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Underpricing and Index Excess Returns

by

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Keywords: underpricing, index excess returns, IT firms

JEL classification: G14, N24

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Abstract

We study the link between underpricing of initial public offerings (IPOs) and index excess returns in secondary markets. We use a theoretical model to argue that underpricing of IPOs raises investors' attention and, thereby, triggers investments in secondary markets. Our theoretical model implies that such investments should give rise to positive index excess returns in secondary markets. The results of our empirical tests, based on a dataset of stocks from the *Neuer Markt* and the *Nouveau Marché*, are in line with the implication of our theoretical model.

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I Introduction

The textbook method of stock valuation implies that stock prices only depend on estimates of the entire stream of future dividend payments. In the real world however, estimation of the stream of future dividend payments is virtually impossible. Estimation of the stream of future dividend payments is especially difficult with regard to young firms in stock market segments for fast-growing firms. For such firms, not even estimates of past performance are available that could be extrapolated to estimate future dividend payments. Hence, investors in such markets probably do not even try to apply the textbook method of stock valuation, but base the valuation of stocks directly on expected future stock prices or expected short-term returns. A key question is, therefore, how investors form their expectations of short-term returns.

The easiest way to form expectations is to use realized returns from the near past to form expectations. If investors form their expectations in this way, it is likely that large returns observed in the near past have a particularly strong impact on the formation of expectations and, thus, on returns. Large returns can often be observed when firms go public. In an initial public offering (IPO), the issue price in the primary market almost always differs from the first price in the secondary market. If the latter exceeds the former, the IPO is underpriced. Large positive initial returns resulting from underpricing of IPOs often raise considerable attention of the general public and the mass media and may, thus, have a significant impact on the formation of investors’ expectations. This, in turn, may lead to a significant link between (under-) pricing of IPOs and returns in secondary markets.

We develop a theoretical model and empirically test its implications to analyze whether such a link exists. The key feature of our model is the impact of the interplay of demand of uninformed investors and arbitrage transactions carried out by informed investors on index excess returns in secondary markets with limits on arbitrage. With unlimited arbitrage, prices in secondary markets would always equal fundamental values and, hence, would not be affected by underpricing of IPOs in primary markets. In contrast, our model implies that, when arbitrage is limited, underpricing of IPOs should not only affect index excess returns on the day of the IPO, but it should also affect index excess returns on the following days.

We used a novel dataset for the *Neuer Markt* and the *Nouveau Marché* to test this implication of our theoretical model. In the second half of the 1990s, these markets boomed. At that time, more than 400 firms went public on the *Neuer Markt* and the *Nouveau Marché*, and for many investors their investment in the stocks of these firms was the first stockmarket investment they had ever made. Our theoretical model implies that the presence of such inexperienced investors together with limits on arbitrage by informed investors should have led to positive abnormal index excess returns in secondary markets on days on which substantial underpricing of IPOs could be observed. In order to empirically test this implication, we calculated index excess returns in secondary markets from various indexes that we constructed from daily share prices of all German and French firms that went public on the *Neuer Markt* and the *Nouveau Marché*. Besides using an all-share index, we also constructed indexes for large firms, for firms operating in the information and communications industry, and for firms operating in the in the biotechnology industry.

The key result of our empirical analysis is in line with the implication of our theoretical model. There is evidence for a statistically significant positive link between underpricing of IPOs and index excess returns in secondary markets. To be more precise, we report evidence of a positive link between the *magnitude* of underpricing of IPOs and positive index excess returns in secondary markets. We found this link in a linear regression model as well as in a GARCH model.

Our theoretical model offers a possible interpretation of our empirical result. In our model, the link between underpricing of IPOs in primary markets and index excess returns in secondary markets is due to the behaviour of inexperienced investors who are dazzled by high initial returns in primary markets. In perfect markets, the influence of such inexperienced investors would be neutralized by arbitrageurs. Because we found a link between underpricing of IPOs and index excess returns in secondary markets, we conclude that our results lend support to the view that one reason for abnormal index excess returns in secondary markets was market inefficiencies caused by limited arbitrage. (See Shleifer (2000) for a useful survey of the literature on market inefficiencies.)

Our research strategy is fundamentally different from the research on underpricing of IPOs undertaken by other authors. We used time-series data in order to study the link between underpricing of IPOs and excess returns in secondary markets. Other authors, in contrast, have commonly analyzed a cross section of firms that went public to study underpricing of IPOs. For example, many authors have analyzed underpricing of IPOs as a measure of letting money-on-the-table (Loughran and Ritter 2002) or they have analyzed the pricing of IPOs in primary markets (Bradley and Jordan 2002, Fishe 2002, Aussenegg et al. 2006 among many others). Other authors have focused on the role played by, for example, the reputation of underwriters and venture capital companies for underpricing of IPOs. Yet other authors have focused on the role played by the selling of shares on underpricing of IPOs (Aggarwal et al. 2002, Booth and Smith 1986, Chowdry and Sherman 1996, Habib and Ljungqvist 2001). Houston and James (2006) have analyzed the valuation of IPO firms in secondary markets relative to their valuation by investment bankers setting issue prices in primary markets.

The remainder of our paper comes in five parts. In Section II, we develop a theoretical model in order to analyze the conditions under which underpricing of IPOs leads to index excess returns in secondary markets. In Section III, we describe the novel dataset we used to test the implication of our theoretical model. In Section IV, we lay out the benchmark empirical model we estimated and we present our empirical results. In Section V, we present results for a GARCH model. This model allows the dynamic interactions of excess returns, market volatility, and underpricing of IPOs to be jointly modeled. In Section VI, we provide additional empirical evidence for several sub-indexes of the *Neuer Markt* and the *Nouveau Marché*. In Section VII, we summarize our main results and offer some concluding remarks.

II The Model

We consider a stock market on which trading of shares takes place at three points of time: $t = 0$, $t = 1$, and $t = 2$. Investors can invest in a riskless asset and in a portfolio of stocks (i.e., an index) traded at price I_t. We assume for simplicity that the riskless rate is zero. The supply of the riskless asset is perfectly elastic with respect to changes in demand conditions. The supply of the portfolio is normalized to unity. The future price of the portfolio at $t = 2$ is uncertain. We start with the assumption that, for all investors, the expected value of the portfolio at $t = 2$ is I^F. The risk of investing in the portfolio is measured by the variance, σ^2, of its price at $t = 2$.

Investors are risk averse and maximize the certainty equivalent of their future wealth, $E(W_2) - \frac{\theta}{2} Var(W_2)$, where θ denotes the coefficient of aggregate risk aversion and W_2 denotes terminal wealth at $t = 2$. Terminal wealth, W_2, depends on the investment decisions at $t = 0$ and $t = 1$. We define λ_t^I to be the number of stocks in the portfolio demanded by investors at $t \in \{0,1\}$. As a result, we get $W_2 = W_0 - \lambda_0^I I_0 + (\lambda_0^I - \lambda_1^I) I_1 + \lambda_1^I I_2$. We assume that, at $t = 0$, investors are not planning to restructure their investments at $t = 1$ because they do not expect a systematic change in their information set. (Otherwise they would anticipate the change in their demand already at $t = 0$.). Therefore, investors' expectations of terminal wealth are given by $E_0(W_2) = W_0 - \lambda_0^I I_0 + \lambda_0^I I^F$. It follows that terminal wealth only depends on investors' investment decision, λ_0^I, at $t = 0$. Also, the variance of terminal wealth is given by $Var(W_2) = (\lambda_0^I)^2 Var^I(I_2) = (\lambda_0^I)^2 \sigma^2$. Using the first two moments of the distribution of uncertain terminal wealth, we can solve for investors' demand for the portfolio at $t = 0$ by using the first-order condition for their maximization problem. The result is the following demand function:

(1) $$\lambda_0^I = \frac{I^F - I_0}{\theta\sigma^2}.$$

From this demand function, and from the condition of market clearing, $\lambda_0^I = 1$, we get for the price of the portfolio at $t = 0$:

(2) $$I_0 = I^F - \theta\sigma^2.$$

This price is simply the expected future price, I^F, minus the price of risk, $\theta\sigma^2$, which depends on the portfolio's risk, σ^2, and the coefficient of aggregate risk aversion, θ.

We now assume that an IPO takes place at $t = 0$. That is, new shares of stock have been sold at the primary market at price S_E, and the first trade takes place at $t = 0$ on the secondary market at price S_0. If $S_0 > S_E$ ($S_0 < S_E$) the IPO was underpriced (overpriced). We assume that underpricing (overpricing) of an IPO influences subsequent trading on the secondary market. Specifically, high initial returns from underpricing of an IPO attract the attention of inexperienced investors. Inexperienced investors may try to jump on the "bandwagon" by investing either in the newly traded shares or the shares of already listed firms with similar characteristics.[1] Alternatively, inexperienced investors may simply update their expectations of future prices whenever they observe underpricing of IPOs. This is what we assume in the following. To keep things as simple as possible, we assume a linear adjustment of expectations to observed underpricing:

Assumption: *Given the observed initial return from underpricing of an IPO,*

(3) $$up = \frac{S_0}{S_E} - 1,$$

investors update their beliefs in a way such that they expect the price of the portfolio of shares at $t = 2$ *to be given by*

(4) $$E(I_2 | up) = I^F + \alpha up,$$

where $\alpha > 0$ *is a parameter that captures the investor's sensitivity to underpricing of IPOs.* □

Given this assumption, investors revise their expectations of the value of the portfolio such that $E(I_2 | up) > I^F$ whenever they observe underpricing of an IPO, $up > 0$. Whenever investors observe overpricing of an IPO, $up < 0$, they revise their expectations such that $E(I_2 | up) < I^F$. The updating of investor's expectations implies an adjustment of portfolios. After having observed underpricing, investors' demand for the portfolio at $t = 1$ is given by

(5) $$\lambda_1^I = \frac{I^F + \alpha up - I_0}{\theta \sigma^2}.$$

Hence, the market-clearing price of the portfolio at $t = 1$ is given by

(6) $$I_1 = I^F - \theta \sigma^2 + \alpha up.$$

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1 The increase in the number of investors would be of no effect on prices of traded assets in an efficient market, except for the fact that the market price of risk is decreasing in the number of market participants. This follows from risk sharing. See Wilson (1968).

This price exceeds the price I_0 from (2) if investors observe underpricing of an IPO (and falls short of I_0 for overpricing):

(7) $$I_1 > I_0 \;\Leftrightarrow\; \alpha up > 0.$$

The price increase from I_0 to I_1 implies an excess return from investing in the portfolio over the period from $t=0$ to $t=1$. This, of course, is an immediate consequence of our assumption. Because the fundamental value of the portfolio has not changed, and because no risk has been resolved, the increase (decrease) in the price of the portfolio is a symptom of market inefficiency. The market inefficiency is the result of the actions taken by investors who respond to the underpricing of an IPO, even though the latter does not signal future performance in general, and it certainly does not signal performance of other stocks. Hence, we may call such investors inexperienced traders or noise traders.

For market inefficiency to prevail, we must have limits to arbitrage. If informed investors could act as arbitrageurs, they would buy shares at $t=0$ whenever an underpriced IPO has taken place in an attempt to profit from the anticipatable price increase until $t=1$.[2] Without limits to arbitrage, the price I_0 would be driven up until it would equal I_1, implying that no excess return in secondary markets would be observed. Moreover, arbitrage would assure that I_1 equals its fundamental value. A limit to arbitrage may result, for example, from risk aversion of arbitrageurs or from noise trader risk (De Long et al. 1990, De Long 1991), from a lack of perfect substitutes of risky assets (Wurgler and Zhuravskaya 2002), or from arbitrageurs being agents of less well informed investors (Shleifer 2000, Chapter 4). Instead of resorting to such forms of limits to arbitrage, we introduce a limit to arbitrage by simply

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2 We do not analyze the demand of inexperienced investors in the primary market. Their demand might depend on anticipated excess returns or other private information. See Lee at al. (1999).

assuming that arbitrageurs are “big” in the sense that they are aware of the impact of their trades on prices. Thus, we assume that arbitrageurs act in concert as a monopolist.

We denote the profit of arbitrageurs from investing in the portfolio at $t=0$ by $\lambda_0^A(I_1 - I_0)$. Thus, profits depend on their demand, λ_0^A. Atomistic arbitrageurs would expand their demand for the portfolio as long as $I_1 - I_0 > 0$, taking I_0 as given. Because I_0 depends on aggregate demand, prices would rise until $I_1 = I_0$. However, in our model with a monopolistic arbitrageur, the first order condition for the monopolistic arbitrageur implies

(8) $$\lambda_0^A = \frac{I_1 - I_0}{\frac{dI_0}{d\lambda_0^A}}.$$

Thus, monopolistic arbitrageurs take into account the impact of their demand on market prices, $\frac{dI_0}{d\lambda_0^A} > 0$. In order to calculate the impact on market prices, the market clearing condition can be used to get

(9) $$\begin{aligned} \lambda_0^I + \lambda_0^A = 1 \quad &\Leftrightarrow \quad \frac{I^F - I_0}{\theta\sigma^2} + \lambda_1^A = 1 \\ &\Leftrightarrow \quad I_0 = I^F - (1 - \lambda_1^A)\theta\sigma^2 \\ &\Rightarrow \frac{dI_0}{d\lambda_0^A} = \theta\sigma^2. \end{aligned}$$

It follows that the arbitrageurs demand function is given by

(10) $$\lambda_0^A = \frac{I_1 - I_0}{\theta\sigma^2}.$$

Adding up investors’ and arbitrageurs’ demand functions, the market clearing price at $t=0$ can be calculated as follows:

(11) $$\lambda_0^I + \lambda_0^A = 1 \quad \Leftrightarrow \quad \frac{I^F - I_0}{\theta\sigma^2} + \frac{I_1 - I_0}{\theta\sigma^2} = 1$$

$$\Rightarrow I_0 = I^F - \theta\sigma^2 + \frac{1}{2}\alpha up .$$

Thus, a key result is that, due to the arbitrageur acting as a monopolist, only one half of the underpricing component in the market price at $t = 1$ is already anticipated at $t = 0$. Yet, even though only half of the price markup is anticipated at $t = 0$, positive excess returns can be observed already at $t = 0$. Figure 1 illustrates our key result graphically for the case of an underpricing of an IPO.

— Insert Figure 1 about here. —

We summarize our key result by the following

Proposition: *If investors react positively to observed underpricing of an IPO in the sense that their demand shifts to the right, and arbitrage is limited, returns at the time and immediately after an underpriced IPO takes place are on average positive and, hence, exceed the returns that would have been realized without underpricing:*

(12) $$I_{-1} < I_0 \quad \Leftrightarrow \quad I^F - \theta\sigma^2 < I^F - \theta\sigma^2 + \frac{1}{2}\alpha up \quad ,$$

(13) $$I_0 < I_1 \quad \Leftrightarrow \quad I^F - \theta\sigma^2 + \frac{1}{2}\alpha up < I^F - \theta\sigma^2 + \alpha up \quad .$$

□

Hence, our key result is that returns on investing in the portfolio should exceed the normal return at the first day of trading in shares from an underpriced IPO, and at the day after, if many investors update their expectations. Excess returns on the first trading day will be positive only if arbitrageurs are in the market and arbitrage is limited.

III The Data

We used a novel dataset for the *Neuer Markt* in Frankfurt and the *Nouveau Marché* in Paris to test whether underpricing of IPOs is positively linked to index excess returns in secondary markets. Data on underpricing of IPOs were taken from a dataset that was partly compiled by the *Kiel Institute for World Economics* within a project on European Financial Markets.[3] The initial return from an IPO is defined as the difference between the opening price on the first trading day and the issue price, divided by the issue price. There was underpricing if the opening price on the first trading day was larger than the issue price. Because on some days more than one firm went public, we constructed two different measures of underpricing. The first measure is defined in terms of the average percentage of underpricing per day. The second measure is defined in terms of the maximum percentage of underpricing per day.

— Insert Table 1 about here. —

Table 1 offers summary statistics of developments in primary markets. During our sample period, 304 firms went public at the *Neuer Markt* and 151 firms went public at the *Nouveau Marché*. Most of the firms on the *Neuer Markt* went public in 1999 and 2000. In contrast, the number of firms that went public on the *Nouveau Marché* is more equally distributed over the period of time 1998–2000. There is another interesting difference between the two primary markets: While most firms that went public on the *Neuer Markt* realized an underpricing of their shares in the IPO, firms that went public on the *Nouveau Marché* often realized an overpricing of their shares. On average, underpricing was larger on the *Neuer Markt* than on

[3] The project *Venture Capital, and High-Tech Firms* was funded by the European Union, DG Research (Contract No. HPSE-CT-1999-00039).

the *Nouveau Marché*. Underpricing amounted to an average of 63 percent on the *Neuer Markt*,[4] but only to 10 percent on the *Nouveau Marché*.

Starting point for calculating index excess returns is a dataset of daily share prices for all firms listed at the *Neuer Markt* and the *Nouveau Marché*. The *Institut fuer Entscheidungstheorie und Unternehmensforschung (IEU)* at the University of Karlsruhe, Germany, provided data on share prices, dividend payments, and the number of shares traded of firms listed on the *Neuer Markt*. The *Bourse de Paris* provided data on share prices, the number of shares issued, and the number of shares traded of firms listed on the *Nouveau Marché*. From the shares prices, we calculated four indexes, all of them are based on German and French firms only (we excluded foreign firms) that had their IPO at the *Neuer Markt* or the *Nouveau Marché* (secondary listings are excluded as well). For calculating indexes, we used the procedure recommended by the Deutsche Boerse (Deutsche Boerse 2005).[5] The four indexes are: an all-share index, an index that only includes firms whose number of employees is larger than 80 at their IPO, an index that only includes firms operating in the information and communications industry, and an index that only includes firms operating in the biotechnology industry.

We used either opening or closing prices to calculate discrete compounded daily excess returns from indexes of either the *Neuer Markt* or the *Nouveau Marché*, R_t, according to the following formula:

(14) $$R_t = 100 \times \left(index_t - index_{t-1}\right)/index_{t-1} - F_t / 365,$$

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[4] For the *Neuer Markt*, Franzke (2003) has reported an average underpricing of 49.8 percent. Because we ignore IPOs of foreigners, our numbes are larger than the ones reported by Franzke.

[5] In order to account for IPOs and secondary offers we updated our indexes at the end of each quarter.

where F_t denotes the riskless interest rate *per annum*. As riskless interest rates, we used the one-month Fibor rate in the case of the *Neuer Markt*, and the one-month Pibor rate in the case of the *Nouveau Marché*. Both series have been taken from *Thompson Financial Datastream.*

In the case of the *Neuer Markt*, the sample period starts in January 1998. In the case of the *Nouveau Marché*, the sample period starts in January 1997. The reason for starting 9 months after the markets have been founded is that otherwise our indexes would be based on a very small number of firms. We rescaled our indexes to assume the value 100 on January 1997 and January 1998, respectively. The sample period ends in December 2000 because thereafter very few IPOs took place.

— Insert Table 2 about here. —

Table 2 offers summary statistics of daily index excess returns. The means and medians of daily index excess returns on the *Neuer Markt* and the *Nouveau Marché* were more often negative than index excess returns in the main markets. The maximum index excess returns on the *Neuer Markt* and the *Nouveau Marché* were substantially larger than in the main markets. The unconditional index excess return distributions are slightly negatively skewed, and they are leptokurtic. Thus, their kurtosis exceeds that of the normal distribution. From this it follows that the unconditional return distributions have “fat tails”. Empirical research in financial markets has shown that such “fat tails” are likely to be caused by a time-varying conditional volatility of returns. For this reason, we estimated in our empirical analysis a model that allows the dynamics of the conditional volatility of excess returns to be studied (Section 5).

IV Benchmark Empirical Model and Estimation Results

Our benchmark empirical model is a linear regression model that accounts for the result of capital market theory that excess returns on a stock are proportional to its systematic risk. Systematic risk, in turn, is a function of the covariance of a stock's return with the returns on the market portfolio. In addition, results documented in the empirical literature on the predictability of stock returns suggest that excess returns on a stock may depend on their own past values. In order to take these results into account, we started our empirical research with the following regression equation that we estimated separately for the *Neuer Markt* and the *Nouveau Marché*:

(15) $$R_t = \alpha_0 + \sum_{m=0}^{m=2} \alpha_{1,m} up_{t-m} + \alpha_2 M_t + \alpha_3 R_{t-1} + \alpha_4 T_{t-1} + \varepsilon_t \, ,$$

where M_t denotes the discrete compounded excess returns on total market performance indexes. As total market performance indexes we used the MSCI total performance indexes for Germany and France, respectively. The term T_t denotes the trading intensity. We used trading intensity as a control variable because movements in excess returns may be caused by illiquity that, at times, was relatively pronounced in both the *Neuer Markt* and the *Nouveau Marché*. We calculated the trading intensity as the number of shares traded of each firm as a percentage of the number of shares issued by each firm. We averaged these percentages over all firms included in our indexes. The term ε_t denotes an error term.[6]

Using our theoretical model, we postulated that index excess returns are linked to underpricing of IPOs in primary markets, up_t. In order to measure underpricing of IPOs, we used the magnitude of underpricing. For each individual firm that went public, we calculated

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6 We also included day-of-the-weak, month-of-the-year and year dummies in the vector of regressors in order to control for potential seasonal effects in index excess returns.

underpricing of IPOs as described in Equation (3). Based on our data for underpricing of IPOs, we calculated a time series of underpricing. On days on which no IPO took place, this time series equals zero. On days on which one IPO took place, this time series equals the magnitude of the observed underpricing. On days on which more than one IPO took place, the time series equals either the underpricing averaged over the IPOs or the maximum amount of underpricing.

As Figure 1 shows, underpricing of an IPO at t has a positive impact on share prices at $t+1$ and therefore results in a positive index excess return at $t+1$ if inexperienced investors respond to underpricing of an IPO. Moreover, underpricing of an IPO has an immediate positive impact on share prices at t, resulting in a positive excess return at t. This is the case if arbitrageurs anticipate noise traders' demand. Thus, we distinguish two types of effects: the effect of lagged underpricing on excess return, $\partial R_t / \partial up_{t-1} > 0$, and the effect of contemporaneous underpricing, $\partial R_t / \partial up_t > 0$.

The expected index excess returns in the second period after an IPO are positive if the effect of underpricing is relatively small as compared to the price of risk:

$$I^F - \theta\sigma^2 + \alpha up < I^F \quad \Leftrightarrow \quad \alpha up < \theta\sigma^2 .$$

From this it follows that expected excess returns in the second period after an IPO are driven by two factors: the price of risk the investors charge for holding stocks and the price markup resulting from the shift in noise traders' demand. Hence, it is important to be careful when interpreting any effect of underpricing lagged twice, $\partial R_t / \partial up_{t-2}$, on index excess returns in secondary markets.

According to our theoretical model, a positive link between excess returns and underpricing of IPOs results from two effects: the trading of noise traders and the anticipation of the trading of noise traders by arbitrageurs. Thus, a positive link between underpricing of an IPO calculated using the opening price of that day and index excess returns calculated using the closing price of the same day may either result from noise trading or from the anticipation of such trading by arbitrageurs. In contrast, a positive link between underpricing of IPOs and index excess returns calculated using opening prices cannot be the result of noise trading. In the context of our theoretical model, only arbitrageurs' anticipation of noise trading can result in such a positive link because information on underpricing is not available to traders at that point in time.

We summarize our estimation results in Table 3. Columns (1)–(4) summarize the results for the *Neuer Markt*, and columns (5)–(8) summarize the estimation results for the *Nouveau Marché*. In columns (1), (3), (5) and (7), we present results for returns calculated using indexes based on closing prices, and in columns (2), (4), (6) and (8), we present results for returns calculated using indexes based on opening prices. In columns (1), (2), (5) and (6), we report estimation results for the average of the magnitude of underpricing. In columns (3), (4), (7) and (8), we report estimation results for the maximum amount of underpricing.[7]

— Insert Table 3 about here. —

Our estimation results show that index excess returns in the *Neuer Market* were not linked to underpricing of IPOs.[8] We found that the coefficient of average contemporaneous underpricing is positive and weakly significant when we used the index based on opening

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[7] Results for regressions in which we used the (positive and negative) intial returns of IPOs as an regressor rather than the average of the magnitude or the maximum amount of underpricing yielded very similar results. All estimation results that are not reported are available from the authors upon request.

[8] We also estimated regression equations in which we used a dummy variable equal to one if one or more IPOs took place. We found that the dummy variable does not have a significant effect on excess returns in secondary markets.

prices, but not when we used the index based on closing prices. The sign of the average lagged underpricing is negative and insignificant, while the sign of underpricing lagged twice depends on the index chosen. When we used opening prices to calculate index excess returns, the coefficient is negative. When we used closing prices to calculate index excess returns, the coefficient is positive. In both cases, the coefficient of underpricing lagged twice is not statistically significant. We got similar results for the maximum magnitude of underpricing.

As regards the *Nouveau Marché*, there is evidence of a significant positive link between underpricing of IPOs in primary markets and index excess returns in secondary markets. The coefficient of average contemporaneous underpricing is significant when opening and closing prices are used to calculate index excess returns. In addition, the coefficient of average lagged underpricing is positive and highly statistically significant when we used returns calculated using opening prices. The coefficient lacked significance when we used returns calculated using closing prices. The sign of the coefficient of average underpricing lagged twice depends on the index excess returns chosen. In the case of index excess returns calculated using opening prices the coefficient has a positive sign. In the case of index excess returns calculated using closing prices the coefficient has a negative sign. In both cases, the coefficient is not significant. We got similar results for the coefficient of the maximum magnitude of underpricing.

Comparing the results for the *Nouveau Marché* with those for the *Neuer Markt*, we conclude that investors' response to underpricing of IPOs in primary markets differs between the *Nouveau Marché* and the *Neuer Markt*. Our empirical results indicate that only in the case of the *Nouveau Marché* there was a positive link between underpricing of IPO and index excess returns. Moreover, the economic importance of underpricing of IPOs and the way it was linked to index excess returns in secondary markets differed between the two markets. Concerning the *Neuer Markt*, only contemporaneous underpricing had a weakly significantly positive effect on index excess returns. As regards the *Nouveau Marché*, there is evidence for a strong positive effect of contemporaneous and lagged underpricing on index excess returns. This positive effect of contemporaneous and lagged underpricing on index excess returns is in line with the key result of our theoretical model. Thus, the difference between the results for the *Nouveau Marché* and the *Neuer Markt* might indicate that the arbitrage at the expense of noise traders described in our theoretical model was less profitable in the case of the *Neuer Markt*. As concerns the interpretation of our results for index excess returns calculated using closing and opening prices, our theoretical model suggests that both types of market participants, arbitrageurs and noise traders, were active in the *Nouveau Marché*. Thus, underpricing of IPOs did not only affect index excess returns *via* noise traders' demand. Rather, arbitrageurs anticipated the additional demand by noise traders, and this gave rise to a significant positive link between underpricing and contemporaneous excess returns calculated from opening prices.

Regarding our control variables, we found that the coefficients of the index excess returns of the main market are highly significant and positive. This is in line with capital market theory and earlier empirical studies (e.g., Fama and French 1993). In the case of the returns based on opening prices for the *Neuer Markt*, the size of the coefficients indicates that excess returns in this market segment closely moved with excess returns in the main market.

In the case of the *Neuer Markt,* we found that index excess returns were predictable when we used indexes calculated from closing prices. There is no evidence of predictability of index excess returns calculated using opening prices. Predictability of daily returns in the European stock markets for fast-growing firms has been documented and discussed in the recent literature (Pierdzioch and Schertler 2005). Finally, the trading intensity has a positive impact on index excess returns in both markets. It is, however, only statistically significant in the case of the *Nouveau Marché*.

V Evidence from a GARCH Model

We analyzed the robustness of our results by estimating GARCH models. GARCH models have been an important modeling framework for many empirical studies of the dynamics of stock returns (see, for example, Bollerslev et al. 1988; De Santis and Gerard 1997). In order to setup our GARCH model, we used the result from capital market theory that excess returns are a function of the covariance of a stock's return with the returns on the market portfolio. In the case of the market portfolio, index excess returns are a linear function of the conditional variance of the market portfolio, $h_{M,t}$. In the case of the *Nouveau Marché* and the *Neuer Markt*, index excess returns are a function of the conditional covariance with the returns on the market portfolio, $h_{M,t}$. In order to test the implications of our theoretical model, we further assumed that, in the case of the *Nouveau Marché* and the *Neuer Markt*, index excess returns are linked to underpricing of IPOs. In addition, we accounted for the potential predictability of index excess returns by including index lagged excess returns in the vector of regressors. Finally, we took into account that the lagged trading volume may have influenced index excess returns. Hence, we specified the following model for index excess returns:

$$
\begin{aligned}
M_t &= \kappa h_{M,t} + \varepsilon_{M,t} \\
R_t &= \kappa h_{M,t} + \sum_{i=0}^{2} \beta_{1,m} up_{t-i} + \beta_2 R_{t-1} + \beta_3 T_{t-1} + \varepsilon_{R,t}
\end{aligned} \quad . \tag{16}
$$

The disturbance terms, $\varepsilon_{M,t}$ and $\varepsilon_{R,t}$, are normally distributed with zero mean and conditional variance-covariance matrix given by Σ_t. In order to account for potential seasonal effects, we ran a regression of returns on day-of-the-week-effect dummies, months-of-the-year-effect dummies, and yearly dummies before estimating our GARCH model.

In order to estimate our GARCH model, we used a Choleski decomposition to decompose the matrix H_t (see Tsay 2002). According to this decomposition, the variance-covariance matrix can be written as $H_t = LG_tL'$, where L is a lower-triangular matrix with unit diagonal elements, and G_t is a diagonal matrix. We assumed that the dynamics of the elements of the matrix G_t are given by the following GARCH(1,1) processes:

$$\text{(17)} \quad \begin{aligned} g_{M,t} &= \beta_{10} + \beta_{11}\varepsilon^2_{M,t-1} + \phi_{11}g_{M,t-1} + \varphi_{11}d_{M,t}\varepsilon^2_{M,t-1} \\ g_{R,t} &= \beta_{20} + \beta_{22}(\varepsilon_{R,t-1} - l_{21}\varepsilon_{M,t-1})^2 + \phi_{22}g_{R,t-1} + \varphi_{22}d_{R,t}(\varepsilon_{R,t-1} - l_{21}\varepsilon_{M,t-1})^2, \end{aligned}$$

where $d_{M,t}$ and $d_{R,t}$ are TARCH dummy variables that account for potential asymmetries in the response of variance to “good” news and to “bad” news (Glosten et al. 1993). Hence, the dummy variables are defined as $d_{M,t} = 1$ if $\varepsilon_{M,t-1} < 0$ and $d_{M,t} = 0$ otherwise, and $d_{R,t} = 1$ if $\varepsilon_{R,t-1} - l_{21}\varepsilon_{M,t-1} < 0$ and $d_{R,t} = 0$ otherwise.

The Choleski decomposition implies that the GARCH(1,1) processes specified in Equation (17) translate into the dynamics of the conditional variance-covariance matrix as follows:

$$\text{(18)} \qquad H_t = \begin{pmatrix} h_{M,t} & h_{R,M,t} \\ h_{R,M,t} & h_{R,t} \end{pmatrix} = \begin{pmatrix} g_{M,t} & l_{21}g_{M,t} \\ l_{21}g_{M,t} & g_{R,t} + l^2_{21}g_{M,t} \end{pmatrix}.$$

The conditional correlation of returns is given by $\rho_t = h_{R,M,t} / \sqrt{h_{M,t}h_{R,t}}$, which may be rewritten as $\rho_t = l_{21}\sqrt{\sigma_{M,t} / \sigma_{R,t}}$. The log-likelihood function to be maximized is given by (see Tsay 2002):

$$\text{(19)} \qquad LL^1 = -\frac{1}{2}\sum_{t=1}^{T}\left(ln(g_{M,t}) + ln(g_{R,t}) + \frac{\varepsilon^2_{M,t}}{g_{M,t}} + \frac{(\varepsilon_{R,t} - l_{21}\varepsilon_{M,t})^2}{g_{R,t}} \right).$$

Figure 2 shows the conditional volatilities and the conditional correlations that we obtained upon estimating the GARCH model given in Equations (16)-(19) by maximum likelihood. Table 4 summarizes the estimation results.[9] With regard to the correlation of underpricing of IPOs in primary markets with index excess returns in the secondary markets, the results corroborate the results given in Table 3. In the case of the *Neuer Markt*, the coefficients that capture the contemporaneous link between underpricing and index excess returns in the secondary market are insignificant. There is some evidence for predictability of returns when closing prices are used to compute index excess returns. The magnitudes of the coefficients that capture the link between underpricing of IPOs and excess returns in the secondary markets are roughly the same as in the benchmark model.

— Insert Figure 2 about here. —

As regards the *Nouveau Marché*, the coefficients of the contemporaneous and lagged underpricing of IPOs are significantly positive. The coefficient of underpricing lagged twice is insignificant. The magnitude of the coefficients that capture the link between underpricing of IPOs and index excess returns in the secondary market is comparable to the magnitude of the respective coefficients in the benchmark model. Thus, as in the case of the *Neuer Markt*, the estimation results for the *Nouveau Marché* strongly support the estimation results that we obtained when we estimated our benchmark model. The coefficient of the lagged endogenous variable is positive and statistically significant.

— Insert Table 4 about here. —

The results of the diagnostic tests suggest that our relatively simple GARCH model fits the data quite well. With regard to the *Neuer Markt*, only the hypothesis of no positive sign bias cannot be rejected. With regard to the *Nouveau Marché*, there is evidence for some

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9 For the sake of brevity, we only report estimation results for the conditional mean equations. Estimation results for the conditional variance equations are available from the authors upon request. Before estimating the GARCH model, we regressed index excess returns on day-of-the-weak, month-of-the-year and year dummies in order to control for potential seasonal effects in index excess returns.

remaining first-order serial correlation in main market returns, and for a negative size bias in main market conditional volatility that has not been accounted for by the TARCH dummy. Moreover, the results of the diagnostic tests suggest that there is some autocorrelation in squared standardized residuals and a remaining negative size bias when closing prices are used to compute excess returns for the *Nouveau Marché*. However, given that we mechanically estimated, for the sake of comparability of results, the same GARCH model to study all eight models described in Table 4, the evidence for correct model specification is remarkably strong.

VI Size- and Industry-Specific Indexes

In order to further assess the robustness of our results, we analyzed whether the link between underpricing of IPOs and index excess returns depends on characteristics of the firms included in the index. This might give additional insights with regard to the behavior of noise traders and arbitrageurs. More specifically, if noise traders prefer investing in large firms or in firms belonging to particular industries, the link between index excess returns and underpricing of IPOs may only show up when index excess returns are calculated based on size-specific and industry-specific indexes.

We calculated three size- and industry-specific indexes from the individual share prices of firms listed on the *Neuer Markt* and the *Nouveau Marché*. Our first index includes firms whose number of employees was larger than 80 at their IPO. Because of their size, these firms might have been more preferred by inexperienced investors than smaller sized firms. Thus, it could be the case that underpricing of IPOs affected this index to a stronger extent than the all-share index. Our second index only includes firms that operated in the information and communications industry. Our third index includes firms that operated in the biotechnology industry.

Table 5 presents estimation results based on index excess returns calculated from closing prices. In columns (1)–(4) we present results for the *Neuer Markt*, and in columns (5)–(8) we present results for the *Nouveau Marché*. In columns (1) and (5) we repeat the results of the benchmark model. In columns (2) and (6) we present results for index excess returns calculated using the index of large firms, in columns (3) and (7) we present results for index excess returns calculated using the index for firms operating in the information and communications industry, and in columns (4) and (8) we present results for index excess returns calculated using the index for firms operating in the biotechnology industry.

When we used index excess returns from the index that includes only large firms, the coefficients of contemporaneous underpricing for the *Neuer Markt* and the *Nouveau Marché* were significantly positive. The coefficients of lagged underpricing und underpricing lagged twice were not significant. While this evidence does not yield new insights in the case of the *Nouveau Marché*, it yields new insights in the case of the *Neuer Markt*. When we used index excess returns calculated using the all-share index, we found that index excess returns in secondary markets are not linked to underpricing of IPOs. In contrast, as the results summarized in Table 5 reveal, when we used index excess returns calculated using an index of large firms, the coefficient of contemporaneous underpricing of IPOs is significant.

When we used index excess returns calculated using the index that includes only firms that operated in the information and communications industry, the coefficient of contemporaneous underpricing is significantly positive for both the *Neuer Markt* and the *Nouveau Marché.* The coefficients of lagged underpricing and underpricing lagged twice are again insignificant. In general, results for index excess returns for the index of firms that operated in the information and communications industry and for large firms are very similar.

When we used index excess returns calculated using the index that includes only firms that operated in the biotechnology industry, there is no evidence for a significant link between contemporaneous underpricing of IPOs and index excess returns in the secondary market. However, the coefficient of lagged underpricing is significantly positive, and the coefficient of underpricing lagged twice is significantly negative. In terms of our theoretical model, this negative effect can be explained by the vanishing of the impact of noise traders' demand on prices. Compared to our indexes for large firms and for firms operating in the information and communications industry, the indexes of firms that operated in the biotechnology industry are based on a relatively small number of firms. Therefore, these indexes are not as broad as the other indexes used.

Concerning predictability of index excess returns, we found mixed results. Index excess returns calculated using indexes of the *Neuer Markt* are in some cases predictable, while index excess returns of the *Nouveau Marché* are not. In the case of the GARCH model, however, we also found predictability for index excess returns for the *Nouveau Marché* in two cases.

Regarding our other control variables, we found that the total market return is positive and significant. In contrast, the price of risk is positive but insignificant in the GARCH model. The trading intensity is significantly positive in the case of the *Nouveau Marché*, but it often lacks significance in the case of the *Neuer Markt*.

VII Summary and Concluding Remarks

We analyzed the link between underpricing of IPOs and index excess returns in secondary markets. We used a theoretical model to argue that if underpricing triggers an increase in demand for stocks from inexperienced investors the result should be an impact of underpricing on excess returns of already listed firms. This result rests on the assumption of imperfect arbitrage and, hence, market inefficiency. Our model predicts a positive impact of underpricing of IPOs on index excess returns.

We used a dataset for the *Neuer Markt* and the *Nouveau Marché* to test whether index excess returns in secondary markets are significantly linked to underpricing of IPOs in primary markets. Using a linear regression model and a GARCH model, we tested whether index excess returns calculated from all-share indexes of the *Neuer Markt* and the *Nouveau Marché* are significantly higher after days on which underpricing of IPOs was observed. The results of our empirical research suggest that there is evidence for a significant link between index excess returns of already listed firms and underpricing of IPOs in primary markets. We found that this link is strong and statistically significant in the case of the *Nouveau Marché* the evidence for such a link is only weak in the case of the *Neuer Markt*.

In order to gain further insights into the link between underpricing of IPOs and index excess returns, we calculated several sub-indexes for the *Neuer Markt* and the *Nouveau Marché*. We claimed that in a size-based and an industry-based analysis the statistical link between underpricing of IPOs and index excess returns in secondary markets is stronger if inexperienced investors prefer investing in firms with particular size-based and an industry-based characteristics. Concerning the *Neuer Markt*, we found that the evidence of a link between underpricing of IPOs and index excess returns strengthens when index excess returns are calculated using a sub index for firms operating in the information and communications industry. Moreover, we found that index excess returns calculated using an index of firms operating in the information and communications industry react differently to underpricing of IPOs than index excess returns calculated using an index for firms operating in the biotechnology industry.

Our theoretical model can be used to interpret the statistical link between underpricing of IPOs in primary markets and index excess returns in secondary markets. Our theoretical model implies that it was the presence of inexperienced investors dazzled by high initial returns from IPOs that may have been an important characteristic of the *Neuer Markt* and the

Nouveau Marché in the second half of the 1990s. Bringing together the implication of our theoretical model and the results of our empirical analysis, we conclude that one can argue that the dynamics of index excess returns in the *Neuer Markt* and the *Nouveau Marché* at the end of the 1990s can at least partly be attributed to investment decisions of inexperienced investors that were triggered by underpricing of IPOs in primary markets. Therefore, the results of our research may indicate that establishing institutions that help to control and to shape developments in primary markets can be important to guarantee the health of secondary markets.

The type of noise trading we described in this paper was certainly not the only factor that shaped developments in the *Neuer Markt* and the *Nouveau Marché* in the second half of the 1990s. Moreover, one could think of explanations different from the one we proposed to interpret the link between index excess returns and underpricing of IPOs that we recovered in our empirical analysis. However, our theoretical model renders it possible to give our empirical results a structural interpretation, and given the robustness of our results across various different specifications of our empirical models, we think that the empirical evidence that we presented in this paper is compelling. Of course, a lot of work still needs to be done. In particular, when interpreting our results, one should be aware of the fact that the time-series-based approach that we used in this paper to analyze the link between underpricing of IPOs and index excess returns in secondary markets is new. The earlier literature on underpricing of IPOs has mainly analyzed a cross section of firms that went public. For this reason, more research into the nature of the link between index excess returns in secondary markets and underpricing of IPOs in primary markets is necessary. Such research might not only use our noise-trader-based approach to yield a deeper understanding of this link, but might also use alternative approaches and different structural interpretations to paint a picture of this link as detailed as possible.

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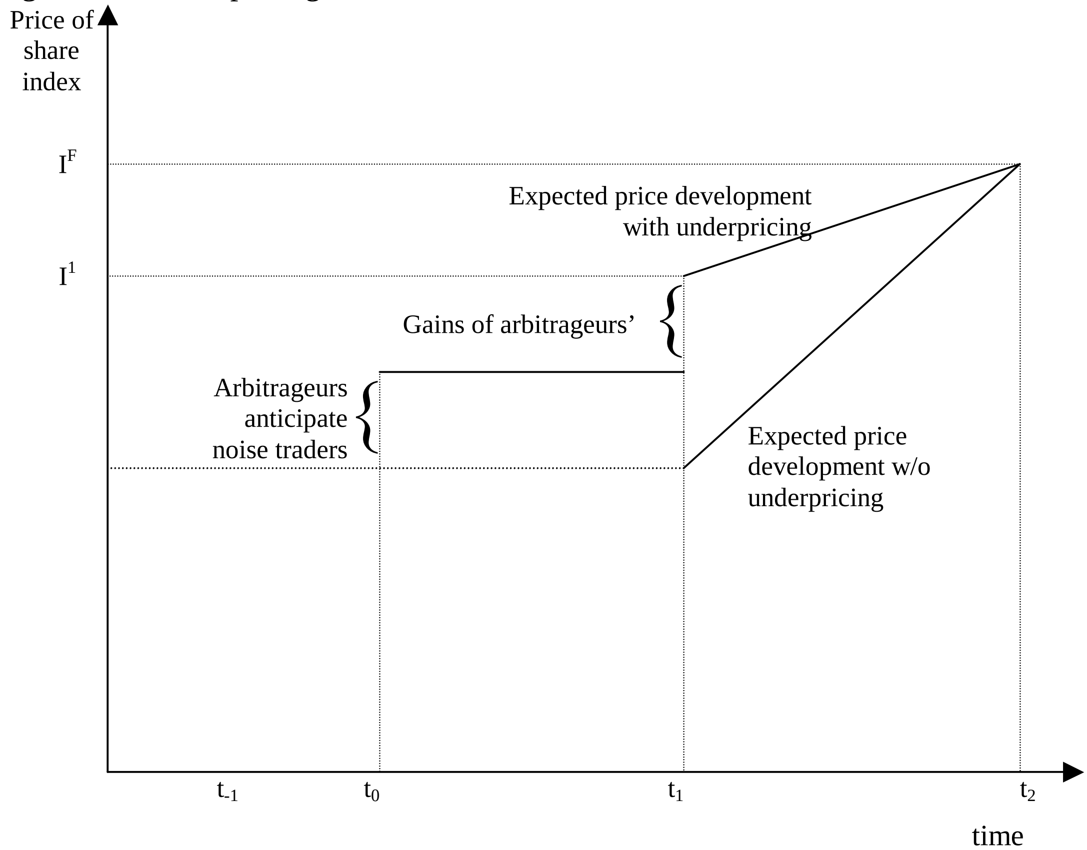
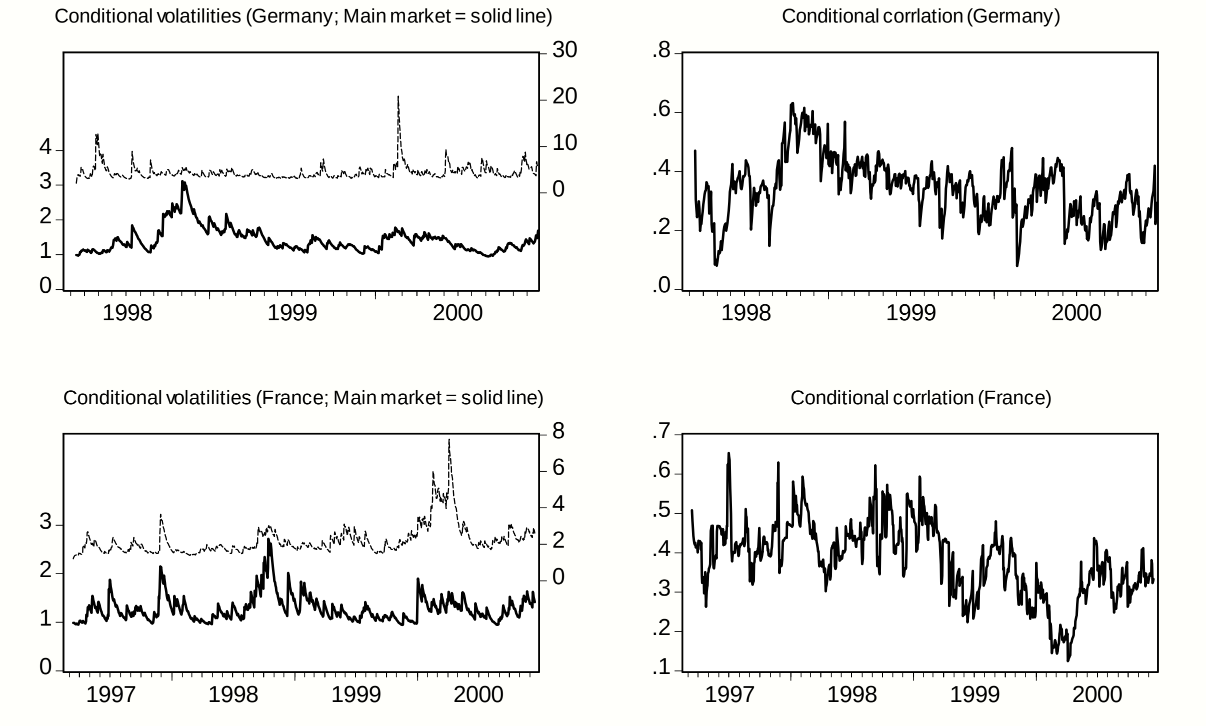
Figure 1 — Underpricing and the Price of the Portfolio



Note: This figure shows the price of the share index in response to underpricing of an IPO, which is observed by noise traders in t_1.

Figure 2 — Estimated Conditional Volatilities and Correlations



Note: This figure shows conditional volatilities and conditional correlations computed by estimating the model given in (16)-(19) by maximum likelihood. Endogenous variable is the index excess returns calculated using all-share indexes of the *Neuer Markt* and the *Nouveau Marché*. Index excess returns are based on closing prices. Underpricing is defined as the opening price minus the issue price, scaled by the issue price. Average underpricing is the average of underpricing in the case of several IPOs per day.

Table 1 — Summary Statistics of IPOs

		1996	1997	1998	1999	2000
				Neuer Markt		
Number of IPOs			9	40	130	125
Number of underpriced IPOs			9	39	112	108
Underpricing:	min		0.29	0.00	0.00	0.00
	mean		131.83	97.46	49.63	56.78
	max		649.18	568.66	288.89	866.07
Over- and underpricing	min		0.29	-25.44	-13.16	-29.66
	mean		131.83	96.76	47.96	51.22
	max		649.18	568.66	288.89	866.07
				Nouveau Marché		
Number of IPOs		15	18	38	31	49
Number of underpriced IPOs		6	9	36	8	5
Underpricing:	min	0	0	0	0	0
	mean	28.12	9.09	9.26	11.49	6.13
	max	298.04	72.78	70.00	126.67	213.64
Over- and underpricing	min	-36.33	-5.41	-24.33	-4.55	-15.19
	mean	23.30	8.47	8.61	11.26	5.71
	max	298.04	72.78	70.00	126.67	213.64

Note: This table reports summary statistics of IPOs in the *Neuer Markt* and the *Nouveau Marché*. Underpricing is defined as the opening price on the first trading day minus the issue price, scaled by the issue price. Data come from the Deutsche Boerse, the Bourse de Paris, and the Institut fuer Entscheidungstheorie, Karlsruhe.

Table 2 — Summary Statistics of Daily Index Excess Returns

	Germany			France		
	opening prices	closing prices	main market	opening prices	closing prices	main market
Mean	0.3417	0.2669	0.0562	0.1041	0.1072	0.1000
Median	-0.0097	-0.0116	0.1373	0.0837	0.1026	0.1182
Maximum	52.5631	45.0959	5.7670	24.7857	20.1622	6.1870
Minimum	-18.2305	-19.1223	-6.1835	-20.9130	-12.3106	-5.6518
Standard deviation	5.3619	4.6344	1.4974	2.9195	2.5030	1.3204
Skewness	2.4132	1.7642	-0.2980	-0.0569	0.1674	-0.2551
Kurtosis	23.6426	17.4568	4.3053	15.8688	11.0116	4.4603
LM ARCH (1)	6.230***	1.869	38.715***	132.605***	72.824***	50.285***
LM ARCH (2)	5.538***	1.066	26.761***	70.448***	50.013***	35.57***
JB	21186.2***	16421.76***	153.634***	3733.29***	2151.172***	212.811***
Observations	752	752	752	1004	1004	1004

Note: The table gives summary statistics of daily index excess returns. For the German stock market indexes, the sample period is 01.01.1998–31.12.2000. For the French stock market indexes, the sample period is 01.01.1997–31.12.2000. *LM-ARCH*(*i*) denotes Engle's (1982) Lagrange multiplier test for autocorrelation of order *i* in squared returns. The Jarque-Bera (*JB*) test is a test for normality of the unconditional returns distribution. *** denotes significance at the one percent level.

Table 3 — Underpricing and Index Excess Returns: Benchmark Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Neuer Markt				*Nouveau Marché*		
	CL	OP	CL	OP	CL	OP	CL	OP
	UP	UP	MUP	MUP	UP	UP	MUP	MUP
Underpricing	0.006	0.009*	0.003	0.006	0.014***	0.012**	0.015***	0.012**
	(1.43)	(1.8)	(1.11)	(1.35)	(2.59)	(2.21)	(2.71)	(2.33)
Underpricing (1)	-0.002	-0.001	-0.002	-0.001	0.008	0.018***	0.009*	0.017***
	(0.83)	(0.4)	(1.1)	(0.44)	(1.57)	(3.93)	(1.67)	(4.24)
Underpricing (2)	0.002	-0.003	0.002	-0.002	-0.002	0.006	-0.002	0.007
	(0.64)	(1.08)	(1.18)	(1.24)	(0.66)	(1.11)	(0.61)	(1.2)
Endogenous variable(1)	0.112**	0.025	0.111**	0.022	0.07	-0.069	0.07	-0.069
	(2.41)	(0.53)	(2.39)	(0.47)	(1.4)	(1.06)	(1.39)	(1.06)
Market returns	1.032***	0.385***	1.031***	0.383***	0.798***	0.315***	0.797***	0.315***
	(8.48)	(2.71)	(8.44)	(2.68)	(10.22)	(3.98)	(10.21)	(3.97)
Trading intensity	0.282	0.372	0.283	0.378	2.810**	3.858***	2.803**	3.855***
	(1.41)	(1.24)	(1.41)	(1.26)	(2.35)	(2.92)	(2.35)	(2.92)
Observations	752	752	752	752	1004	1004	1004	1004
F-test	10.434***	8.6***	10.499***	8.607***	6.93***	3.797***	6.955***	4.049***

Note: This table reports estimation results of ordinary least square regressions. Endogenous variable is the index excess return calculated using all-share indexes of the *Neuer Markt* and the *Nouveau Marché*. Index excess returns are either calculated using opening prices (OP) or closing prices (CL) of German and French firms that went public on the *Neuer Markt* and the *Nouveau Marché*. Underpricing is defined as the opening price minus the issue price, scaled by the issue price. UP denotes the average underpricing defined as the average of underpricing in the case of several IPOs per day. MUP denotes the maximum underpricing defined as the maximum underpricing in the case of several IPOs per day. Absolute Newey-West t-statistics are reported under the coefficients. (1) denotes the first lag. (2) denotes the second lag. All estimations include day, month, and year dummies. *** (**, *) denotes significance at the one (five, ten) percent level.

Table 4 — Underpricing and Index Excess Returns: GARCH Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Neuer Markt				*Nouveau Marché*		
	CL	OP	CL	OP	CL	OP	CL	OP
	UP	UP	MUP	MUP	UP	UP	MUP	MUP
Underpricing	0.003	-0.001	<0.000	-0.002	0.016***	0.014*	0.017**	0.014**
	(0.86)	(0.32)	(0.10)	(0.68)	(2.50)	(1.91)	(2.39)	(1.82)
Underpricing (1)	0.003	-0.003	0.002	-0.003	0.011	0.017***	0.012**	0.017***
	(0.86)	(1.07)	(0.46)	(1.40)	(2.65)	(5.11)	(2.65)	(4.87)
Underpricing (2)	0.001	<-0.000	0.003	0.001	-0.003	0.005	-0.003	0.006
	(0.53)	(0.09)	(0.80)	(0.27)	(0.55)	(1.11)	(0.48)	(1.21)
Endogenous	0.144**	-0.021	0.140*	-0.022	0.102***	0.078*	0.102**	0.078**
variable(1)	(2.01)	(0.44)	(1.85)	(0.50)	(2.99)	(1.94)	(2.52)	(2.03)
Price of risk	0.007	0.007	0.007	0.007	0.007	0.007	0.0107	0.007
	(0.35)	(0.30)	(0.29)	(0.31)	(0.30)	(0.29)	(0.33)	(0.31)
Trading intensity	-0.013	0.064	-0.020	0.068	-0.09	-0.041	-0.102	-0.155
	(0.17)	(0.39)	(-0.21)	(0.265)	(0.39)	(0.14)	(0.32)	(0.46)
				Standardized residuals main market				
$Q(z,1)$	0.74	0.74	0.74	0.74	0.03**	0.03**	0.03**	0.03**
$Q(z^2,1)$	0.20	0.20	0.20	0.20	0.31	0.31	0.31	0.31
Sign bias	0.33	0.33	0.33	0.33	0.25	0.25	0.25	0.25
Neg. Bias	0.41	0.41	0.41	0.41	0.02**	0.02**	0.02**	0.02**
Pos. Bias	0.04**	0.03**	0.03**	0.03**	0.16	0.16	0.16	0.16
Joint	0.16	0.16	0.16	0.16	0.11	0.11	0.11	0.11
$E(z)=0$	0.72	0.72	0.72	0.72	0.53	0.53	0.53	0.53
$E(z^2)=1$	0.98	0.99	0.99	0.99	0.94	0.94	0.94	0.94
$E(z^3)=0$	0.21	0.21	0.21	0.21	0.03**	0.03**	0.03**	0.03**
$E(z^4-3)=0$	0.33	0.33	0.33	0.33	0.26	0.26	0.26	0.26
				Standardized residuals *Neuer Markt* / *Nouveau Marché*				
$Q(z,1)$	0.75	0.36	0.69	0.35	0.67	0.63	0.67	0.63
$Q(z^2,1)$	0.61	0.70	0.61	0.67	<0.00***	0.14	<0.00***	0.14
Sign bias	0.37	0.78	0.67	0.75	0.90	0.53	0.86	0.54
Neg. Bias	0.99	0.42	0.98	0.38	<0.00***	0.16	<0.00***	0.16
Pos. Bias	0.73	0.62	0.71	0.61	0.16	0.52	0.16	0.52
Joint	0.51	0.82	0.95	0.80	<0.00***	0.30	<0.00***	0.31
$E(z)=0$	0.56	0.59	0.54	0.60	0.58	0.39	0.58	0.33
$E(z^2)=1$	0.92	0.94	0.93	0.93	0.97	0.89	0.97	0.89
$E(z^3)=0$	0.10	0.21	0.10	0.20	0.19	0.54	0.19	0.17
$E(z^4-3)=0$	0.16	0.15	0.15	0.13	0.08*	0.12	0.08*	0.12

Note: This table reports estimation results for GARCH models. Endogenous variable is the index excess return calculated using all-share performance indexes of the *Neuer Markt* and the *Nouveau Marché*. Index excess returns are either calculated from opening prices (OP) or closing prices (CL) of German and French firms that went public on the *Neuer Markt* and the *Nouveau Marché*. Underpricing is defined as the opening price minus the issue price, scaled by the issue price. UP denotes the average underpricing defined as the average of underpricing in the case of several IPOs per day. MUP denotes the maximum underpricing defined as the maximum underpricing in the case of several IPOs per day. Absolute values of asymptotic t-statistics are reported below the coefficients. Robust standard errors were used to compute t-statistics. (1) denotes the first lag. (2) denotes the second lag. *** (**, *) denotes significance at the one (five, ten) percent level. $Q(z,1)$ denotes p-values of Ljung-Box Q-tests for first-order serial correlation in standardized residuals, z. $Q(z2,1)$ denotes p-values of Ljung-Box Q-tests for first-order serial correlation in squared standardized residuals, z. Sign bias, Neg. sbias, Pos. bias and Joint denote p-values of the Sign bias, Negative size bias, Positive size bias, and Joint tests proposed by Engle and Ng (1993). $E(z)$, $E(z^2)$ $E(z^3)$, $E(z^4)$ denote p-values of Nelson's (1991) tests for orthogonality conditions for the first four moments of standardized residuals.

Table 5 — Size- and Industry-Specific Indexes of the *Nouveau Marché*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Neuer Markt				*Nouveau Marché*			
	Baseline	LARGE	IT	BM	Baseline	LARGE	IT	BM
				Linear model				
Underpricing	0.006	0.005**	0.006**	-0.004	0.014***	0.018***	0.018***	-0.003
	(1.43)	(2.35)	(2.58)	(0.98)	(2.59)	(2.83)	(2.58)	(0.73)
Underpricing (1)	-0.002	0.001	0.001	0.009**	0.008	0.01	0.007	0.008**
	(0.83)	(0.42)	(0.25)	(2.5)	(1.57)	(1.49)	(1.05)	(2.07)
Underpricing (2)	0.002	-0.001	-0.002	-0.005*	-0.002	0.002	-0.002	-0.007*
	(0.64)	(0.69)	(0.76)	(1.81)	(0.66)	(0.47)	(0.48)	(1.72)
Endogenous variable (1)	0.112**	0.124**	0.147***	0.04	0.07	0.063	0.044	0.023
	(2.41)	(2.4)	(2.95)	(0.61)	(1.4)	(1.34)	(0.95)	(0.56)
Main market returns	1.032***	1.099***	1.119***	1.064***	0.798***	0.818***	0.825***	0.745***
	(8.48)	(9.32)	(8.98)	(10.58)	(10.22)	(10)	(9.78)	(8.26)
Trading intensity	0.282	0.177	0.156	0.796***	2.810**	2.755**	2.963**	2.154*
	(1.41)	(0.94)	(0.76)	(3.37)	(2.35)	(2.21)	(2.2)	(1.78)
				Nonlinear model				
Underpricing	0.003	0.007	0.004***	-0.003	0.016***	0.022**	0.018*	<0.000
	(0.86)	(0.36)	(2.68)	(1.27)	(2.50)	(2.33)	(1.81)	(0.02)
Underpricing (1)	0.003	0.121***	0.001	0.001	0.011	0.012	0.007	0.010**
	(0.86)	(3.44)	(0.94)	(0.44)	(2.65)	(1.58)	(1.34)	(2.17)
Underpricing (2)	0.001	0.004**	-0.002	-0.004	-0.003	0.001	-0.003	-0.002
	(0.53)	(2.15)	(1.09)	(1.53)	(0.55)	(0.14)	(0.51)	(0.38)
Endogenous variable (1)	0.144**	-0.002	0.125***	0.077*	0.102***	0.104***	0.079*	0.039
	(2.01)	(0.97)	(3.48)	(1.95)	(2.99)	(2.70)	(1.87)	(0.87)
Price of risk	0.007	0.002	0.07	0.007	0.007	0.007	0.007	0.007
	(0.35)	(0.94)	(0.30)	(0.26)	(0.30)	(0.28)	(0.28)	(0.32)
Trading intensity	-0.013	-0.016	-0.010	0.16*	-0.09	0.077	0.19	-0.16
	(0.17)	(0.23)	(1.09)	(1.66)	(0.39)	(0.20)	(0.51)	(0.32)

Note: This table reports estimation results for ordinary least square regressions and for GARCH models. Endogenous variable is the index excess returns calculated using various indexes of the *Neuer Markt* and the *Nouveau Marché*. EXC denote index excess returns calculated using an index from which the first 3 days of newly listed firms are excluded. LARGE denotes index excess returns calculated using an index of firms that had more than 80 employees at the time of the IPO. IT denotes index excess returns calculated using an index of firms operating in the information and communications industry. BM denotes index excess returns calculated using an index from share prices of firms operating the biotechnology and medical industry. Index excess returns were calculated using closing prices. Underpricing is defined as the opening price minus the issue price, scaled by the issue price. Average underpricing is defined as the average of underpricing in the case of several IPOs per day. Absolute *t*-statistics computed by using robust standard errors are reported below the coefficients. (1) denotes the first lag. (2) denotes the second lag. All estimations include day, month and year dummies. *** (**, *) denotes significance at the one (five, ten) percent level.