Decomposing and Testing Long-run Returns

With an Application to Initial Public Offerings in Denmark

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WP 2000-2

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ISBN 87-90705-32-7
ISSN 0903-0352

Decomposing and testing Long-run Returns

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First version: October 1998
Current version: November 1999

Abstract

An improved method for measuring and testing long-run returns is proposed. The method adjusts for the right-skewed distribution of long-run buy-and-hold by decomposing average cross-sectional buy-and-hold returns into mean components and volatility components. The method is applied to initial public offerings in Denmark. The mean-component under performance of initial public offering stocks compared to the market is 30 percent and significant after five years. Compared to matching firms the under performance of IPO stocks is 13 percent after five years but insignificant.

Keywords: Market efficiency; initial public offerings; long-run returns; right skewed distributions; testing; volatility filtering.
JEL classification: G14, G32

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[*] Corresponding author. An earlier version of the paper has been presented at the European Financial Management Association in Paris, June 1999. We would like to thank Michael Rockinger and an anonymous referee for valuable comments. We have also benefited from comments at seminars at the Aarhus School of Business and Lund University.

1. Introduction

Recently, attention has been directed to the methodological issues of measuring and testing long-run returns, e.g. Barber and Lyon (1997), Fama (1998), Kothari and Warner (1997), and Lyon, Barber and Tsai (1999). Fama (1998) argues that the anomalies like over or under performance in studies of, e.g. initial public offerings and seasoned equity offerings are due to methodological problems and especially in the long run where the problem with the right-skewed distribution of long-run returns arises. Fama (1998), however, does not propose a method that can solve the problem with the right skewed distribution of long-run returns. Lyon, Barber and Tsai (1999) suggest a skewness-adjusted t-test statistic for testing long-run abnormal returns. The skewness adjustment origins from the third order moment adjustment of the asymptotic normality test but otherwise the distribution properties of long-run returns are not pursued any further. In the further pursuit of measuring and testing long-run returns we propose a methodology that does consider the distribution properties of long-run returns and according to the distribution properties explicitly model the long- run returns.

This paper addresses the statistical problems of measuring and testing long-horizon returns. We question the validity of prior tests of long-run returns, especially in the literature of initial public offerings and seasoned equity offerings. We show that prior tests applying simple t-tests cannot be assumed valid because of the right skewed distribution of the long-run returns. We propose a new method for measuring and testing long-run returns. Our point of origin is that the distribution properties of long-run returns have to be considered. The proposed method consists of two steps. First, we investigate whether the long-run returns are log-normally distributed. If the long-run returns of the data series are rejected as being log-normally distributed we look for transformations of the data series that will have long-run returns that can be accepted as being log-normally distributed. Secondly, when we have data transformations that are accepted as being log-normally distributed, we decompose each of the average cross-sectional long-run returns at the different time horizons into two components: a mean component and a volatility component. Each of those components can be tested for significance against alternatives and the marginal dynamics of the cross-sectional long-run returns, for the different time horizons, can be represented by geometric Brownian motions. The proposed method can be applied to any analysis of long-run returns. We apply the method to initial public offerings in Denmark in the period 1984-1992 allowing us to follow the long-run returns for up to five years after the offerings. We find that if data are transformed to wealth relatives the long-run returns of the wealth relatives can be accepted as being log-normally distributed.

The paper is organised as follows. Section 2 briefly describes, for our study, relevant findings of the initial public offerings literature. Section 3 describes the data of the study. Section 4 discusses the calculation of returns compatible with log-normality of cross-sectional buy-and-hold returns. Section 5 presents the proposed method and the decomposition, and section 6 presents the tests of the components. Section 7 summarises and concludes.

2. Initial Public Offerings

Several studies have shown that investment in initial public offering stocks (IPO stocks) is a money loosing strategy in the long run, however that result is in sharp contrast to a substantial number of studies of the first-day returns (initial returns) that concurrently report that it is indeed a very profitable strategy to invest in IPO stocks in the offering period.[1,2] The relatively large positive short-term returns are taken as indicating that the offering prices of IPO stocks are systematically set too low.[3,4] Regarding the long run, no theory has been proposed that satisfactorily can explain the long-run under performance of IPO stocks that is observed for up to five years after the initial public offerings. Loughran and Ritter (1995) go as far as to describe this pattern as being a "puzzle".

With Ritter's path breaking paper, Ritter (1991), the start was given to several studies of the long-run returns of IPO stocks on the international capital markets. Ritter (1991) and Loughran and Ritter (1995) find for US data that IPO stocks on average under perform other stocks up to five years after the initial public offerings. For the US, an average under performance of 29 percent is reported after the first three years and not less than 50 percent after five years. For other capital markets Levis (1993) finds that English IPO stocks experience an average loss of 30 percent three years after their initial public offerings compared to the market. Corresponding results have been found in Brazil and Chile (Aggarwal et al., 1993), Finland (Keloharjo, 1993), Switzerland (Kunz and Aggarwal, 1994), Australia (Lee et al., 1996) and in South Africa (Page and Reyneke, 1997).

Cross-sectional analyses of the stock returns by using broad economic and company specific characteristics have contributed with some interesting empirical results. Shaw (1971) finds indications that the under performance is the most widespread in periods with many initial public offerings - the so-called "hot-issue" periods. Loughran and Ritter (1995) confirm that under performance is relatively modest in periods with few initial public offerings and prominent in periods with many initial public offerings. Ritter (1991) finds that the under performance is more pronounced among small capitalisation offers and that this under performance is concentrated among relatively younger growth firms that are being offered in periods with a high initial public offering activity. That result is supported by Levis (1993) who also finds that the size of the issue is an important factor for explaining the under performance of small offers. A recent study by Brav and Gompers (1997) finds that the under performance is relatively modest among firms with venture companies behind the initial public offerings while it is more pronounced among firms without venture companies behind the offering.

3. The data

Our data set consists of Danish initial public offerings in the period 1984-1992 allowing us to calculate up to five years buy-and-hold returns for the period 1984-1997. Within the period 1984-1992 a firm that went public on the Copenhagen Stock Exchange could choose between an offering either of the fixed price system or of the tender system.[5] For the fixed-price system the new shares are offered to the public at a fixed price that is set in agreement between the IPO firm and the issuing bank/consortium in charge of the initial public offering. All orders are settled at the agreed price. In earlier times this method was widely used but the absolutely most widespread method within the analysed offering period is the so-called tender system. The tender system differs from the fixed price system by inviting the public to place binding orders at different prices above a specified minimum price. When settling the offering price of the IPO stock two conditions must be fulfilled in order to be allowed to float the stocks on the Copenhagen Stock Exchange. (i) The face value of the issue must be sold at the highest possible price and (ii) the spread of the stocks on different shareholders has to be sufficient. All orders with higher order prices than the actual offering price of the stocks are settled at the actual offering price no matter what the price offer had been. The sufficiency-spread rule regarding the allocation of the stocks on different shareholders is ambiguous and is assessed in each case by the Copenhagen Stock Exchange. The sample consists of 76 stocks within the population of shipping, trading, service, and industry (non-financial) that were offered at the Copenhagen Stock Exchange in the period January 1984 to December 1992. All the examined stocks were offered via the tender system. In Table 1 below the annual distribution of initial public offerings for the population is shown as well as the corresponding sample distribution of the 76 initial public offerings. Information about the individual stock characteristics (last day of offering, the price at the last day of offering, the issued amount, first day of trading, etc.) is gathered from Account Data.

[Insert Table 1 around here]

Table 1 shows that the number of and the value of the initial public offerings are not equally distributed through the sampling period as 64 out of the 76 initial public offerings (84 percent) took place within the period 1984-1986 with 90 percent of the total issued amount. The period 1984-1986 was a so-called hot-issue period characterised by high first-day returns and high volumes. This hot-issue period may be due to two effects: an increased attention on stocks by both firms and investors and the presence of a small capitalisation stock exchange. The increased attention on Danish stock in the mid-1980's was probably tricked by good business cycle conditions and a so-called 'real bond-yield tax' on institutional investors that was effectuated in 1983 and implied that capital moved towards the stock market resulting in increasing stock prices and increasing equity financing. Secondly, in 1982 a so-called small-capitalisation stock exchange was opened to promote stock financing of small size companies (2-15 mil. DKK). In 1989 the small-capitalisation stock exchange was closed. The distribution of the initial public offerings on the small-capitalisation stock exchange was 14 in 1984, 2 in 1985, 14 in 1986, 1 in 1987, and 1 in 1988. However, the small-capitalisation initial public offerings can only partly account for the large amounts of capital issued in the period 1984-1986. For the whole sample period 1984-1992 a total of 7 initial public offerings were excluded from the study either because the offerings followed the fixed price system (6 cases) or lack of access to data (1 case). The sample of the 76 initial public offerings covers 91.6 percent of the total number of initial public offerings within the period 1984-1992 and 89.3 percent of the total amount offered.

Besides data for individual stock characteristics we also include data for the market (we use the Danish Total Stock Index of the Copenhagen Stock Exchange) and data for stocks of matching firms. For each IPO stock we specifically choose a quoted stock of a matching firm of approximately the same size by market value that has been quoted on the Copenhagen Stock Exchange for at least five years.[6] We observe those two reference data series with the same frequency and dates as the IPO stocks. For instance, for the IPO stock: Ambu International Ltd. the last day of offering (the closing date of the initial public offering) was on 27th February 1992. We observe simultaneously the Danish Total Stock Index and the stock of the matching firm from the same date, 27th February 1992, and with the same frequency. This procedure is used for each of the 76 initial public offerings. The first-day return (initial return) of an IPO stock is defined as the percentage change of the stock price from the last day of offering to the first day of trading. The period between the last day of offering and the first day of trading is typically 8 to

10 days. The longest period observed in the sample is 19 days.[7] Regarding the after-market performance which covers the period from the first day of trading and onwards, the sampling frequency of the returns is monthly and the observations are end of month observations.[8] However, the first day of trading is usually not at the end of a month but e.g. in the middle of the month. This timing problem is corrected for by calculating the return of the first month as the return between the first day of trading and end of month of the subsequent month adjusted for the number of days between the two dates.[9]

4. Calculating returns

We are interested in investigating how the stock returns of the IPO stocks have performed compared to the market and the stocks of the matching firms for up five years after the initial public offerings.[10] For each stock, the long-run returns in the after market is calculated from the first day of trading and to the month where the IPO stock was either de-listed or celebrated its five years anniversary. If an IPO stock is de-listed on the Copenhagen Stock Exchange before its five years anniversary the return is followed to the month of the de-listing. The relevant measure of long-run returns is the so-called buy-and-hold return (BHR).[11] If an amount $W_{i,0}$ is invested in a stock i with the stochastic monthly return $r_{i,t}$ the amount after T months is $W_{i,T}$:

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

Accordingly, the buy-and-hold return of the stock i after T months is:

$$BHR_{i,T} = \prod_{t=1}^{T}(1 + r_{i,t}) - 1 \quad (2)$$

Figure 1A shows equally weighted average buy-and-hold returns for the IPO stocks, the market (Danish Total Stock Index), and the stocks of the matching firms. Figure 1B shows the corresponding standard deviations of the cross-sectional buy-and-hold returns.

[Insert Figure 1A and Figure 1B around here]

Figure 1A shows that the cross-sectional average buy-and-hold returns of the IPO stocks all are below the cross-sectional average buy-and-hold returns of the stocks of the matching firms. After 30 months the average buy-and-hold return of the IPO stocks starts to increase while the corresponding returns of the stocks of the matching firms do not. This indicates a diverging trend in the growth rates. Compared to the market (Danish Total Stock Index) the average buy-and-hold returns of the IPO stocks are above the average buy-and-hold returns of the market for the first 30 months but thereafter below. The average buy-and-hold returns of the IPO stocks increase after 30 months and increase with an average growth rate near the growth rate of the average buy-and-hold returns of the market, which indicates a converging trend in the growth rates. Figure 1B shows that the cross-sectional standard deviations of the Danish Total Stock Index starts at 6 percent and increases softly to 25-30 percent and stabilises at that level. The cross-sectional standard deviations of the IPO stocks and the stocks of the matching firms follow each other closely. They start at 7-10 percent and rise steeply the first 18-24 months to a level of 85-105 percent and stabilise at that level. Table 2 shows that the average cross-sectional buy-and-hold return 60 months after the initial public offerings is 43.2 percent for the IPO stocks, 69.8 percent for the market, and 55.5 percent for the stocks of the matching firms. (Table 2 also report cumulative abnormal returns though that measure is in general a misleading measure of long-run returns because the method of cumulative abnormal return does not account for the compounding effect that is inherent in buy-and-hold returns.)

[Insert Table 2 around here]

The performance differences between the average cross-sectional buy-and-hold returns of the IPO stocks and the market, and the stocks of the matching firms, are not as large as is the case of most other studies. After 3 years the IPO stocks under perform on average by 10 percent compared to the market ([1.129/1.263]-1) and after 5 years the IPO stocks under perform on average by roughly 16 percent compared to the market. That is a much smaller under performance than is the case for Great Britain and US (see above). Considering the cumulative abnormal returns in table 2 it is seen that there are differences to the buy-and-hold returns. The differences are due to the fact that cumulative abnormal returns do not account for the compounding effect as the buy-and-hold returns do. The differences between the buy-and-hold returns and the cumulative abnormal returns show that the cross-sectional buy-and-hold returns are not symmetrically distributed. Moreover, the p-values in brackets in table 2 reject all of the cross-sectional buy-and-hold returns as being normally distributed; though with the exception of the cross-sectional buy-and-hold returns of the market after five years which is accepted as being normally distributed on a 15-percent critical level of significance.[12]

Caution regarding inference has to be taken on the background of the average cross-sectional buy-and-hold returns if nothing is known about the distribution of the buy-and-hold returns. If the buy-and-hold returns are not symmetrically distributed around the averages as table 2 indicates, the standard deviations are insufficient statistics to describe the distribution of the buy-and-hold returns. It is necessary to determine how skewed the distributions of the cross-sectional buy-and-hold returns are. All in all, it is necessary to have a statistical starting point with distribution regularities in order to perform an analysis of the buy-and-hold returns.

5. Method and model

Our point of origin is that the cross-sectional buy-and-hold returns should be log-normally distributed at any time horizon. If that is the case we can decompose average cross-sectional buy-and-hold returns and model the marginal dynamics of long-run returns by the geometric Brownian motion model.

Log-normality and wealth relatives

In figure 2 the log-normality of cross-sectional buy-and-hold returns is tested. In particular, logarithms of the cross-sectional buy-and-hold returns are tested for normality on a five-percent critical level of significance using the normality test of Doornik and Hansen (1994) that adjust for the sample size. Figure 2 shows that the cross-sectional buy-and-hold returns of the market index are strongly rejected as being log-normally distributed. Also, the cross-sectional buy-and-hold returns of the IPO stocks are rejected as being log-normally distributed. However, the stocks of the matching firms are after the initial nine months after the initial public offering accepted as being log-normally distributed.[13]

[Insert figure 2 around here]

As the cross-sectional long-run returns of the data series, with the exception of the stocks of the matching firms, are rejected as being log-normally distributed we look for combinations or transformations of the three data series such that the transformed data series can be accepted as being log-normally distributed. We find that wealth-relative transformations can be accepted as being log-normally distributed, and they are:

$$\left(\frac{W_{i,T}^{IPO}}{W_{i,T}^{Market}}\right) \quad \text{and} \quad \left(\frac{W_{i,T}^{IPO}}{W_{i,T}^{Matching}}\right) \qquad \text{(T1)}$$

$$\left(\frac{W_{i,T}^{Market}}{W_{i,T}^{IPO}}\right) \quad \text{and} \quad \left(\frac{W_{i,T}^{Matching}}{W_{i,T}^{IPO}}\right) \qquad \text{(T2)}$$

for $i = \{1,\ldots,76\}$ and $T = \{1,\ldots,60\}$. Wealth-relative transformations have been used before in the literature, e.g. Ritter (1991) and Loughran and Ritter (1995).[14,15] The T2-transformations are just the reverse relationships of the T1-transformations. Figure 3 shows the test statistics for the logarithm of the wealth-relative transformations.[16]

[Insert figure 3 around here]

For the IPO stocks versus the market index it is seen in Figure 3A that here are problems with log-normality for up to 8 months after the first day of trading and again a bit after 4 years. For the IPO stocks versus the stocks of the matching firms the same qualitative picture applies in the beginning of the period.[17]

Consider the wealth relative W_T^{IPO} / W_T^{Market} at the end of month T, where $r_{IPO,t}$ and $r_{Market,t}$ are stochastic returns at the end of month t.

$$\frac{W_T^{IPO}}{W_T^{Market}} = \frac{W_0^{IPO}}{W_0^{Market}} \cdot \frac{\prod_{t=1}^{T}(1+r_{IPO,t})}{\prod_{t=1}^{T}(1+r_{Market,t})} = \frac{W_0^{IPO}}{W_0^{Market}} \cdot \prod_{t=1}^{T} \frac{(1+r_{IPO,t})}{(1+r_{Market,t})} \tag{3}$$

Taking the logarithm of the wealth relative gives:

$$\begin{aligned} \log\left(\frac{W_T^{IPO}}{W_T^{Market}}\right) &= \log\left(\frac{W_0^{IPO}}{W_0^{Market}}\right) + \sum_{t=1}^{T}\log(1+r_{IPO,t}) - \sum_{t=1}^{T}\log(1+r_{Market,t}) \\ &= \log\left(\frac{W_0^{IPO}}{W_0^{Market}}\right) + \sum_{t=1}^{T}\left\{\log(1+r_{IPO,t}) - \log(1+r_{Market,t})\right\} \end{aligned} \tag{4}$$

Going back to levels, the expression is:

$$\frac{W_T^{IPO}}{W_T^{Market}} = \frac{W_0^{IPO}}{W_0^{Market}} \cdot e^{\sum_{t=1}^{T}\left\{\log(1+r_{IPO,t}) - \log(1+r_{Market,t})\right\}} \tag{5}$$

Given that the cross-sectional buy-and-hold returns of the wealth relative is log-normally distributed at different time horizons T, the logarithms of the cross-sectional buy-and-hold returns of the wealth relative at different time horizons are normally distributed:

$$\log\left(\frac{W_T^{IPO}}{W_T^{Market}}\right) - \log\left(\frac{W_0^{IPO}}{W_0^{Market}}\right) \sim f\left(m_{\frac{IPO}{Market},T} \cdot T \quad , \quad s_{\frac{IPO}{Market},T} \cdot \sqrt{T}\right). \tag{6}$$

The subscript "T" on the mean parameter $m_{\frac{IPO}{Market},T}$ and the volatility parameter $s_{\frac{IPO}{Market},T}$ captures the feature that the parameters are allowed to vary over time. There are sixty different mean parameters and sixty different volatility parameters going from a one-month time horizon up to a sixty-month time horizon. The purpose of this flexibility of the mean and the volatility parameters is that it allows for marginal determination and tests of the average cross-sectional buy-and-hold returns for the different time horizons. For a given time horizon T, the cross-sectional buy-and-hold returns at that particular time horizon is considered only, and independent on other time horizons.

If a wealth relative is log-normally distributed an explicit structure can be invoked by the geometric Brownian motion model that gives the wealth relative a dynamic representation. Usually, a geometric Brownian motion has a constant drift parameter, e.g. m, and a constant volatility parameter, e.g. s . Here, however, with time varying parameters the geometric Brownian motion only gives an expression for the marginal dynamics of the wealth relative and is given by:

$$\frac{W_T^{IPO}}{W_T^{Market}} = \frac{W_0^{IPO}}{W_0^{Market}} \cdot e^{\left(m_{\frac{IPO}{Market},T} \cdot T \ + \ s_{\frac{IPO}{Market},T} \cdot Z_T \right)} \tag{7}$$

where $m_{\frac{IPO}{Market},T}$ and $s_{\frac{IPO}{Market},T}$, are the constants described above, and dZ_t is a Wiener process with $dZ_t \sim N(0, dt)$. This formulation of the wealth relative implies that wealth relative at a time horizon T is log-normally distributed and, thus, the natural logarithm of the wealth relative at the time horizon T is normally distributed. The expected change of the logarithmic wealth relative over the time interval dt measured from time T is given by $m_{\frac{IPO}{Market},T}\, dt$ and the unexpected change over the same time interval is given by $s_{\frac{IPO}{Market},T}\, dZ_t$. As the wealth relative is log-normally distributed the expected value and the variance of the wealth relative at time T is given by, respectively:

$$E\left(\frac{W_T^{IPO}}{W_T^{Market}} \right) = e^{\left(m_{\frac{IPO}{Market},T} + \frac{1}{2} s^2_{\frac{IPO}{Market},T} \right) T} \tag{8}$$

$$Var\left(\frac{W_T^{IPO}}{W_T^{Market}} \right) = e^{(2 \cdot m_{\frac{IPO}{Market},T} + s^2_{\frac{IPO}{Market},T}) \cdot T} \cdot \left(e^{s^2_{\frac{IPO}{Market},T} \cdot T} - 1 \right) \tag{9}$$

From expression (8) and for a given time horizon T, it is seen that the expected value of the wealth relative depends on both the mean parameter and the volatility parameter. If the volatility parameter is zero meaning there is no noise, the wealth relative is purely described by the drift parameter $m_{\frac{IPO}{Market},T}$ in the exponential function in expression (8). If noise is present the volatility parameters will be positive and increase the expected value of the wealth relative. For the expected value of the inverse wealth relative, i.e. the market measured against the IPO stocks, the drift parameter is given by $-m_{\frac{IPO}{Market},T}$ but the volatility parameter will remain unchanged. The volatility is identical irrespectively of how the wealth relative is measured, i.e. IPO stocks against the market or the market against the IPO stocks. The volatility captures the variation between the two wealth variables. We cannot test directly on the average cross-sectional buy-and-hold returns in levels as the expected buy-and-hold returns in expression (8) are not exactly log-normally distributed. However, we can estimate and test the parameters, which is done in section 6.

Table 3 shows the average cross-sectional buy-and-hold returns for different buy-and-hold horizons according to the left-hand-side of equation (8) and corresponding standard deviations according to the square root of expression (9).

[Insert Table 3 around here]

Table 3 shows that the average cross-sectional buy-and-hold returns of the wealth relative between the market and the IPO stocks are positive and very large compared to the averages in figure 1 and table 2, above. Five years after the first day of trading the average buy-and-hold return of the equal weighted wealth relative between the market and the IPO stocks is 84.6 percent.[18] For the stocks of the matching firms relative to the IPO stocks the average buy-and-hold return of the wealth relative after five years is also quite large at 62.6 percent. For both but the wealth relatives the standard deviations are very large, too. For the other transformations, i.e. T1-transformations, table 3 shows that the average buy-and-hold returns of the wealth relative between the IPO stocks and the market, or the wealth relative between the IPO stocks and the stocks of the matching firms, are not very large compared to the T2-transformations. From the first day of trading and five years hence the average under performance of the IPO stocks relative to the market is not more than 10.6 percent and relative to the stocks of the matching firms the IPO stocks actually out perform by 22.7 percent. Again, the standard deviations of the buy-and-hold returns of the wealth relatives are quite large.

Decomposing average buy-and-hold returns

It may seem contra intuitive that the average cross-sectional buy-and-hold returns of the wealth relatives vary so much depending on whether the T1- or the T2-transformations are used. The reason is the volatility parameter in expression (8) is identical whatever way a wealth relative is measured, e.g. IPO versus Market or Market versus IPO (equivalently for IPO versus matching firms and matching firms versus IPO). For instance, for the stocks of the matching firms relative to the IPO stocks, it is seen in table 3 that the average cross-sectional out performance after five years is 62.5 percent. However, for the inverse measure (IPO stocks measured relative to the stocks of the matching firms) an out performance also observed and it is 22.7 percent after five years. This seems inconsistent but it turns out that there is nothing peculiar in it when expression (8) is decomposed. Consider the following decomposition of the expected wealth relative in expression (8).

$$E\left(\frac{W_T^{IPO}}{W_T^{Market}}\right) = \underbrace{e^{m_{\frac{IPO}{Market},T} \cdot T}}_{\substack{\text{mean}\\ \text{component}}} \cdot \underbrace{e^{\frac{1}{2} s^2_{\frac{IPO}{Market},T} \cdot T}}_{\substack{\text{volatility}\\ \text{component}}} \tag{10}$$

When the average cross-sectional buy-and-hold returns have been volatility adjusted, i.e. the volatility component in expression (10) has been taken out, the mean-component under performance of the IPO stocks relative to the stocks of the matching firms is 13.1 percent (volatility is positive 41.3 percent). Correspondingly, the volatility-adjusted out performance of the stocks of the matching firms relative to the IPO stocks is 15.1 percent (volatility is positive 41.3 percent). The large volatility has a positive influence on the average cross-sectional buy-and-hold return that, in the case where the IPO stocks are measured against the stocks of the matching firms, results in a large dominance by the volatility component. The under performance measured by the mean component (-13.1 percent) is out weighted by the large volatility (43.1 percent) which gives a misleading result of 22.7 percent (i.e. 0.227=(1-0.131)(1+0.413)-1) out performance that seems inconsistent. The volatility component captures the variation between the wealth of the two variables that enters the wealth-relative measure. As the volatility component is a common factor for a wealth relative and for its inverse transformation it is necessary to adjust for the volatility component. Otherwise the interpretation of the performance of a wealth relative does not make sense. It should be noted that we consider a wealth relative as a single variable that can be measured in two ways according to the transformations T1 and T2, and it is on that variable that we make our interpretation. We do not form any interpretation on each of the variables that the wealth variable consists of, as we cannot do that according to our tests of log-normality. We are only making inference from the wealth-relative measure using the decomposition in expression (10).

In figure 4 and figure 5 below the average cross-sectional buy-and-hold returns of expression (8) are shown on the left-hand side of the charts and the decomposition into the mean components and the volatility components in expression (10) are shown on the right-hand side. We have chosen to show figures thereby enabling the reader to see all the time horizons. However in table 4 a few numbers are shown. In the figures the mean component is normalised to zero and is given by $e^{m_{J,T} \cdot T} - 1$, and the volatility component is also normalised to zero and is given by $e^{\frac{1}{2} s_{J,T}^{2} \cdot T} - 1$, for $J = \{\frac{IPO}{Market}, \frac{IPO}{Matching}, \frac{Market}{IPO}, \frac{Matching}{IPO}\}$ and $T = \{1, \ldots, 60\}$.

[Insert Figure 4 around here]

[Insert Figure 5 around here]

[Insert Table 4 around here]

The volatility component has a positive common effect on an average buy-and-hold return independent on which of the transformations T1 or T2 that is considered. Independent of the transformation T1 or T2 the volatility component is exactly the same for a given wealth relative and a given time horizon. That is an implication of the log-normal distribution of a wealth relative and is seen in figure 4 (panel B and panel D) and in figure 5 (panel B and panel D). The volatility contributes positively to the level average value of a wealth relative, and the more the longer the time horizon is. If the mean component of the logarithmic transformation is zero and there is noise present under the logarithmic transformation the level average cross-sectional buy-and-hold returns will be positive and increase with the time horizon. The intuition is that even if the mean component of the logarithmic transformation is zero the positive gains will accumulate more than the losses. That gives a right skewed distribution that is observed in the cross-sectional buy-and-hold returns. Noise is in this sense beneficial for long-term investors.

However, the effect of the mean component depends on the transformation. The effect of the normalised mean component on the average buy-and-hold returns of the wealth relatives is positive when the ratio is measured as the market or the stocks of the matching firms relative to the IPO stocks (figure 4 - panel B and figure 5 - panel B). The normalised mean component is correspondingly negative when the IPO stocks are measure relative to the market or relative to the stocks of the matching firms (figure 4 - panel D and Figure 5 - Panel D). Depending on whether the normalised mean component is positive or negative the two components (the mean component and the volatility component) either amplify each other or dampen each other. For instance, after 5 years the mean-component under performance of the IPO stocks relative to the market is 30.4 percent (figure 4 - panel D) and the mean-component under performance of the IPO stocks relative to the stocks of the matching firms is 13.1 percent (figure 5 – panel D).

6. Testing

The above analysis shows average buy-and-hold returns and the decomposition into mean components and volatility components. However, we do not a priori know whether a result of under performance or out performance is significant or not by just observing the mean components. We need to test it. In expression (6) it is shown that the logarithms of the cross-sectional buy-and-hold returns of the wealth relatives are normally distributed. Normalising the initial wealth relative to one, the estimated mean and the estimated standard deviation of $\log(W_{J,T})$ are given by $\tilde{m}_{J,T} \cdot T$ and $\tilde{s}_{J,T} \cdot \sqrt{T}$, respectively and the marginal parameter estimates are given by:

$$\tilde{m}_{J,T} = \frac{1}{76 \cdot T} \sum_{i=1}^{76} \log\left(W_{i,\,J,T}\right) \tag{11}$$

$$\tilde{s}_{J,T} = \sqrt{\frac{1}{75 \cdot T} \cdot \sum_{i=1}^{76} \left(\log(W_{i,\,J,T}) - \hat{m}_{J,T} \cdot T\right)^2} \tag{12}$$

where $J = \{\frac{IPO}{Market}, \frac{IPO}{Matching}, \frac{Market}{IPO}, \frac{Matching}{IPO}\}$ and $T = \{1,...,60\}$.

We can test the marginal estimates $\tilde{m}_{J,T} \cdot T$ and $\tilde{s}_{J,T} \cdot \sqrt{T}$ using ordinary test statistics. The tests are marginal tests meaning that we only consider the cross-sectional buy-and-hold returns at a given time horizon T independent on other time periods. The test of the marginal estimate of the mean at time T against an alternative is t-distributed with 75 degrees of freedom (e.g. Aitchison and Brown, 1969). An obvious hypothesis to test is that the marginal estimate at time T is zero against the alternative that it is not.

$$\begin{aligned} H_0 &: \quad \tilde{m}_{J,T} \cdot T = 0 \\ H_A &: \quad \tilde{m}_{J,T} \cdot T \neq 0 \end{aligned} \tag{13}$$

$J = \{\frac{IPO}{Market}, \frac{IPO}{Matching}, \frac{Market}{IPO}, \frac{Matching}{IPO}\}$ and $T = \{1,...60\}$.

Rather than showing a few selected statistics we show the test graphically in figure 6 by showing marginal estimates and the corresponding 95-percent confidence intervals. In figure 6, the marginal estimates and the confidence intervals are transformed back to levels, i.e. $e^{\tilde{m}_{J,T} \cdot T} - 1$, to make them directly comparable with figure 4 and figure 5. On the left-hand side of figure 6 we show the mean components and confidence intervals for the different wealth relatives. On the right-hand side we show the volatility components and corresponding 95-percent confidence intervals. (Marginal estimates of the volatility at time T, i.e. $\tilde{s}^2_{J,T} \cdot \sqrt{T}$, and the tests against positive alternatives are c^2-distributed with 75 degrees of freedom.) The marginal estimates are significant when the confidence intervals are away from the alternative.

For the IPO stocks versus the market (or vice versa) the mean component is significant different from zero after 26 months on a 95-percent level of significance. For the IPO stocks versus the stocks of the matching firms (or vice versa) the mean component is significant different from zero after 22 months on a 95-percent level of significance. However, after sixty months the IPO stocks are not significantly different from the stocks of the matching firms. Thus, it takes roughly two and a half years before the IPO stocks significantly differs from the benchmarks. The most significant benchmark is the Market whereas the benchmark of the stocks of the matching firms is not that significant. Table 5 compares the different methods.

[Insert Table 5 around here]

Table 5 shows that the cross-sectional averages of the different methods vary. A problem with the arithmetic average of method 1 is that it is not possible to test the level averages by ordinary t-tests due to the right skewed distributions of the buy-and-hold returns.[19] Moreover, a difference between two average cross-sectional buy-and-hold returns does not make sense as the difference, at best, would be a difference between two log-normal distributions and that is non-sense. For method 2 where the buy-and-hold returns of the wealth relatives are described as log-normal distributions it is also a problem to test the average cross-sectional buy-and-hold returns in levels because it is a joint test of the mean and volatility components; see equations (8). Method 3 makes it possible to test the mean components and the volatility components, separately. The procedure is the following. First, the wealth relatives are transformed to logarithms, thereby making the logarithmic distributions symmetric. Subsequently, the means and the variances of those symmetric distributions can be tested against alternatives. For graphical exposition and comparison to the cross-sectional level averages, the mean components and the volatility components over the are transformed back to levels and normalised to zero. Thus, method 3 decomposes the averages cross-sectional buy-and-hold returns into mean components and volatility components. This procedure makes it possible to compare the T1- and the T2-transformations and therefore form inference on the wealth-relative measure.

An illustrative example is to consider figure 4 after 30 months from the first day of trading. Considering figure 4 – panel C and panel D, the average cross-sectional buy-and-hold return of the wealth relative of IPO stocks versus the market is zero. However, the mean and the volatility components are -17 percent and 20 percent, respectively, and significantly different from zero. If the ratio had been turned around, i.e. figure 4 – panel A and panel B, the average over performance of the market relative to the IPO stocks is 46 percent. That over performance consists of a significant mean-component over performance of 20 percent and a significant volatility-component over performance of 20 percent. Hence, considering an average cross-sectional buy-and-hold return of a wealth relative does not by itself make any sense; it is either 0 percent or 46 percent. However, the decomposition does make sense. As the size of volatility component is the same independently of the used transformation, it is natural to filter it out and look at the mean component for making conclusions. Looking at the mean component the conclusion is that compared to the market the IPO stocks under perform by 17 percent after thirty months.

After five years the mean-component under performance of the IPO stocks relative to the market is 30.4 percent. This is equivalent to a mean-component over performance of the market relative to the IPO stocks of 43.7 percent (see figure 4 - panel B and D). If the decomposition had not been made the two numbers that could be compared would just be the cross-sectional level averages: –10.6 percent and 84.6 percent, respectively, (see table 3); and those two numbers are not easily compared. For a given time horizon, the volatility is, as stated above, the same for both transformations and it is 28.4 percent after five years. By multiplying the gross buy-and-hold returns of the mean component and the volatility component the average gross buy-and-hold return in level prevails.[20]

7. Conclusions

The proposed procedure of this paper is to find data transformations that enable the cross-sectional long-run returns to become log-normally distributed. Subsequently, the mean components and the volatility components are estimated for different time horizons. From such estimates it can be deduced how much of a given average cross-sectional buy-and-hold return that is due to the mean component and how much that is due to the volatility component (noise).

We investigate the long-run performance of 76 stocks of Danish non-financial firms that were offered by the tender system on the Copenhagen Stock Exchange in the period January 1984 – December 1992. We follow the stocks of those firms (IPO stocks) for up to five years after the initial public offerings and compared them to a market index (Danish Total Stock Index) and stocks of matching firms. We find that the cross-sectional buy-and-hold returns are skewed to the right, which invalidates the use of normal t-tests for testing average cross-sectional buy-and-hold returns. We apply the proposed method for testing long-run returns. The method uses a decomposition that necessitates that the cross-sectional buy-and-hold returns are log-normally distributed. However, as the cross-sectional buy-and-hold returns of the individual data series cannot just be assumed to be log-normally distributed it may be necessary to make transformations of the data series. We find for the data of this study, that the transformation of the data to wealth-relatives makes the cross-sectional buy-and-hold returns acceptable as being log-normally distributed. As the cross-sectional buy-and-hold returns of wealth relatives are accepted as being log-normally distributed, the average cross-sectional buy-and-hold returns of the wealth relatives can be decomposed into mean components and volatility components. The (log-) mean components and the (log-) volatility components can be tested against alternatives by simple tests like the t-test and χ^2-test.

In general, we find that the market (Danish Total Stock Index) performs better than the IPO stocks. Also, the stocks of the matching firms perform better than the IPO stocks though not as pronounced. As the applied transformation measure of our study is wealth relatives, it is necessary to filter out the volatility to achieve a clear picture of the performance between data series. The volatility adjusted under performance of the IPO stocks compared to the market is 30.4 percent after five years. The volatility adjusted under performance of the IPO stocks compared to the stocks of the matching firms is 13.1 percent after five years. Our overall results regarding the under performance of IPO stocks compared to the market and stocks of matching firms are consistent with results of other studies that support the hypothesis that the long-run pattern of returns is not sampling or country specific.

Presently, there exists no convincing theory that can explain the observed long-run under performance of IPO stocks. Ibbotson (1975) calls this under performance a 'mystery' and Loughran and Ritter (1995) calls it a 'puzzle'. Arguments concerning over-reaction and over-optimism among investors and analysts are presently the most promising to explain the long-term under performance (Loughran and Ritter, 1995). The hypothesis of over-reaction and over-optimism hinge on the argument that the market participants are short-sighted and contribute too much weight to improvements in operating income up to the time of an initial public offering. The market participants ignore the long-term trends of mean reversion of the profitability of the operation incomes. As a consequence, the trading prices on the first days of trading show a high degree of capitalisation of transitory profit improvements as if the improvements had been permanent. As time passes and the market receives information by annual reports etc. of the origins of the transitory profitability improvements a downward adjustment of the initial estimates of the future profitability takes place causing declining stock prices. The problem is however to provide a good and consistent theory.

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[1] See e.g. Ritter (1991); Aggarwal et al. (1993); Keloharju (1993); Levis (1993); Kunz and Aggarwal (1994); Loughran and Ritter (1995); Lee et al. (1996), and Page and Reyneke (1997).

[2] The first-day return is the return from the last day of offering to the first day of trading.

[3] For a Danish study see Christensen and Sørensen (1988). For a survey over other studies see Loughran et al. (1994).

[4] These include Rock's (1986) ”winners curse” hypothesis and Kunz and Aggarwal's (1994) explanation of emission banks and lag of experience among IPO firms.

[5] The so-called book-building system did first become relevant in 1994.

[6] The method is at the 31st. December for each of the years 1983-1991 to rank all shipping, trading, servicing, and industry firms (non-financial) according to their market value. The firm with market value closest to and larger than the IPO firm is chosen as the matching firm. In the case that a matching firm is de-listed before its corresponding IPO firm a second or if necessary a third firm is merged to take the place of the de-listed firm. For instance, if a firm is offered in December 1986 and the matching firm's last observed stock price in Account Data is July 1989 another matching firm (that was not offered within the last five years) is merged to take over from August 1989.

[7] We could have standardised the first-day returns to weekly returns in order to be capable of comparing the first-day returns across different periods between the last day of offering and the first day of trading. The

standardisation would be the following: weekly return = $\left(\frac{P_{i,1}}{P_{i,0}}\right)^{7/days} - 1$, where $P_{i,0}$ is the offering price, $P_{i,1}$ is the stock price at the first day of trading, and *days* is the number of calendar days between the last day of offering and the first day of trading. It turns out that standardising to weekly returns does not have any effect on qualitative results of this study. Therefore we just use the raw first-day returns.

[8] Monthly returns inclusive dividends in the after market for any stock i is calculated as: $r_{i,t} = \frac{P_{i,t} + D_{i,t} - P_{i,t-1}}{P_{i,t-1}}$ where $P_{i,t}$ is the stock price at time t and $D_{i,t}$ is the dividend at time t. Monthly stock price data for the IPO stocks and the stocks of the matching firms are gathered from Account Data while data for the Danish Total Stock Index (market proxy) are gathered from the Monthly Reports of the Copenhagen Stock Exchange.

[9] First monthly return = $\left(\frac{P_{i,2}}{P_{i,1}}\right)^{30/days} - 1$, where $P_{i,1}$ is the stock price on the first day of trading, $P_{i,2}$ is the stock price at the end of the subsequent month. and *days* = number of days left for the first month+30. E.g. is the first day of trading for Ambu International A/S, March 9, 1992 thus, *days* = 21+30.

[10] We do not include the first-day return in our calculation of the long-term return because it is often difficult to buy to the offering price. The market price on the first day of trading is usable for a portfolio strategy.

[11] A measure like the Cumulative Abnormal Return (CAR) is not a relevant measure in the long run as it does not take the compounding effect of returns into account. E.g. if a deposit account gives a certain periodic return of 10 percent the CAR method measures a buy-and-hold return of 50 percent after five periods whereas the true buy-and-hold return is $(1.10)^5$-1 = 61 percent. The CAR method is only a reasonable approximation for short-horizon returns.

[12] For the cross-sectional buy-and-hold returns of the market index 68.3 percent of the sixty cross-sectional distributions are rejected as being normally distributed on a 5-percent critical level of significance. The cross-sectional buy-and-hold returns of the market index are closer to being normally distributed than the other two: For the IPO stocks 88.3 percent of the sixty cross-sectional buy-and-hold returns are rejected as being normally distributed and for the stocks of the matching forms the rejection percentage is 98.3.

[13] There are 60 months at which the logarithm of the cross-sectional buy-and-hold returns are tested for normality. For the IPO stocks 16 out of 60 (26.7 percent) months are rejected on a five-percent critical level of significance. For the Market 34 out of 60 (56.7 percent) are rejected. For the stocks of the matching firms the logarithmic cross-sectional buy-and-hold returns are accepted as being normal distributed as only 7 out of 60 months (11.7 percent) are rejected, and the rejection is in the first nine months after the initial public offering.

[14] Ritter (1991) and Loughran and Ritter (1995) use the wealth relatives in another way than we do. They take the average in the numerator and denominator separately. The way they make their averages has the weaknesses that this study is about and which we correct for.

[15] We do find another transformation that also can be accepted as being lognormal distributed and we denote it: the transformed buy-and-hold abnormal return (T-BHAR). The transformation is: $T\text{–}BHAR_{Market-IPO,T} = \prod_{t=1}^{T}(1 + r_t^{Market} - r_t^{IPO})$. That is, the difference between the returns is accumulated. The expression, as expressed here, says that one holds a long position in the market index and a short position in the IPO stocks. The proceeds are realised each month and reinvested assuming no transaction costs.

[16] We use Doornik and Hansen (1994) test for normality that adjusts for the sample size. The test statistics are the same whether the T1- or the T2-transformation is applied.

[17] 20 percent of data is rejected for the IPO stocks versus the market while only 15 percent of data is rejected for the IPO stocks versus the stocks of the matching firms.

[18] We have investigated whether value weighting has any effect. By value weighting we mean capitalisation weighting. If an IPO stock A receives an amount of, say, X by the offering while another IPO stock B receives an amount of, say, 5X by the offering, the weight that we put on IPO stock B will be 5 times as large as the weight on IPO stock A. When we did that the distributions degenerated totally. The buy-and-hold returns of all of the combinations that we investigated were strongly rejected. The Chi-squared statistics were well above 100. Value weighting did not give us a usable foundation for testing.

[19] In a recent paper Lyon, Barber and Tsai (1999) suggest the use of a skewness-adjusted t statistic. The statistic uses a third order moment correction like in ordinary and asymptotic normality tests but their method is quite different from the method that we proposed.

[20] The mean component is ca. –0.308 and the volatility component is ca. 0.284 for the IPO/Market-wealth relative after five years. The level average is –0.104 which is equal to (-0.304+1)*(0.284+1)-1 in accordance with expression (10).

TABLE 1

The annual distribution and first-day returns of initial public offerings within shipping, trading, servicing, and industry 1984-1992. First-day returns are average returns within each year.

	Total		Sample			Sample coverage	
Year	Number of IPOs	Amount Issued mill. DKK.	Number of IPOs	Amount Issued mill. DKK.	First-Day Returns in percent	Percent of IPOs	Percent of amount issued
1984	27	1158.7	26	1108.7	2.89	96.3	95.7
1985	15	1346.0	14	1324.7	6.76	93.3	98.4
1986	24	1358.1	24	1358.1	4.36	100.0	100.0
1987	4	79.0	3	70.0	1.00	75.0	93.3
1988	3	50.4	2	41.6	0.63	66.7	82.5
1989	3	87.4	2	79.0	3.58	66.7	90.4
1990	2	269.0	1	31.5	1.78	50.0	11.7
1991	3	220.3	2	51.5	2.68	66.7	23.4
1992	2	130.9	2	130.9	1.46	100.0	100.0
Total	83	4699.8	76	4196.0	3.90	91.6	89.3

TABLE 2

The table shows percentage average cross-sectional buy-and-hold returns (BHR) and percentage average cross-sectional cumulative abnormal returns (CAR). All returns are measured from the first day of trading and up to 5 years after the introduction for stocks of: the IPO firms, the Danish Total Stock Index (Market), the matching firms, the differences between IPO firms and the market and matching firms. In {·} are shown percentage p-values for normality using the Doornik and Hansen (1994) small-sample test procedure to test for normality. All returns and p-values are in percent.

	Buy-and-Hold Returns (BHR) in percent		
Stocks	0-12 months	0-36 months	0-60 months
IPO firms	12.4 {0.00}	12.9 {0.00}	43.2 {0.00}
Market	4.4 {0.00}	26.3 {0.00}	69.8 {15.00}
Matching firms	22.0 {0.00}	45.9 {0.00}	55.5 {0.00}
	Cumulative Abnormal Returns (CAR) in percent		
	0-12 months	0-36 months	0-60 months
IPO firms	6.3 {14.47}	10.3 {0.00}	32.8 {0.00}
Market	4.2 {19.23}	26.3 {35.02}	58.7 {4.71}
Matching firms	18.9 {0.00}	48.5 {0.00}	64.6 {0.00}
IPO – Market	2.1 {19.26}	-16.1 {0.03}	-25.9 {0.00}
IPO - Matching firms	-12.6 {0.00}	-38.3 {0.06}	-31.8 {0.00}

TABLE 3

The table shows the percentage average cross-sectional buy-and-hold returns in levels of the different wealth relatives (J). The buy-and-hold returns are calculated from the first day of trading and until the end of the month shown in the table. The average cross-sectional buy-and-hold returns, normalized to zero, are given by $E(J) = e^{(\tilde{m}_{J,T} + \frac{1}{2}\tilde{s}^2_{J,T}) \cdot T} - 1$. In the table in $(\cdot)$ are shown the cross-sectional standard deviations in percent of the different wealth relatives: $s(J) = \sqrt{e^{(2\tilde{m}_{J,T} + \tilde{s}^2_{J,T}) \cdot T}\left(e^{\tilde{s}^2_{J,T} \cdot T} - 1\right)}$. NN indicates non-normality on a five-percent critical level of significance of the logarithmic transformations using the Doornik and Hansen (1994)-test procedure.

	Average cross-sectional Buy-and-Hold Returns in percent		
J	0–12 months	0–36 months	0–60 months
$\frac{W_T^{Market}}{W_T^{IPO}} - 1$	10.6 (46.9)	59.9 (112.6)	84.6 (148.8)
$\frac{W_T^{Matching}}{W_T^{IPO}} - 1$	24.6[NN] (74.2)	81.3 (182.7)	62.6 (162.3)
$\frac{W_T^{IPO}}{W_T^{Market}} - 1$	6.7 (45.2)	-6.5 (65.9)	-10.6 (72.0)
$\frac{W_T^{IPO}}{W_T^{Matching}} - 1$	8.7[NN] (64.7)	11.3 (112.2)	22.7 (122.5)

TABLE 4

The table shows in percent the decomposition of average cross-sectional buy-and-hold returns into mean components and volatility components for different time horizons *T*. The shown value of the mean component is $e^{\tilde{m}_{J,T} \cdot T} - 1$ and the value of the volatility components is $e^{\frac{1}{2}\tilde{s}^2_{J,T} \cdot T} - 1$, and in $\{\cdot\}$ are given the percentage probabilities (p-values in percent) of the values being equal to zero. (The decomposition implies that the gross return of the two components have to be multiplied to give the gross average cross-sectional buy-and-hold returns in table 3.)

	Measure		Buy-and-Hold Returns of the components in percent: 0 – 12 months	0 - 36 months	0 - 60 months
Figure 4	$\frac{W_T^{Market}}{W_T^{IPO}} - 1$	mean	1.8 {35.06}	30.7 {0.03}	43.7 {0.00}
		volatility	8.8 {0.00}	22.2 {0.00}	28.4 {0.00}
	$\frac{W_T^{IPO}}{W_T^{Market}} - 1$	mean	-1.8 {35.06}	-23.5 {0.03}	-30.4 {0.00}
		volatility	8.8 {0.00}	22.2 {0.00}	28.4 {0.00}
Figure 5	$\frac{W_T^{Matching}}{W_T^{IPO}} - 1$	mean	7.1 {14.41}	27.6 {0.71}	15.1 {7.39}
		volatility	16.4 {0.00}	42.0 {0.00}	41.3 {0.00}
	$\frac{W_T^{IPO}}{W_T^{Matching}} - 1$	mean	-6.6 {14.41}	-21.6 {0.71}	-13.1 {7.39}
		volatility	16.4 {0.00}	42.0 {0.00}	41.3 {0.00}

TABEL 5

The table shows percentage cross-sectional averages calculated by the three different methods. For each of the methods the time horizons (T) are 1 year, 3 years, and 5 years after the first day of trading. Method 1 is the usual arithmetic cross-sectional averages after T years and in $(\cdot)$ are given the standard deviations. Method 2 shows the cross-sectional average level values, normalized to zero, calculated from the hypothesis that the buy-and-hold returns marginally develop according to a geometric Brownian motions $E(J) = e^{\left(\tilde{m}_{J,T} + \frac{1}{2}\tilde{s}^2_{J,T}\right)T} - 1$ where $J = \{\frac{W_T^{IPO}}{W_T^{Market}}, \frac{W_T^{IPO}}{W_T^{Market}}\}$ and in $(\cdot)$ are given the relevant standard deviations. In method 3 at a given time horizon T, average cross-sectional buy-and-hold return is decomposed into a mean component and a volatility component (the noise). The shown value of the mean component is $e^{\tilde{m}_{J,T} \cdot T} - 1$ and the value of the volatility components is $e^{\frac{1}{2}\tilde{s}^2_{J,T} \cdot T} - 1$, and in $\{\cdot\}$ are given the percentage probabilities (p-values in percent) of the values being equal to zero. The decomposition implies that the gross return of the two components have to be multiplied to give the level average gross return of method 2.

Method	Measure		0 – 12 months	0 - 36 months	0 - 60 months
method 1	IPO firms		12.4 (52.2)	12.9 (72.1)	43.2 (118.5)
	Market		4.4 (18.2)	26.3 (27.8)	69.8 (27.5)
	Matching firms		22.0 (63.6)	45.9 (94.6)	55.5 (99.9)
method 2	$\frac{W_T^{IPO}}{W_T^{Market}} - 1$		6.7 (45.2)	-6.5 (65.9)	-10.6 (72.0)
	$\frac{W_T^{IPO}}{W_T^{Matching}} - 1$		8.7 (64.7)	11.3 (112.2)	22.7 (122.5)
method 3	$\frac{W_T^{IPO}}{W_T^{Market}} - 1$	mean	-1.8 {35.06}	-23.5 {0.03}	-30.4 {0.00}
		volatility	8.8 {0.00}	22.2 {0.00}	28.4 {0.00}
	$\frac{W_T^{IPO}}{W_T^{Matching}} - 1$	mean	-6.6 {14.41}	-21.6 {0.71}	-13.1 {7.39}
		volatility	16.4 {0.00}	42.0 {0.00}	41.3 {0.00}

Figure 1A: Average cross-sectional buy-and-hold returns

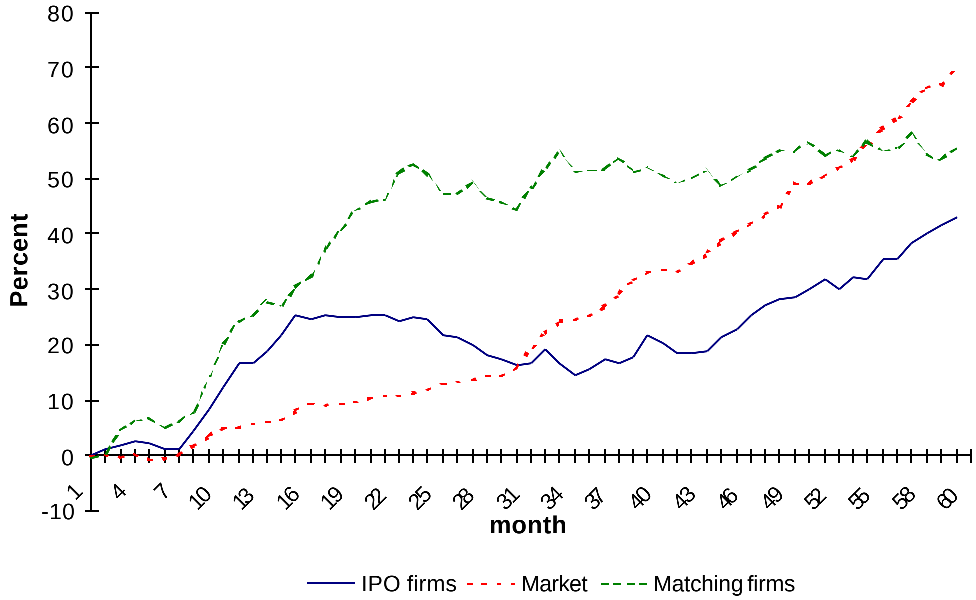

Figure 1B: Standard deviations of cross-sectional buy-and-hold returns

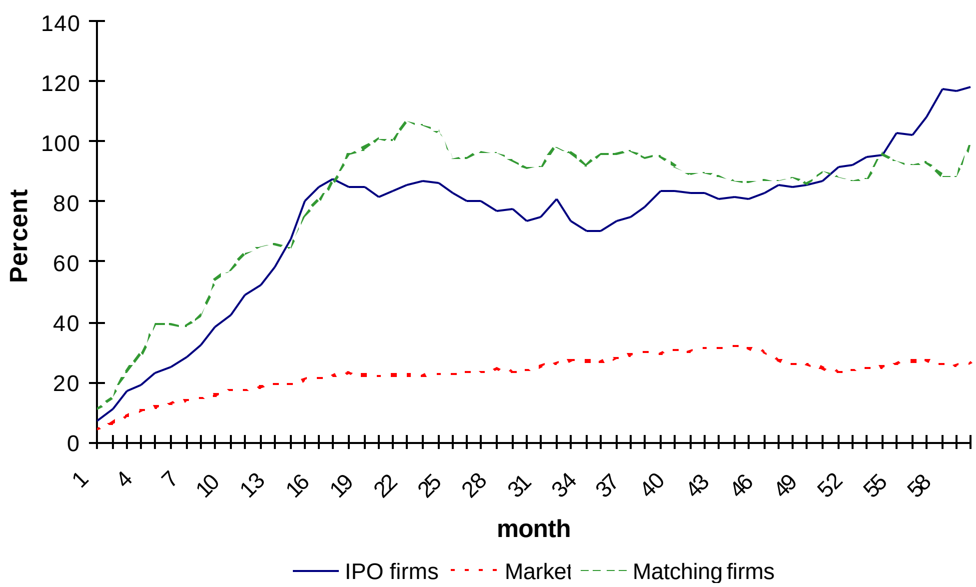

Figure 2A: Normality Test of Log(IPO)

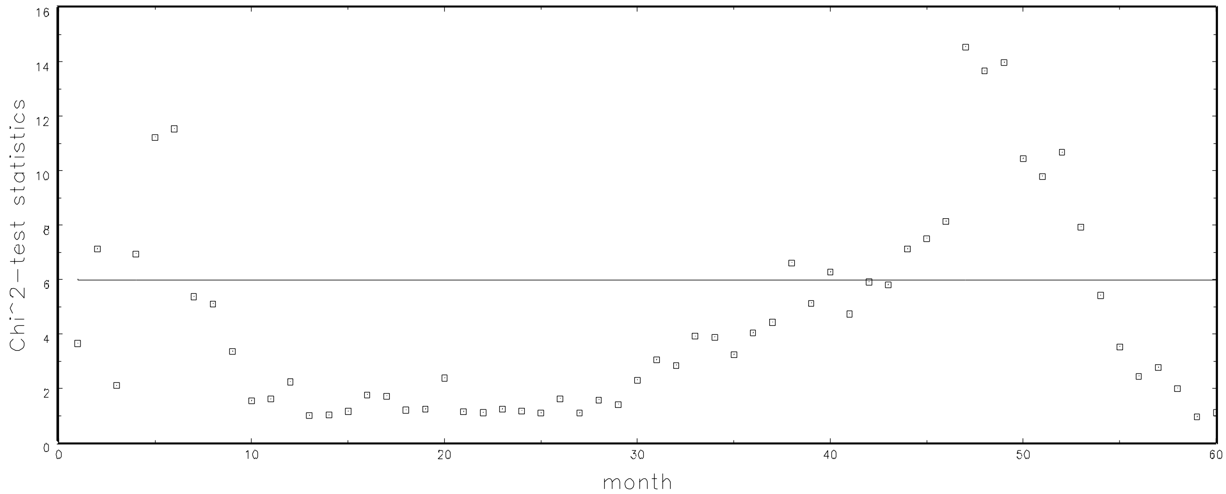

Figure 2B: Normality Test of Log(Market)

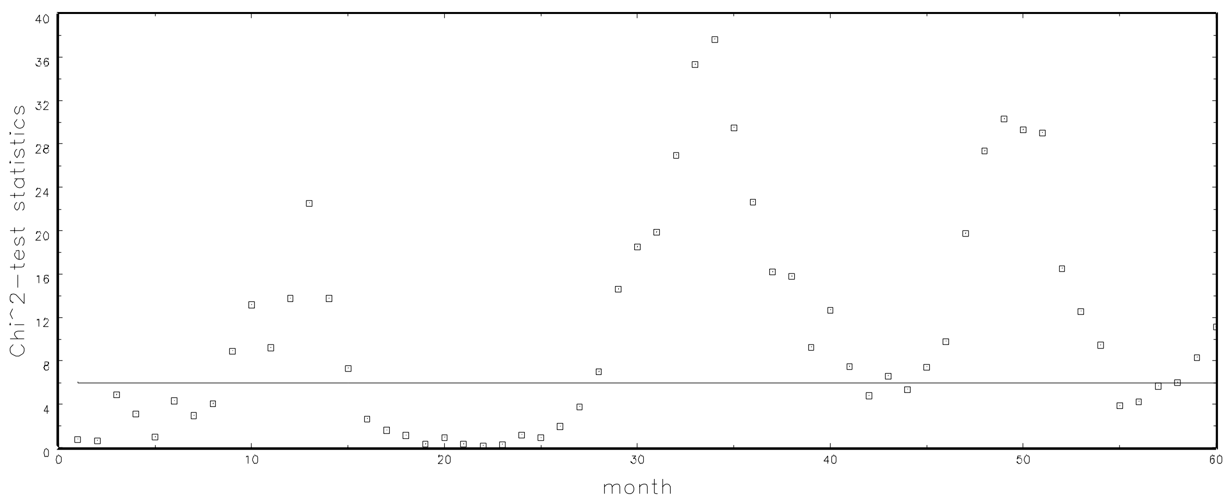

Figure 2C: Normality Test of Log(Matching firms)

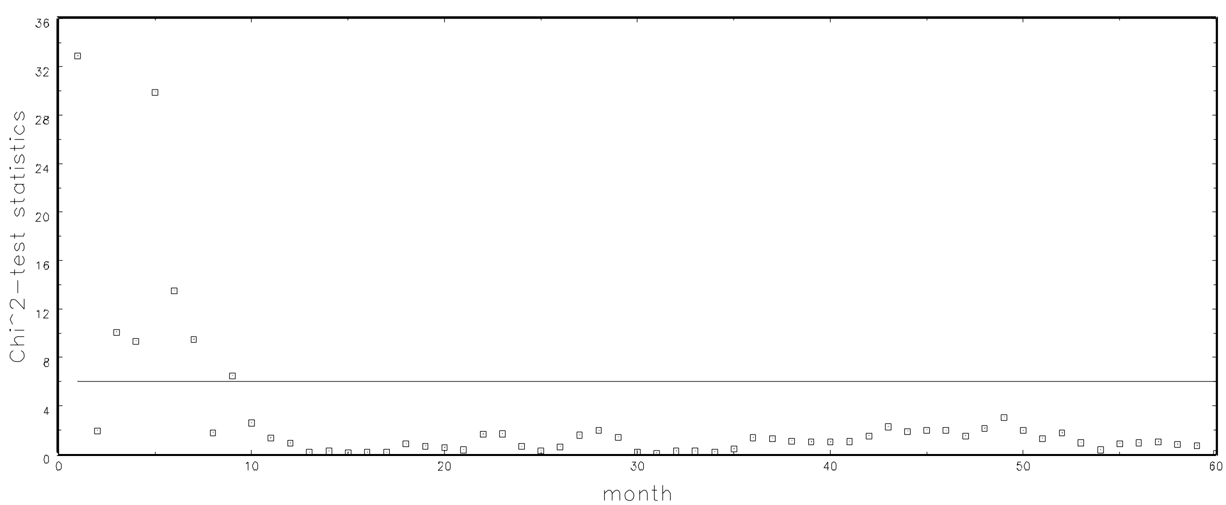

Figure 3A: Normality Test of Log(IPO/Market)

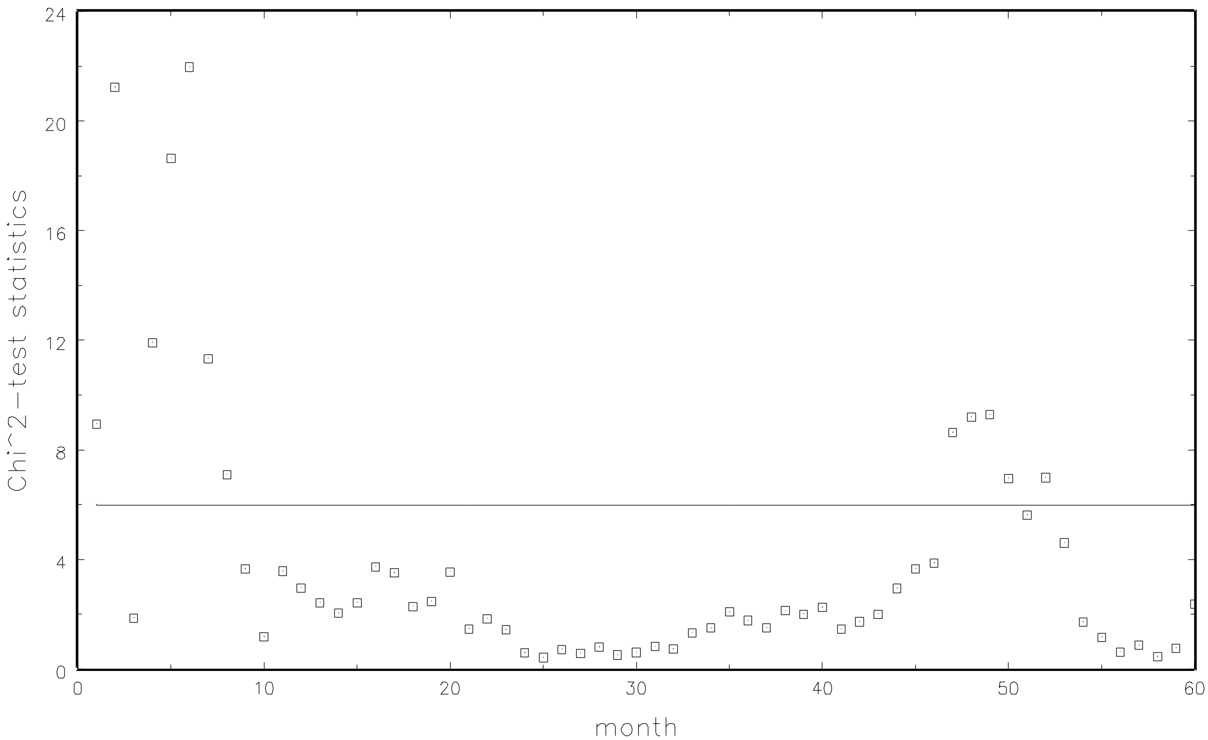

Figure 3B: Normality Test of Log(IPO/Matching)

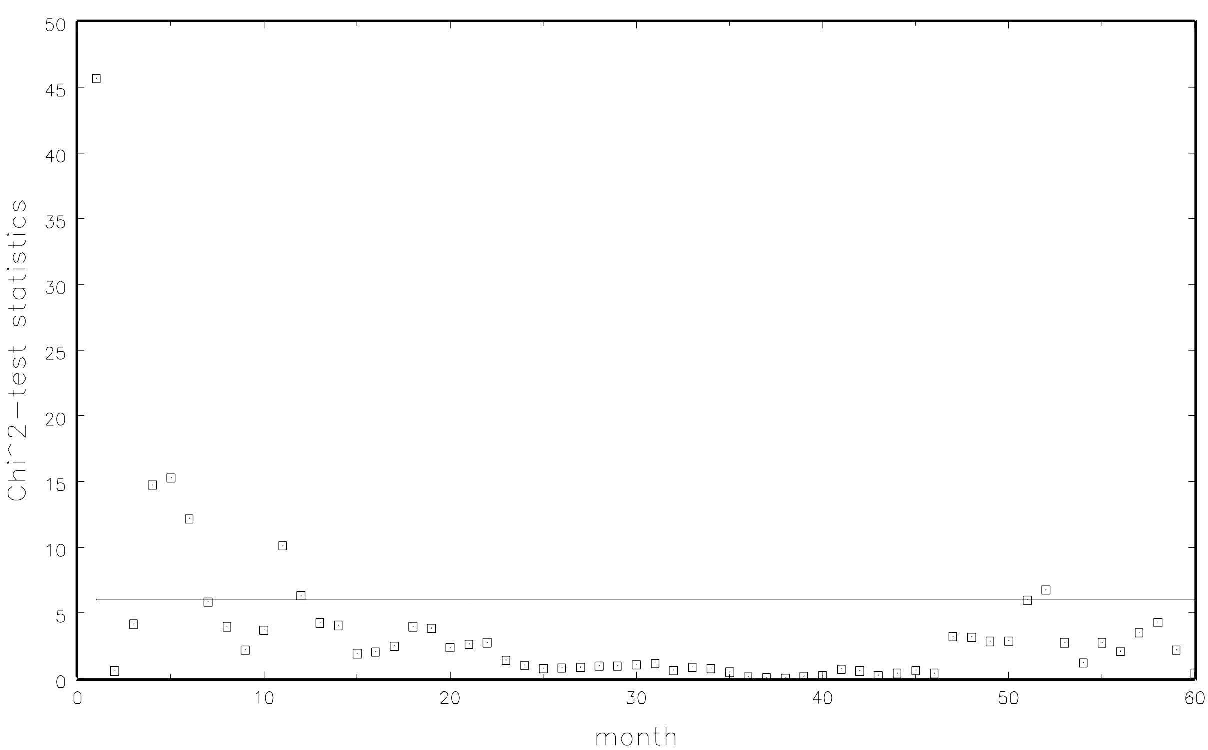

Figure 4 – Panel A
Average buy–and–hold returns
Market versus IPO

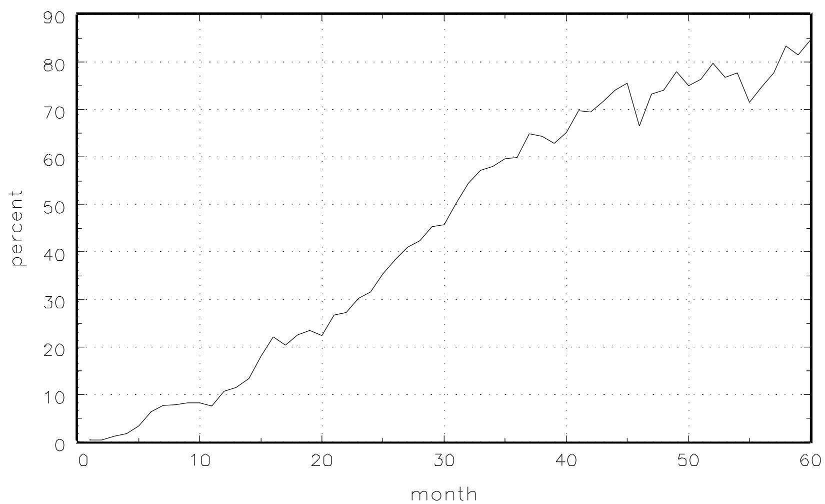

Figure 4 – Panel B
mean and volatility components
Market versus IPO

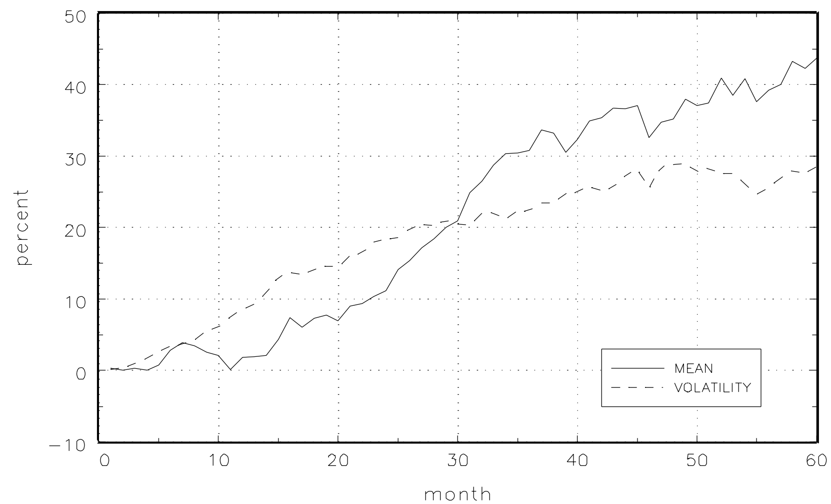

Figure 4 – Panel C
Average buy–and–hold returns
IPO versus Market

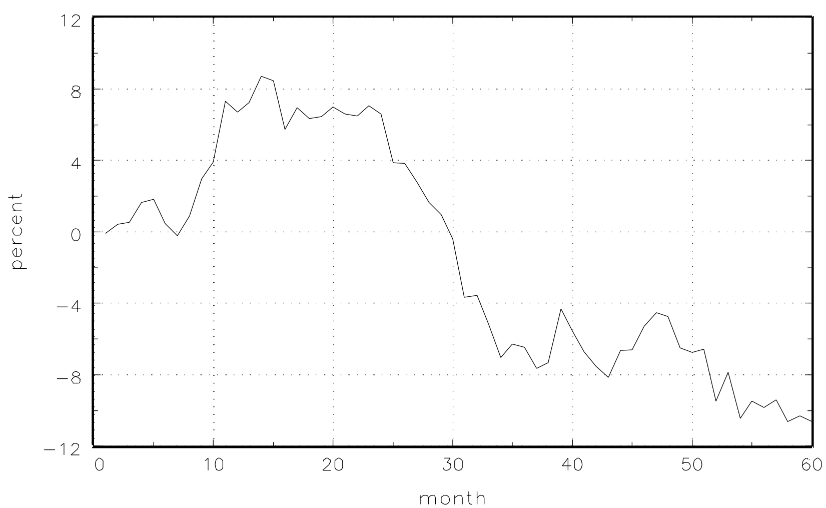

Figure 4 – Panel D
mean and volatility components
IPO versus Market

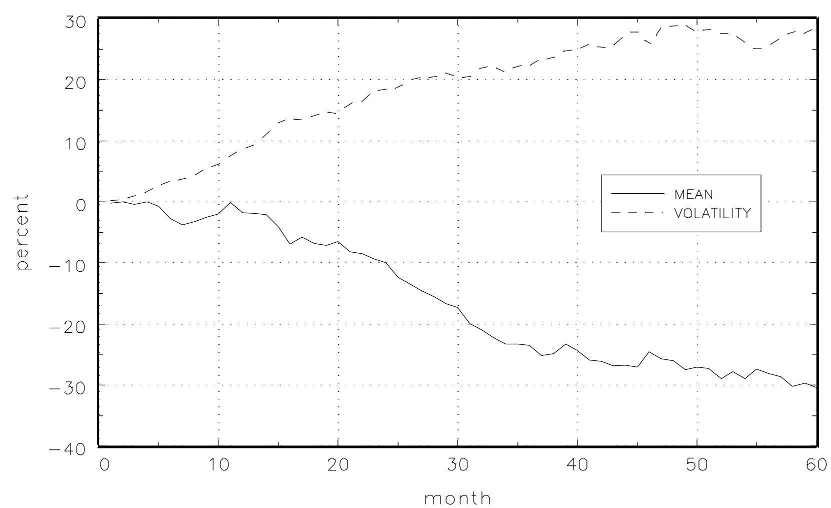

Figure 5 – Panel A
Average buy-and-hold returns
Matching versus IPO

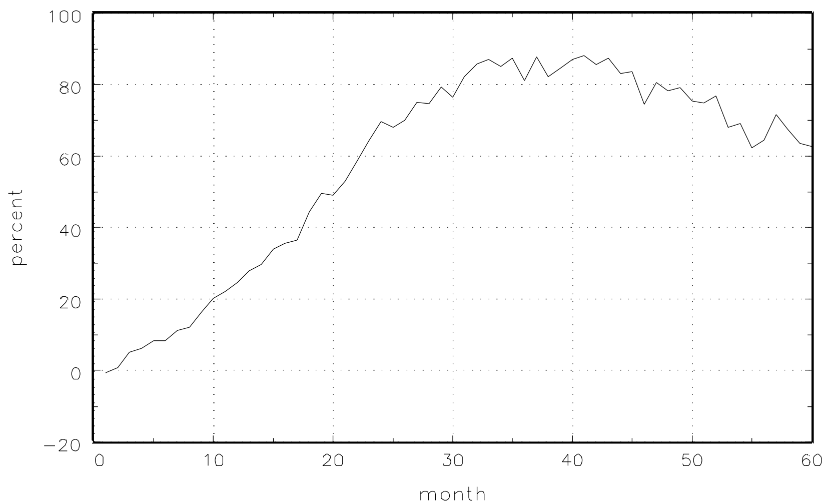

Figure 5 – Panel B
mean and volatility components
Matching versus IPO

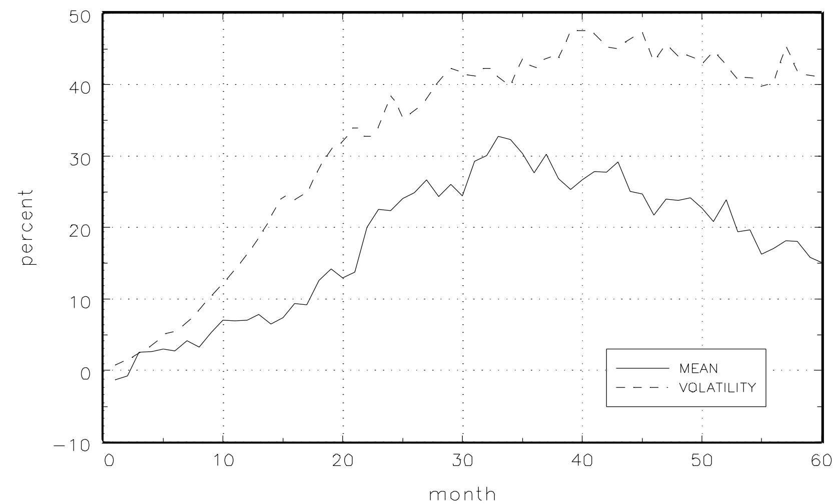

Figure 5 – Panel C
Average buy-and-hold returns
IPO versus Matching

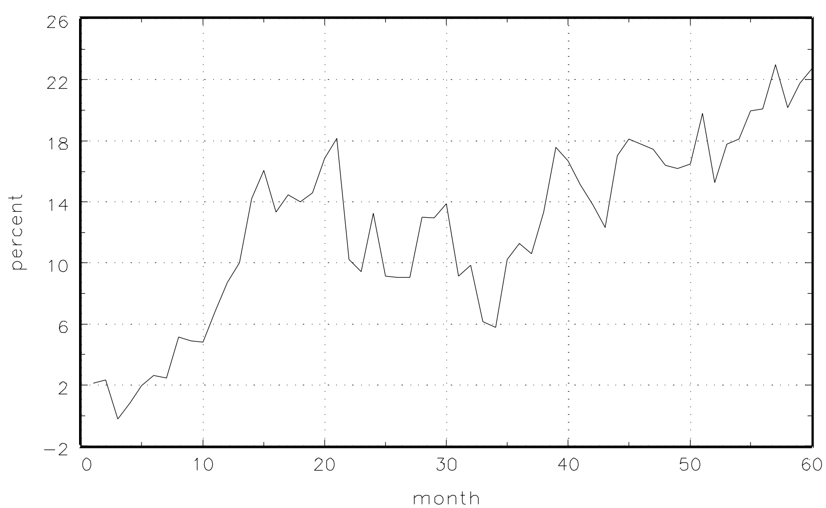

Figure 5 – Panel D
mean and volatility components
IPO versus Matching

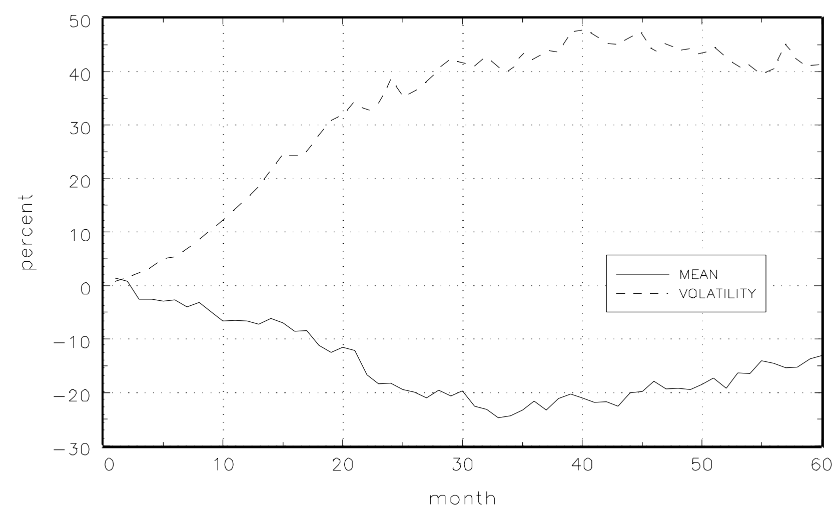

Figure 6 – Panel A: Mean component
Market versus IPO

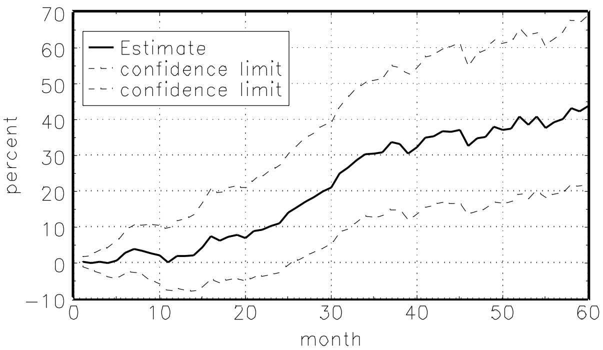

Figure 6 – Panel B: Volatility component
Market versus IPO

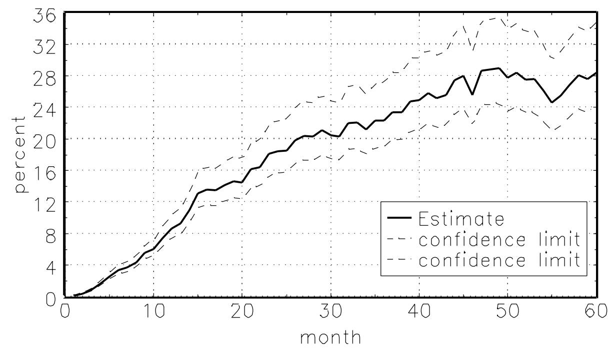

Figure 6 – Panel C: Mean component
IPO versus Market

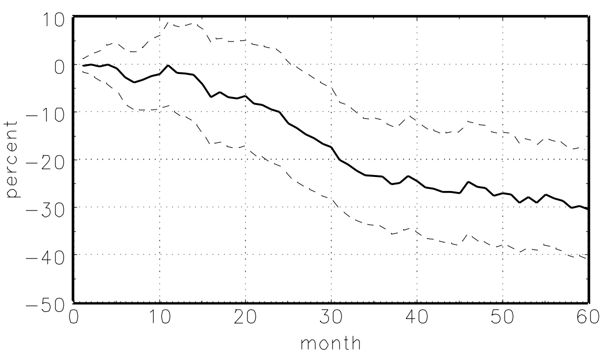

Figure 6 – Panel D: Volatility component
IPO versus Market

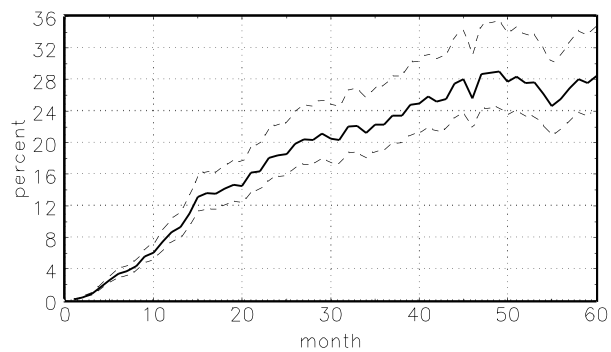

Figure 6 – Panel E: Mean component
Matching versus IPO

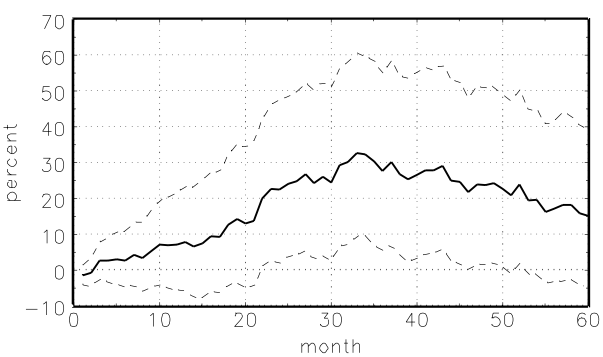

Figure 6 – Panel F: Volatility component
Matching versus IPO

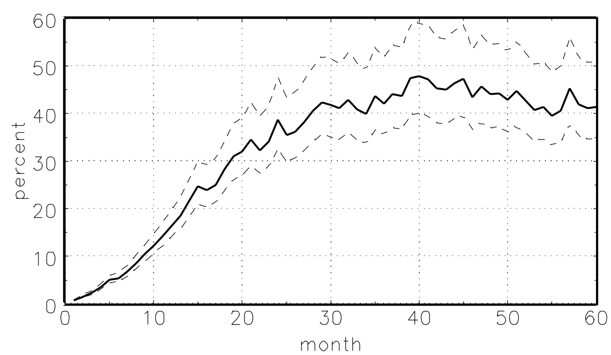

Figure 6 – Panel G: Mean component
IPO versus Matching

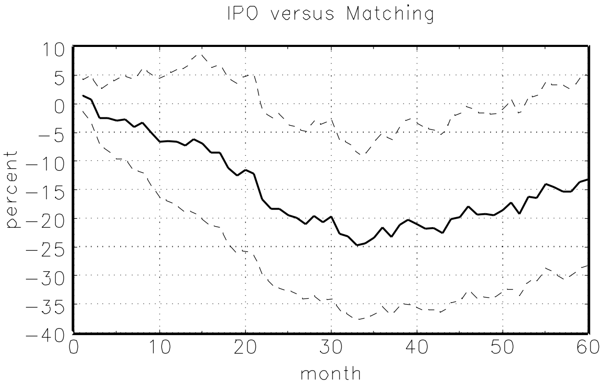

Figure 6 – Panel H: Volatility component
IPO versus Matching