Designing Value: Design Protection and the Market Value of Firms

Anton Ekman
Uppsala University
Department of Business Studies
anton.ekman@outlook.com

Anton Huila
Uppsala University
Department of Business Studies
anton@huila.se

Fredrik Tell
Please fill out
Please fill out
fredrik.tell@fek.uu.se

David Emanuel Andersson
Uppsala University
Department of Business Studies
david.andersson@fek.uu.se

Abstract

We provide the first longitudinal study of the impact of design protection on the market value of firms by using data on both Swedish national and European design rights 2003-2013. We furthermore analyse design protection together with patents, research and development and trademarks. Using nonlinear least-squares estimation, we show that design protection is positively related to the market value of firms. The effect is similar in size to patents and research and development. The use of design protection is concentrated to manufacturing industries, but is not as linearly related to firm size as patents. The results of the study show that in general, financial markets tend to reward companies who invest in design protection.
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Abstract

We provide the first longitudinal study of the impact of design protection on the market value of firms by using data on both Swedish national and European design rights 2003-2013. We furthermore analyse design protection together with patents, research and development and trademarks. Using nonlinear least-squares estimation, we show that design protection is positively related to the market value of firms. The effect is similar in size to patents and research and development. The use of design protection is concentrated to manufacturing industries, but is not as linearly related to firm size as patents. The results of the study show that in general, financial markets tend to reward companies who invest in design protection.

JEL Codes: O34, L25, O32
Keywords: intellectual property, market value, Tobin’s q, R&D, patents, trademarks, designs

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1 Introduction

In May 2018, a California jury ordered Samsung to pay Apple $533.3 million in damages for infringing on several of Apple’s design patents regarding the original iPhone and the iPad.\textsuperscript{1} These lawsuits also included Apple’s registered community design (RCD) in the EU related to the iPad. The ruling had its origins in an infringement case dating back to 2011 when Apple litigated Samsung in several countries for infringing on several design patents and utility patents. After the ruling Apple’s official statement said that they “believe deeply in the value of design”.\textsuperscript{2} Conversely, in March 2018, the European General Court upheld the decision by the European Intellectual Property Office (EUIPO) to revoke Crocs Inc’s RCD No. 257001-0001. The design protected their well-known footwear which had generated more than $1 billion in yearly sales since its launch in 2002.\textsuperscript{3} Crocs Inc similarly lost a major infringement litigation in the Delhi High Court against seven Indian footwear manufacturers over its Indian design registration (Ghosh & Khan, 2018). The increased use of design protection is also visible in the large increase of RCD application to the EUIPO. Figure 1 reveals that between 2003 and 2016, designs filed with the European Intellectual Property Office (EUIPO) has grown with 160% to 105,597 from 2003 to 2016. 15 years after the establishment of the community design regulation, approximately 1.1 million designs have been filed.

Filings for design rights are thus catching up to those of other intellectual property rights such as patents and trademarks. The examples provided above also illuminate that firms put a high value on their design rights and are prepared to aggressively enforce them. At the same time, empirical research relating design rights to firm performance and firm value is scarce, to say the least. According to Filitz et al. (2015) there existed no systematic research on design protection prior to 2011. Along the same lines, Holgersson & van Santen (2018) have showed that design research is virtually non-existent in the IP management literature. Rare exception are to be found in studies of Australian design rights. For instance, Bosworth & Rogers (2001) included design protection in their study of intellectual property and the market value of Australian firms in the mid-90s. Moreover, Griffiths et al. (2011) have investigated the related issue of profits and designs but found little to no evidence for a positive connection between them. As RCD applications are increasing, longitudinal data

\textsuperscript{1}In total Samsung had to pay $538.6 million where $5.3 million was for infringing on Apples utility patents. USA Today, at https://eu.usatoday.com/story/tech/2018/05/24/samsung-must-pay-apple-539-million-copying-iphone-patents/623908002/ (last accessed: 19 February 2019)

\textsuperscript{2}See footnote 1.

on design rights is becoming more readily available, but these data remain under-utilized as a complement to patent data in innovation studies (Filitz et al., 2015).

![Graph showing applications filed at EPO and EUIPO. Sources: EPO and EUIPO.]

**Figure 1:**
**PATENT, TRADEMARK AND DESIGN APPLICATIONS, 2003-2016**

*Notes:* The graph shows applications filed at EPO and EUIPO. Sources: EPO and EUIPO.

Design rights are a type of intangible assets. While the importance of intangible assets is reflected in its contribution to productivity growth on an aggregate level (Adams, 1990; Griliches, 1958; Romer, 1990), the concern of this paper is mainly restricted to firm-level value. Firms can be conceived as bundles of tangible and intangible assets and resources that creates market value (Penrose & Penrose, 2009; Barney, 1991). Such value creation is reflected in firm performance and expectations of future profits reflected in stock prices (Griliches, 1981; Hall, 1999; Nesta & Saviotti, 2006). Intellectual property rights constitute a particularly important category of assets. First, intellectual property rights are formal devices for deriving value appropriation from value creation since it contains protection from imitation (Teece, 1986; Arundel, 2001). Second, in contrast to many other intangible assets, intellectual property rights also provide explicit accounts of corporate knowledge assets that may reflect a firm’s innovative capability for creating future profitable products and services (Montgomery & Wernerfelt, 1988; Andrews & Criscuolo, 2013).

This being said, there are different types of intellectual property rights. For instance, the World Intellectual Property Organization (WIPO) refers to three main types of industrial
intellectual property rights: trademarks, patents and designs. A trademark is a registered
distinctive sign that identifies certain goods or services produced or provided by an individual
or a company, while a patent is an exclusive right granted for a technical invention. In
comparison, an industrial design refers to the ornamental or aesthetic aspects of an article.
A design may consist of three-dimensional features, such as the shape or surface of an article,
or two-dimensional features, such as patterns, lines or color (WIPO, 2003).

Previous literature suggests that industrial designs capture important aspects of innovation
different and potentially to those of patents (Walsh, 1996; Gil & Tether, 2011; Hernández
et al., 2018). Given the scarcity of systematic empirical research, little is however known
about how this particular type of intellectual property right influence firm value. It is there-
fore the purpose of this paper to investigate the effect of national and European design
protection on the market value of firms. We also evaluate design protection in conjunc-
tion with R&D, patents and trademarks. To do this we employ the market value approach
(Griliches, 1981; Hall et al., 2005, 2007; Sandner & Block, 2011) to answer our question.
We develop the market value equation to include IP portfolios. We use data from Swedish
companies, whose accounting data tend to be of good quality (Porta et al., 1998). The use
of design has furthermore been shown to vary across countries (Livesey & Moultrie, 2008).

We use both national and European property rights. We collect designs, patents and
trademarks publicly available from The Swedish Patent and Registration Office (PRV), EPO
and the EUIPO. Our results indicate that in general, the financial markets tend to reward
companies who invest in design protection. Furthermore, patents, R&D, and trademarks
also indicate a positive relationship with a firm’s market value. The use of design protection
is concentrated in manufacturing industries however the relationship between investments in
design protection and firm size is not as linear as compared with patents.

The rest of the paper is organized as follows. In Section 2, we introduce the legal back-
ground of design protection as intellectual property. Section 3 elaborates on the theoretical
basis of the market value approach, including our adaption of the theoretical framework. In
Section 4, we introduce our dataset, methodological considerations and explain critical vari-
ables in depth. In Section 5, we present the results from our estimations of the contribution
of design protection to firm value. Section 6 concludes.

2 Design protection

Designs differ in function and form from both patents and trademarks. Whereas patents
focus on function, designs focus on form. Designs offer firms the possibility for a company to

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4Copyrights are also included in IPR, but WIPO does not classify copyrights as industrial IPR).
protect investments in product design and style attributes to gain a competitive advantage through differentiation (Bosworth & Rogers, 2001; Filitz et al., 2015). Furthermore, in contrast to trademarks, designs are more straightforwardly related to innovation since there is a novelty and individual character requirement for a design to be granted and registered (see Figure 2). Design protection has a vital role in promoting design innovations and secondary innovations through competing designs, product differentiation, and in price competition through the efficient use of raw material and design in manufacturing (Filitz et al., 2015; Rothwell, 1992; Walsh, 1996). Livesey & Moultrie (2008) state that innovative firms use design more extensively compared to less innovative firms. Further, there is a need to consider innovation and design, and not only technological innovation. For this reason, scholars have proposed using registered designs as a proxy for measuring innovation. If the firm registers a design, it suggests that the firm consider itself to have created something new and that it puts a value on it (Rogers, 1998). Design is a central way for companies to add value to its customers and strengthen competitiveness (Livesey & Moultrie, 2008) as well a way to use products to interact with its customers (Verganti, 2003). Most previous research has focused on patents on an isolated level or in combination with R&D (Blundell et al., 1999; Griliches, 1981; Hall et al., 2007). Some studies have investigated either trademarks or designs, but they do either not include design protection or there are few observations (Bosworth & Rogers, 2001; Greenhalgh & Rogers, 2006, 2007; Sandner & Block, 2011). This constrains the generalizability of conclusions across IP classes (Candelin-Palmqvist et al., 2012).

![Figure 2: IPRs and Innovation](image-url)

On a European level, the area of design protection has transformed in two different stages (Filitz et al., 2015). First, the European Council passed an EU directive in 1998 requiring all EU members to have a formal process for registration of designs enabling harmonized national protection. This directive established a definition of designs as "the appearance of the whole or a part of a product resulting from the features of, in particular, the lines, contours, colors,
shape, texture and/or materials of the product itself and/or its ornamentation” (European Council, 1998). A design needs to be new and distinguishable from other existing designs to be eligible for protection. The upper limit for protection is 25 years, and a renewal fee is paid every five years. The second step in harmonizing designs in EU was made through the community design regulation in 2002 (European Council, 2001). Two types of designs arose within EU, as a result of the regulation. One type of design is the registered community design (RCD) which is the European equal to the earlier national designs defined in the design directive mentioned above. The second type of design right is unregistered community design (UCD) which provides automatic protection in EU three years from disclosure. In line with The Hague System, owners of designs can also register its designs at World Intellectual Property Organization (WIPO). An application through WIPO enables a simplified process since the owner only needs to apply to WIPO to receive protection in many countries, including EU wide protection. See Table 1 for an overview of different IP rights.

Swedish design protection has its origins in the law regarding the ‘protection of certain patterns and models’, which was enacted on July 10, 1899. From the beginning design protection was only granted for five years from the filing date of the application. Currently, design protection is regulated by the design protection law from 1970 and design protection is granted for one or more five-year periods up to a maximum of 25 years. The applicant can choose to apply for several time periods at ones or renew the design protection every five years. National Swedish design protection is administered by the Patent and Registration Office (PRV).

3 Design protection and market value

Accounting data is commonly used to estimate the economic value of IP and the return of innovation-generating activities (Lindenberg & Ross, 1981; Montgomery & Wernerfelt, 1988). Tobin’s Q is one of the most popular methods. Lindenberg & Ross (1981) developed the first method using accounting values based on Tobin’s (1969) formulation of the variable q; the ratio of market value to replacement cost. The market value of a firm includes both physical and intangible assets from this perspective. Investors in the financial markets evaluate future returns from various companies. These expectations form the base for the valuation reflected in the stock price. Assuming that markets are efficient, the stock price is equal to all future cash flows to be generated by the company (Fama, 1970). Therefore can the market value be

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5 Lag om skydd för vissa mönster och modeller, Swedish Code of Statutes (SFS) 1899:59.
6 Mönsterskyddslagen, Swedish Code of Statutes (SFS) 1970:485. Protection for components (a spare part) is limited to 15 years.
Table 1: Overview of intellectual property rights

<table>
<thead>
<tr>
<th>Intellectual Property Right</th>
<th>Type</th>
<th>Jurisdiction</th>
<th>Time</th>
<th>Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Design</td>
<td>Design</td>
<td>National</td>
<td>25 years</td>
<td>National</td>
</tr>
<tr>
<td>Registered Community Design (RCD)</td>
<td>Design</td>
<td>EU</td>
<td>25 years</td>
<td>EUIPO</td>
</tr>
<tr>
<td>Unregistered Community Design (UCD)</td>
<td>Design</td>
<td>EU</td>
<td>3 years</td>
<td>EUIPO</td>
</tr>
<tr>
<td>Industrial Design (Hague system)</td>
<td>Design</td>
<td>Global</td>
<td>25 years</td>
<td>WIPO</td>
</tr>
<tr>
<td>National Patent</td>
<td>Patent</td>
<td>National</td>
<td>20 years</td>
<td>National</td>
</tr>
<tr>
<td>European Patent(^a)</td>
<td>Patent</td>
<td>EU</td>
<td>20 years</td>
<td>EPO</td>
</tr>
<tr>
<td>Patent (PCT)(^a)</td>
<td>Patent</td>
<td>Global</td>
<td>20 years</td>
<td>WIPO</td>
</tr>
<tr>
<td>National Trademark</td>
<td>Trademark</td>
<td>National</td>
<td>No limit</td>
<td>National</td>
</tr>
<tr>
<td>Community Trademark (CTM)</td>
<td>Trademark</td>
<td>EU</td>
<td>No limit</td>
<td>EUIPO</td>
</tr>
<tr>
<td>International Trademark (Madrid system)(^a)</td>
<td>Trademark</td>
<td>Global</td>
<td>No limit</td>
<td>WIPO</td>
</tr>
</tbody>
</table>

Notes: \(^a\): Refers to national patents or trademarks applied for through a common application administered by EPO or WIPO.

seen as a lead indicator of future company performance (Hall, 1999). Hall et al. (2007) state that the market value approach assumes that a company is a composition of assets. The market value approach assumes that the company value is a function of its component assets and determined in financial markets. This includes all assets, physical as well as intangible of all sorts. Griliches (1981) put forth that assets are added up in a typical linear market value equation, Eq. (1).

\[
V_{it}(A_{it}, K_{it}) = q_{it}(A_{it}, \gamma K_{it})^\sigma \tag{1}
\]

With

\[
q_{it} = \exp(y_t + m_t + u_{it}) \tag{2}
\]

\(V_{it}\) represents the value of company \(i\) at time \(t\). \(A\) stands for tangible assets and \(K\) for knowledge assets. Knowledge assets can, for example, be R&D, patents, trademarks and designs. The value of the company is the sum of tangible and knowledge assets. \(\sigma\) captures returns to scale and \(\sigma = 1\) indicate returns proportionate to scale (Pemberton & Rau, 2015). \(\gamma\) is the marginal contribution value of one more unit spent on knowledge assets. \(\gamma\) is the shadow value of knowledge assets relative to tangible assets, when \(\sigma = 1\) (Hall & Oriani, 2006). Consequently, the product of \(q_{it}\) and \(\gamma\) reflect the absolute shadow value of investors’ expectations on knowledge assets. We fixate \(\gamma\) to prevent variations across time despite the loss of accuracy in line with other studies (Hall & Oriani, 2006; Sandner & Block, 2011). The shadow value is to be understood as the implicit market outcome of the interaction between companies and their investment activities and investors and their evaluations of
the former in financial markets. The shadow value is not to be understood as a structural parameter (Hall, 1999; Hall & Oriani, 2006). \( q_{it} \) is the valuation coefficient which captures factors affecting the valuation in a multiplicative way, Eq. 2 (Hirsch & Seaks, 1993). The multiplicative factors may include individual risk as well as market conditions (Griliches, 1981). The valuation coefficient, \( q_{it} \), comprises factors, representing valuation effects of time \( t \), industry \( l \) and individual disturbances \( u_{it} \). The general effects on valuation caused by these factors are represented by \( y_t \) and \( m_l \).

R&D investments can represent knowledge assets, \( K \) (Hall et al., 1993; Hall & Oriani, 2006). It is also possible to let patents represent knowledge assets (Blundell et al., 1999). A plentiful of studies have included patents and R&D (Cockburn & Griliches, 1988; Griliches et al., 1991; Hall et al., 2005; Hall & MacGarvie, 2010; Toivanen et al., 2002). Hall et al. (2005) found that simple patent counts have much less explanatory power than citation-weighted patent stocks, which accounts for a lot of the unequally distributed value of patents.

### 3.1 Adding Intellectual Property into the Market Value Equation

We continue by including design protection, patents and trademarks to the market value equation. There are two main ways of doing this. First, IP may be assumed to be commensurate with knowledge assets. We would then add a separate term for IP portfolios in the market value equation. Several other studies apply this method (Bosworth & Rogers, 2001; Greenhalgh & Rogers, 2007; Hall & Oriani, 2006; Sandner & Block, 2011). Second, IP portfolios can fit multiplicatively into the variable \( q_{it} \), assuming that they have an impact on market conditions. As such, a company’s risk profile, potential monopoly position and other market structures might be included in \( q_{it} \) (Griliches, 1981; Hirsch & Seaks, 1993). We let IP portfolios consist of patent assets, trademark asset, and design assets and we assume that these assets can be treated alongside knowledge assets. Consequently, we include IP portfolios as an additional additive term, \( I \), in Eq. (3). R&D is used to represent \( K \). Eq. (4) shows that \( I \) in its turn consists of design assets, \( D \); patent assets, \( P \) and trademark assets, \( TM \). We reformulate the market value equation to include IP portfolios.

\[
V_{it}(A_{it}, K_{it}, I_{it}) = q_{it}(A_{it}, \gamma_K K_{it}, \gamma_I I_{it})^\sigma
\]

where

\[
I_{it} = D_{it} + P_{it} + TM_{it}
\]

By treating the different asset types symmetrically, we assume that a company can choose to invest in any of these assets. \( \gamma_I \) represents the shadow value of one additional unit of
investment in IP portfolios to physical assets. By including logarithms to account for returns to scale, the estimating equation, see Eq. (5), becomes:

$$ln \left( \frac{V_{it}}{A_{it}} \right) = lnq_{it} + (\sigma - 1)lnA_{it} + \sigma ln \left( 1 + \gamma \frac{K_{it}}{A_{it}} + \gamma \frac{I_{it}}{A_{it}} \right)$$

(5)

4 Methodological Considerations and Data

4.1 Data

We use data from Swedish firms. Their accounting tends to be of good quality (Porta et al., 1998) and Sweden repeatedly ranks as one of the world’s most innovative countries, with high levels of R&D input, output, and efficiency (WIPO et al., 2017). The high innovativeness of Swedish firms makes them suitable subjects for studying the effects of design protection. In contrast to previous studies, we use both European and national Swedish IP data from five databases. For Swedish data on patent, trademarks and designs, the Swedish Patent Database, the Swedish Trademark Database and Swedish Design Database are used respectively to access the data through the Swedish Patent and Registration Office. We access European patent data through EPO’s PATSTAT Online Autumn 2017 edition. The EUIPO’s Open Dataset is used to collect EU-wide trademark and design data. For firm characteristics and financial accounting data, we use Thomson Reuters’s Eikon database. We gather time-series data on inflation rates (CPI) from the Statistics Sweden (SCB).^7

Since the market value equation needs input in the form of market value to function, only publicly traded companies are considered. The Thomson Reuters’s Eikon is used to identify firms listed on the NASDAQ Stockholm Exchange lists Largecap, Midcap, and Smallcap, considering the scope of Swedish firms for this study. The aim is to represent all companies listed on the NASDAQ Stockholm Exchange, thus we impose no restrictions on specific industries. Thomson Reuters Eikon provide financial and accounting data for the years 2003-2013. More specifically we collect data on revenue, enterprise value, cash and cash equivalents, total assets, total debt, R&D expenditures and standard industrial classification. A random sample check was also performed to validate the financial data from Eikon, which we confirmed by annual reports. We deflate SEK-values to real 2003 prices by using SCB’s yearly consumer price index.

The data extracted from PATSTAT and EUIPO databases extend to applications originating in 2017. Indeed, not all those applications have been processed and granted. As

^7We conducted five interviews with representatives of companies from our sample to validate our calculated stocks and get qualitative insight into their IP management, which could help explain the results of the regressions.
the number of applications still in process increases in more recent years, this results in a lower number of registered rights. Since the study is interested in granted applications, the data is truncated to include only those applications granted before the end of 2013. We set the end of our observation period to 201, to minimize the effect of eventual truncation bias due to the lag between submitted and granted applications. Data from the Swedish Patent and Registration Office and EUIPO suggest that 97% of submitted applications have been decided upon after four years, which leaves a negligible effect on the 2013 cohort. This approach has the strength of using actual patent stocks for the later years of the observation period instead of using assumptions to prevent truncation bias.

The Swedish data extracted reflect all available historically granted rights for the firms in our sample registered at the Swedish Patent and Registration Office. We start tracking patents in 1984 since 1984 is the earliest year in which a particular patent would still be valid in 2003, considering the start of our observation period. The Swedish trademark data begin in 1884. The Swedish design data with juridical persons as applicants begin in 1993 in our dataset. Following the same rationale as for Swedish data, we collect the international data on patents from PATSTAT Online from 1984 to 2016 based on the filing date. The Open Dataset provided by EUIPO contains European trademark from 1996 and onwards. No CTMs could be filed before 1996 since EUIPO commenced its operations in 1996. The European design data begin in 2003. The community design regulation came about in 2002 introducing EU-wide design rights. Thus, no European data before 2003 exist. Together, this enable us to build accurate asset stocks for the companies in our sample.

4.2 Variables

We choose to calculate all assets as stock variables instead of flow variables, that is, the stock variable captures all annual inflows into the stock up to a specific point in time \( t \), whereas a flow variable captures the annual inflow in year \( t \). For instance, if a company’s design stock in \( t - 1 \) is 50 and it files for 5 more designs in year \( t \), the stock in year \( t \) would be 55. You may account for obsolescence by letting the stock of \( t - 1 \) depreciate (Hall, 2007). A company is valued by the discounted future cash flows it will generate with its assets (Fama, 1970). Experience from past investments in, for instance, R&D is assumed to underlie current knowledge used in product development. Even though such investments depreciate over time, they influence investors’ estimation of future company performance and valuation. Our approach is in line with the work of Sandner & Block (2011), who used stock variables to account for R&D, patents and trademarks. Observations which lack patents, trademarks, designs or R&D are coded as zero and accounted for by a corresponding dummy
variable.

4.2.1 Tobin’s q

We use the natural logarithm of Tobin’s q as the dependent variable, see Eq. (6). We define it as the ratio of a company’s market value, \( V \), to the book value of its total assets, \( A \) (Greenhalgh & Rogers, 2006; Hall & Oriani, 2006; Sandner & Block, 2011).

\[
\ln q_t = \ln \frac{V_t}{A_t}
\] (6)

The market value of a company is the aggregated market value of equity and the market value of debt. We proxy the market value of equity with its market capitalization plus preferred stock and minority interests. The market capitalization is defined by the number of outstanding shares times share price. We proxy the market value of debt with the book value of total debt. Total debt is equal to short-term debt plus long-term debt (Blundell et al., 1999, 1992; Hall & Oriani, 2006). The book value of total assets is total assets on the balance sheet. Researchers in corporate finance have developed advanced estimates of Tobin’s q (Perfect & Wiles, 1994), but it is always a trade-off between precision and sample size (DaDalt et al., 2003).

4.2.2 Knowledge assets

Knowledge assets are not observable through the balance sheet. We choose to operationalize it with R&D and IP. R&D expenses are usually not capitalized on the balance sheet due to the uncertain value of many R&D investments (Ross, 1983). They are usually expensed immediately. However, we choose to capitalize R&D expenses for the sake of estimating knowledge assets. We use historical R&D expenditures to calculate stocks with the widely used declining-balance formula, see Eq. (7) (Hall, 2007; Hall et al., 2005). We use a fixed depreciation rate, \( \delta \), to account for obsolescence. \( \delta \) is set to 15% in line with earlier research (Hall, 2007).

\[
RD_t^{stock} = RD_t^{flow} + (1 - \delta)RD_{t-1}^{stock}
\] (7)

The financial data in our dataset only goes back to 2002. We assume that R&D stocks grew at a constant annual growth rate, \( g \), of 8% to compute the initial R&D stocks (Hall et al., 2007; Hall & Oriani, 2006), for the first observed year, see Eq. (8).

\[
RD_0^{stock} = \frac{1}{\delta + g}RD_0^{flow}
\] (8)
Disclosure of R&D expenses is loosely regulated by law (Hall et al., 2007). It makes the decision to disclose more arbitrary. Some companies may consider such information as internal and not disclose it (Toivanen et al., 2002). This might cause a sample selection bias (Belcher et al., 1996). The calculation of R&D stocks requires uninterrupted historical data of R&D expenditures. We assign an R&D dummy variable to companies, which lack R&D expenditures or have partial R&D histories. Missing values are coded zero in line with earlier research (Hall, 2007; Sandner & Block, 2011).

### 4.2.3 Design protection

We use the declining balance formula to calculate design stock, \( D \), as well, see Eq. (13). We use the registration date of the design application to define the yearly flows. We let design stocks depreciate, since designs have a limited life span of a maximum of 25 years. A design can also be related to technical inventions, which become obsolete. There is no other research with depreciating design stocks, therefore there is no consensus as to what an appropriate depreciation rate is. Since designs are in some way related to R&D with a connection to technological innovation (Filiz et al., 2015), we choose to use the same depreciation rate, \( \delta \).

\[
D_{t}^{stock} = D_{t}^{flow} + (1 - \delta)D_{t-1}^{stock}
\] (9)

We do not calculate any initial stocks since the Swedish design data goes back to 1979 and the European designs did not exist before 2003 when our data on European designs start.

### 4.2.4 Patents

We use the same methodology as with R&D stocks to arrive at patent family stocks, see Eq. (9)

\[
F_{t}^{stock} = F_{t}^{flow} + (1 - \delta)F_{t-1}^{stock}
\] (10)

We choose to calculate patent family stocks because patent family stocks represent the underlying inventions, which are protected by patents. We apply a 15% yearly depreciation rate, \( \delta \), to write down the patent family stock (Hall, 2007; Sandner & Block, 2011). The firm-specific yearly flow of patents is determined based on the priority application and filing year in each simple patent family. We did not compute initial stocks since the time interval started in 2003 and data was collected from PATSTAT starting in the year 1984. The pure stock of patents has limited explanatory power since the value of patents is not normally
distributed (Harhoff et al., 1999, 2003). To ensure that quality is captured among patents, quality measures such as citations, family size and oppositions can be employed. Following prior research we also calculated citations (Bloom & Van Reenen, 2002; Hall, 2007; Hall et al., 2005; Sandner & Block, 2011). 

Citations are references made by following patent applications of the original patent application after the publication of the latter. A citation indicates that the original invention has laid the groundwork, at least partially, for an antecedent invention, which indicates a higher technological value of the cited patent (Hall et al., 2005). We calculate family-to-family citations of simple families, which is the closest form of one invention citing another invention. In this study, we consider citations in a time window of three years after publication. Following earlier research, this captures the bulk of the patent citations during its entire lifetime (Marco, 2007; Mehta et al., 2010; Sandner & Block, 2011). Also, by applying a constant time limit of three years, we limit the risk of truncation issues regarding the year of application. To introduce a quality measure to the firm-specific patent stock, we weigh each patent inflow to its citations. The citation stock follows the following formula:

\[ C_{t}^{\text{stock}} = C_{t}^{\text{flow}} + (1 - \delta)C_{t-1}^{\text{stock}} \] 

(11)

4.2.5 Trademarks

To compute the trademark stock, we apply the same methodology as with R&D stocks and patent stocks. We calculate the flow of trademarks in any specific year with the registration date of the trademark. The trademark data from EUIPO lacked registration dates. Instead, filing dates of registered trademarks were used. Since about 90% of trademarks are published within 11 weeks from filing (Office, 2011), it does not affect the stocks much. We do not depreciate the trademark stock, despite the similar method in computing the trademark stock compared to R&D asset stock. R&D assets are likely to lose value as time passes, due to obsolescence following technological development. Also, patents have a restricted lifetime and for this reason, a depreciation rate is introduced when determining the value of knowledge assets and patent stocks (Hall, 2007). This is different from trademarks which we argue can become more valuable as time progress. Trademarks are not restricted to a maximum time limit in which it can be exploited, that is, the grant period is infinite, if renewal fees are paid continuously, most often every ten years. Therefore, as time passes firms can employ their portfolios of trademarks and generate value from it as time goes on. For this reason, we do not apply any depreciation rate. In this study, a trademark is considered dead once the renewal fee is not paid or if the registration office cancel the trademark, because of a successful termination request by a competing firm. The first case
is handled by including an estimated renewal rate, \( r \). The average renewal rate of CTMs originating in 1996-2007 was about 45% (Office, 2018). We set \( r \) to 45%. The second case does not have a substantial impact in practice considering statistics from EUIPO during the time frame of 2003 to 2013 only 8305 applications were recorded as cancellation cases compared to 896 169 trademark applications during the same time frame (Office, 2018). The formula below illustrates the estimation of the trademark stock:

\[
TM_{t,stock} = TM_{t,flow} - (1 - r)TM_{t-10}^{flow} + TM_{t-1}^{stock}
\]  

We do not compute initial stocks for trademarks, but for the sake of simplicity trademark applications filed before 1983 are bundled together. 5% of the trademark applications are affected. We assume that trademarks are held in infinity after the first renewal. However, this simplifying assumption does only affect 8.6% of the trademark applications. So together the simplifications have a negligible effect on the stocks. The data provide a full history of the Swedish trademarks. European trademark data from EUIPO are available from 1996. However, the reason for this is because EUIPO commenced its operations in 1996, that is, no CTMs were available before 1996. Also, a substantial amount of applications in 1996 refers to international trademarks since firms sought to gain EU protection of already existent trademarks (Sandner & Block, 2011).

4.2.6 Control variables

Following prior studies, we control the market valuation for time and industry effects by including year and industry dummies (Blundell et al., 1999; Griliches, 1981; Hall et al., 2007; Sandner & Block, 2011). We use SIC codes as the basis of our industry classification. We sorted all firms in the sample into their respective main division, resulting in 8 groups, for example, ‘manufacturing’, ‘construction’ and ‘services’. Since 73% of the firms belonged to the ‘manufacturing’ division and to allow for more variability among industries, we broke up the manufacturing division into more granulated industry groups using the first two numbers of the SIC codes. Thus, we ended up with 12 industry classes in total with the largest class representing 14.6% of the firms. See Section 5.1 for more details on industry characteristics.

4.3 Econometric model

In the next step, we include the variables into the equation by pairing them with their appropriate bases to measure their respective intensities, see Eq. (14). R&D stock, \( RD \), is paired against total assets, \( A \); patent family stock, \( F \), to R&D stock, \( RD \); citation stock, \( C \),
to patent family stock, $F$; trademark stock, $M$, to total assets, $A$; and design stock, $D$, to total assets, $A$.

$$\ln \frac{V_{it}}{A_{it}} = \ln q_{it} + (\sigma - 1) \ln A_{it} + \sigma \ln \left( 1 + \gamma_1 \frac{RD_{it}}{A_{it}} + \gamma_2 \frac{D_{it}}{A_{it}} + \gamma_3 \frac{TM_{it}}{A_{it}} + \gamma_4 \frac{F_{it}}{RD_{it}} + \gamma_5 \frac{C_{it}}{F_{it}} \right)$$

(13)

The dataset used in this paper holds the format of unbalanced panel data. We do not hold unidentified firm-level components constant (Hall, 2007; Sandner & Block, 2011). Firstly, with the help of a pooled regression model, we intend to study the market value of IP portfolios throughout a broad range of firms and industries, which limits the impact of unidentified firm level components for our purpose. Secondly, tangible assets, knowledge assets and IP portfolios are altering slowly year on year. If we apply fixed firm-level effects, a relatively low degree of variance in the data would be observed. Significant deltas in the asset base within specific firms would need a rigid time interval, which we do not consider in this paper.

To estimate Tobin’s $q$, we apply a non-linear least square (NLLS) regression (Hall et al., 2007; Rahko, 2014; Sandner & Block, 2011). Prior studies using ordinary least squares (OLS) have used $X$ as an approximation for $\ln(1 + X)$. However, this estimation is not precise when $X$ increases in size. Proposed by Hall et al. (2007), this method of approximating $X$ leads to imprecision once knowledge assets to physical assets increase. They propose using the NLLS technique to allow accurate estimations of non-linear functions, where the market value equation is such a function. Because of non-linearity, interpretation of coefficients is not straightforward. Also, the independent variables involve different units (SEK, trademarks, designs, patents etc.). Considering non-linearity and to enable easier comparison and interpretation of the coefficients, we apply elasticities for each main independent variable relating to Tobin’s $q$.

### 4.4 Descriptive statistics

For the years 1984 to 2013 we consolidate trademarks, design, and patents on the firm level to construct IP portfolios. Since we are primarily interested in accessing market values of IP portfolios, or lack thereof, we do not exclude observations that lack values or where the value was zero for trademarks, designs or patents respectively. We gather financial data from all publicly listed firms on NASDAQ Stockholm large, mid and small cap lists between 2003 and 2013. We account for firms on a month-by-month basis to not loose firms not observed by
the end of each financial year. This initial step yield 3070 observations attributable to 400 firms. A total of 33 110 patent families, trademarks, and designs were matched.\(^8\) We adjust for missing values on the components of our dependent variable Tobin’s q and observations without any knowledge assets or IP at all, that is no R&D, patents, trademarks or designs. This result in 2059 observations and 269 firms. We adjust the dataset for extreme outliers.\(^9\) 104 observations were affected. This cut the dataset to 1945 observations and 268 firms. Since this study’s main focus is on the value of design rights, we finally excluded all firms without design applications. The final dataset consists of 487 observations for 73 firms.

5 The Effect of Design protection on Firm Value

Firms from a vast range of industries are present in our sample since we do not limit our selection criteria to particular industries. As shown in Table 3, the sample is representative for Swedish firms in general. ‘Machinery, ‘Other manufacturing’ and ‘Instrument’ are the largest industries presented in the sample.

\(^8\)We matched the patent data against the financial data by querying the 16 synonyms in the financial data with four available synonyms in PATSTAT. This step yielded 94,207 matched records. These belonged to 20,592 patent families and 148 firms. We extracted citation data separately from PATSTAT by matching patent family id with citation id. We filtered the records on individual family-to-family citations. This resulted in 29,005 unique family-to-family citations attributable to 122 firms in our sample. We extracted 126,743 records of trademark applications with company owners from the Swedish Trademark Database. The EUIPO Open Dataset yielded 1,478,599 trademark application records from 1996 to 2013. We checked for duplicates and matched 5909 trademark applications to 270 firms in our sample. The earliest matched trademarks originated in 1885 and belonged to Holmen AB and Swedish Match AB. The design data extract from Swedish Design Database amounts to 5592 records. We extracted 1,105,811 records on design applications from EUIPO’s Open Dataset. We matched the records against the financial dataset, which yielded a total of 1890 records representing 6609 designs. 94 firms in the sample matched with the records.

\(^9\)Observations in the 1st and 99th percentile of Tobin’s q, R&D Stock/Total Assets, Patent Stock/Total Assets, Trademark Stock/Total Assets; and Design Stock/Total Assets were removed.
<table>
<thead>
<tr>
<th></th>
<th>mean</th>
<th>sd</th>
<th>min</th>
<th>median</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobinsq</td>
<td>1.736</td>
<td>1.536</td>
<td>.304</td>
<td>1.275</td>
<td>10.05</td>
</tr>
<tr>
<td>Market Value (billion SEK)</td>
<td>61.76</td>
<td>1433.</td>
<td>.089</td>
<td>13.76</td>
<td>1042.3</td>
</tr>
<tr>
<td>Total Assets (billion SEK)</td>
<td>77.89</td>
<td>298.6</td>
<td>.062</td>
<td>10.40</td>
<td>2319.9</td>
</tr>
<tr>
<td>TotalDebt (billion SEK)</td>
<td>26.33</td>
<td>116.7</td>
<td>0</td>
<td>1.854</td>
<td>933.8</td>
</tr>
<tr>
<td>Revenue (billion SEK)</td>
<td>32.99</td>
<td>50.30</td>
<td>.009</td>
<td>10.60</td>
<td>280.9</td>
</tr>
<tr>
<td>R&amp;D Stock (billion SEK)</td>
<td>5.450</td>
<td>17.00</td>
<td>.013</td>
<td>1.161</td>
<td>151.3</td>
</tr>
<tr>
<td>R&amp;D/Total Assets</td>
<td>.207</td>
<td>.309</td>
<td>.003</td>
<td>.094</td>
<td>2.678</td>
</tr>
<tr>
<td>Patent stock</td>
<td>83.51</td>
<td>125.3</td>
<td>.039</td>
<td>9.109</td>
<td>542.6</td>
</tr>
<tr>
<td>Patent stock/Total Assets</td>
<td>5.922</td>
<td>15.11</td>
<td>.018</td>
<td>1.834</td>
<td>142.0</td>
</tr>
<tr>
<td>Patent stock/R&amp;D stock</td>
<td>35.81</td>
<td>75.79</td>
<td>.781</td>
<td>19.28</td>
<td>841.5</td>
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<td>Citation stock</td>
<td>132.3</td>
<td>355.9</td>
<td>0</td>
<td>9.281</td>
<td>2698.2</td>
</tr>
<tr>
<td>Citation stock/Patent stock</td>
<td>1.138</td>
<td>1537</td>
<td>0</td>
<td>7221</td>
<td>9.101</td>
</tr>
<tr>
<td>Trademark stock</td>
<td>37.29</td>
<td>54.50</td>
<td>.45</td>
<td>11.6</td>
<td>242.5</td>
</tr>
<tr>
<td>Trademark stock/Total Assets</td>
<td>6.303</td>
<td>13.21</td>
<td>.009</td>
<td>1.805</td>
<td>89.22</td>
</tr>
<tr>
<td>Design stock</td>
<td>10.07</td>
<td>19.31</td>
<td>.063</td>
<td>1.991</td>
<td>109.1</td>
</tr>
<tr>
<td>Design stock/Total Assets</td>
<td>1.493</td>
<td>2.858</td>
<td>.001</td>
<td>.473</td>
<td>18.09</td>
</tr>
<tr>
<td>No R&amp;D dummy</td>
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<td>.442</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No Patent dummy</td>
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<td>.355</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No Trademark dummy</td>
<td>.088</td>
<td>.284</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: n=487 observations and n=73 firms. a: Prices were deflated to the real year 2003 prices using CPI data from Statistics Sweden. b: We excluded observations with no reported R&D, patents or trademarks. R&D data were available for 357 observations. Patent data were available for 415 observations. Trademark data were available for 444 observations.
<table>
<thead>
<tr>
<th></th>
<th>Observations</th>
<th>Observations (%)</th>
<th>Total assets$^a$</th>
<th>Tobin’s Q</th>
<th>Patent stock</th>
<th>Design stock</th>
<th>Trademark stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining &amp; Construction</td>
<td>22</td>
<td>4.52</td>
<td>48.12</td>
<td>0.66</td>
<td>3.23</td>
<td>0.73</td>
<td>16.75</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>63</td>
<td>12.9</td>
<td>11.92</td>
<td>1.74</td>
<td>57.30</td>
<td>6.13</td>
<td>68.62</td>
</tr>
<tr>
<td>Paper</td>
<td>39</td>
<td>8.0</td>
<td>81.32</td>
<td>0.79</td>
<td>83.96</td>
<td>17.17</td>
<td>15.16</td>
</tr>
<tr>
<td>Other metal</td>
<td>56</td>
<td>11.5</td>
<td>8.26</td>
<td>1.41</td>
<td>23.57</td>
<td>2.58</td>
<td>14.31</td>
</tr>
<tr>
<td>Machinery</td>
<td>71</td>
<td>14.6</td>
<td>31.92</td>
<td>1.70</td>
<td>126.73</td>
<td>14.25</td>
<td>30.02</td>
</tr>
<tr>
<td>Electronics</td>
<td>36</td>
<td>7.4</td>
<td>22.39</td>
<td>2.31</td>
<td>58.33</td>
<td>17.98</td>
<td>70.62</td>
</tr>
<tr>
<td>Instruments</td>
<td>57</td>
<td>11.7</td>
<td>10.09</td>
<td>2.93</td>
<td>10.30</td>
<td>1.61</td>
<td>7.38</td>
</tr>
<tr>
<td>Public utilities</td>
<td>9</td>
<td>1.8</td>
<td>229.66</td>
<td>1.13</td>
<td>225.81</td>
<td>47.86</td>
<td>109.07</td>
</tr>
<tr>
<td>Trade</td>
<td>27</td>
<td>5.5</td>
<td>17.36</td>
<td>3.57</td>
<td>0</td>
<td>1.01</td>
<td>26.67</td>
</tr>
<tr>
<td>Finance</td>
<td>11</td>
<td>2.3</td>
<td>1982.06</td>
<td>0.44</td>
<td>245.80</td>
<td>35.66</td>
<td>36.65</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>41</td>
<td>8.4</td>
<td>94.40</td>
<td>0.97</td>
<td>207.92</td>
<td>12.64</td>
<td>33.91</td>
</tr>
<tr>
<td>Services</td>
<td>55</td>
<td>11.3</td>
<td>11.52</td>
<td>1.62</td>
<td>26.13</td>
<td>10.40</td>
<td>34.25</td>
</tr>
</tbody>
</table>

Notes: n = 487 from n = XXX firms. a: Billion SEK real 2003 prices.
Certain variables do fluctuate across industries. Tobin’s q vary considerably across industries ranging from 0.44 to 3.57. Considering the extremes, ‘trade’ corresponded to the maximum value of 3.57 and ‘finance’ to the minimum value of 0.44. 8 out of 12 industries (66.7%) do on average have a Tobin’s q above 1.0. The average patent stock and design stock in general show a larger variation across industries compared to the average trademark stock. No firms in the ‘trade’ category have any patents. The average trademark stock shows the lowest variance across industries among the IP stocks. Designs are present to a smaller extent in all industries, the lowest value is in ‘mining & construction’.
<table>
<thead>
<tr>
<th>Decile</th>
<th>Observations</th>
<th>Observations (%)</th>
<th>Total assets$^a$</th>
<th>Tobin’s Q</th>
<th>Patent stock</th>
<th>P*yStock</th>
<th>Trademark stock</th>
<th>Design stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>49</td>
<td>10.06</td>
<td>.26</td>
<td>2.50</td>
<td>2.57</td>
<td>20.21</td>
<td>4.21</td>
<td>1.76</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td>10.06</td>
<td>.58</td>
<td>2.29</td>
<td>6.70</td>
<td>51.67</td>
<td>8.68</td>
<td>1.53</td>
</tr>
<tr>
<td>3</td>
<td>49</td>
<td>10.06</td>
<td>1.24</td>
<td>2.36</td>
<td>8.00</td>
<td>51.20</td>
<td>11.11</td>
<td>2.82</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td>9.86</td>
<td>2.48</td>
<td>1.40</td>
<td>4.95</td>
<td>26.99</td>
<td>12.41</td>
<td>1.68</td>
</tr>
<tr>
<td>5</td>
<td>49</td>
<td>10.06</td>
<td>5.67</td>
<td>1.39</td>
<td>12.00</td>
<td>73.90</td>
<td>13.80</td>
<td>2.20</td>
</tr>
<tr>
<td>6</td>
<td>49</td>
<td>10.06</td>
<td>19.44</td>
<td>1.86</td>
<td>76.38</td>
<td>1125.96</td>
<td>49.99</td>
<td>12.16</td>
</tr>
<tr>
<td>7</td>
<td>48</td>
<td>9.86</td>
<td>29.95</td>
<td>1.12</td>
<td>79.45</td>
<td>989.61</td>
<td>58.13</td>
<td>7.21</td>
</tr>
<tr>
<td>8</td>
<td>49</td>
<td>10.06</td>
<td>43.03</td>
<td>2.37</td>
<td>100.27</td>
<td>647.31</td>
<td>51.28</td>
<td>12.57</td>
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<tr>
<td>9</td>
<td>49</td>
<td>10.06</td>
<td>76.27</td>
<td>1.18</td>
<td>182.94</td>
<td>1147.19</td>
<td>75.31</td>
<td>19.69</td>
</tr>
<tr>
<td>10</td>
<td>48</td>
<td>9.86</td>
<td>608.26</td>
<td>.80</td>
<td>240.61</td>
<td>1669.14</td>
<td>55.52</td>
<td>39.46</td>
</tr>
<tr>
<td>Total</td>
<td>487</td>
<td>100</td>
<td>77.89</td>
<td>1.73</td>
<td>71.16</td>
<td>578.38</td>
<td>33.99</td>
<td>10.07</td>
</tr>
</tbody>
</table>

Notes: n = 487 from n = XXX firms. a: Billion SEK real 2003 prices.
Table 4 illustrates the sample by firm size, which we proxy by total assets. We split the sample into ten equally large tranches based on the amount of total assets. We observe a Pareto distribution where large firms have disproportionately large total assets to the mean. Smaller firms tend to have higher Tobin’s q. The smallest firms in the sample have on average a Tobin’s q of 2.50 while the largest firms have on average a Tobin’s q of 0.80. Of our observations, the largest 30% contribute to the majority of the patent stocks, namely tranches 8 to 10.

Interestingly enough, design stocks and trademarks stocks do not follow firm size as linearly as patent stocks. For the average trademark stock, the minimum stock of 2.02 are found in the first tranche while the maximum average trademark stock of 75.31 are found in tranche 9 and mid-sized firms have trademark stocks in the same size as the largest. For average design stock, the minimum value of 1.53 belong to firms in the second tranche while the maximum of 39.46 belong to tranche 10. However, also here mid-sized firms have similar design stocks as tranche 8 and 9.

We furthermore compute the correlations between our variables of interest (see Table 5). Statistically significant correlations are denoted with asterisks. All correlations against Tobin’s q are statistically significant at the 5 percent level. All regressors but ln(Total Assets) report a positive correlation with Tobin’s q to varying degrees. Design stocks, trademark stocks and R&D intensity are negatively correlated with total assets suggesting that smaller firms tend to invest relatively more in these assets than larger firms. Both design stocks and trademark stocks are furthermore positively correlated with R&D intensity. Finally designs and trademarks are correlated as they also followed similar patterns in terms of firm size in Table 4. Since some of the correlation coefficients in Table 5 were above 0.3, we calculated the VIF values for all variables to check for multicollinearity. Although total assets display a higher VIF value then the rest of the variables all are far below the critical value of 10, which indicates that there is no multicollinearity in our data.

<table>
<thead>
<tr>
<th>Tobin’s Q</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>VIFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>log Total Assets</td>
<td></td>
<td>-0.349***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.20</td>
</tr>
<tr>
<td>R&amp;D/assets</td>
<td></td>
<td></td>
<td>0.271***</td>
<td>-0.286***</td>
<td></td>
<td></td>
<td>1.83</td>
</tr>
<tr>
<td>Patents/R&amp;D</td>
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<td></td>
<td></td>
<td>0.218***</td>
<td>-0.062</td>
<td>0.030</td>
<td></td>
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<tr>
<td>Citations/Patents</td>
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<td></td>
<td></td>
<td>0.109*</td>
<td>0.114*</td>
<td>0.372***</td>
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<tr>
<td>Trademarks/assets</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.252***</td>
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<tr>
<td>Designs/assets</td>
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<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

* p < 0.05, ** p < 0.01, *** p < 0.001
Table 6 contains the results of the NLLS regressions. The log of total assets shows varying negative and positive coefficients in all models and it is only significant in 2 out of 6 models. However, it is a slight indication that there are weak economies of scale among our firms, that larger firms are valued higher. R&D intensity is strongly positively related to Tobin’s q in all model. In model 3 and 4 the coefficient is above unity. Assuming efficient financial markets, the R&D-intensity coefficient around 1 implies that firms are investing at optimal levels of R&D. Although in model 2 and 6 R&D intensity is slightly below 1, which would indicate that firms are investing more than they should since the R&D assets are worth less than investments in physical assets. An alternative reason for the coefficient to be slightly below 1 is that our applied depreciation rate of 15% is too low and actual R&D assets are depreciating faster (Hall & Oriani, 2006; Rahko, 2014). Also, R&D disclosure is not mandatory, and thus companies investing in R&D but not disclosing are not present in our study. Lack of R&D disclosure can negatively affect the evaluation of R&D since information asymmetries increase (Hall & Oriani, 2006). When adding R&D intensity to the regression in model 2, $R^2$ increases from 0.434 to 0.0467 compared to model 1. The obtained elasticity of R&D intensity is similar to what Rahko (2014) found. Sandner & Block (2011) show a considerably lower elasticity of 2.75% compared to 7.50% obtained in our results. The interpretation of the elasticity is that a 100% increase in R&D intensity has a positive impact of 7.50% on the market value. Out of all our independent variables, R&D intensity seems to have the largest impact on Tobin’s q. The result is different from Sandner & Block (2011) and Rahko (2014), whose main variables were trademarks and organizational capital respectively. The similar elasticities for R&D intensity found by us and Rahko (2014) could be due to the Swedish and Finnish firms in our samples. Nordic markets seem to value R&D intensity higher than other European markets. Also, the presence of small research-intensive companies may contribute to the deviating results in comparison to studies not including small companies. The R&D intensity of Swedish firms is in line with German and French firms (Hall & Oriani, 2006), but higher than for Finnish, Danish, UK and Italian firms. US firms tend to outrival Swedish firms regarding R&D intensity (Bloch, 2008; Hall & Oriani, 2006; Rahko, 2014).

Patent Stock to R&D Stock is positively related and significant to Tobin’s q in all models. Our findings suggest that additional yields of patent families from R&D investments contribute to the market value of the firm. Our interpretation is that financial markets reward increased efficiency of R&D efforts regarding patentable inventions, which was also the interpretation of Rahko (2014). The positive relationship between the patent yield of R&D and market value corroborates the notion that patents are used to commercialize products and to secure returns from R&D investments (Saracho, 2002). $R^2$ increased from 0.467 in
Table 6: Results of NLLS regressions

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<th>(2)</th>
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Notes: Robust standard errors in parentheses. Full set of year (10 categories) and industry dummies (12 categories) were used for all models. Reference group for industry: Mining & construction. Reference year: 2003. *p < 0.10, ** p < 0.05, *** p < 0.01
model 2 to 0.51 in model 3 when the patent family yield was introduced, which indicates that the variable provides additional information to explain the variance. Our patent family yield of R&D is positively related with Tobin’s q, which is consistent with the findings of Rahko (2014) and Hall et al. (2005). Other studies find no such relation (Sandner & Block, 2011; Toivanen et al., 2002). As Sandner & Block (2011) have a higher threshold for small firms in their sample in comparison to Rahko (2014) and us, one hypothesis is that there might be a small-company effect in the patent yield of R&D in relation to the market value of firms. Interviews with the companies confirm that they are small companies, whose sole purpose is to conduct R&D and their revenue solely depends on patentable inventions. They are relatively intensive in patent yields.\(^{10}\)

Our analysis does not suggest that value indicators of patents contribute to firm value in a positive way. Our patent citation variable was insignificant or weakly negative in contrast to earlier research (Hall et al., 2005; Rahko, 2014; Sandner & Block, 2011). Our variable measure family-to-family citations whereas other researchers often rely on aggregated measures of citations, including self-citations. One explanation for the insignificance in our measure might be that restricting the citation variable to forward family-to-family citations limits the incorporated information too much to signal any value among patents. It could also be an indication that financial markets value the absolute patent stock and are less prone to distinguish between ‘high’ or ‘low’ value patents. However, another possible explanation could also be that patents with more citations belong to technologies were competition is high. ‘Well-known’ patents could in that way possibly attract new competitors which in the end could mean smaller market shares for the firm.

Trademark stock to total assets is only included in model 6 but shows a positive and significant relation to firm value when controlling for R&D, patents and design protection. This result is in line with Sandner & Block (2011) and Greenhalgh & Rogers (2007). However, Bosworth & Rogers (2001) did not find such a relationship. Our results add to this body of research, which shows that trademarks serve a purpose in defending companies’ marketing assets and further innovative product development, which require trademarking. We interpret it as that trademarks have a valuable function in hampering counterfeits, infringement and dilution of company brands (Kopp & Suter, 2000). Such a function of trademarks also attracts funding from investors, which should be reflected in the market value. The elasticity of trademarks in model 6 is similar to the results of earlier studies (Greenhalgh & Rogers, 2007; Sandner & Block, 2011). The effect of trademarks on the market value of firms in Sweden seems to be in line with the UK and other European markets.

Finally, the ratio of designs to total assets are included in model 5 and 6. In model 5 it

\(^{10}\)The interview was conducted on condition of anonymity. We have transcribed records of the interview.
is included without any other IP and R&D. The coefficient 0.126 is strongly positive and if interpreted as the shadow value of design protection, it indicates that one additional design protection is valued at SEK 126 million. This is very close to the amount found by Sandner & Block (2011) for trademarks. This number is lower in model 6 when we also control for patents, trademarks and R&D however the coefficient remains significant at the 5-percent level.

To make our results more comparable to previous research we calculate the elasticities with respect to tobin’s q for all variables. The elasticities are significant for all variables except for citations to patent stock in model 4. The elasticity of R&D goes from was around 9% in models 2-4 to 7.5% in model 6. This is higher compared to both Sandner & Block (2011) and Rahko (2014) but lower than Hall et al. (2007). The elasticity for patent stock to R&D is of similar size in all models. To compare the models in Table 6 we use $R^2$ values. Compared to the baseline model 1 including only total assets, $R^2$ values increase from 43.4 to 51.0 when including both R&D intensity and patent stock to R&D. The $R^2$ for model 5 with only design stock is a bit lower, but increases to 56.0 when we include all the variables in our full model 6.

5.1 Robustness Tests

To confirm our results from the NLLS regressions in Table 6 we also estimate the same models using a regular OLS framework. Table 7 presents the results from the OLS regressions. The OLS regressions are qualitatively in line with the results presented in the NLLS regressions. The OLS did report slightly lower $R^2$ values. All the signs of the coefficients are similar across both NLLS and OLS regressions, but citations to patent stock are not significant in any of the models, again pointing to a weak relationship of this variable to how financial markets value the firms in our sample.

5.2 Limitations

There are some limitations to our study. For instance, our IP data only have European and Swedish coverage. We can thus not claim the IP portfolios for the firms in the study to be complete since they might own IP rights in countries outside of Sweden and the rest of the European Union. There is however no reason to expect a bias in the matching process. Thus, we can still draw conclusions regarding the difference between and relative importance

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11 We also estimate NLLS and OLS regressions on an extended dataset. The extended dataset includes n=541 observations. This dataset has not been subject to adjustment for extreme outliers. The results from the NLLS on the broader dataset yield no major differences from the analysis of the primary dataset.
### Table 7: Results of OLS regressions

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<td>0.0130</td>
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<td>(0.0157)</td>
<td>(0.0173)</td>
<td>(0.0172)</td>
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<td>0.534**</td>
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<td>(0.228)</td>
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<td>$R^2$</td>
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**Notes:** Robust standard errors in parentheses. Full set of year (10 categories) and industry dummies (12 categories) were used for all models. Reference group for industry: Mining & construction. Reference year: 2003. *p < 0.10, **p < 0.05, ***p < 0.01
of separate IP stocks. The quality of the data is on par with other studies in this field (Sandner & Block, 2011; Rahko, 2014). The delimitation to Swedish firms of the study has its advantages and disadvantages. On one side, it limits the degree of generalizability of our conclusions by the narrow geographic scope. On the other hand, we can see if the observed relationships from studies with other geographic scopes are valid in a Swedish institutional settings. Our study contributes to the body of research by validating the robustness of observed relationships of R&D, patents and trademarks across varying institutional settings. Another potential limitation of the study concerns unobserved variables. We do employ control variables for time, industry, IP and R&D possession. We do not consider other potential variables, which can affect the market value of firms. However, our set of variables is similar to other studies (Hall et al., 2005, 2007; Sandner & Block, 2011; Rahko, 2014) in the field, which makes our results comparable in a broader context. We have avoided assumptions as far as possible, but some assumptions are always unavoidable. Maybe the most critical is the assumption of a 15% depreciation rate of design, R&D and patent assets. Hall (2007) showed that it is hard to approximate an appropriate depreciation rate. However, 15% is still seems to be the norm in this field of study, which makes our calculations comparable to other studies despite its potential flaws. Our assumption of the renewal rate of trademarks and the holding period is not feasible on a very long timeline. In our case the effect is small, and it allows us to use data from a considerably longer period.

6 Conclusions

The purpose of the study was to investigate the relationship between design and the market value of firms. A secondary aim was to map out differences in IP portfolios across firm sizes and industries. We used the market value approach and developed the market value equation to include IP portfolios. Our results provide new evidence on the market value of design protection. This also holds when we study them together with more traditional intangible assets such as R&D, patents and trademarks. Financial markets tend to reward companies, ceteris paribus, who invest in design protection. The results indicate that R&D intensity contributes to the market value of firms, while the coefficient per se suggests that R&D investments are not optimal, or the discount rate is too low, which coincides with other studies (Hall and Oriani, 2006; Rahko, 2014). The patent yield of R&D investments tends to explain the market value of firms. This indicates that financial markets value the patent yield as an efficiency measure of R&D investments. Trademark intensity in firms seems to be positively valued by financial investors. This supports the notion made that defending marketing assets or engaging in product development, which requires trademarking, is valued
by investors. Our results carry implications for both practice and academia. In practice, our results indicate that IP strategy affects shareholder value. The importance of IP strategy is confirmed in interviews by the fact that the sole purpose of some firms is to conduct R&D, from which the output needs to be protected by IP. The results confirm that company efforts in design protection, patenting and trademarking are worthwhile and our examples in the introduction confirm see them as such. For future research, our study confirms Filitz affirmation that design protection offer a rich opportunity for further research. Our study as has used design data together with patents and trademarks, but we still lack knowledge about how these types of intellectual property complement each other. Furthermore, in this study we only used design stocks. Future research should investigate how quality indicators for design protection, such as renewals, Locarno classes and appeals are related to firm and industry characteristics. Finally, it is not likely that designs depreciate in the same way as patents as they have different life spans, renewal structures and functions. This also leaves ample opportunity for future research on design rights.

References


WIPO (2003). What is intellectual property? Number 450. WIPO.