0735)	0.0010 (0.0876)
	After	-0.0063 (0.0927)	0.0035 (0.1300)	0.0033 (0.0963)	-0.0024 (0.0680)	-0.0128 (0.1017)	-0.0029 (0.0977)
Average Market Model Returns ($AMAR_t$)	Before	0.0041 (0.0977)	0.0327 (0.1226)	-0.0173 (0.0745)	0.0129 (0.0586)	0.0145 (0.0661)	0.0066 (0.0813)
	After	0.0121 (0.0823)	-0.0097 (0.1186)	-0.0002 (0.0925)	0.0142 (0.0655)	0.0090 (0.0880)	0.0051 (0.0899)

Table II. Price response around the announcements.

The abnormal returns in the event-window around the event date are calculated from the expected return using a market model. The market model is: $\boldsymbol{R}_i = \boldsymbol{X}_i q_i + e_i$, where $R_i = [R_{iTo+1} \, .. \, R_{iT1}]'$ is an $(L_1 x\ 1)$ vector of returns for firm i in the estimation window, $X_i = [i, \boldsymbol{R}_m]$ is an $(L_1\ x\ 2)$ matrix with a vector of ones in the first column and the value-weighted market return vector $\boldsymbol{R}_m = [R_{mTo+1} \, .. \, R_{mT1}]'$ in the second column. $q_i = [a_i\ b_i]$ is the (2x1) parameter vector. $e_i = \boldsymbol{R}_i - \boldsymbol{X}_i q_i$ is the $(L_1\ x\ 1)$ vector of abnormal returns in the estimation window. The estimation of the parameter vector, q_i, can be obtained by the ordinary least square method and the abnormal return vector for the event window is; $e^{\circ}_i = \boldsymbol{R}^{\circ}_i - \boldsymbol{X}^{\circ}_i q$, where ° denotes that the vector is from the event window. The cumulative average market model abnormal return is calculated from 15 days before the event to 15 days after. The test statistic $Z = \left[\frac{N^+}{N} - 0.5\right] \cdot \frac{N^{0.5}}{0.5} \sim N(0.1)$, where N^+ is the number of positive *CAR* and N is the number of observations is asymptotically normal distributed. The z-test is a non-parametric test of whether the abnormal returns are positive or negative.

Event Time	Cumulative Average *MAR*	t-test	p-value	Generalized Sign *Z*	p-value
-15:-1	1.459%	2.568	0.012[a]	1.424	0.157
-5:-1	1.207%	3.631	0.000[a]	1.659	0.100[b]
-1:+1	0.707%	2.706	0.008[a]	1.386	0.169
0:1	0.327%	1.543	0.126	2.020	0.046[a]
+1:+5	-0.125%	-0.393	0.695	0.479	0.633
+1:+15	-1.223%	-2.199	0.030[a]	-0.653	0.515
-15:+15	0.402%	0.285	0.776	1.275	0.205

[a,b] Statistical significance in 2-tailed tests at the 1% and 10% levels, respectively.

Table III Average Cross-Sectional Buy-and-hold returns

The time horizon is three years assuming that an investor invests in an equally weighted portfolio of firms immediately after the acquisition announcement. Wealth relatives are used to calculate buy-and-hold returns, $W_{i,t} = W_{o,t} \cdot \prod_{t=1}^{T}(1+r_{i,t})$. Applied transformations are $\left(W_{i,T}^{M} / W_{i,T}^{A}\right)$ and $\left(W_{i,T}^{A} / W_{i,T}^{M}\right)$, respectively. Two versions of the market model are applied, the standard method where the abnormal return (1) is $MAR_t = r_{it} - (a + b \cdot r_{mt})$, but also by subtraction firms-specific return from the market return (2) $MAR_t = (a + b \cdot r_{mt}) - r_{it}$. The MAR_t is used to calculate the transformed buy-and-hold abnormal return (T-BHAR). Standard deviation is in parentheses.

Months	N	Acquisition Buy-and-hold return $W_{A,t}$-1	Market Index Buy-and-hold return $W_{M,t}$-1	Wealth Relative $\left(W_{M,T} / W_{A,T}\right)$-1	Wealth Relative $\left(W_{A,T} / W_{M,T}\right)$-1	T-BHAR (1) $\prod_{t=1}^{T}(MAR_t)$-1	T-BHAR (2) $\prod_{t=1}^{T}(MAR_t)$-1
6	122	0.075 (0.166)	0.106 (0.101)	0.048 (0.162)*	-0.023 (0.151)	0.006 (0.178)	-0.022 (0.186)
12	104	0.195 (0.299)	0.215 (0.176)	0.065 (0.247)*	-0.010 (0.230)	0.062 (0.335)	-0.061 (0.294)
18	87	0.321 (0.423)	0.340 (0.253)	0.091 (0.323)*	-0.003 (0.295)	0.099 (0.455)	-0.072 (0.407)
24	72	0.435 (0.628)	0.458 (0.305)	0.179 (0.493)*	-0.004 (0.417)	0.149 (0.632)	-0.082 (0.500)*
30	53	0.491 (0.656)*	0.524 (0.313)*	0.190 (0.525)*	0.004 (0.443)	0.119 (0.683)	-0.081 (0.570)*
36	33	0.527 (0.744)*	0.533 (0.222)*	0.250 (0.661)*	0.024 (0.542)*	0.070 (0.762)	-0.093 (0.611)

*Normal distributed. Normality Test (Doornik and Hansen 1994)

Figure 1. The Development in the Mean Component and the Volatility Component.

The development in mean return and volatility are shown for buy-and-hold return. The development in average buy-and-hold return is shown in Panel A and C for $\left(W_{M,T}/W_{A,T}\right)$ and $\left(W_{A,T}/W_{M,T}\right)$ transformations, respectively. In panel B and D is the average components of the cross-sectional buy-and-hold return are decomposed in a mean component, $e^{m_{J,T}\cdot T}$ *-1*, and in a noise component, $e^{\frac{1}{2}s^{2}_{J,T}\cdot T}$ *-1*. The noise component is independent of whether $\left(W_{M,T}/W_{A,T}\right)$ or $\left(W_{A,T}/W_{M,T}\right)$ is used, and the noise component has a positive influence on the average long-horizon wealth relative performance. The average component of the buy-and-hold return depends on the used transformation of wealth relatives.

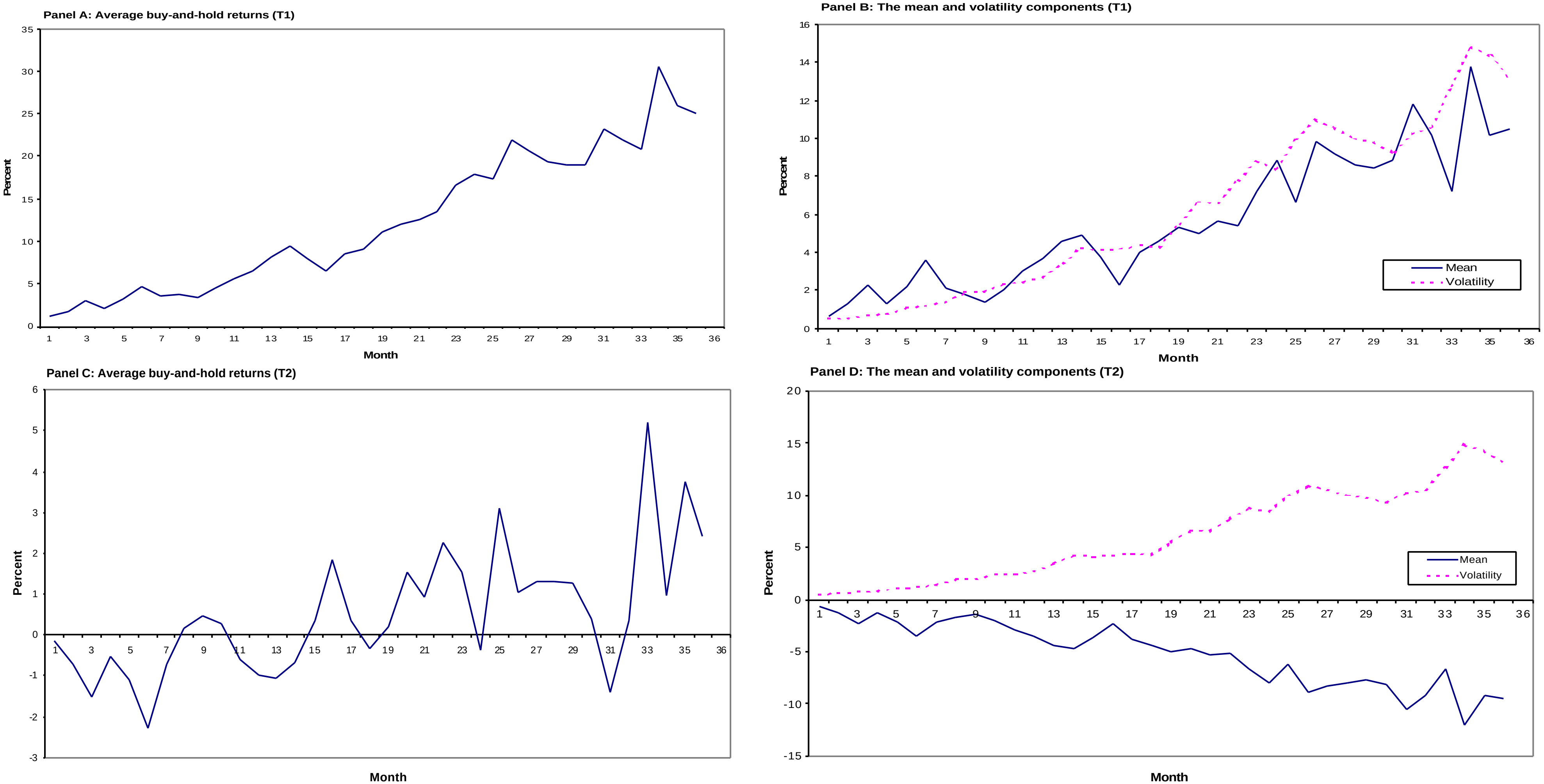

Figure 2 Test of the corrected long-horizon security performance

We test the maximum likelihood estimate $m_{j,T}\cdot T$. The test is H_0: $m_{j,T}\cdot T = 0$, H_1: $m_{j,T}\cdot T \neq 0$ where $j = \{M/A, A/M\}$ and $T = \{1, \ldots 36\}$. The maximum likelihood estimate $m_{j,T}\cdot T$ and also 95 percent marginal confidence intervals are shown. The mean component $e^{m_{j,T}\cdot T}-1$ for wealth relatives and their confidence intervals are shown in panel A and B, respectively. The volatility component $e^{\frac{1}{2}s^2_{j,T}\cdot T}-1$ and its confidence intervals are shown in panel C.

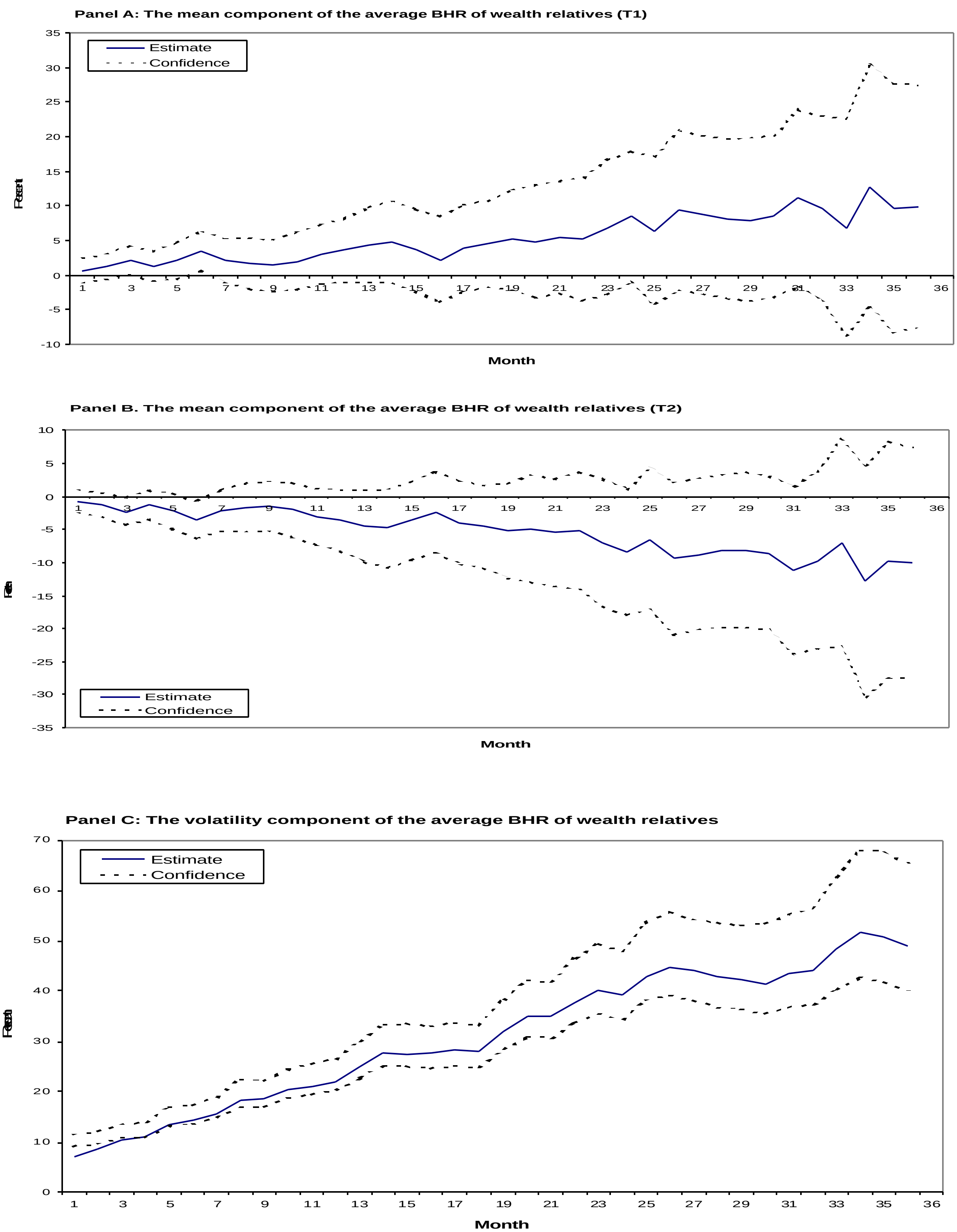

Figure 3 P-values of the Chow Test for Cross-Sectional Structural Changes
A simple Chow test is performed to test for structural changes of the beta coefficient of the market model. For each acquiring firm, a beta estimate is calculated prior to the announcement of an acquisition, and for the whole period. The Chow test tests for significant difference in the beta for the whole period compared to the pre-announcement period. The various estimation windows are -6:+6, -12:+12, and -24:+24 months. The panels show p-values.