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Who do you trust while Shares are on a Roller-Coaster Ride? Balance Sheet and Patent Data as Sources of Investor Information During Volatile Market Times

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Abstract:
We originally investigate the comparative usefulness of patent data as a source of investor information depending on the market cycle (bull/bear market). Based on comprehensive data for firms listed on German exchanges between 1997 and 2002, we demonstrate that patent data contain complementary explanatory power to accounting data irrespective of the standard used to prepare the financial statement (German GAAP, IAS and US GAAP). Moreover, we provide original evidence that only patent data are able to provide plausible investor information in both bull-market and bear-market periods, whereas accounting information overvalues intangible assets in bull markets and undervalues them in bears.

Key words: Investor information, market value, patents
JEL Codes: D82, G14, M41, K11

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1 Introduction

Annual financial statements are a key instrument of investor information. On the basis of financial statement information, investors should be able to make a market-based assessment of a firm's value at all times, which means during periods of both rising share prices (bull market periods) and falling share prices (bear market periods). In modern hi-tech companies, in particular, a good insight into a firm's intangibles is important for investors in order to assess the firm's value though notoriously difficult (see Goyal et al., 1998: 303). Depending on the information base used to prepare the financial statements, however, this item is open to considerable discretionary leeway. International accounting standards were introduced in Germany and other continental European countries in the 1990s with the aim of standardization. With regard to the accounting treatment of intangibles, a seemingly positive side effect arose for investors: the ability, under IAS, to value in-house (self-created) research and development at market rates. Companies listed in Germany could therefore, using IAS, list their R&D investment on the balance sheet in a similar fashion to their US competitors. They are no longer forced to be so conservative in their information policy for R&D owing to the ban on capitalizing own intangible goods imposed by German GAAP as codified in the German Commercial Code (HGB). Doubts regarding the undivided superiority of international regulations arose, however, when examples such as EM-TV showed that an overly optimistic balance-sheet valuation of intangible assets harbors potential risks to investors that might, in some cases, show up only during bear-market periods. This notorious trade-off between objectivity and relevance of information raises several interrelated questions for (outside) investors. A systemic question, ie in the framework of the existing accounting regime, is that of the standard-specific suitability of types of information already being used depending on the market cycle. Another particular question that then arises is whether, besides that information currently used to write annual reports, additional complementary sources of information exist which would allow a firm's intangibles to be valued objectively and at market conditions. These sources of information should, first and foremost, provide valid information in times of share price volatility. Put differently, they should be able to separate justified income expectations from unjustified expectations in times of shifting market sentiment.

The existing literature, however, has thus far devoted insufficient attention to examining the issue of potential asymmetries or cyclical dependencies in the relationship between

market values in volatile markets and investor information. This is particularly puzzling as recent evidence illustrates that high market volatility is correlated with significant declines in available outside capital (Schill, 2004) – reinforcing the need for reliable information during volatile market periods.

Our study homes in on that research gap and concurrently spans two different fields of research. It joins the current debate on accounting standards (see Bartov et al. 2004, Fields et al. 2002, Leuz and Verrechia 2000, and Ramb and Reitzig 2005) with regard to the phase-related meaningfulness of information already used for balance sheet purposes, especially in the area of R&D value relevance studies. This aspect of the work, however, is subordinate and only significant insofar as it is useful for discussing the comparative usefulness of complementary sources of information. The latter theme relates primarily to the area of corporate finance, and this is where our focus lies.

In the search for suitable sources of information for assessing the share of firms' market value accounted for by intangibles, Griliches (1981) was the first to suggest using patent data. A number of subsequent empirical studies, including by Connolly and Hirschey (1988), Megna and Klock (1993), Hall et al. (2000/2005), Hirschey and Richardson (2004) and Czarnitzki et al. (2005), confirmed a statistically significant contribution of patent data to explaining the market value of listed companies. For phases of rising share prices, some of these studies also found a certain complementarity between the information content of accounting data and patent data (see Hall et al. 2005, Hirschey and Richardson 2004), although accounting information, viewed in isolation, was already positively correlated with companies' market value.

Notwithstanding their contribution, all of the above-mentioned studies fail to answer the question of the complementarity between patent information and accounting information in terms of their information content for investors depending on the market cycle. This should be judged critically, however, since the latest research has produced indications that accounting data *per se* display a phase-related bias in that they are asymmetrically correlated with companies' market values in bull and bear market phases. Ramb and Reitzig (2005) show in their research that in bear market periods accounting information, depending on the standard, is negatively correlated with the residual market value of firms and therefore maps sometimes undesired overinvestment, hence possibly misleading investors. It is precisely in these volatile market phases, however, that patent data take on a stature of major importance as a complementary source of information about which, to date, nothing is known.

Our key question, therefore, is whether, even in times of highly volatile share prices, patents can complement annual financial statements by providing additional information for explaining the market value and can thus reduce information asymmetry between firms and investors. On the basis of a Q model, this empirical analysis for Germany studies the explanatory power of different accounting standards and patent information regarding market value. We specifically confine ourselves to the 1997-2002 period, which is characterized by a tendency towards volatile share prices (market values). We have chosen Germany for our study because for the observation period we can study the complementarity between patent data and accounting information for several accounting standards simultaneously.

Our key finding is that only patent data (which, from the point of view of companies, are largely exogenous) are positively correlated with firms' residual market value in *both* bull *and* bear market periods, whereas this is never the case with R&D information (which, to companies, is largely endogenous) according to any of the accounting standards studied (IAS, US GAAP and German GAAP). The latter produce positive correlations *either* during the bull market period *or* during the bear market period.

The rest of the article is structured as follows. Section 2 briefly recapitulates the required capital market theory background, describes relevant preceding research and then, on this basis, develops the central hypothesis for the empirical study. Section 3 is devoted to describing the empirical estimation model, the data sources and the generation of the key variables in the study. The data is described in Section 4, and statistical inference results are presented in Section 5. Section 6 summarises the results and provides an outlook regarding planned future research.

2 Institutional framework, related empirical work and hypothesis formulation

The question at the centre of our paper lies at the crossroads of several avenues of research: the science of accounting practices, empirical industrial economics, but most importantly corporate finance. Hence, we will briefly describe below what researchers have found out regarding the accounting standard-specific value relevance of balance sheet information as well as findings on the usefulness of patent information as investor information. Since the empirical analysis was run on companies listed in Germany for

the reasons cited above, we will begin by briefly summarising the institutional framework for Germany, especially from a capital market theory perspective.

2.1 Institutional framework in Germany

The literature typically distinguishes between two different types of accounting systems. We have, on the one hand, the *arm's length* or *outsider* system, and, on the other, the *relationship-based* or *insider* system (Franks and Meyer 1994, Rajan and Zingales 1998, Allen and Gale 2000, and Nowak 2001). These two systems differ with regard to methodology, the transmission channels through which capital is routed to the various investment vehicles, the design of investor guarantees, and the degree of information asymmetry between the contracting parties (providers of equity and debt capital). *Outsider* systems are primarily defined by a close (*arm's length*) relationship between investors and the company and by an accounting system that is designed to inform investors as comprehensively as possible. By contrast, *relationship* systems are characterized by a close relationship between companies and providers of debt capital (banks or other financial intermediaries). Such systems, moreover, feature an accounting system that provides incentives to facilitate debt financing. Thus, with such a system, other "private" sources of information are relevant to potential investors. According to this classification, US and UK financial and accounting systems (US GAAP and IAS) are regarded as *outsider* systems and German GAAP as an *insider* system.

The simultaneous existence of both accounting systems in Germany since the introduction of IAS and US-GAAP in 1994? is of empirical interest, as it also enables the usefulness of the source of information to be tested.[1] In the past few years, accounting in Germany has been fundamentally altered by the arrival of international standards and practices on the German scene. The transfer to international accounting standards is reflected first and foremost in the framework conditions created by Deutsche Börse for the now-defunct market segments "Neuer Markt" and "SMAX" and the newly established "TecDax" segment regarding the publication of balance sheet data. These market segments are required, under the Deutsche Börse's rules, to use

[1] To this extent, Germany can be regarded as a natural experiment. However, since a trend towards the use of international accounting practices can also be seen in other continental European countries and Japan, the present paper may serve as the starting point for studies in other countries.

some sort of international standard (IAS, US GAAP or IFRS)[2] to prepare their financial statements. In the official and regulated market,[3] companies are free to choose which accounting standard they wish to apply. This is also the case for the newly created General Standard, whereas the Prime Standard requires the use of international accounting practices.

2.2 The standard-related value relevance of R&D balance sheet information

In the past ten years, scientific analysis' relevance of studies between between accounting information and market value has increased considerably. Numerous theoretical and empirical studies were conducted that examine the suitability of accounting standards to mark close to market. Holthausen and Watts (2001) collate the result in a summary article. Since our paper primarily examines the accounting of intangibles in relation to market value (R&D value relevance), we will confine ourselves exclusively to earlier studies having the same focus. Lev and Sougiannis (1996), Lev and Zarowin (1999), and Chan et al. (2000) find distinct evidence of the relevance of R&D information for companies' market value for corporations traded in the US. Regarding the comparative usefulness of different accounting standards, a majority of studies, in addition, argue that IAS, which is authorized for use in the United States, is superior to US GAAP, which is likewise authorized in the USA, regarding the value relevance of R&D information. Lev and others attribute this primarily to the fact that IAS allows R&D expenditure to be capitalized, whereas US GAAP allows the capitalization of such expenditure only in the profit and loss statement (see also Bange and de Bondt, 1998). Capitalization, however, allegedly signals to investors that future revenue streams may be expected. However, the cited studies focus on the Anglo-American financial and legal system and can be transposed to continental Europe and Japan to only a limited extent (Ali and Hwang 2000; Pope and Walker 1999). In

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[2] The objective being pursued by the International Accounting Standard Committee (IASC) Foundation is the development and interpretation of international accounting standards. The German Accounting Standards Committee (*Deutsche Rechnungslegungs Standards Committee*, DSRC) has the additional aim of supporting the Federal Government in an advisory capacity.

[3] The official market is one of the segments of the German stock exchanges. A large percentage of exchange-traded securities are traded on the official market. In contrast to the unofficial market ("Freiverkehr") and the regulated market, here only officially listed securities are allowed for trading. Permission for listing on the regulated market and the unofficial market involves fewer obligations than for official market listing.

addition, the reporting period in many studies tends to feature a phase of rising share prices, thus preventing the study of potential asymmetries.

Zhao (2002) extends the corpus of findings for the USA by being the first to show, in an international empirical study, that R&D is a relevant source of information for several European countries as well. The study by Zhao (2002), however, does not permit a comparison of different accounting standards, for several reasons. One problem is that this study, like earlier studies, is fraught with the (codex unrelated) problem of comparing data across the boundaries of socially and culturally distinct "accounting regimes" (Ali and Hwang 2000; Pope and Walker 1999). A further fundamental problem afflicting this study is that potential bias resulting from companies' selection of a given standard is not accounted for (Fields et al. 2002). For Germany (as a natural experiment), where, since 1998, three different accounting standards have led a parallel existence (IAS, US GAAP and German GAAP), thus enabling them to be compared within one accounting regime, recent papers by Bartov et al. (2004), Leuz and Verrechia (2000), and Ramb and Reitzig (2005) have addressed the issue of standard-related effects. None of the papers finds standard-specific effects for the Neuer Markt after controlling for self-selection. The results for the official market and the regulated market vary depending on the group of authors. For example, Bartov et al. (2004) find that US GAAP and IAS show a standard-specific higher value relevance, which is robust to selection, than German GAAP. By contrast, Ramb and Reitzig (2005) find German GAAP to have greater value relevance for these market segments, something which is of advantage particularly in times of generally falling share prices.

[0]2.3 Patent information and market values

The disclosure of patent information is mandatory in all relevant jurisdictions. This feature has led us to consider the use of patent information as an additional source of information alongside balance sheet data.

The cited studies are extensively listed in Hall et al. (2000/2005), Bosworth and Rogers (2001) and Hirschey and Richardson (2004) and are only briefly outlined below in terms of their most important similarities and differences for the purposes of this paper. The shared (and most important) outcome of all studies is that patent variables, along with R&D variables, are significantly positively correlated with firms' residual market

value in all studies.[4] Irrespective of (or precisely because of) the existing differences between the studies, patent information therefore appears to be a suitable indicator of companies' market value, which, alongside R&D expenditure, provides complementary information. Here, there is a consensus among all authors that patents are a measure of future earnings from R&D activity.[5] This being said, it is difficult to compare the coefficients found in earlier works for quantifying the effects because of the peculiarities of the individual studies.[6] The results of earlier papers can, however, basically be distinguished along four key lines: (1) the nationality of the firms and patents studied; (2) the goodness of data; (3) the formation of the patent variable as a *flow* or *stock* variable; and (4) the quality weighting of the patent variable.

Whereas Cockburn and Griliches (1988), Megna and Clock (1993), Connolly et al. (1986), Connolly and Hirschey (1988), Hall et al. (2000) and Hirschey and Richardson (2004) study US firms and US patents, Bloom and van Reenen (2000) have recourse to UK patent information. Hirschey and Richardson (2004) study the relevance of different patent variables and of R&D expenditures to share prices for different size categories of firms listed in the United States. Bosworth and Rogers (2001) study the connection between market values and patent citations for Australian firms; pending better information by the authors it may be assumed that Australian patent information was used. Differences between the cited studies regarding the coefficients found could theoretically also be related to a peculiarity in the US patent system that existed until just a short time ago: patent information was published only after the patent was issued, causing a delayed-information effect of patents to investors. Furthermore, the sample sizes vary sharply, both cross-sectionally and longitudinally. Whereas Hall et al. (2000/2005) form a *panel* of the 1965-1995 period comparing patent variables with patents issued for around 1,700 firms per year, the analysis by Bosworth and Rogers (2001) covers a cross-section of patents registered in 1996. This study consequently contains the patent variable as a *flow* variable, whereas Cockburn and Griliches (1998), Hall et al. (2000) and Bloom and van Reenen (2000) use (cumulative) *stock* variables.[7] This difference appears to be crucial regarding the "information content" of patent

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4 NB: This does not apply to all tested specifications in the publications mentioned above.

5 See explicitly Megna and Klock (1993), p. 268. Cockburn and Griliches (1988), however, suspect that patent variables do a "worse" job functioning as proxy variables for a firm's R&D output than does balance sheet information in providing content for R&D input.

6 See Bosworth and Rogers (2001) for a relevant experiment (Table A1).

7 The authors were not able to draw such a clean-cut dividing line for the studies by Megna and Klock (1993), Conolly et al. (1986) and Conolly and Hirschey (1988).

information for market value since research and development, the importance of which grows cumulatively (Scotchmer 1991, Green and Scotchmar 1995, and Scotchmer 1996), is better mapped by a *stock* variable than by a *flow* variable. Finally, the latest research by Hall et al. (2000/2005), Bloom and van Reenen (2000), and Hirschey and Richardson (2004) take due account of the fact that the value distribution of patents is left-skewed and can plausibly be weighted by the measure of (extrapolated) forward citations (Trajtenberg 1990).

In summary, it may be stated that patent information, along with information on R&D expenditures from annual financial statements, represent suitable indicators of expected income from R&D. However, most of the studies published thus far use data that tend to be characterised by rising share prices. To that extent, the statistical correlations found by those studies apply, strictly speaking, only for that market phase. To date, there are no known asymmetries regarding the suitability of patent data as a source of investor information in bull and bear market periods.

2.4 Deriving the hypothesis

The presented synopsis of prior research shows the fundamental relevance of information from financial statements and patents for the intangible part of firms' market values. With regard to accounting information, however, standard-specific differences exist. Their presence is particylarly felt during times of share price volatility. Within standards, the link between R&D information and firms' residual market value is not symmetrical across cycles; moreover, asymmetries differ between standards. The complementary explanatory power of patent data as investor information has to date been confirmed only for US firms (which prepare their statements using IAS and US GAAP) and only for bull market phases. The found standard-specific effects of accounting information and their phase-related dependency on the stock market cycle require a more extensive test regarding the additional explanatory power of patent data as a source of investor information. Our central (optimistically formulated) hypothesis reflects this test:

H1: *In times of high share price volatility, patent information makes an additional contribution to financial statement information from various accounting standards (German GAAP, IAS or US GAAP) to explaining firms' residual market values.*

3 Model and underlying data

3.1 Model

To test the hypothesis, we follow the established approach of Brainard and Tobin (1968), typically referred to in the literature as Tobin's Q. Like Griliches (1981) and many subsequent papers (Cockburn and Griliches 1988, Megna and Klock 1993, Bloom and van Reenen 2000, and Hall et al. 2000), we assume an additively separable linear market value function at firm level. This model assumes that the marginal shadow value of assets is equally distributed across the firms in a sample. Equation 1 formalizes the association:

$$V_{i,t} = q_i \cdot \left(A_{it} + \gamma \cdot K_{it}\right)^o \quad (1),$$

where A_{it} denotes the nominal tangible assets and K_{it} the nominal intangible assets. Through logarithmization and by transposing Equation 1, given constant scale returns $(o = 1)$, we obtain Equation 2,

$$log\left(\frac{V_{i,t}}{A_{i.t}}\right) = log\, Q_{i,t} = log\, q_i + log\left(1 + \gamma \frac{K_{it}}{A_{it}}\right) \quad (2),$$

which, using the simplification $log(1+x) \approx x$ for small values of x, already serves as the basic framework for estimating Tobin's Q in numerous empirical studies. The latter simplification, however, does not appear justified for the data being examined in this paper. In line with Greene (2003, pp. 165-166), we linearize the model and transpose Equation 2 to the general estimation equation 3:

$$\begin{aligned} y_{it} = \alpha_i + f\left(x_{it} \cdot \beta\right) + \varepsilon_{it} = \alpha_i + f\left(x_{it} \cdot \beta^0\right) \\ + \frac{\partial f\left(x_{it} \cdot \beta^0\right)}{\partial \beta^0}\left(\beta - \beta^0\right) + \varepsilon_{it} \end{aligned} \quad (3),$$

where

$$y_{it} = log\left(\frac{V_{it}}{A_{it}}\right), f\left(x_{it} \cdot \beta\right) = log\left(1 + \gamma \frac{K_{it}}{A_{it}}\right)$$

and

$$\frac{\partial f\left(x_{it}\cdot\beta^{0}\right)}{\partial\beta^{0}}=\frac{\frac{K_{it}}{A_{it}}}{1+\gamma^{0}\cdot\frac{K_{it}}{A_{it}}}\cdot$$

The aim here is to estimate the equation using a fixed effects approach (within estimator) in which the error term ε_{it} is decomposed into a fixed effect (η_i), a time effect (τ_t) and a stochastic error term (υ_{it}). Rearranging Equation 3 gives us Equation 4,

$$y_{it}^{*}=y_{it}-f\left(x_{it}\cdot\beta^{0}\right)=\alpha_i+\frac{\partial f\left(x_{it}\cdot\beta^{0}\right)}{\partial\beta^{0}}\left(\beta-\beta^{0}\right)+\varepsilon_{it} \qquad (4),$$

in which now the coefficient $\left(\beta-\beta^{0}\right)$ is estimated. Equation 4 therefore allows us to indirectly calculate the γ we are looking for for pooled cross-section data and pooled panel data alike.[8]

In order to take account of potential distortions caused by self-selection, in a first stage we estimate a Heckman selection model (Heckman 1979). According to the approach of Bartov et al. (2004), variables that are not already included in the Q model are entered into this equation.

$$\begin{aligned}H_i^{s}=\;&\alpha_0+\beta_1\,Cash\,Flow_i+\beta_2\,Size_i+\beta_3\,Intangibles_i\\&+\beta_3\,Leverage_i+\varepsilon_{it}\end{aligned} \qquad (5).$$

Here, Cash Flow is the quotient of cash flow and tangible assets, Size the logarithm of the balance sheet total, Intangibles the quotient of intangible assets and tangible assets, and Leverage the quotient of liabilities and the balance sheet total. Along with these balance sheet variables, we also took account of sector dummies based on the German sectoral classification scheme WZ93.[9] Since panel econometric methods are used to estimate Equation (4), it is necessary to define time-variant and individual-variant Mill's ratios. We do this by independently estimating Equation (5) for all reporting years.

For the test of the hypothesis, the estimation equation (4) is enlarged by adding the inverse Mill's ratio and an additional variable that distinguishes between observations

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[8] Here, Equation 4b is estimated iteratively until the coefficient $\left(\beta-\beta^{0}\right)$ converges to zero. The value of the real γ from Equation 3 can then subsequently be calculated.

[9] The official system used by Germany's Federal Statistical Office.

using different standards. Finally, the estimation equation is enlarged such that all proxies for intangible assets can be estimated in a joint model (n=1: German GAAP; n=2: US GAAP; n=3: IAS). Equation 6 reflects the association:

For the test of the hypothesis, estimation equation (4) is additively enlarged such that all proxies for intangible assets can be estimated in a joint model (n=1: German GAAP; n=2: IAS, n=3: US GAAP; n=4: R&D expenses; n=5: patents). In addition, we enlarge the equation additively to include the inverse Mill's ratio and add dummies which control for changes in the type of financial statement during the reporting period.

$$\begin{aligned} y_{it}^{*} &= y_{it} - \sum_{n=1}^{5} f\left(x_{n,it} \cdot \beta_n^0\right) \\ &= \alpha_i + \sum_{n=1}^{5} \frac{\partial f\left(x_{n,it} \cdot \beta_n^0\right)}{\partial \beta_n^0}\left(\beta_n - \beta_n^0\right) + \lambda \cdot Mill's_{it} \\ &\quad + \delta_1 \cdot FinState_{it}^{1} + \delta_2 \cdot FinState_{it}^{2} + \varepsilon_{it} \end{aligned} \tag{6}.$$

To test our hypothesis, in addition the non-linear terms are interacted with a dummy that separates between the bull market phase (of rising prices) and the bear market phase (falling stock prices). This gives us Equation 7:

$$\begin{aligned} y_{it}^{*} &= y_{it} - \sum_{n=1}^{5} f\left(x_{n,it} \cdot \beta_n^0\right) \\ &= \alpha_i + \left(\sum_{n=1}^{5} \frac{\partial f\left(x_{n,it} \cdot \beta_n^0\right)}{\partial \beta_n^0}\left(\beta_n - \beta_n^0\right) \right)^{H} \\ &\quad + \left(\sum_{n=1}^{5} \frac{\partial f\left(x_{n,it} \cdot \beta_n^0\right)}{\partial \beta_n^0}\left(\beta_n - \beta_n^0\right) \right)^{B} + \lambda \cdot Mill's_{it} \\ &\quad + \delta_1 \cdot FinState_{it}^{1} + \delta_2 \cdot FinState_{it}^{2} + \varepsilon_{it} \end{aligned} \tag{7}.$$

It should be noted that the non-linear coefficients of equation 7 cannot be interpreted structurally.[10] Generally speaking, the equation can be studied empirically with both a within estimator and with instrument variable estimators (such as GMM). For the latter

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[10] If our goal were a structural interpretation of the coefficients from Equation 5 $\left(\beta_1 - \beta_1^0\right)$, $\left(\beta_2 - \beta_2^0\right)$ and $\left(\beta_3 - \beta_3^0\right)$, this would mean that, theoretically, we would be assuming a multiplicative association of different intangible assets from national and international accounting standards and from the income statement and patent information in Equation 1. This does not seem realistic. Therefore, the result of Equation 5 can only be evaluated in a statistically comparative manner. The construction of an

procedure, a minimum of five consecutive observations for each individual is necessary, however.

3.2 Data

The present data set was generated using information from various sources. To the authors' knowledge, this is the first dataset of this type for Germany which fuses national and international annual financial statements with stock market data and patent data.

3.2.1 Balance sheet data

The Hoppenstedt corporate database is a commercial database which provides detailed annual accounts information for firms using German GAAP, IAS or US GAAP to prepare their financial statements. For the analysis, firms meeting the following conditions were chosen:

- Existence of consolidated financial statements
- The group is in one of the following sectors: manufacturing, data processing and/or the provision of commercial services.
- Market information (share prices and number of securities) is available.

This selection resulted in 555 firms with a total of 2,339 observations for the period 1997-2002. The empirical analysis was conducted owing to potential selection effects for different market segments. Of these, 350 firms (1,676 observations) were in the official and regulated market and 205 (665 observations) in the Neuer Markt segment.

3.2.2 Stock market data

The share prices and number of securities were obtained using Datastream. Market information on 555 firms was collected in line with the Hoppenstedt corporate database standards. The share prices used were those on the last trading day in the calendar year. The information on the number of securities contains stock denominations[11] and the associated correction factors. The market value of a firm is then the product of the corrected share price and the number of securities.

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estimation equation that would reflect the additively separable character of potentially different intangible assets at firm level (Brainard and Tobin 1968) is not trivial.

[11] Following the introduction of the Euro as the Euroepan currency, many corporations' shares were redenominated.

3.2.3 Patent data

European patent data were extracted for the sample.[12] The official online patent data register of the European Patent Office (http://www.epoline.org/) was the source of the data. Data were extracted in November-December 2003, which meant that all patent applications up to May-June 2002 were recorded.[13] To identify the relevant patent (applications), specific fragments of the firm name, which were as unique as possible, were taken as the basis. The underlying data were also manually consolidated in order to review them for correctness prior to being matched with balance sheet and stock exchange data. The extraction yielded an absolute figure of 124,738 European patent applications[14] by the respective firms in the 1978-2002 period. On the whole, during that period 231 of the firms being sought in the sample had registered patents with the European Patent Office.

3.2.4 Generating the variables

The market value of a firm *i* at time *t* is produced by the market value of the firm's capital, defined as the product of the number of shares of diversified ownership and the stock price, as well as the book value of liabilities. Tobin's Q is the quotient of market values and tangible assets (capital stock). The capital stock variables are needed at recovery cost for tangible and intangible assets. The perpetual inventory method is used to calculate these variables separately for each of the three accounting methods from the asset grid. The capital stock of intangibles is calculated differently for national and international financial statements. Whereas German GAAP statements only include concessions, property rights and licenses, international accounting rules mandate that capitalized development costs also be attributed to the intangible capital stock. Here, too, the stocks have been entered into the calculation at historical cost. Along with the balance sheet variables, expenditure on R&D from the profit and loss statement has also been used, in line with the approach taken by other studies. Since, during the

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[12] Given that the sample contains only firms listed on stock exchanges, it appeared to make more sense to choose European patent data than German patent data. This logic is based on the assumption that German companies listed on stock exchanges generally possess cross-border product markets in Europe and will therefore, for the most part, seek international patent protection. The choice of only one source of patent information derives from a simple budget constraint.

[13] See above: European patent applications are published with a publication deadline of 18 months.

[14] This is to be understood as the number of European patent *families*; a family can include not only the European contracting states (27) but also additional extension states (4).

observation period, some firms switched from one accounting standard to another,[15] relevant indicator variables which give an indication of the accounting method used to prepare financial statements for each individual observation were declared.

Like accounting information, patent information was calculated at group level, i.e. patents of subsidiaries were grouped with the patents of the conglomerate. In all, two different patent *stocks* which were alternatively tested in multivariate specifications were calculated. To form the first variable, European patent applications[16] were aggregated at group level and the stock variable of a year *t* calculated as a cumulative variable across the period from 1978 to *t*.[17] As in Hall et al. (2000/2005), patents were discounted at a value of 15% p.a. to model the fall in the value of a given technology over time. While this type of discount has its justification particularly where *patent stock* is regarded as an indicator of the firm's cumulative knowledge (the value of which diminishes over time at a constant percentage), one may also argue, conversely, that industry-specific product cycles can show more complex patterns[18] than is given by the exponentially falling discounting function. Returning to one of the central ideas of the seminal paper by Pakes (1986), we therefore calculate the second *patent stock* variable, which discounts the value of the patent to zero once it expires (and the technology therefore becomes publicly available).[19] No other discounting of the patent value over time is undertaken, however. Given the fact that European patents are broken down into a bundle of national property rights upon issue, renewal decisions can only be retraced at the national level.[20] Consequently, national patents in the contracting states and not

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15 134 enterprises switched from German GAAP to IAS, 60 from German GAAP to US GAAP, 7 from IAS to US GAAP and another 7 from US GAAP to IAS.

16 Nota bene: it can take several years before a patent is issued by the European Patent Office. The literature tells us that this period averages 4.3 years in the biotech and pharmaceuticals sectors. Since our reporting period is located in the recent past and we particularly want also to record firms' patent activity in that period (1997 to 2002), we therefore have recourse to applications and not to patents issued. When interpreting the results further on in this paper, we will take account of the fact that patent applications are, on average, less valuable than patents issued (Guellec and van Pottelsberghe 2000).

17 Nota bene: for 2002, owing to the 18-month disclosure deadline, at the time of data collection (November 2003) patent applications were available only up until the end of April 2002. Therefore, patent stock values for 2002 have to be adjusted. Assuming that the number of applications for the second half of the year can be extrapolated from the number of applications in the first five months of 2002, real patent stocks for 2002 were multiplied by 12/5.

18 On this see, e.g., Kotler and Bliemel (1995).

19 We are aware of the fact that the original paper by Pakes (1986), which looks at patent renewal decisions, has a different background and pursues a different methodology. Therefore, when using the term "recourse", we only mean taking advantage of renewal decisions which are publicly available.

20 Nota bene: to the best of the authors' knowledge, it is at the discretion of national patent offices to make available the national patent offices' notification of patent renewal to the European Patent Office. It therefore cannot be ruled out, or, in fact, may be assumed, that the renewal information for

the entire European patent family form the basis for the second patent variable as an object of study.

Finally, it remains to be noted that the patent variables we use are based on pure counting variables. Quality weighting of patent stocks using forward citations of the patents that are now frequently visible in the literature (see Trajtenberg 1991 and Hall et al. 2005) do not appear to be feasible for applications that are often very recent. The quality weighting of patent stocks with contemporarily available indicators, used in earlier studies as quality indicators, such as the family size or backwards citations (e.g. Harhoff and Reitzig, 2004; Lanjouw and Schankerman, 2004), did not improve the informative quality of our estimations and are therefore not described in detail below.

4 Empirical results

4.1 Descriptive statistics

In the early 1990s, all market segments in Germany saw their stock prices rise tremendously. Towards the end of that decade, stock prices underwent distinct corrections, leading to a considerable reduction in the market value of companies listed on stock exchanges. Figure 1 shows the market to book ratio of the companies in the sample and highlights the trend that took place during the reporting period. A breakdown of the sample into the various accounting systems shows that the subsamples differ from one another. The slide in stock prices, however, can be retraced completely independently of the accounting system in question. It must be observed, though, that companies using international standards to prepare their financial statements have a much greater variance. In addition, the size of each subsample changes owing to market entries and exits as well as changes in accounting standards.

Insert Figure 1.

Figure 2 shows the average trend of the variables used to estimate the selection model that maps firms' choice of a given accounting standard. The variables included in the estimation are geared towards theoretical considerations about the aforementioned imputed connection and towards the work of Leuz and Verrechia (2000) and Bartov et

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each contracting state listed on www.epoline.org is incomplete. This data inadequacy was unable to be remedied for the draft of this version of the article.

al. (2004). These variables illustrate, in particular, the financial difficulties encountered by companies as the 1990s neared their end. *Cash Flow*, which is regularly cited as a measure of a company's profitability, diminished significantly during the period of stock price corrections. The average ratio of intangibles to tangibles fell continuously starting in 2000; however, this tends to be attributable to an increase in tangible assets. Average corporate indebtedness declined slightly beginning in 2001. The reason for this is that the sample is composed of relatively young companies, whose balance sheet totals are growing more strongly relative to liabilities.

Insert Figure 2.

Table 1 provides a detailed description of the data used and illustrates the relative heterogeneity of the data. Unlike other empirical studies, what is particularly striking in this case is the extremely large value for the ratio between the market value and tangible assets (fundamental value). This is partly due to overvaluation on the Neuer Markt. The ratio of intangibles to tangibles, which is nearly 2 on average, may be regarded as very high. With the percentage share of concessions and capitalised production costs averaging 0.7 (IAS), 0.4 (US GAAP) and 0.1 (German GAAP), it may be assumed that the funds were used to take over other companies (or participating interests in these companies).

Insert Table 1

The following should be mentioned with regard to the patent variables. In all, during the reporting period 124,378 European patent families were applied for by the firms in the sample. To construct the variable Patentstock2, we first disaggregated European patent families at the individual patent level. To improve the comparability of the coefficients of the patent variables with the euro-denominated balance sheet variables for the subsequent multivariate analysis, finally the patent variables were multiplied with an average value for each patent. For this, the value of €500,000 was assigned to a European patent family (Patentstock1), and one-tenth of the value – €50,000 – to an individual national patent.[21] Under these assumptions, it may be noted that, in the group

[21] These multipliers are estimates which, based on the data found by Harhoff et al. (2003) and Reitzig (2004), appear plausible in terms of their magnitude.

of companies actually taking out a patent, the patents' inherent (expected) net revenue averages between €77 million and €256 million (depending on how the *patent stock* variable is constructed).

Figure 3 shows that, for both variables, the percentage share of evaluated patents in tangible assets rises throughout the entire observation period. In this manner, they resemble the other 'exogenous' variables (intangible assets), yet the patent variables' increase is smaller across the same time span.

Insert Figure 3.

4.2 *Multivariate analysis*

The multivariate analysis estimates the models of equations (6) and (7). It is divided into 2 sections in which the coefficients are listed first for the entire reporting period and then separately for the bull market and bear market period. In the first section, we will focus entirely on the official and regulated market, while in the second part we will extend our results separately for the official and regulated market and for the Neuer Markt.

Table 2 summarizes the results found when estimating for the entire observation period for the official and regulated market without any separate breakdown in bull market and bear market periods. Starting with Equation (6), we estimate the Q model initially only using information on intangible assets.[22] The results of the estimations are in column (1) of Table 2. We then test, in the second step, what additional explanatory contributions are made by additional balance sheet information on intangibles, namely information on R&D expenditures. Column (2) contains the results of the estimations using R&D expenditures. Finally, the additional explanatory contribution of patent variables is provided in Table 2 by the parameterizations of columns (3) and (4).[23]

A summary look at the models in Table 2 initially shows the absence of visible selection effects and the insignificance of the dummies for the respective accounting standards.

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[22] In all estimates, we use the sum of licences and own intangibles as a variable for measuring the intangible capital stock. The intangibles balance sheet position is distorted by valuations that are classifiable under the firm value. R&D expenditures, by contrast, are taken from the income statement and, in contrast to the intangible capital stock, are a flow variable. Moreover, they also contain expenditure which is not eligible for capitalisation, such as salaries of R&D staff or laboratory rents.

[23] All outcomes are the result of different adjustments for outliers where, for each of all the variables, the uppermost and lowermost 1 percentile are excluded. Furthermore, each subsample contains only those firms which, after adjustment for outliers, show at least three consecutive observations.

Column (1) shows that, regardless of the accounting standard, none of the balance sheet items relating to intangibles (capital stocks) is significant. If the coefficients for R&D expenditures are estimated at the same time, this changes the results, indicating partial correlation between the capital stock variables and the flow variables from the income statements. R&D expenditures according to IAS and US GAAP have a positive sign. If R&D expenditures are used, the coefficient for the US GAAP capital stock variable assumes a negative sign (see Column (2)). Both patent variables prove to be positively correlated with the residual market value (Columns (3) and (4)). Column (5) shows the combination of all information sources. Along with the balance sheet variables under US GAAP, only R&D expenditures according to IAS show significant coefficients.[24]

The results for Table 2 appear of interest insofar as they largely confirm the knowledge gained for US samples of the complementarity of patent and accounting information based on this German dataset. Despite the fact that they still shed no light on our central hypothesis, they do indicate the comparability of additional results gained from this dataset with those of earlier studies. This possibility of forming inferences is especially important in view of the results of Tables 3 and 4, in which we look for answers to the main question in our work.

In Tables 3 and 4 we form (departing from estimation Equation 7) potential information asymmetries of accounting and patent data in bull market and bear market periods by using an interaction term. This term separates the period of rising prices (bull market) from that of falling prices (bear market). As, in addition, the accounting requirements are different for the various market segments in Germany, we present separate estimations for the official and regulated market (Table 3) and the Neuer Markt (Table 4).

With the exception of the estimation that exclusively uses balance sheet variables (Table 3 column 1), all other estimations for the official and regulated market share a significant selection variable and significant dummies for the standard variable. According to the results of Ramb and Reitzig (2005), different coefficients for phases of rising and falling prices occur regarding the accounting variables (Column 1). In times of falling prices, in particular, the German GAAP accounting information is the only information to show the positive sign desired by investors for the connection between

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[24] We have consciously refrained from listing the relevant results for the Neuer Markt. See Ramb and Reitzig (2005) for results regarding this market segment.

residual market value and intangible assets. By contrast, US GAAP and IAS show implausible negative signs. R&D expenditure (Column 2) likewise shows a positive sign in the bear market period. The patent variable (column 3), by contrast, is the only one to have a positive sign in both bull and bear market periods. This result is upheld even if R&D expenditures are included at the same time (Column 4).

On the whole, we are compelled to regard the multivariate analysis for the Neuer Markt as unsatisfactory. For the accounting variables, as in Ramb and Reitzig (2005), there are no visible plausible results, and for R&D expenditures and the patent variables, the coefficients that are visible are exclusively insignificant. We attribute this mainly to the particular situation in this market segment, which was characterized by, among other things, major overvaluation owing to market players' faulty judgement. Under such underlying conditions, the connection between market values and financial statement information is only limited and is not reflected in a multivariate analysis.

5 Discussion

For the discussion of the empirical findings, we direct the reader's attention back to the opening question concerning the phase-related usefulness of investor information. Our main issue concerns (see our hypothesis) analyzing the usefulness of patent information for giving investors additional information (beyond the financial statement) about the real value of the firm. For studying this complementary, in the first step it is important to make a note of, and empirically measure, the existence of differences in the information content of financial statement prepared using different accounting standards, as well as their extent.

Looking at Table 2, in this first step it must initially be noted that, for the selected sample of our firms in the official and regulated market, none of the capital stock information in the balance sheet was really good at explaining firms' residual market values. None of the accounting information from the balance sheet, regardless of whether German GAAP, US GAAP or IAS was used, is able, on balance, to reasonably map the value of the firm's intangibles for the whole, strongly volatile time span (Table 2). The coefficients according to IAS and German GAAP are insignificant, while those according to US GAAP are, contrary to expectations, negative. Only the flow variable for R&D expenditures, constructed according to IAS, displays a certain explanatory power. In view of our central hypothesis, Table 2 initially gives the impression that

patent information could likewise, throughout the whole observation period, make a sound explanatory contribution for investors, therefore functioning as a complementary source of information on financial statements in times of stock price volatility. A further look, however, makes it appear as if the cumulative patent stock variable information is, oddly enough, highly correlated with the flow variable for R&D, since the latter is the only one to remain significant in a joint estimation in Table 2, Column 5.

Only a look at Table 3 enables us to resolve the cognitive dissonance and to shine a clearer light on the underlying dynamics of the results. A breakdown of the market cycle between 1997 and 2002 in its bull market and bear market phases shows, for the first time, the comparative pros and cons of the individual items of R&D accounting information from the investor's point of view. During the bear market period, the much-maligned German GAAP proves to be a relevant source of information which takes account of prudent market expectations thanks to its application of the lower of cost or market (LOCOM) principle. Downward adjustments of balance sheet data during the bear market period owing to corrections of income expectations, which are possible and necessary according to US GAAP, are not visible in precisely this standard (German GAAP). It seems plausible to assume that the one-off commitment effect of firms for higher income expectations in the bull market period makes corrections during the bear market period more difficult. Logically, US GAAP information systematically misleads investors relying on the financial statement, especially in bear market periods. Even the seemingly non-phase-related explanatory power of the R&D flow variable according to IAS is demystified in Table 3. This information provides investors with reasonable information only in the bear market period. The likely explanation is that firms which undertake R&D-specific expenditures in phases of general uncertainty (bear markets) are justifiably rewarded by investors in the form of rising market values. The extent to which these expenditures lead to long-term income cannot be analyzed based on the short time series used here; this, however, should be left to future research.

It is far and away only the cumulative patent stock, by contrast, which demonstrates its ability as a reliable source of investor information in bull and bear market periods alike. This outcome is all the more compelling if we contrast the multivariate results with a simple look at Figures 1 to 3. One initially suspects that neither the balance sheet information nor the patent information should be correlated with firms' market value. Whereas market values slumped, at times dramatically, across the observation period, all 'exogenous' variables rose, on average.

Although this study thus compellingly underscores the complementary informative value of patent information relative to financial statement information in periods of market volatility when looking at the whole study, this still leaves open the question of how to further enhance the plausibility of the results.

A key to explaining the comparative advantageousness of patent information and its reliability as a source of investor information may be derived from the costs to the firm that the information entails. Whereas firms can transmit signals regarding expected income inexpensively through the balance sheet ("talk is cheap")[25], the signaling of expected income by registering a patent is much more cost-intensive. This reduces the firm's scope for running an opportunistic short-term, Pollyanna-ish information policy during bull market periods. This line of logic, among other things, is reflected by the expression of greater "objectivity" of patent information that often abbreviates the context. At the same time, patent information is, by definition, future-oriented and contains theories about future income that, in the classic German accounting method for own R&D, were completely ignored. Going along the same lines, though, it is still understandable why patent information does not "collapse" in bear market periods as was the case for capital stock information according to US GAAP. A co-determinant of the adaptation of the patent stock variable to reduced income expectations in the bear market period will be the non-renewal of the patent (through non-payment of renewal fees). This step, necessary for most firms in bear market periods because, once again, of cost reasons, forestalls the possibility of unjustifiably keeping afloat income expectations through cost-related signaling.

Our results clearly confirm the exceeding usefulness of patent variables in determining market values in volatile capital markets. The future-oriented character of this information, along with the credibility of the signals being emitted by the firm regarding future income, can form a basis for investors' investment decisions. Against the background of the results for the Neuer Markt, however, the limitations of this information are also visibly clear. In distorted markets that are characterized by overinvestment, among other things, neither balance sheet information nor external sources were able to meet expectations regarding the provision of investor information.

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[25] The evidence provided by Bange and de Bondt (1998) that managerial changes in R&D budgets can anticipate extreme gaps between analysts' forecasts and reported income supports our interpretation.

Irrespective of this, it would be appropriate to discuss how much sense it would make to disclose patent activity in the annex to the financial statement.

6 Summary and outlook

Against the background of the extraordinary fluctuations in stock prices between 1997 and 2002 which were visible in Germany, the present paper sought to answer the question of what information is best suited to reflecting firms' true market value for investors in such periods. We studied whether patent data represented a suitable source of information along with balance sheet and financial statement information to capture the firms' crucial intangible value.

The paper presented an empirical analysis in order to answer this question. Based on a relatively large sample of listed manufacturing enterprises from 1997 to 2002 as well as the attendant market, balance sheet and (European) patent data, the picture drawn by the empirical analysis was clear. During the selected observation period, which in Germany was characterized first and foremost by stock price volatility, evidence for the official and regulated market shows that patent data provide a positive contribution to explaining the residual market value in phases of both rising and falling share prices. Whereas balance sheet information prepared according to German GAAP show plausible results at least in the bear market period, IAS information is wholly incapable of providing any reasonable explanatory contribution. Only the information on R&D expenditures obtained from the income statement show a positive correlation to the residual market value in the bear market period as well. We could not confirm any of these results for the Neuer Markt. This is attributable to the special framework conditions in this segment. This segment, characterized by speculative bubbles, can apparently no longer be mapped using a theoretical model such as the Q approach.

The present study hence expands existing knowledge from earlier studies, such as Connolly et al. (1986), Connolly and Hirschey (1988), Hall et al. (2000/2005), Bloom and van Reenen (2000) and Bosworth and Rogers (2001) in two ways. Using Germany as a natural experiment, our study is, for one thing, the first to show that patent data, a publicly available source of information, complements the financial statement as a basis for valuing enterprises, irrespective of the accounting standard used to prepare the financial statement.

Our findings also show that patent data are the only source of information on firms' own R&D which, in times of stock price volatility, map *relevant* future income expectations in bull market periods with a sufficient level of optimism but at the same time, through their *"objectivity"* (or, more precisely, the cost aspect of the attendant signals – see above), reduce the risk of unjustified overinvestment during bear market periods. We attribute the complementary nature of the informational content of patent information, irrespective of market cycles and accounting standards, to the fact that patent data, owing to their very specific features, point to the future more clearly than any currently capitalizable R&D balance sheet item, Patent data, therefore – as called for by Lev et al. – express potential income prospects but can be manipulated by firms at only a prohibitive cost. We once again wish to point out the limitations of the interpretability of our results. Above all, we cannot rule out the possibility of a partial signaling effect on the market value of balance sheet and patent information, thereby indicating the existence of endogeneity problems and/or a dynamic that is not captured in a simple Q model. The imperfections of this study – as always – leave open fields for future research. For the present dataset, the approach of Bond and Cummins (2000), who propose a new definition of the fundamental value, seems to hold out much promise for more in-depth research work.

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Annex

Figure 1. Average values of the market to book ratio (total sample)

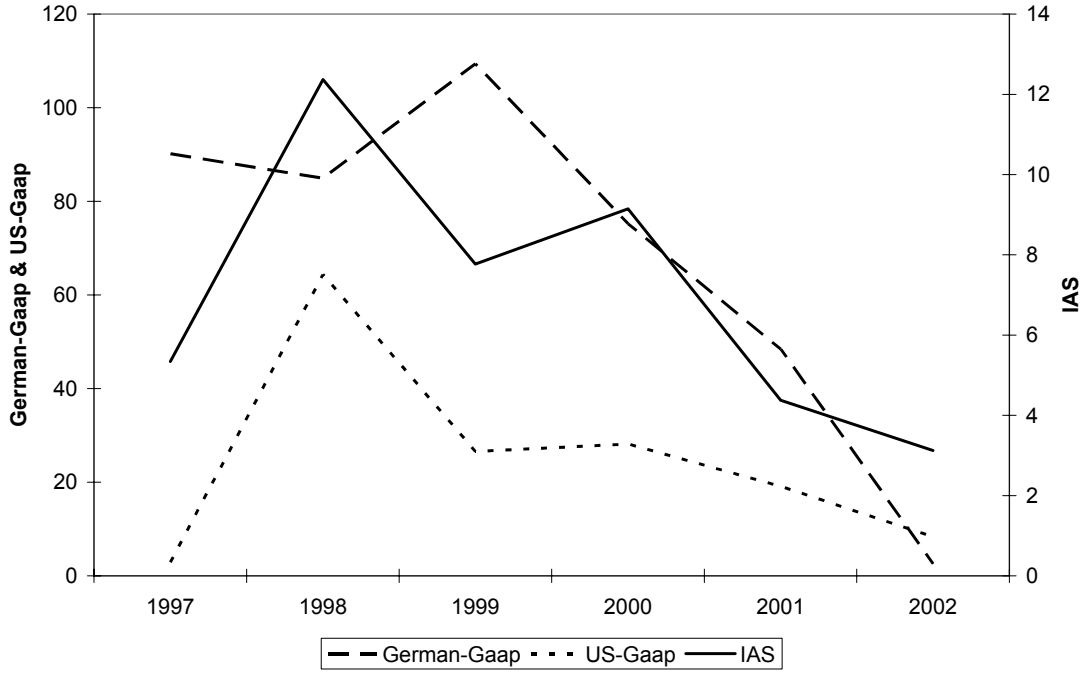

Figure 2. Average values of the explanatory variables for the selection equation (total sample)

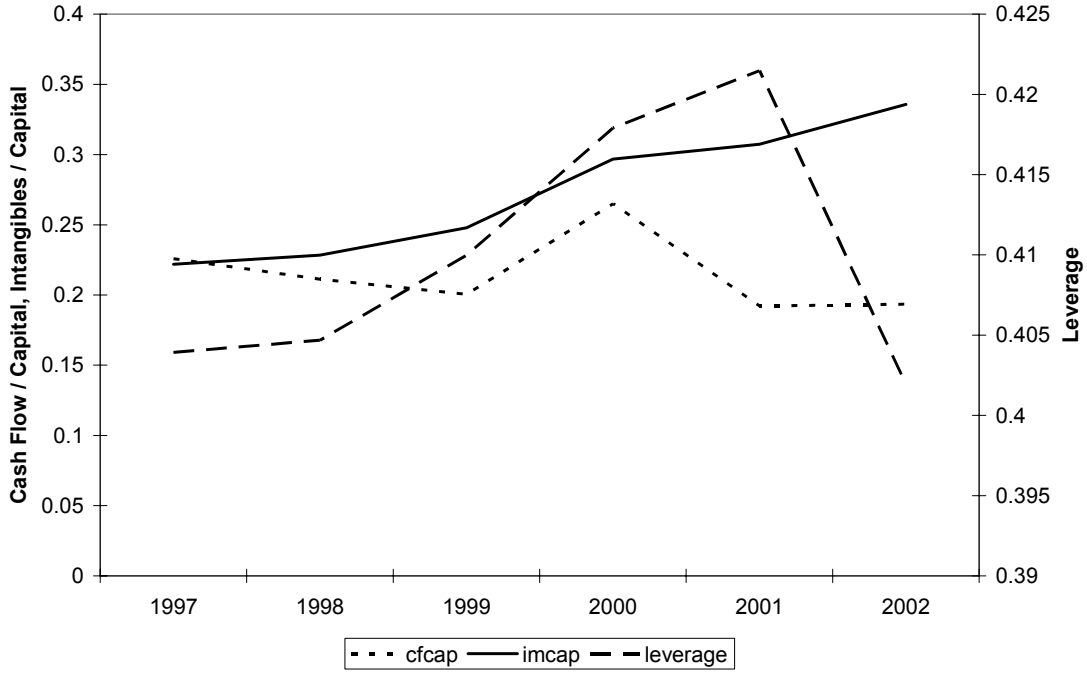

Figure 3. Average values of the patent variables

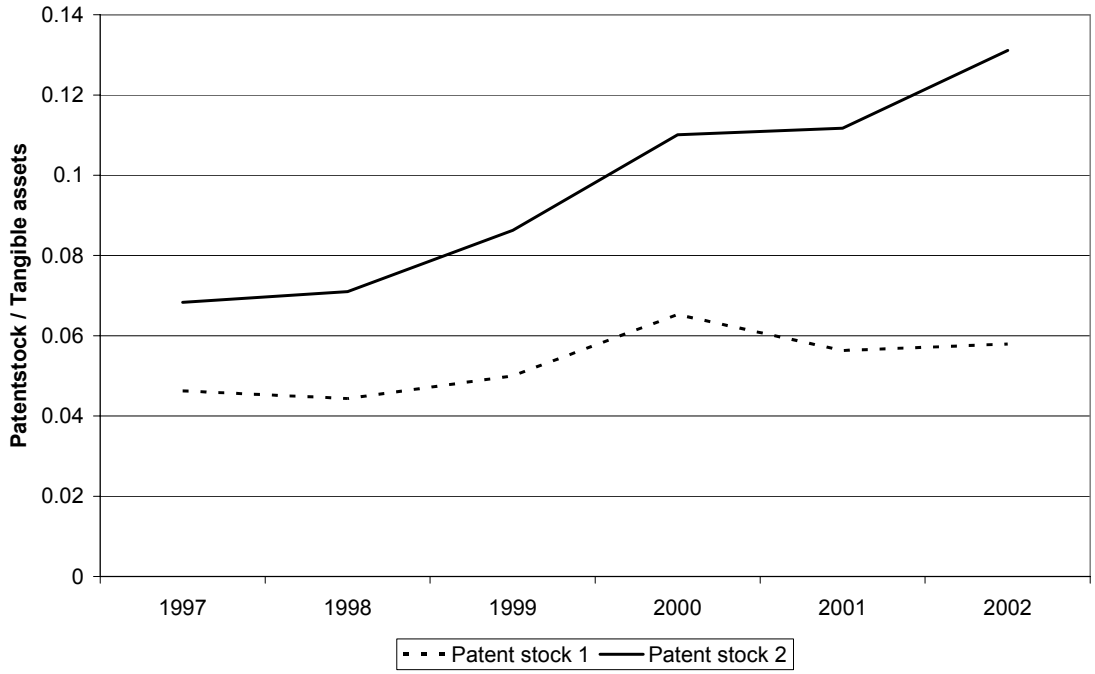

Table 1: Descriptive statistics (entire sample)

	Obs.	Mean	St.Dev.	Median	Lower Percentile	Upper Percentile
Market Value / Tangible Assets	2,476	50.261	626.4569	2.3281	0.2161	338.873
Intangible Assets / Tangible Assets (German-Gaap)	1,603	1.7870	52.4388	0. 0647	0	10.7840
F&E assets / Tangible Assets (German-Gaap)	1,603	0.1423	0.8765	0.0289	0	2.0754
Intangible Assets / Assets (IUS-Gaap)	548	1.4532	3.0799	0.3858	0	14.0716
F&E assets / Tangible Assets (US-Gaap)	548	0.4145	1.1809	0.0788	0	4.5228
F&E Expenditures / Tangible Assets (US-Gaap)	548	0.3036	0.5942	0.0208	0	3.9199
Intangible Assets / Assets (IAS)	793	1.9378	3.2659	0.5078	0	17.1083
F&E assets / Tangible Assets (IAS)	793	0.7024	1.9641	0.1483	0	8.7273
F&E Expenditures / Tangible Assets (IAS)	793	0.0964	0.4005	0	0	2.3604
Patclass / Tangible Assets	1,123	0.1394	0.3948	0.0363	0	1.9759
Patnew / Tangible Assets	1,139	0.2547	0.6765	0.0683	0	3.8918
Cash flow / Tangible assets	2,476	-4.2249	131.053	0.1411	-16.3389	4.5289
Liabilities / Total assets	2,476	0.3546	0.2322	0.3453	0	0.8651
Log total assets	2,476	18.9148	1.8637	18.6136	15.3993	24.6093

Legend for Table 1:

The random sample for the period from 1997 to 2002 comprises firms from the official market, the regulated market and the Neuer Markt. Market values are calculated based on the last available price within a year. On the whole, information is available on 555 firms, 343 of which use German GAAP, 212 IAS and 140 US GAAP. There were 208 documented changes of accounting standard during the reporting period. Patent information is available for 231 firms. Tangible assets, intangible assets and R&D assets are calculated using the perpetual inventory method and are based on historical costs. R&D assets are composed of concessions and capitalised own work, while R&D expenditures are taken from the income statement. Cash flow is the sum of annual surplus and depreciations. Patclass denotes the

stock of patents including an annual depreciation rate of 15%. Patnew is calculated as the patent stock using a country-specific depreciation rate.

Table 2. Official and regulated market

F&E Assets					
	(1)	(2)	(3)	(4)	(5)
Constant	2.40	2.35	2.25	2.23	2.25
	(1.29)*	(1.28)*	(1.28)*	(1.28)*	(1.27)*
German	0.31	0.39	0.31	0.31	0.38
	(0.24)	(0.25)	(0.24)	(0.24)	(0.25)
US-Gaap	-0.15	-0.48	-0.16	-0.16	-0.46
	(0.15)	(0.08)***	(0.15)	(0.15)	(0.08)***
IAS	0.07	0.06	0.13	0.13	0.11
	(0.33)	(0.31)	(0.35)	(0.35)	(0.32)
R&D US		4.04			3.61
		(2.60)			(2.34)
R&D IAS		1.51			1.29
		(0.52)***			(0.46)***
Patclass			3.67		1.89
			(2.21)*		(1.37)
Patnew				1.93	
				(1.08)*	
Mill's ratio	-0.14	-0.14	-0.14	-0.14	-0.14
	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)
Standard D1	-1.99	-1.94	-1.95	-1.92	-1.91
	(1.28)	(1.27)	(1.27)	(1.27)	(1.26)
Standard D2	-0.85	-1.12	-0.82	-0.81	-1.07
	(0.74)	(0.74)	(0.73)	(0.73)	(0.73)
Observations	1487	1487	1487	1487	1487
Number of ID	283	283	283	283	283
R-squared	0.10	0.11	0.10	0.10	0.11

Legend for Table 2:

All calculated coefficients and standard errors (in parentheses) are based on a linearised fixed effects estimation using a complete set of time dummies for the 1997-2002 period. *** Significant at the 10% level, ** significant at the 5% level and * significant at the 1% level. The selection was modelled by German GAAP versus US GAAP/IAS. The inverse Mill's ratio is calculated from a time-specific probit estimation at the first stage. This estimation incorporates intangible assets / tangible assets, cash flow / tangible assets, liabilities / total assets, the logarithm of total assets and industry dummies as the explanatory variables. The logarithm of market value to book value is the dependent variable in the second stage. In all estimations the quotient of licenses and capitalized development costs (R&D assets) for tangibles is used for German GAAP, US GAAP and IAS each. Patclass denotes the stock of patents including an annual depreciation rate of 15%. Patnew is calculated as the patent stock using a country-

specific depreciation rate. Standard D1 and Standard D2 are indicator variables that reflect a standard change.

Table 3. Official and regulated market – Time interaction

F&E Assets				
	(1)	(2)	(3)	(4)
Constant	2.47	0.41	2.27	0.29
	(1.31)*	(0.05)***	(1.31)*	(0.07)***
German (H)	0.11	0.23	0.09	0.20
	(0.20)	(0.23)	(0.19)	(0.22)
German (B)	0.57	0.90	0.59	0.90
	(0.33)*	(0.38)**	(0.33)*	(0.38)**
US-Gaap (H)	-0.25	-0.22	-0.26	-0.24
	(0.07)***	(0.05)***	(0.07)***	(0.05)***
US-Gaap (B)	-0.16	-1.71	-0.17	-1.63
	(0.23)	(0.45)***	(0.22)	(0.47)***
IAS (H)	-0.59	-0.44	-0.56	-0.42
	(0.57)	(0.61)	(0.57)	(0.61)
IAS (B)	0.02	-0.02	0.07	0.02
	(0.32)	(0.26)	(0.33)	(0.28)
R&D (H)		0.27		0.23
		(0.28)		(0.27)
R&D (B)		3.22		3.05
		(0.84)***		(0.79)***
Patnew(H)			2.35	1.81
			(1.30)*	(1.04)*
Patnew(B)			2.08	1.49
			(1.15)*	(0.88)*
Mill's ratio	-0.15	-0.18	-0.14	-0.17
	(0.09)	(0.09)**	(0.09)	(0.09)*
Standard D1	-2.04	1.29	-1.96	1.25
	(1.31)	(0.58)**	(1.30)	(0.58)**
Standard D2	-0.87	2.49	-0.83	2.40
	(0.75)	(1.28)*	(0.75)	(1.27)*
Observations	1487	1484	1487	1484
Number of ID	283	283	283	283
R-squared	0.10	0.11	0.10	0.12

Legend for Table 3:

All calculated coefficients and standard errors (in parentheses) are based on a linearized fixed effects estimation using a complete set of time dummies for the 1997-2002 period. *** Significant at the 10% level, ** significant at the 5% level and * significant at the 1% level. The selection was modeled by German GAAP versus US GAAP/IAS. The inverse Mill's ratio is calculated from a time-specific probit estimation at the first stage. This estimation incorporates intangible assets / tangible assets, cash flow /

tangible assets, liabilities / total assets, the logarithm of total assets and industry dummies as the explanatory variables. The logarithm of market value to book value is the dependent variable in the second stage. In all estimations the quotient of licenses and capitalized development costs (R&D assets) for tangibles is used for German GAAP, US GAAP and IAS each. Patnew is calculated as the patent stock using a country-specific depreciation rate. Standard D1 and Standard D2 are indicator variables that reflect a standard change. The German GAAP, IAS and US GAAP variables are used time-interactively, as is the patent variable 2. H designates the bull-market period from 1997-1999 and B the bear-market period from 2000-2002.

Table 4: Neuer Markt – Time interaction

Licences & own work				
	(1)	(2)	(3)	(4)
Constant	12.18	18.43	9.66	15.44
	(12.80)	(12.72)	(12.78)	(12.70)
US-Gaap (H)	-1.10	-0.80	-1.06	-0.80
	(0.30)***	(0.07)***	(0.31)***	(0.07)***
US-Gaap (B)	-0.06	-0.03	-0.06	-0.04
	(0.12)	(0.13)	(0.12)	(0.13)
IAS (H)	0.14	0.08	0.08	0.04
	(0.32)	(0.25)	(0.27)	(0.22)
IAS (B)	0.02	-0.01	-0.05	-0.07
	(0.11)	(0.09)	(0.07)	(0.06)
R&D (H)		0.63		0.56
		(0.45)		(0.42)
R&D (B)		0.35		0.33
		(0.23)		(0.21)
Patnew (H)			2.39	2.27
			(1.90)	(1.85)
Patnew (B)			2.33	2.34
			(1.87)	(1.87)
Mill's ratio	-1.49	-2.53	-1.12	-2.08
	(2.07)	(2.06)	(2.06)	(2.05)
Standard D1	-8.87	-15.19	-6.56	-12.41
	(12.62)	(12.54)	(12.57)	(12.49)
Observations	420	421	420	421
Number of ID	119	119	119	119
R-squared	0.65	0.65	0.66	0.67

Legend for Table 4:

All calculated coefficients and standard errors (in parentheses) are based on a linearized fixed effects estimation using a complete set of time dummies for the 1997-2002 period. *** Significant at the 10% level, ** significant at the 5% level and * significant at the 1% level. The selection was modeled by German GAAP versus US GAAP/IAS. The inverse Mill's ratio is calculated from a time-specific probit estimation at the first stage. This estimation incorporates intangible assets / tangible assets, cash flow / tangible assets, liabilities / total assets, the logarithm of total assets and industry dummies as the explanatory variables. The logarithm of market value to book value is the dependent variable in the second stage. In all estimations the quotient of licenses and capitalized development costs (R&D assets) for tangibles is used for German GAAP, US GAAP and IAS each. Patnew is calculated as the patent stock using a country-specific depreciation rate. Standard D1 and Standard D2 are indicator variables that reflect a standard change. The German GAAP, IAS and US GAAP variables are used time-interactively,

as is Patnew. H designates the bull-market period from 1997-1999 and B the bear-market period from 2000-2002.