

Technology-related peso problems in stock returns

Aku Penttinen*

Swedish School of Economics and Business Administration

Department of Economics

PO Box 479, FIN-00101 Helsinki, Finland

Abstract

In the empirical testing of many asset pricing models it is assumed that realised returns are an unbiased estimate of expected returns over the period of study. In this paper it is argued that the occurrence of negative jumps in a firm's future earnings and, consequently, in its stock price, is positively related to the level of network externalities in the firm's product market. If the ex post frequency of these negative jumps in a sample does not equal the ex ante assessed probability of occurrence, the sample is subject to a peso problem. The hypothesis is tested for by regressing the skewness coefficient of a firm's realised stock return distribution on the firm's R&D intensity, i.e. the ratio of the firm's research and development expenditure to its net sales. The empirical results support the technology-related peso problem hypothesis. In samples subject to such a peso problem, the returns are upward and the variances downward biased.

Keywords: Asset pricing; Peso problem; Skewness; Technology risk

JEL classification codes: G12, G14

* Telephone +358 9 431 33 365
Facsimile +358 9 431 33 382
E-mail aku.penttinen@shh.fi

If the Internet turns out not to be the future of computing, we're toast.

- Oracle CEO Larry Ellison, February 1, 2000

1. Introduction

Although it is empirically well documented that historical stock returns cannot fully be characterised by a symmetric distribution, one of the main assumptions in many modern asset pricing models is that stock returns are log-normally distributed. This assumption is usually motivated by claiming that it is a sufficiently good approximation of the true underlying conditions, so that realised returns can be used as a proxy for expected returns, and that the theoretical modelling of normally distributed random variables is relatively easy.

In this paper it is argued that due to a highly specific technology-related risk, the expected stock returns of firms making products for markets with network externalities cannot completely be characterised by a symmetric probability distribution. Instead of being supplied by several firms using different technologies, markets with network externalities tend to be dominated by a single technology. As long as a firm is in the race for the dominant technology, its stock price is expected to develop in a relatively continuous manner. However, when it becomes publicly known that a certain firm is about to lose the race for technological dominance, as happened to e.g. Iridium World Communications in the race for the global mobile telephone technology, the expected earnings growth rate is strongly revised down. As a consequence, the firm's stock price will experience a dramatic fall. Due to this risk of a negative jump in the stock price, the ex ante expected stock return distributions of firms producing goods and services to markets with network externalities are more negatively skewed than those of other firms.

A sample where the frequency of these negative jumps does not equal the ex ante assessed probability is subject to a peso problem. If investors correctly anticipate the potential risk of a negative idiosyncratic jump in the stock price, they require to be compensated for bearing this risk by a higher expected return in periods where the risk is not realised. Conditional on a return series sample containing a lower frequency of negative jumps than is rationally expected by the market ex ante, the ex post return is biased up and the ex post variance is biased down. Thus, a seemingly high in-sample return and low in-sample variance may rationally be explained by the existence of a technology-related peso problem.

Peso problems have been used to explain various situations where there is a small positive probability of an important event and investors take this probability into account when setting market prices. Many attribute the first use of the term "peso problem" to Milton Friedman who used it in his examination of the Mexican interest rate market in the early 1970s (Evans, 1996). Although the Mexican peso (MXP) was officially pegged to the USD in the period 1954-1976, Mexican deposit rates were substantially higher than the US rates. Friedman argued that this interest rate differential was due to devaluation expectations. Rogoff (1980) studied the MXP spot and futures markets in the probably first written discussion of the peso problem. Krasker (1980) and Lizondo (1983) lay the more formal foundation of foreign-exchange-rate-related peso problem analysis.

Possible peso problems in the foreign exchange markets have also been studied by Kaminsky (1993), Flood and Rose (1996), and Sercu and Vinaimont (1999). Among the papers that cover peso problems caused by the risk of a regime switch in the interest rate markets are Hamilton (1988), Lewis (1991), Evans and Lewis (1994) and Bekaert,

Hodrick and Marshall (1997). Apart from the closely linked foreign exchange and interest rate markets, peso problems have also been found to exist in the stock market. Rietz (1988) and Brown, Goetzmann and Ross (1995) study peso problems caused by infrequent catastrophes in stock markets. Discrete regime switches in the dividend process have been analysed by Kandel and Stambaugh (1990) and Evans (1996). Berglund and Löflund (1996) examine how a peso problem caused by a fundamental exchange rate disequilibrium could explain seemingly persistent negative rates of return in the stock market index. Penttinen (2000) also finds evidence of devaluation-risk-related peso problems in individual stock returns whereas Bekaert et al. (1998) show that the returns on many emerging stock markets contain jumps.

The aim of this paper is to test whether a technology-specific peso problem exists in small stock return samples. If the peso problem hypothesis holds, the stock return distributions of firms whose product markets have a higher level of network externalities should have lower, or more negative, skewness coefficients than firms whose product markets exhibit a lower level of network externalities. A joint test is conducted on the research hypothesis, *per se*, and the validity of the empirical measure, the firm's R&D intensity, that is used as a proxy for the level of network externalities in a firm's product market.

This paper contributes to the international literature on asset pricing in two important ways. First, it is shown that stock returns may be subject to a technology-related peso problem. The existence of such a peso problem may have severe implications for the performance measurement of investment strategies. Second, a microeconomic explanation which is neither related to firm leverage (Black, 1976, and Christie, 1982) nor market

microstructure effects (e.g. Ball et al., 1995) is provided for the possible asymmetry in expected and historical stock return distributions.

The structure of the rest of the paper is as follows. The theoretical framework is provided in Section 2. The research methodology is explained in Section 3. Section 4 provides an analysis of the sample data. The empirical results are described in Section 5. And finally, a conclusion is provided in Section 6.

2. Theoretical Framework

If the true stock return distributions were symmetric, deviations from symmetry in empirical return distributions could exist in small samples but the asymptotical distributions would be symmetric around their means. The assumption of normality may well be a suitable approximation for modelling the return generating process of the stocks of firms in conventional, mature industries but, as argued in this paper, it is not a suitable assumption in the modelling of stock returns of firms producing products for markets with network externalities.

Network externalities are positive effects one owner or user has on other owners and users of the same or compatible technology or product. Contrary to many other markets, in markets with network externalities a buyer's expectation about the others' choice of technology is important. As a consequence, the dynamics of industries subject to network externalities are fundamentally different from those of conventional industries (Katz and Shapiro, 1986). Network externalities give rise to demand side economies of scale, which will vary with consumers' expectations (Katz and Shapiro, 1985). Due to lock-in and lock-

out effects, only one technology will come to dominate the market in the long run (Habermeier, 1989). Hence, instead of maturing into a relatively stable oligopoly or a (nearly) perfectly competitive market, the product markets of firms with network externalities are expected to develop in a much more discontinuous manner. This has been empirically shown, among others, in the markets for pharmaceutical products (Ellison et al., 1997) and spreadsheets (Gandal, 1994). As long as the rivalry for the dominant technology is expected to continue, the expected stock returns of the firms still competing for market dominance is positive. However, when it becomes clear that a certain technology will lose the race, the firm whose expected earnings strongly depend on the breakthrough of this specific technology will experience a dramatic fall in its stock price. The case of the competing video cassette recorder (VCR) standards in the 1980s is a very illustrious example of this. As long as it was unclear whether VHS, Beta, or Video 2000 would become the industry's dominant technology, the stock prices of the competing firms developed relatively smoothly. But, as the market learned that Sony's Beta technology was to lose the competition for market dominance in VCRs, Sony's stock price fell dramatically.

The high sensitivity of the stock price to a permanent change in the dividend growth rate, which in this case is equivalent to the earnings growth rate, can be seen by using the Gordon (1962) growth model:

$$P_t = \frac{(1+G)D_t}{R-G} \quad (1)$$

where P_t is the stock price at time t , G is the (constant) dividend growth rate, R is the discount rate, and D_t is the dividend payment at t , and $R > G$. In the model the dividend growth rate elasticity of the stock price is above 1. For example, if the dividend payment at time t , D_t , is USD 1, the discount rate, R , is 5%, and the dividend growth rate, G , is 4%, the stock price is USD 104. But, if the dividend growth rate falls by 25% to 3%, the stock price falls dramatically by more than 50% to USD 51.5.

Thus, the stock returns of firms in markets with network externalities can be characterised by a long series of relatively high positive returns, as compensation for the possibility of a highly idiosyncratic and dramatic fall in the stock price, and infrequently occurring but highly negative returns, as the technology-related risks are realised. This term producing the positive trend prior to the expected crash is not a common risk premium since it will also exist under risk neutrality. Additionally, this risk is asymmetric, i.e. there exists no similar technology-related risk of a large positive jump in the stock price since the race for technological dominance continues for the remaining firms and potential new entrants even after a loser firm has fallen out of the race. A firm may be subject to the technology-related risk in many technologies. Thus, even after a firm has lost its possibilities in some technology race, it may continue to compete for technology dominance in another field.

Using the Krasker (1980) and Lizondo (1983) framework, the expected return on an asset in a situation where market participants assess a positive probability of a crash in the stock price caused by a loss in the competition for the dominant technology can be stated formally as:

$$E[r_{i,t}|\Omega_{t-1}] = p_{i,t}E[r_{i,t}|out] + (1-p_{i,t})E[r_{i,t}|in] \quad (2)$$

where $E[r_i|\Omega_{t-1}]$ is the expected rate of return on asset i in period t conditional on all information available in the period $t-1$ (the information set Ω_{t-1}), $p_{i,t}$ denotes the probability of firm i falling out of the competition for the dominant technology between periods $t-1$ and t as assessed by the market in period $t-1$, $E[r_{i,t}|out]$ is the expected return on asset i in period t conditional on that the firm has lost the race for the dominant technology, and $E[r_{i,t}|in]$ is the expected return on asset i in period t conditional on firm i still being in the race for the dominant technology.

If $p_{i,t} > 0$ and $E[r_{i,t}|out] < 0$, then clearly $E[r_{i,t}|in] > E[r_i|\Omega_{t-1}]$. Thus, if market participants assess the technology-related risk correctly and a sample of stock returns analysed contains these negative jumps with a lower frequency than the assessed probability would predict, the return series will be subject to a peso problem. In such a situation, the average return is higher and the variance is lower than ex ante expected by the market. Thus, the returns will seem anomalously high and the variance anomalously low in comparison to the return characteristics of otherwise similar stocks.

3. Methodology

To test for the existence of a possible peso problem caused by anticipated negative jumps in the earnings process, we could either directly use empirical data on firm earnings or alternatively use stock return data that, under market efficiency, should reflect the same

information. Since earnings data for most US firms are only available on a quarterly basis and stock returns on a much more frequent basis, we choose to use stock returns data.

If the technology-related peso problem hypothesis is correct, the higher is the level of network externalities in the market for which the firm is producing goods and services, the more negatively skewed should the return distribution of its stock be in the long run. This can clearly be seen from the simple Monte Carlo simulation results of equation (2) presented in Table 1 which shows the percentage of return series for which the null hypothesis of no skewness can be rejected. In these simulations $E[r_i|\Omega_{t-1}]$ has been fixed at 5% p.a., and $p_{i,t}$, the crash probability, is a constant 10% p.a., whereas $E[r_{i,t}|out]$, the magnitude of the crash, and the number of years of daily stock returns are let to vary. The number of years of 250 daily returns, running from one to ten, is given on the horizontal axis, and the magnitude of the crash, with values from -10% to -50%, is provided on the vertical axis. 1000 simulations of a series of 250 daily returns per year are randomly drawn for each $E[r_{i,t}|out]$, so that $E[r_{i,t}|in]$ is drawn from a (symmetric) normal distribution with a mean that satisfies equation (2) and a variance of 25% (p.a.). Every return series consisting of up to ten years of daily returns is tested for skewness by the common t -test at the 5% level under the null of no skewness and the skewness coefficient being normally distributed with a variance of $6/T$, where T is the number of daily returns in the sample (Stuart and Ord, 1987).

A clear pattern seems to emerge. As is predictable, the longer the time period over which the simulation is run, and the more negative the crash return, the higher is the percentage of return series for which we can reject the null hypothesis of no skewness. For

example, to reject the null of no skewness in 50% of the cases, we seem to need approximately 9 years of daily data.

[Table 1]

Because of the long time horizon needed for the peso effect to become visible, we need data over a long time period to test for the peso problem hypothesis. Thus, instead of using ex ante expected stock return distributions implied by options prices which are only available for relatively short maturities, we use long-run historical stock returns. To test for the peso problem hypothesis with empirical data, we regress the skewness coefficient of individual stock return distributions on a measure of the level of network externalities in the firm's product market and two control variables. Markets with network externalities are often characterised by intense research and development rivalry (see e.g. Katz and Shapiro, 1986, Kristiansen, 1996, and Shy, 1996). Thus, the level of network externalities in a firm's product market is proxied by the firm's R&D intensity, i.e. the ratio of its research and development expenditure to its net sales.

To control for the possible positive skewness induced (especially) by low stock price levels (Ball et al., 1995), we use the stock price prior to the start of the return series as a control variable. Similarly, we use the financial leverage ratio, i.e. the debt-to-debt-and-equity ratio, at the end of 1972 financial year to control for the asymmetry in volatility caused by financial leverage as argued in Black (1976) and Christie (1982). More formally:

$$skew_i = \mathbf{a} + \mathbf{b}_1 \cdot R \& D_i + \mathbf{b}_2 \cdot P_i + \mathbf{b}_3 \cdot LEV_i + \mathbf{e}_i \quad (3)$$

where $skew_i$ denotes the skewness coefficient of firm i 's return distribution, $R \& D_i$ is the R&D-expenditure-to-sales ratio of firm i , P_i is the stock price of firm i at the end of the 1972 financial year, LEV_i denotes the financial leverage ratio (proxied by the ratio of the par value of total debt to the sum of market value of common equity and par value of total debt) of firm i , and e_i is a normally distributed error term with the common i.i.d., zero expected value, and constant variance assumptions.

In accordance with the peso problem hypothesis, we expect b_1 to differ significantly from zero and its sign to be negative. The signs of the coefficients of the two control variables are also predicted to be negative.

4. Data

The data used in the empirical tests is the intersection of the AMEX/NYSE tape of the Center for Research in Securities Prices (CRSP) stock return database and the COMPUSTAT financial information database so that the R&D intensities, the financial leverage ratios, and stock prices at the end of the financial year prior to the start of the return series used to calculate the skewness coefficients can be retrieved for all companies used in the tests. To minimise selection bias, which is especially important in this implicit analysis of survivorship, no multi-year averages of these variables are taken. This procedure yields a data set of 1584 firms with the explaining variables retrieved from the 1972 annual reports (COMPUSTAT) and the skewness coefficients calculated on the return series starting with the first trading day of July, 1973 through the time of the potential delisting of

the stock or December 31, 1997, whichever is the later date. The six-month lag between the end of the calendar year 1972 and the start of the return series in July 1973 is to ensure that market participants did indeed have the information given in the annual reports. To make comparisons with previous research on skewness possible, returns are calculated over daily, weekly, and monthly intervals.

The firms whose stock is delisted during the period are not excluded from the sample but the skewness coefficient is calculated over the period for which returns data exist. The reason for this is as follows. Since we are testing for a hypothesis according to which the stock price of firms exposed to a higher level of network externalities run a higher risk of falling dramatically during any period, it would be counterintuitive to exclude the firms whose stock price has fallen dramatically during the sample period from the data sample. Namely, exactly the firms whose stock price has developed negatively tend to be delisted with a higher probability than the stocks of otherwise similar firms. Hence, it is important that *all* firms covered by COMPUSTAT in 1972 and by CRSP starting from July 1973 are included in the data sample.¹ However, although all firms for which stock returns data exist in July 1973 are included in the sample, a delisting bias still exists in the sample. As documented by Shumway (1997), omitted delisting returns average about -30%. This bias weakens our ability to test for the peso problem hypothesis in the sample. Consequently, if the empirical results, despite of this bias, support the negative relationship between the level of network externalities and skewness of the stock distribution, the results can be interpreted as strongly supportive for the peso problem hypothesis.

5. Empirical Results

5.1 *A Sample characteristics*

As shown in Table 2, the firms' R&D intensities vary strongly between 0% and 23.3%, but the sample median and mean values are as low as 0% and 0.89%, respectively. Thus, the R&D intensity has a rightly skewed distribution. In fact, only 397, or 25%, of the 1584 firms in the sample have an R&D intensity higher than 1%. Similarly to the R&D intensity, the stock price at the end of the 1972 financial year and the financial leverage ratio have high variances compared to the sample means of 21.13 and 0.44, respectively. However, with median value of 0.43, the values of the financial leverage ratio seem to be relatively symmetrically distributed between the extreme values of 0 and 0.97.

The average skewness coefficient is positive for daily, weekly, and monthly returns, and in each case significantly so at the 1% level. In accordance with many prior studies, this confirms the a priori assumption that stock return distributions exhibit skewness. The range of the skewness coefficient, i.e. the difference between its maximum and minimum values, seems to get smaller as the time interval over which the returns are calculated is increased. Since weekly and monthly log returns are sums of daily log returns, this convergence towards normality is expected.

[Table 2]

¹ In fact, in a logistic regression explaining the probability of a stock being delisted in the period 1973-97

5. B Regression results

As can be seen in Table 3, the sign of the estimates of the coefficient of the R&D intensity variable is negative, as predicted, in all regressions, both with and without the control variables and over the three return intervals applied. In the regressions based on weekly and monthly returns data and without the control variables, the estimates are significantly different from zero at the 10% level. However, the inclusion of the control variables increases the uncertainty in the estimation of the coefficient of the R&D variable. The estimates of the coefficient of the stock price variable are, as predicted, negative. They are significantly different from zero at the 1% level on weekly and monthly data and at the 10% level on daily data. The intercept is positive at the 1% level in all regressions.

[Table 3]

To test for whether the results are sensitive to the log transformation of the right-hand side variables in equation (3), the regressions are also run on the natural logarithms of the RHS variables. In these regressions, the R&D intensity of the firms with 0% R&D intensity is omitted. As can be seen in Table 4, the main results remain unchanged from the case with no log transformation. Omitting financial firms or the returns in October 1987 from the sample does not either significantly change the results of regression (3). For brevity, these results are not presented.

for a negative reason, i.e. bankruptcy or liquidation, with the firm's R&D intensity, the R&D coefficient

[Table 4]

Since the skewness of a return series may vary strongly due to random reasons with the length of the sample, we run regression (3) over other sample lengths than that of up to 24.5 years. As shown in Table 5, in the regressions without the control variables the estimates of the R&D intensity coefficients are negative but become less negative when the control variables are included in the regressions. The first effect is as predicted by the results of the Monte Carlo simulations provided in Table 1.

[Table 5]

Based on the results presented in Tables 3, 4 and 5, it seems plausible that the proxy we are using for the level of network externalities, the firm's R&D intensity, seems to catch up some other effect relevant to explaining skewness than merely the level of network externalities in the firm's product market. In the total sample, the R&D intensity has a correlation of 0.2 with the stock price variable that, on the other hand, correlates strongly ($\rho=0.565$) with the market value of the firm. Thus, the R&D proxy could be picking up some small firm effect in the data that is not directly related to network effects. To investigate this further, we include market value, as a proxy for firm size, and the book-to-market ratio, commonly used to measure the level of "valueness" of a stock, in the regression:

gets a negative value, although not significantly so.

$$skew_i = \mathbf{a} + \mathbf{b}_1 \cdot R \& D_i + \mathbf{b}_2 \cdot P_i + \mathbf{b}_3 \cdot LEV_i + \mathbf{b}_4 \cdot MV_i + \mathbf{b}_5 \cdot B/M_i + \mathbf{e}_i \quad (4)$$

where MV_i denotes the market value of the common equity of firm i , B/M_i is the ratio of the book and market values of firm i 's common equity, and the other variables are as in (3).

The results for (4) are presented in Table 6. On part of the R&D intensity variable, the results are very similar to those of (3). The effect of instability caused by the stock price and market value variables can be seen in the fact that the significance levels of the coefficient estimates seem to change in opposite directions whether or not logs of the RHS variables are taken. The firm's market value seems to be negatively related to the skewness coefficient of its stock return distribution. The book-to-market ratio, on the other hand, seems to have a positive effect on the skewness although the estimates do not, with the exception of the case with monthly returns and log transformations, differ significantly from zero.

[Table 6]

Based on the results of (4), it seems logical to sort the sample according to market value and run (3) separately for each subsample. For this purpose, the main sample is split into three subsamples according to the firms' market values. The results for regression (3) run for these three subsamples are presented in Table 7. For the subsample with firms belonging to the group of highest market value, all variables are significantly different from zero. In the regression without control variables, the coefficient of the R&D intensity variable differs significantly from zero at the 1% level. When the control variables are included to the

regression, its t -value falls in absolute value from -2.703 to -1.838 , but the coefficient estimate still remains significantly negative with a p -value of 0.067 . In the two other subsamples, the sign of the R&D intensity coefficient still remains negative but the F -values of the regressions are very low.

[Table 7]

6. Conclusion

In this paper it is argued that a firm's stock returns may be affected by a technology-related peso problem the existence of which depends on the market dynamics of the firm's product market. If the market a firm supplies with goods and services is affected by network externalities, as is often the case in industries with high research and development activities, the industry dynamics tend to differ strongly from those of more mature industries. The positive network externalities in the products market affect the industry so that the technology of one firm eventually tends to dominate the industry. When the market learns that a certain technology will not become the dominant technology in the industry, the firm, whose expected earnings strongly depend on it managing to win the race for technology dominance, will experience a dramatic fall in its stock price. Rational investors require to be compensated for the possibility of a highly negative rate of return in the form of a relatively high return when this risk is not realised. Although the unconditional expected return might equal that of other stocks, in small samples where the frequency of these negative jumps is lower than the ex ante assessed probability, a peso problem will exist in the firm's stock

returns so that the stock's ex post return will be higher than that of other stocks, *ceteris paribus*.

If the peso problem hypothesis is correct, the the level of skewness in the firm's long-run historical stock return distribution and the level of network externalities in the firm's product market should be negatively related. This is tested for by regressing the skewness coefficient of a firm's stock return distribution on the firm's R&D intensity, i.e. the proxy for the level of network externalities in the firm's product market, and control variables.

Despite the fact that the data sample suffers from a bias that makes the skewness coefficients of the stock return distributions of badly performing firms to be biased upward, the empirical results support the proposed peso problem hypothesis. In samples including small and medium sized firms, the R&D intensity variable used as a proxy for the level of network externalities seems to pick up other phenomena apart from network externalities that also affect the skewness of stock return distributions. This measurement problem is, however, much smaller in samples of firms with high market values.

Two main conclusions can be drawn from the empirical results. First, in a sample where the negative jumps occur less often than (ex ante) rationally anticipated, the return will be upward and the variance downward biased. The existence of such a peso problem has direct implications for performance measurement of investment strategies. The recent boom in the stocks of many firms relying on new technologies which are subject to network externalities, such as the Internet, could possibly be explained as a period in which the risks correctly (ex ante) anticipated by the market were merely not realised.

Second, a microeconomic explanation that is neither related to firm leverage (Black, 1976 and Christie, 1982) nor market microstructure effects (e.g. Ball et al., 1995) is

provided for the asymmetry in expected and historical stock returns. This questions the usefulness of models that assume a symmetric return distribution.

Future research is needed to develop a better proxy for the level of network externalities in a firm's product market than that of R&D intensity. Also, it would be of great interest to test the peso problem hypothesis on portfolio returns rather than individual stock returns. Additionally, it would be interesting to examine whether the level of network externalities in a firm's product market could help to explain the volatility skew documented in the implied volatilities of stock options prices.

References

- Ball, R., Kothari, S.P. and Shanken, J. (1995): Problems in measuring portfolio performance – An application to contrarian investment strategies, *Journal of Financial Economics*, 38, 79-107.
- Bekaert, G., Erb, C., Harvey, C. and Viskanta, T. (1998): Distributional Characteristics of Emerging Market Returns and Asset Allocation, *Journal of Portfolio Management*, 24, 102-116.
- Bekaert, G., Hodrick, J.R. and Marshall, D.A. (1997): "Peso Problem" Explanations for Term Structure Anomalies, *NBER Working Paper Series*, Working Paper # 6147.
- Black, F. (1976): Studies of Stock Price Volatility Changes, *Proceedings of the 1976 Meetings of the American Statistical Association, Business and Economics Section*, 177-181.
- Berglund, T. and Löflund, A. (1996): Exchange Rate Devaluations and Peso Phenomena in Stock Returns, Swedish School of Economics and Business Administration Working Paper, 334.
- Brown, S., Goetzmann, W. and Ross, S. (1995): Survival, *Journal of Finance*, 50, 853-873.
- Christie, A. (1982): The Stochastic Behavior of Common Stock Common Stock Variances, Value Leverage and Interest Rate Effects, *Journal of Financial Economics*, 10, 407-432.
- Ellison, S.F., Cockburn, I., Griliches, Z., and Hausman, J. (1997): Characteristics of Demand for Pharmaceutical Products: An Examination of Four Cephalosporins, *RAND Journal of Economics*, 28, 426-446.
- Evans, M.D.D. (1996): Peso Problems: Their Theoretical and Empirical Implications. In: Maddala, G. and Rao, C., (Eds.), *Handbook of Statistical Methods in Finance*, North Holland Amsterdam pp. 613-646.
- Evans, M.D.D. and Lewis K.K. (1994): Do Risk Premia Explain it all? Evidence from the Term Structure, *Journal of Monetary Economics*, 33, 285-318.
- Flood, R.P. and Rose, A.K. (1996): Of the Forward Discount Puzzle, *Review of*

Economics and Statistics, 78, 748-752.

- Gandal, N. (1994): Hedonic Price Indexes for Spreadsheets and an Empirical Test for Network Externalities, *RAND Journal of Economics*, 25, 160-170.
- Gordon, M. (1962): *The Investment, Financing, and Valuation of the Corporation*, Irwin, Homewood, IL.
- Habermeier, K. (1989): Competing Technologies, the Learning Curve, and Rational Expectation, *European Economic Review*, 33, 1293-1311.
- Hamilton, J.D. (1988): Rational Expectations Analysis of Changes in Regime: An Investigation of the Term structure of Interest Rates, *Journal of Economics, Dynamics and Control*, 12, 385-424.
- Kaminsky, G. (1993): Is there a Peso Problem? Evidence from the Dollar/Pound Exchange Rate, 1976-1987, *American Economic Review*, 83, 450-472.
- Kandel, S. and Stambaugh, R. (1990): Expectations and Volatility of Consumption and Asset Returns, *Review of Financial Studies*, 3, 207-232.
- Katz, M. and Shapiro, C. (1986): Technology Adoption in the Presence of Network Externalities, *Journal of Political Economy*, 94, 822-841.
- Katz, M. and Shapiro, C. (1985): Network Externalities, Competition, and Compatibility, *American Economic Review*, 75, 424-440.
- Krasker, W.S. (1980): The Peso Problem in Testing the Efficiency of the Forward Exchange Markets, *Journal of Monetary Economics*, 6, 269-76.
- Kristiansen, E.G. (1996): R&D in markets with network externalities, *International Journal of Industrial Organisation*, 14, 769-784.
- Lewis, K.K. (1991): Was there a "Peso Problem" in the US Term Structure of Interest Rates: 1979-1982?, *International Economic Review*, 32, 159-173.
- Lizondo, J.S. (1983): Foreign Exchange Futures Prices under Fixed Exchange Rates, *Journal of International Economics*, 14, February, 69-84.
- Penttinen, A. (2000): Devaluation-risk-related peso problems in stock returns, *Journal of International Financial Markets, Institutions & Money*, 10, 181-197.
- Rietz, T.A. (1988): The Equity Risk Premium, A Solution, *Journal of Monetary Economics*, 22, 117-131.

- Rogoff, K.S. (1980): Essays on Expectations and Exchange Rate Volatility,
Unpublished Ph.D. Dissertation, Massachusetts Institute of Technology.
- Sercu, P. and Vinaimont, T. (1999): Peso Effects in the Forward Bias: Evidence from
the Private ECU, Working paper presented at the European Finance Association's
annual conference in Helsinki, August 28, 1999.
- Shumway, R.H. (1997): The Delisting Bias in CRSP Data, *Journal of Finance*, 52,
327-340.
- Shy, O. (1996): Technology revolutions in the presence of network externalities,
International Journal of Industrial Organization, 14, 785-800.
- Stuart, A., and Ord, K. (1987): Kendall's Advanced Theory of Statistics, Vol I,
Oxford University Press, New York, pp. 320-344.

Table 1**Monte Carlo Simulation Results:****Percentage of Return Series with Negative Skewness**

In these simulations $E[r_t|\Omega_{t-1}]$ has been fixed at 5% p.a., and $p_{i,t}$, the crash probability, is a constant 10% p.a., whereas $E[r_{i,t}|out]$, the magnitude of the crash, and the number of years of daily stock returns are let to vary. The number of years of 250 daily returns, running from one to ten, is given on the horizontal axis, and the magnitude of the crash, with values from -10% to -50%, is provided on the vertical axis. 1000 simulations of a series of 250 daily returns per year are randomly drawn for each $E[r_{i,t}|p_{i,t}]$, so that $E[r_{i,t}|in]$ is drawn from a (symmetric) normal distribution with a mean that satisfies equation (2) and a variance of 25% (p.a.). Every return series consisting of up to ten years of daily returns is tested for skewness with the common t -test at the 5% level under the null of no skewness and the skewness coefficient being normally distributed with a variance of $6/T$, where T is the number of daily returns in the sample.

Magnitude of Crash (%)	Number of Years of Daily Returns with a 10% p.a. Prob. of Crash									
	1	2	3	4	5	6	7	8	9	10
-10	0	0	0	0	1	2	3	2	1	4
-20	0	0	0	0	2	1	3	4	3	6
-30	8	3	4	4	5	2	6	5	7	6
-40	5	17	21	29	31	22	21	18	19	24
-50	8	14	21	28	33	39	57	47	51	54

Table 2
Descriptive Statistics

Independent Variables (N = 1584)						
	Mean	Median	St.Dev.	Min.	Max.	
R&D Intensity (%)	0.89	0.00	1.89	0.00	23.30	
Stock Price (USD)	21.13	15.40	21.59	0.50	346.50	
Financial Leverage Ratio	0.44	0.43	0.23	0.00	0.97	

Dependent Variable = Skewness						
Return Period	N	Mean	Median	t-value	Min.	Max.
Daily	1584	0.68	0.37	6.91***	-7.03	79.47
Weekly	1584	0.50	0.40	11.67***	-5.86	33.23
Monthly	1580	0.23	0.18	9.24***	-4.11	16.61

*** Indicates that the estimate is significantly different from zero at the 1% level.

Table 3

Main Regression Results (Non-Log RHS)

$skew_i = \mathbf{a} + \mathbf{b}_1 \cdot R\&D_i + \mathbf{b}_2 \cdot P_i + \mathbf{b}_3 \cdot LEV_i + \mathbf{e}_i$ where $skew_i$ denotes the skewness coefficient of firm i 's return distribution over the period from July 1973 through either December 1997 or the delisting of the stock, $R\&D_i$ is the R&D-expenditure-to-sales ratio of firm i at the end of the financial year 1972, P_i is the stock price of firm i at the end of the 1972 financial year, LEV_i denotes the financial leverage ratio (proxied by the ratio of the par value of total debt to the sum of market value of common stock and par value of total debt) of firm i at the end of the financial year 1972, and \mathbf{e}_i is a normally distributed error term with the common i.i.d., zero expected value, and constant variance assumptions.

		Coefficients of Independent Variables (where applicable)				Adjusted R-square	F-value (<i>p</i> -value)
Return Period		Intercept (<i>t</i> -value)	R&D (<i>t</i> -value)	P (<i>t</i> -value)	LEV (<i>t</i> -value)		
Daily		0.730 (6.701)***	-5.480 (-1.053)			0.000	1.109 (0.292)
Weekly		1.007 (3.631)***	-3.841 (-0.715)	-0.009 (-1.921)*	-0.210 (-0.466)	0.001	1.611 (0.185)
Monthly		0.532 (11.224)***	-3.829 (-1.794)*			0.002	3.217 (0.073)
Daily		0.770 (6.499)***	-1.848 (-0.846)	-0.010 (-4.826)***	-0.093 (-0.486)	0.017	9.325 (0.000)
Weekly		0.261 (9.271)***	-2.449 (-1.932)*			0.002	3.734 (0.054)

0.433 (6.209)***	-0.754 (-0.585)	-0.008 (-6.585)***	-0.035 (-0.312)	0.032	17.064 (0.000)
---------------------	--------------------	-----------------------	--------------------	-------	-------------------

* Indicates that the estimate is significantly different from zero at the 10% level.
 *** Indicates that the estimate is significantly different from zero at the 1% level.

Table 4

Main Regression Results (Log RHS)

$skew_i = \mathbf{a} + \mathbf{b}_1 \cdot R \& D_i + \mathbf{b}_2 \cdot P_i + \mathbf{b}_3 \cdot LEV_i + \mathbf{e}_i$ where $skew_i$ denotes the skewness coefficient of firm i 's return distribution over the period from July 1973 through either December 1997 or the delisting of the stock, $R \& D_i$ is the log of the R&D-expenditure-to-sales ratio of firm i at the end of the financial year 1972, P_i is the log of the stock price of firm i at the end of the 1972 financial year, LEV_i denotes the log of the financial leverage ratio (proxied by the ratio of the par value of total debt to the sum of market value of common stock and par value of total debt) of firm i at the end of the financial year 1972, and \mathbf{e}_i is a normally distributed error term with the common i.i.d., zero expected value, and constant variance assumptions.

	Coefficients of Independent Variables (where applicable)				Adjusted R-square	F-value (p-value)
Return Period	Intercept (t-value)	R&D (t-value)	P (t-value)	LEV (t-value)		
Daily	0.546 (2.814)***	-0.009 (-0.808)			0.000	0.653 (0.419)
	1.037 (2.832)***	-0.007 (-0.625)	-0.171 (-1.461)	0.005 (0.037)	0.000	1.050 (0.370)
Weekly	0.168 (0.895)	-0.063 (-1.567)			0.002	2.454 (0.118)
	0.894 (3.259)***	-0.033 (-0.795)	-0.196 (-2.824)***	0.042 (0.532)	0.019	5.177 (0.002)
Monthly	0.014 (0.117)	-0.049 (-1.925)*			0.004	3.705 (0.055)

0.657 (3.815)***	-0.025 (-0.954)	-0.190 (-4.370)***	0.007 (0.148)	0.041	10.081 (0.000)
---------------------	--------------------	-----------------------	------------------	-------	-------------------

* Indicates that the estimate is significantly different from zero at the 10% level.
 *** Indicates that the estimate is significantly different from zero at the 1% level.

Table 5

Skewness of Weekly Returns over Different Time Period Lengths

$skew_i = a + b_1 \cdot R \& D_i + b_2 \cdot P_i + b_3 \cdot LEV_i + e_i$ where $skew_i$ denotes the skewness coefficient of firm i 's distribution of weekly returns over the period from July 1973 through either the end of the period given below or the delisting of the stock, $R \& D_i$ is the R&D-expenditure-to-sales ratio of firm i at the end of financial year 1972, P_i is the stock price of firm i at the end of the 1972 financial year, LEV_i denotes the financial leverage ratio (proxied by the ratio of the par value of total debt to the sum of market value of common stock and par value of total debt) of firm i at the end of the financial year 1972, and e_i is a normally distributed error term with the common i.i.d., zero expected value, and constant variance assumptions.

	Coefficients of Independent Variables (where applicable)			Adjusted R-square	F-value (p-value)
Intercept (t-value)	R&D (t-value)	P (t-value)	LEV (t-value)		
Panel A: 12 Years					
0.530 (26.114)***	-1.973 (-2.058)**			0.002	4.235 (0.419)
0.680 (13.441)***	-0.292 (-0.302)	-0.007 (-8.289)***	-0.015 (-0.179)	0.047	26.943 (0.000)
Panel A: 6 Years					
0.493 (29.502)***	-1.804 (-2.281)**			0.003	5.203 (0.023)
0.623 (15.207)***	0.128 (0.163)	-0.008 (-10.807)***	0.048 (0.721)	0.082	47.956 (0.000)
Panel A: 3 Years					
0.480 (29.404)***	-2.173 (-2.816)***			0.004	7.927 (0.005)
0.574 (14.276)***	-0.349 (-0.455)	-0.007 (-9.764)***	0.089 (1.353)	0.073	42.675 (0.000)
Panel A: 1 Year					

0.337 (16.347)***	-1.123 (-1.154)			0.000	1.331 (0.249)
0.461 (8.985)***	0.789 (0.808)	-0.008 (-8.505)***	0.057 (0.676)	0.051	29.208 (0.000)

** Indicates that estimate is significantly different from zero at the 5% level.

*** Indicates that estimate is significantly different from zero at the 1% level.

Table 6

Additional RHS Variables

$skew_i = a + b_1 \cdot R \& D_i + b_2 \cdot P_i + b_3 \cdot LEV_i + b_4 \cdot MV_i + b_5 \cdot B / M_i + e_i$ where $skew_i$ denotes the skewness coefficient of firm i 's return distribution over the period from July 1973 through either December 1997 or the delisting of the stock, $R \& D_i$ is the R&D-expenditure-to-sales ratio of firm i at the end of the financial year 1972, P_i is the stock price of firm i at the end of the 1972 financial year, LEV_i denotes the financial leverage ratio (proxied by the ratio of the par value of total debt to the sum of market value of common stock and par value of total debt) of firm i at the end of the financial year 1972, MV_i denotes the market values of the common equity of firm i at the end of the financial year 1972, B / M_i is the ratio of the book and market value of firm i 's common equity at the end of the financial year 1972, and e_i is a normally distributed error term with the common i.i.d., zero expected value, and constant variance assumptions.

	Coefficients of Independent Variables (where applicable)						Adj. R-sqr.	F-value (p-val.)
Return Period	Intercept (t-val.)	R&D (t-val.)	P (t-val.)	LEV (t-val.)	MV (t-val.)	B/M (t-val.)		
Panel A: Non-Log RHS Variables								
Daily	0.946 (3.367)** *	-3.188 (-0.591)	-0.005 (0.849)	-0.175 (-0.387)	-0.0001 (-1.441)	0.000 (0.290)	0.001	1.398 (0.222)
Weekly	0.731 (6.057)** *	-1.508 (-0.689)	0.007 (-2.927)***	-0.007 (-0.361)	-0.0001 (-2.099)**	0.000 (0.134)	0.019	6.489 (0.000)
Monthly	0.420 (5.945)** *	-0.634 (-0.491)	0.007 (-4.857)***	-0.027 (-0.242)	-0.052 (-1.256)	0.000 (0.267)	0.032	10.566 (0.000)
Panel B: Logs of RHS Variables								
Daily	1.014 (2.335)**	-0.005 (-0.399)	0.225 (1.126)	-0.060 (-0.355)	-0.270 (-2.565)***	0.119 (0.595)	0.004	2.227 (0.370)

Weekly	0.762 (2.522)**	-0.040 (-0.929)	0.050 (0.441)	-0.034 (-0.325)	-0.154 (-2.741)***	0.129 (1.102)	0.036	5.506 (0.000)
Monthly	0.528 (2.798)** *	-0.030 (-1.122)	-0.057 (-0.803)	-0.074 (-1.150)	-0.074 (-2.090)**	0.152 (2.082)*	0.063	8.979 (0.000)

** Indicates that the estimate is significantly different from zero at the 5% level.

*** Indicates that the estimate is significantly different from zero at the 1% level.

Table 7

**Firms Sorted by Market Value
(Weekly Returns)**

$skew_i = \mathbf{a} + \mathbf{b}_1 \cdot R\&D_i + \mathbf{b}_2 \cdot P_i + \mathbf{b}_3 \cdot LEV_i + \mathbf{e}_i$ where $skew_i$ denotes the skewness coefficient of firm i 's distribution of the weekly returns over the period from July 1973 through either December 1997 or the delisting of the stock, $R\&D_i$ is the R&D-expenditure-to-sales ratio of firm i at the end of the financial year 1972, P_i is the stock price of firm i at the end of the 1972 financial year, LEV_i denotes the financial leverage ratio (proxied by the ratio of the par value of total debt to the sum of market value of common stock and par value of total debt) of firm i at the end of the financial year 1972, and \mathbf{e}_i is a normally distributed error term with the common i.i.d., zero expected value, and constant variance assumptions.

Coefficients of Independent Variables (where applicable)				Adj. R-sqr.	F-value (p-value)
Intercept (t-value)	R&D (t-value)	P (t-value)	LEV (t-value)		
Panel A: Highest Third of Market Value					
0.136 (4.736)***	-3.012 (-2.703)***			0.013	7.305 (0.007)
0.390 (5.764)***	-2.128 (-1.838)*	-0.005 (-4.892)***	-0.225 (-2.026)**	0.056	10.731 (0.000)
Panel B: Middle Third of Market Value					
0.660 (5.940)***	-3.693 (-0.700)			-0.001	0.490 (0.484)
0.382 (1.079)	-3.926 (-0.738)	0.013 (1.107)	0.130 (0.274)	-0.003	0.573 (0.633)
Panel C: Lowest Third of Market Value					
0.787 (9.372)***	-1.033 (-0.236)			-0.002	0.056 (0.814)
0.908 (3.306)***	-1.304 (-0.292)	-0.003 (-0.152)	-0.195 (-0.535)	-0.006	0.114 (0.952)

* Indicates that the estimate is significantly different from zero at the 10% level.

** Indicates that the estimate is significantly different from zero at the 5% level.

*** Indicates that the estimate is significantly different from zero at the 1% level.