1. Introduction

1.1 BACKGROUND AND MOTIVATION

In developed economies, technological innovation is a primary driver of economic growth (see, for example, Romer, 2003; Solow, 1956). Intensified competition stemming from the deregulation and globalisation of markets has made tangible and financial assets more commodity-like. Simultaneously, growing investment in research and development (R&D) has led to an ever increasing pace of technological change in the sense postulated by Schumpeter (1962), when describing the creative destruction of technologies and markets (see, for example, Christensen, 1997). This trend has put pressure on firms to reinvent their business models (see, for example, Hamel, 2002). However, although both managers and investors increasingly perceive the importance of intangible assets – such as technological innovations – to the commercial success of companies, they often lack knowledge of their economic characteristics and do not have instruments for their measurement and valuation (see, for example, Hand and Lev, 2003). For example, intangible assets are rarely reflected in official measures of economic performance, and most are not accounted for as investments in financial statements (see, for example, OECD, 2008). As a result, financial statements have lost explanatory relevance in relation to the market value of firms (see, for example, Ballou et al., 2004). This has severe implications for the functioning of capital markets.

While the link between tangible assets, such as plants and machinery, and firm value is relatively intuitive and well established in the literature, technology-driven firms have few tangible assets and often spend more on R&D than their annual earnings (see, for example, Chan et al., 2001). Capital markets are therefore often deprived when assessing their value. In essence this means that investors need new measurements to assess the future financial performance of firms in order to allocate financial capital productively (see, for example, Lev, 2001). At the same time technology-driven companies need to communicate their ability to materialise their investments in order to raise capital to finance innovation. The aim of the present study is to suggest ways of bridging the informational deficit in capital markets that stems from the increasingly intangible economy.

According to Lev (2001, p.5): ‘An intangible asset is a claim to future benefits that does not have a physical or financial embodiment.’ Intangibles can take various forms such as technologies, brands, strategic partnerships, customer relationships, and so on. This study, however, focuses on technology-based intangible assets – that is, technological knowledge being accumulated through R&D – some of which is protected by intellectual property rights (IPR).¹ The link between R&D, intangible assets and IPR is well established in the literature. For example, Mahlich (2005) shows how R&D results in new ideas that add to our accumulated knowledge stock. Moreover, research pioneered by Griliches and Mairesse (1981) and Clark and Griliches (1982) finds that R&D expenditures contribute positively to companies’ financial performance. This implies that R&D generates not only new knowledge, but knowledge of economic value. Griliches and Mairesse (1981) thus argue that R&D expenditures provide investments in intangible technology assets – hereafter referred to as intangible assets.

To appropriate their investments, technology-driven companies rely on IPR (see, for example, Allegrezza and Guarda-Rauchs, 1999; Schankerman, 1998). Empirical studies have accordingly shown that IPR contribute to both their productivity and market value. This is true of patents as well as trademarks. For example, Sandner and Block (2011) find that patents, trademarks and R&D are all associated with higher firm value. Moreover, Greenhalgh and Longland (2005) find that firms investing in R&D, and filing for patent and trademark protection, are more productive, while other studies show that patents contribute to both productivity measures and companies’ market value (Bloom and Van Reenen, 2002; Neuhäusler et al., 2011).

However, firms have been successful in designing around patents, rendering appropriation for the innovator. This implies that even though IPR are supposed to perfectly protect against imitation, they do so imperfectly in practice. For this reason, firms rely on more complex patent strategies to generate economic returns based on their innovations (see, for example, Blind et al., 2004), as well as the combination of different types of IPR to achieve more effective protection. For example, Jennewein (2005) shows how Bayer and Cisco Systems created synergies through patent and trademark protection, and thus sustained technology-based competitive advantages created under patent protection beyond patent expiry. In this sense, IPR are not only to be seen as outputs of R&D investments, but are rather to be considered in the wider context of companies’ business models and competitive strategies. From a resource-based view, firms manage their IPR to secure competitive advantages in making technology assets imperfectly imitable (see, for example, Barney, 1991). IPR

thus provide important isolation mechanisms, postulated as crucial to firm performance by resource-based theorists (see, for example Grant, 1991; Wernerfelt, 1984). In addition, firms manage their IPR to restrain the market power of suppliers and enhance the firms' bargaining power within the industry (see, Greenhalgh and Rogers, 2010). Hence, patents are used to counteract competitive forces within industries, described in environmental models pioneered by Porter (1985). Furthermore, by means of offensive blocking, firms actively prevent competitors from developing technological solutions to circumvent or substitute their proprietary technologies (see, for example, Cohen et al., 2000). Thus it is essential for pharmaceutical firms to prevent competitors from commercialising competing chemical substances by also protecting the surroundings of their products (European Commission, 2009), thereby overcoming the threat of substitution (Gassmann and Von Zedtwitz, 2004).

What Hall and Ziedonis (2001) describe as IPR management does not therefore merely relate to improved efficiency in the business process reengineering sense, but is rather a redefinition and extension of its objectives beyond firms' R&D management (Blind et al., 2006). Accordingly, IPR have received increasing attention in a managerial context among research scholars (see, for example, Frey and Wurzer, 2009; Gassmann and Bader, 2010; Harhoff, 2005; Reitzig, 2007), as well as practitioners (see, for example, Frey et al., 2008; PwC 2007; *The Economist*, 2007). A recent survey of 197 executives reveals that approximately 83 per cent consider IPR management to be important or even very important to the performance of their firm (PwC, 2007). Moreover, PwC (2007) finds that IPR management is most often the responsibility of c-level executives, underlining its strategic relevance. Another survey involving 405 executives supports this view in suggesting that the strategic importance of IPR is growing rapidly (*The Economist*, 2007). A similar tendency in perceptions has also been shown among small and medium-sized enterprises (SMEs) (Blind et al., 2009b).

From a capital market perspective, increasingly intangible economies and the changing role of IPR management provide new challenges. These relate to the informational efficiency of capital markets. To allocate financial capital to where it can be used most productively, investors assess the fundamental value of different real investments or securities. This requires that they have access to information that is relevant in explaining their value. The deterioration of the value-relevance of information provided in financial statements, however, suggests that investors lack important information, not least when it comes to the valuation of technology-driven firms which do not have any particular assets in place and largely consist of growth opportunities. For example, Aboody and Lev (2000)

find that gains from insider trading are comparatively substantially larger in technology-driven firms. They conclude that due to asymmetric information regarding companies' R&D, public information fails to directly capture the productivity and value of intangible investments.² Similarly, Nakanishi (2007) argues that financial analyst reports as well as corporate annual reports to a large extent do not provide sufficient quantitative or qualitative information on intangible assets to the public domain, leading to asymmetric information.

Theoretical corporate finance models, such as pecking order theory (Myers and Majluf, 1984), as well as empirical research (see, for example, Aghion et al., 2004), show that the presence of asymmetric information has an impact on companies' capital structure as well as their ability to obtain funding. Carpenter and Peterson (2002) argue that this is due to the high attrition rates of R&D projects, leading to highly skewed returns on R&D investments.³ This is especially problematic from a debt contract perspective. Because creditors do not share the upside of the firm's investments, they are only concerned with the bottom tail of the distribution of economic returns (see, for example, Stiglitz, 1985). Hence, as the borrower's returns are highly uncertain, the creditor will want to raise interest rates in order to compensate. However, Stiglitz and Weiss (1981) show that, as interest rates rise, the nature of debt contracts can ex post lead unmonitored borrowers to invest in higher-risk projects with potentially higher returns, and thus increase the probability of default without offsetting higher gains to the creditor in the event of success. This means that the debt financing of R&D projects comes with moral hazard complications (see, for example, Stiglitz, 1985). Moreover, asymmetric information related to risk and default probabilities potentially leads to adverse selection and a situation where lenders will ration credit rather than raise interest rates, because higher interest rates can cause low-risk borrowers to exit the application pool (Stiglitz and Weiss, 1981).

Equity, on the contrary, does not require any collateral, nor does it cap the upside of investors' returns. Furthermore, equity finance does not give managers incentives to substitute low-risk for high-risk projects because managers themselves most often have their wealth tied up in compensation according to firm performance, mitigating agency problems (see, for example, Jensen and Meckling, 1976). Accordingly, Aghion et al. (2004) find that the use of debt declines with companies' R&D intensity, and that firms with higher R&D intensity issue more equity. This suggests that firms mainly rely on equity to finance innovation. However, Eberhardt et al. (2004) find that the stock market consistently undervalues intangible investments, although R&D spending is associated with subsequent abnormal operating performance. In conformity with these findings, Hall

(2002) suggests that smaller firms in R&D-intensive industries suffer from considerably higher costs of capital compared with larger competitors, as well as companies in less R&D-intensive industries. In addition, Guo et al. (2005) find that the ratio of patented products has a negative impact on the buy–hold return (BHR) on firms' shares, suggesting that investors discount even for proprietary intangible assets.

According to pecking order theory, managers will not want to issue equity under such conditions (Myers and Majluf, 1984). This implies financing constraints for technology-driven firms. The market for venture capital is one response to this problem. However, Sahlman (1990) shows that venture capital is associated with high costs of capital, suggesting high costs for technological innovation. Moreover, venture capitalists react to information provided by public stock markets (Gompers et al., 2008), and try to time initial public offering (IPO) decisions by making an exit when stock market valuations are relatively high. Hence, Black and Gilson (1998) argue that informationally efficient stock markets are crucial for venture capital funding.

While research has revealed informational deficits in capital markets, avenues to bridge such information gaps have been suggested in the literature. According to Ehrat (1997) approximately 80 per cent of all technical knowledge is disclosed in public patent databases. Moreover, this information is disclosed as patents are filed up to three years before the invention is commercialised and returns are generated (see, for example, Ernst, 2001). This means that patent information is not only relevant for the assessment of firms' performance, but is also forward-looking.

The value-relevance of patent information has been confirmed empirically. For example, Ramb and Reitzig (2005a; 2005b) show that European patent applications have a stronger correlation with companies' market value than activated R&D investments on their balance sheet. Moreover, several studies suggest that patent information explains the market value of firms better than information provided in annual financial statements. This is evident from studies conducted by Hirschey and Richardson (2004) in relation to US firms, but is also found to be true for Japanese firms (Hirschey and Richardson, 2001) as well as German ones (Trautwein, 2007).

However, because the value distribution of patents is highly skewed, it is difficult for corporate outsiders to evaluate and distinguish valuable patents from the large number that are of low value (see, for example, Gambardella et al., 2008). Patent information is also relatively complex and cannot be easily assessed without specific knowledge about the patent system. Moreover, in focusing on patent information, past research has failed to link the managerial aspects of the intangible economy to its

capital market implications. Although several studies show that both patents and trademarks are reflected in market values, they consider IPR as outputs of R&D investments, rather than in the wider context of firms' business models and competitive strategies. Because companies' ability to materialise their R&D investments depends on their IPR management, the present study claims that investors need to assess companies' IPR management as part of their investment analysis, which can only partly be done through published patent information.

The scientific objective of the present study is threefold. Firstly, it aims to enhance the understanding of how technology-driven companies use IPR to generate profits based on their R&D investments. This should enable investors to make better assessments of companies' profit potential, and thus their value. Secondly, it looks to examine to what extent companies' IPR management is reflected in their share price performance, and thereby to identify potential areas of asymmetric information. Thirdly, it intends to suggest ways in which such information asymmetries can be reduced in order to improve the informational efficiency of capital markets and to facilitate the financing of technological innovation. In this respect, the present study goes beyond the existing literature in the following ways:

*Through the identification of value-relevant IPR management indicators.*⁴ Although a significant amount of important empirical research has been conducted on companies' patenting behaviour (see, for example, Blind et al., 2006; Cohen, 2005; Pitkethly, 2001), none of these studies has provided a holistic conceptualisation of companies' IPR management. Accordingly, theory development has lagged behind in explaining how firms integrate and organisationally implement IPR strategies to profit from their technological innovations. To bridge this research gap the present study develops a conceptual framework for how pharmaceutical companies conduct their IPR management, and also how that contributes to their financial performance. This framework serves as a starting point for the operationalisation of value-relevant IPR management indicators – enabling investors to better assess the ability of firms to systematically materialise their R&D investments.

By examining whether IPR management information is reflected in share prices. To my knowledge, there is no empirical research on the role of IPR management information in financial analysts' investment analysis, nor on valuations of stock markets. Although several studies have examined the impact of patent and trademark applications on companies' stock market performance (see, for example, Greenhalgh and Rogers, 2006;

Neuhäusler et al., 2011; Sandner and Block, 2011), the stock market's valuation of IPR within the wider context of companies' business models has so far been ignored. Instead, past studies have considered IPR to be the outcome of innovation activities. However, the patent behaviour of firms shows that IPR are no longer only a consequence of an invention, but that firms also have different strategic motives for patenting depending on their business model. The present study therefore looks at whether companies' IPR management – including the strategic use of IPR – contributes to their share price performance. In doing so, it assesses the informational efficiency of equity markets.

By examining whether IPR reporting can reduce asymmetric information. Companies sometimes conduct voluntary information disclosures to reduce information asymmetries, and thus their costs of capital (see, for example, Healy and Palepu, 2001). This also involves reporting on their IPR (see, for example, Seethamraju, 2003). In addition, research has shown that IPR reporting provides new value-relevant information for stock markets. For example, there is empirical evidence that patents which have received attention in the media (Austin, 1993), and the voluntary publication of information related to trademark acquisitions, both have a positive impact on stock market valuations (Seethamraju, 2003). Still, the ability of technology-driven companies to reduce asymmetric information through active IPR reporting has not received much attention in the literature, although frameworks for doing so have been suggested (see, for example, METI, 2004). Moreover, the context of companies' IPR management, which is likely to determine the value-relevance of the information provided, has been left out in the studies mentioned. The present study goes beyond past research in deriving IPR reporting indicators on the basis of how companies manage their IPR, and examining the ability of companies to reduce asymmetric information in stock markets through active reporting.

By examining whether credit rating agencies (CRAs) help reduce IPR-related asymmetric information. The role of CRAs has largely been neglected as a source of reducing informational deficits regarding technology-driven firms in capital markets. Because CRAs gather and process information from various sources, investors can reduce their own research activities and rely more on the information retrieval and analysis of CRAs. This, however, raises the question: do CRAs consider IPR information in their assessments and thereby help technology-driven firms emerge from the fog of asymmetric information? Since past research shows that patents are associated with lower risks of default (see, for example, Bittelmeyer, 2007),

technology-driven firms which rely on patent protection should have lower costs of accessing debt markets, provided that CRAs incorporate patent information in their credit risk assessments. Still, empirical research on the impact of IPR information on ratings is rather limited. Czarnitzki and Kraft (2004) study the impact of R&D intensity, patent stock and newly developed products' share of sales on credit ratings given by a German rating agency. However, they do not differentiate between valuable patents and 'lemons', and thus do not consider the implications of strategic patenting. Moreover, their sample is limited to German firms covered by a national rating agency. Hence, consideration of patent information by international CRAs, such as Standard & Poor's, has to my knowledge not yet been assessed. Finally, past research on the value-relevance of patent information has largely focused on equity markets. Because credit ratings are mainly of concern to lenders, an assessment of CRA use of patent information also, at least implicitly, considers its reflection in debt security prices. In short, the present study aims to bridge this research gap by examining whether CRAs differentiate between valuable patents and lemons, and thereby communicate patent value to debt markets.

1.2 STRUCTURE OF THE STUDY

Chapter 2 consists of a review of the literature on the intangible economy and its implications for managers and investors. This is followed in Chapter 3 by an empirical analysis of the link between patent value indicators and corporate credit ratings. An exploration of pharmaceutical firms' IPR management practices, related information disclosures, and the perceived value-relevance of IPR management information among financial analysts is undertaken in Chapter 4. Chapter 5 presents an empirical study assessing stock market valuation of firms' IPR management, but also the role of voluntary disclosures in reducing stock market uncertainty. Finally, some policy implications and recommendations are derived in Chapter 6.

Chapter 2 reviews the literature regarding the economic consequences of the intangible economy. From a managerial perspective, it reviews the literature on how companies manage their IPR to create and sustain competitive advantages. It goes on to look at the literature examining the relationship between the intangible economy and the deterioration of the value-relevance of financial statements. In doing so, it looks at sources of asymmetric information regarding technology-driven firms, and its implications for corporate finance. Finally, current disclosure regimes are reviewed to identify potential avenues for the reduction of IPR-related

asymmetric information. The chapter thus identifies some sources of asymmetric information stemming from the intangible economy, but also potential ways of reducing them.

Chapter 3 addresses a specific problem related to the flow of information in capital markets and the contribution of CRAs to the reduction of asymmetric information in an intangible economy. In theory, information intermediaries provide an important function in producing and distributing information, enabling investors and creditors to reduce their own research and rely more on the analysis of CRAs. For accurate valuations and risk assessments of technology-driven firms, it is therefore important that CRAs capture information concerning their IPR. As it has been shown that patent data can be used to assess the value of patents, it provides a promising source of value-relevant information. Accordingly, Chapter 3 examines the contribution of information intermediaries to the reduction of IPR-related information asymmetries on the basis of some patent value indicators. It uses a panel dataset, comprising 191 US firms, receiving credit ratings from 1990 to 2001. The results show that patents are valued differently in CRA credit risk assessments than by stock markets. Patent flows have a substantial impact on corporate credit ratings, while patent family size only has a marginal effect. In addition, forward citations have a negative impact on firms' ratings. I argue that the negative impact of the forward citations variable is due to the increased risk of patent lawsuits, which seems likely for several reasons. I further argue that CRAs consider patents as insurance against lawsuits rather than in terms of innovation outputs. This finding suggests that CRAs do not contribute to the informational efficiency of capital markets as expected, in terms of communicating patent value as growth opportunities to investors.

Chapter 4 examines pharmaceutical firms' IPR management by means of exploratory interviews. A qualitative empirical approach was chosen in order to further specify the IPR management term and its dimensions. On the basis of this study, I develop a conceptual framework for how pharmaceutical firms conduct their IPR management that serves as the basic foundation for the operationalisation of IPR management indicators in the quantitative empirical study that follows (see Chapter 5). Notably, I find companies' IPR management to be attached to the product lifecycle, from R&D to marketing and sales. Hence, IPR management is not to be seen as a standalone task, but is rather to be considered within the framework of product management. Moreover, the IPR management experts interviewed revealed several ways in which their company's IPR management contributes to its financial performance. From a capital market perspective, I conclude that related information ought to be value-relevant.

This alone, however, does not enable me to draw conclusions on the

availability of IPR management information in the public domain. Nor does it tell us whether capital markets request it. In addition, I therefore examine whether IPR management information is requested by capital market participants. Additional interviews were conducted with financial analysts to conceptualise the impact of IPR reporting on companies' share price performance. Interestingly, I find that analysts do not consider IPR as such. Rather they do so in relation to products, throughout their respective lifecycles, and in relation to technology flows in terms of patent in- and out-licensing deals.

Following the findings of Chapter 4, Chapter 5 examines two main questions: (a) do share prices reflect information on firms' IPR management? (b) Can firms reduce stock market uncertainty through IPR reporting? The chapter is based on a survey of companies' IPR management practices within the pharmaceutical industry from which I end up with a final sample of 73 companies. The first part of the chapter describes the sampling process in terms of how the data for the empirical study were gathered. Secondly, some descriptive statistics are displayed to create a better understanding of how firms manage their IPR, and which aspects they report on, but also to enhance the reader's understanding of the dataset, its benefits and limits. I then proceed to hypothesise some relationships between firms' IPR management and their share price performance, and examine these through a multivariate analysis. Finally, I turn to the relationships between firms' IPR reporting and stock market uncertainty, which are also examined through multivariate analysis.

My findings suggest that most IPR management indicators are not reflected in companies' share price, although some are. At first sight, it was troublesome to find a common denominator for the indicators exhibiting a significant impact on companies' share price performance. The general pattern, however, seems to be that the indicators with a positive significant impact are those for which related information presumably had been communicated more extensively to the stock market, probably upon request. Most notably, I find that stock markets systematically discount for firms generating their revenue on technology markets, as opposed to on product markets. I argue that this is due to asymmetric information attached to technology markets and find evidence that these asymmetries can be reduced by means of IPR reporting. I conclude that IPR reporting can help companies overcome stock market uncertainties due to asymmetric information and thereby reduce their costs of capital.

Finally, in Chapter 6, I derive some policy recommendations on how to enhance the informational efficiency of capital markets in an intangible economy, and thereby also the ability of technology-driven firms to raise funding to finance investments in technological innovation. I argue

that more forward-looking financial reporting is essential, of which IPR reporting forms a part. I go on to propose the introduction of a *growth statement*, containing forward-looking information about the expected revenues and costs of the R&D projects the company pursues, to which IPR information is to be linked. In addition, I argue that companies ought to disclose more detailed information about their licensing deals, and especially the deal's financial aspects. This would make technology markets more efficient and simultaneously improve the ability of technology-driven companies to access capital markets. These suggestions are followed by some comments on the outlook for future research in this field.

NOTES

1. The present study focuses on patents and trademarks which are together referred to as IPR.
2. Insider gains refer to benefits for traders from having information that is unavailable in the public domain.
3. For example, Mansfield et al. (1977) show that only 27 per cent of R&D projects are financially successful.
4. Information that enables investors to determine the fundamental value of an investment is referred to as *value-relevant* information.