Technological Forecasting & Social Change 196 (2023) 122827

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Industrial design rights and the market value of firms☆

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ARTICLE INFO

JEL classification:
O34
L25
O32

Keywords:
Industrial design rights
Patents
Trademarks
R&D
Intellectual property
Market value
Tobin's q

ABSTRACT

This paper studies how investments in design affect the market value of firms, using European Registered Community Designs and national Swedish design rights data combined with R&D, patent and trademark data, for the period 2003–2013. This paper is the first large-scale quantitative study using industrial designs rights to measure design. Nonlinear least-squares regressions are used to investigate the association between these variables and the market value of Swedish firms. The results show that industrial designs rights have a positive and significant relationship to the market value of firms. It provides both new evidence on the effect of industrial design rights on the market value of firms and internationally comparable results for other intangible assets such as patents, trademarks and R&D. Theoretically, the paper contributes to the understanding of design knowledge and the valuation of design rights.

1. Introduction

As other intellectual property rights (IPR), Industrial Design Rights (IDRs) are knowledge assets that have been suggested to serve as important drivers in the contemporary global economy (Alcacer et al., 2017; Montresor and Vezzani, 2020). In general, there is substantial value accumulations associated with IPR and the U.S. Chamber of Commerce Global Innovation Policy Center 2022 suggests that *"America's IP is worth $6.6 trillion, more than the nominal GDP of any other country in the world"*. At the same time, while there is variegation of intellectual property rights into patents, trademarks and IDRs (WIPO, 2003; Galindo-Rueda and Millot, 2015; Pinate et al., 2022), until recently research has been relatively one-sided in its focus on using patents to assess the value of firms' knowledge assets (Czarnitzki et al., 2006; Hall, 2007; Hall and MacGarvie, 2010; Hall and Oriani, 2006; Toivanen et al., 2002; Chen and Chang, 2010; Lee and Lee, 2017).

While a recent stream of literature has provided analyses of trademarks in relation to patents that show both their economic value (Dosso and Vezzani, 2020; Sandner and Block, 2011) and important theoretical implications for innovation research in particular with respect to market innovations (Castaldi and Dosso, 2018; Castaldi, 2020; Castaldi and Mendonça, 2022), there is still a dearth of studies that assess the relative importance of IDRs for the market value of firms. Admittedly less common than patents and trademarks, Alcacer et al. (2017) still estimate that close to 1 million IDR applications (937.000) were submitted worldwide in 2013. IDR applications had then doubled in ten years and constituted about a fifth of global trademark applications (4.87 million) and less than half of patent applications (2.57 million). The increased use of IDRs is indeed remarkable as *"…growth in the use of IP tools has outpaced growth in both GDP and trade. Interestingly, industrial design applications which were lower in absolute terms than applications for the more-favored IP tools of patents and trademarks have grown even faster than FDI for substantial parts of the decade"* (Alcacer et al., 2017, p. 166).

Fig. 1 exhibits a similar growth pattern in the EU for IPR applications for the period 2003–2016, albeit with patents dominating and a larger proportion of IDR applications relative to trademarks.

☆ Acknowledgments: We thank Shinjinee Chattopadhyay, Per Ekman, Philip Kappen, Jung H. Kwon, Yunchen Sun and Ivo Zander for helpful comments as well as participants of session 12 at DRUID19 (Copenhagen Business School, Denmark). We are grateful to the Swedish Patent and Registration Office (PRV) for giving us access to their trademark and design databases. Maximilian Gustafsson provided excellent research assistance.

Funding: This work was supported by Vinnova (grant number 2017-04473), Torsten Söderbergs Stiftelse (grant number E58/17) and Jan Wallanders och Tom Hedelius Stiftelse samt Tore Browaldhs Stiftelse (grant number P20-0286).

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https://doi.org/10.1016/j.techfore.2023.122827
Received 18 February 2022; Received in revised form 11 August 2023; Accepted 3 September 2023
Available online 16 September 2023

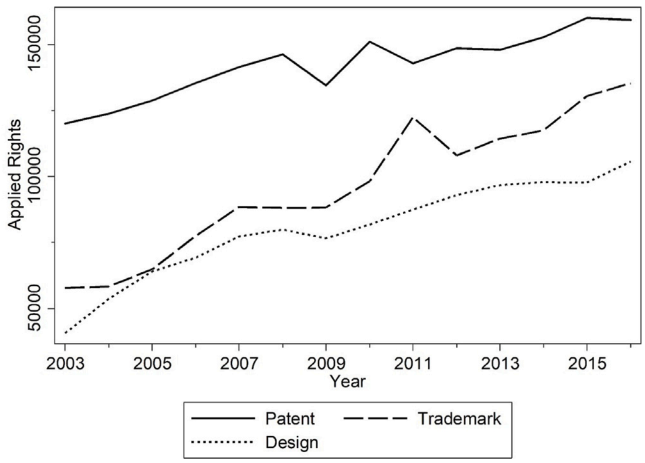

Fig. 1. Industrial design right, trademark and patent applications, 2003–2016.
Notes: This figure depicts applications filed at the EPO and EUIPO.
Source: WIPO Statistics Database and EUIPO Open data.

Yearly Registered Community Designs (RCD)-applications filed with the EUIPO grew by 160% between 2003 and 2016. The number of IDRs filings is approaching the numbers of other IPRs. Following the establishment of the RCD in 2003, in 2018, approximately 1.1 million applications had been filed and it has become one of the largest IDR registers in the world, for users both outside and within the EU and is seen as a quick and relatively cheap way to obtain protection in the EU (Heneghan, 2016). As design rights are under a registration system in Europe while patent applications undergo pre-examination, the relative holdings of granted design rights relative to patents are even higher than for applications.

Illustrating the value firms put on their IDRs and that they are prepared to enforce them aggressively, in May 2018, a judge in California ordered Samsung to pay Apple US$533.3 million in damages for infringement of Apple's EU Registered Community Design (RCD) for the iPad and several of Apple's original iPhone and iPad design patents.[1] The ruling had its origins in a 2011 court case in which Apple accused Samsung of infringements of several design patents and utility patents in several countries. Following the 2018 ruling, Apple's issued an official statement saying that it *"believe[d] deeply in the value of design"*.[2] Another lawsuit, in February 2018, had a different outcome; the European General Court upheld the decision by the European Union Intellectual Property Office (EUIPO) to revoke Crocs Inc.'s RCD No. 257001-0001. The RCD protected the well-known footwear producer's design, which had generated more than US$1 billion in yearly sales since its launch in 2002.[3] Crocs Inc. also lost in a major infringement litigation case heard in the Delhi High Court against seven Indian footwear manufacturers over its Indian industrial design rights (Ghosh and Khan, 2018).

Accordingly, there have been calls for more research into the aesthetic dimension of innovation and the role of IDRs (Filitz et al., 2015; Galindo-Rueda and Millot, 2015; Filippetti et al., 2019; Holgersson and van Santen, 2018). Recent research has demonstrated that firms – in-house or in collaboration with specialized design suppliers – integrate design when innovating (Candi and Gemser, 2010; Filippetti and D'Ippolito, 2017; Montresor and Vezzani, 2020); the importance of design for innovation performance in service and product markets (Candi and Saemundsson, 2011; Fjællegaard et al., 2019; Ghisetti and Montresor, 2019); and indicated challenges for firms to use and defend their holdings of IDRs to appropriate rents when rights are contested (Filitz et al., 2015; Filippetti and D'Ippolito, 2017; Heikkilä and Peltoniemi, 2019).

These and other studies suggest that design constitutes an important innovation capability for firms and that IDRs analogous with patents and trademarks should have the potential to serve as an indicator for specific knowledge assets (Filippetti et al., 2019; Ghisetti et al., 2021) that are valued by investors and financial markets. Therefore, the aim of the study presented in this paper is to investigate: *How does ownership of IDRs relate to firms' market value?*

Using the market value approach of knowledge assets using Tobin's q suggested by Zvi Griliches and Bronwyn Hall with colleagues, later amended by Sandner and Block (2011) to include IPR portfolios, we seek answers to this question by analyzing a novel dataset covering Swedish firms' ownership of IPRs (patents, trademarks, IDRs), accounting data, and stock prices between 2003–2013. More specifically, we evaluate IDRs both in comparison to and combined with R&D, patents and trademarks. We collected and analyzed data on IDRs, patents and trademarks, publicly available from the Swedish Patent and Registration Office (PRV), the European Patent Office (EPO) and the EUIPO. The results show that, in general, financial markets tend to reward companies that invest in IDRs. Our study also reveals that, in line with previous research, patents, R&D and trademarks also indicate a positive relationship to the firm's market value.

This study zooms in on a specific set of knowledge assets (IDRs) in a specific context (Swedish firms). In light of this focus (with its associated benefits and limitations), we suggest that our findings make important empirical and theoretical contributions. Empirically, to our knowledge, the study is the first of its kind to demonstrate the firm market value of an (increasingly) important IPR, namely IDRs. In line with previous research on the market value of patents and trademarks, the study shows that financial markets value also IDRs. Moreover, not only is the absolute value of IDRs indicated by the study (by an increment of 0.126), but this effect is also put in relation to the valuation of patents and trademarks for the same dataset. Finally, while Sweden has been singled out as one of the most design-intensive countries in the world (Filitz et al., 2015; Galindo-Rueda and Millot, 2015), valuation of Swedish firms' design activities emanating in IDRs has not yet been examined in previous research, which contrasts with studies in other prominent European design countries such as the UK (e.g. Bascavusoglu-Moreau and Tether, 2011); Germany (e.g. Filitz et al., 2015); Italy (e.g. Filippetti and D'Ippolito, 2017); Denmark (e.g. Galindo-Rueda and Millot, 2015; Fjællegaard et al., 2019) and Finland Heikkilä and Peltoniemi (2019).

Theoretically, we contribute to the understanding of design knowledge and valuation of design rights by financial markets. Even though IDR in theory appear a relatively weak form of IPR, this study show that despite the uncertainty surrounding the quality of IDRs financial markets evaluate them positively. We suggest three explanations for this observation. First, a particular characteristic of IDRs as an IPR is their explicit product connection (Walsh, 1996). Second, assuming that design capability is an unobservable antecedent of IDRs, such innovative capabilities are attributable to firms competitive advantage (as expected by shareholders). Drawing upon the knowledge based view of the firm (KBV), our findings lend support to prior theoretical conjectures that design is a distinguishable innovative capability that firms can use to reap competitive advantage (d'Ippolito, 2014; Galindo-Rueda and Millot, 2015; Ghisetti, Montresor, and Vezzani, 2021). Third, design is more coupled with embodied aesthetic knowledge (Ewenstein and Whyte, 2007).

In the following, the paper is organized accordingly. Section 2 summarizes the legal background of IDRs in Europe and positions

[1] In total, Samsung was obliged to pay $538.6 million, of which $5.3 million was for infringing Apple's utility patents. See USA Today, at https://eu.usatoday.com/story/tech/2018/05/24/samsung-must-payapple-539-million-copying-iphone-patents/623908002/ (last accessed: 19 February 2020).

[2] See Footnote 1.

[3] Novagraaf, at https://www.novagraaf.com/en/insights/what-croc-crocs-eu-design-revoked (last accessed: 19 February 2020).

the study as a knowledge-based approach to analyzing IDRs and firm value. Section 3 introduces the data and elaborate the methodological approach. Section 4 presents the results from the empirical analysis, while Section 5 provides a concluding discussion entailing limitations, further research, contributions and implications.

2. Industrial design rights: What are they and do they matter for firm value?

2.1. Legal definition and development of industrial design rights in Europe and Sweden

The World Intellectual Property Office (WIPO) refers to different types of IPR: trademarks, patents and IDRs. A trademark is a registered distinctive sign that identifies a certain good or service, produced or provided by an individual or a company; a patent is an exclusive right granted for a technical invention; an IDR protects a design in the form of ornamental or aesthetic aspects (Galindo-Rueda and Millot, 2015; Pinate et al., 2022). Design can include three-dimensional features such as shape and texture, or two-dimensional features such as patterns, lines and color (WIPO, 2003). Previous research suggests that designs contribute to firm value through their connection and complementarity to other types of innovation (Walsh, 1996). Unlike patents, designs are not required to include an inventive step to be granted. At the same time, designs are less general than trademarks, in the sense that the granting of an IDR requires the design to be novel and individual in character, as well as associated with a product or service.

In Europe, the legal foundations of IDRs developed in two stages (Filitz et al., 2015). The European Council passed an EU directive in 1998, requiring all EU members to have a formal IDR registration process to harmonize national protection. This directive established a definition of IDRs 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' (Directive 98/71/EC). That is, a design needs to be new and distinguishable from other existing designs. The second step involved the passing of Community Design Regulation in 2002 (Regulation EC 6/2002), resulting in two types of IDRs across the EU: the registered community design (RCD), and the unregistered community design (UCD) which provides automatic protection throughout Europe three years after disclosure. In line with The Hague System (initiated in 1925), owners of IDRs can also register them with the World Intellectual Property Office (WIPO). Registering through WIPO means that the owner of the IDR needs only to apply to WIPO to receive protection in several European countries. However, for the period covered in this study (2003–2013) a vast majority (ca. 80%–90%) of European IDRs were filed using domestic patent offices, and almost all US and Chinese IDRs were filed domestically (Alcacer et al., 2017, pp. 183–184; 189). In contrast to patents, there is no examination before granting an RCD (i.e. a registration system). However, since third parties can file oppositions to challenge the validity of European design rights, applicants may still be careful in registering designs that do not meet the individuality and novelty criteria (Fjællegaard et al., 2019). The maximum protection time is 25 years, and requires a renewal fee to be paid every five years (Alcacer et al., 2017, p. 191).

At the national level, Swedish industrial design law originated in the 10 July 1899 law on 'protection of specific patterns and models' (Swedish code of Statutes 1899/59). However, this law applied only to the metal working industries and granted protection for only five years from the filing date of the application. Current Swedish IDRs are regulated by the industrial design law passed in 1970 (Law 1970:485) and are granted in increments of one to five years to a maximum of 25 years. The applicant can choose to apply for several increments at the same time or renew every five years. National Swedish IDRs is administered by the Swedish PRV. Table 1 presents an overview of different IPRs.

2.2. Industrial design rights as knowledge assets

Broadly defined, knowledge assets include knowledge about organizational processes, organizational routines and structural arrangements, as well as formal and legally binding documents confirming the firm's rights to the intellectual output produced by the organization and its members. Teece (2000, p. 35) notes that: *"[Knowledge] assets include tacit and codified know-how, both technical and organizational, whether or not protected by the instruments of intellectual property such as trade secrets, copyrights and patents"*. Following Teece's 2000 distinction, and drawing upon Ewenstein and Whyte (2007, pp. 690–692) demarcation between aesthetic knowledge as embodied competency and symbolic style, we conceptually separate two knowledge asset properties attributable to IDRs. First, IDRs are a result of firms' design capabilities, that is, often tacit and embodied know-how that differs from other R&D-based knowledge (see Section 2.2.1). Second, an IDR is a codified intellectual property right (IPR) expressing a certain style represented in symbolic and non-verbal expressions associated with specific and distinguishable jurisdictions and legal procedures (see Section 2.2.2).

2.2.1. Industrial design as capability

While IDRs are conferred to holders as legal rights, they emanate from design activities undertaken by firms seeking to innovate and gain competitive advantage in the marketplace by appealing to aesthetic emotions of customers through form and functionality of products and services. WIPO defines industrial design as *"the creative activity of achieving a formal or ornamental appearance for mass-produced items that, within the available cost constraints, satisfies both the need for the item to appeal visually to potential consumers, and the need for the item to perform its intended function efficiently"* (WIPO, 2004, p. 112). Thus conceived, design activities are exemplars of organizational routines that encapsulate firm-specific organizational knowledge (Nelson, 1991). In line with arguments put forward in knowledge based theories of firms and competitive advantage (Grant, 1996; Kogut and Zander, 1992; Teece, 1982), if such design knowledge is idiosyncratic to the firm and difficult to imitate for competitors while at the same time being conducive to deliver value to customers, investments in design activities serve as a source for competitive advantage.

Design capability specifically designates aesthetic knowledge (Filitz et al., 2015; Walsh, 1996). Several conditions can be fulfilled by design capabilities to contribute to firm performance and sustainable competitive advantage (Barney, 1991; Barney and Hesterly, 2010). By being uniquely tied to products and services design appeals to tactile and symbolic experience and evoke emotions among its users, thereby delivering value to them (Sisodia, 1992). Design capabilities are rare when they are embodied in designers in specific contexts that are unevenly distributed among firms and not readily transferable to competitors. The embodied and tacit nature of aesthetic knowledge (Ewenstein and Whyte, 2007) also makes it difficult for competitors to identify and imitate required capabilities. Moreover, as much aesthetic knowledge takes long time to master and may require apprenticeship practices, there are time compression diseconomies (Dierickx and Cool, 1989) associated with them that further hinder the copy of design capabilities. Finally, it is difficult to organize and integrate design capabilities as it requires both (a) "knowledge integration by design"; that is, creative acts of knowledge generation and conception afforded by the design process in itself; (b) "knowledge integration of design", that is, design knowledge to be articulated, systematized and integrated in relation to other knowledge assets (Åman et al., 2017), (see also Gemser and Leenders, 2001; d'Ippolito, 2014; Montresor and Vezzani, 2020).

Indeed, there is growing evidence that design pay dividends in terms of innovation and firm performance. For instance, empirical research has utilized country-specific (e.g. Marsili and Salter, 2006, for the UK), industry and country specific (e.g. Alegre et al., 2012, for ceramic tile industry in Italy and Spain), regional and sector specific (e.g. Candi and Saemundsson, 2011, for new technology based firms in the

Table 1
Overview of intellectual property rights.
Source: PRV, EUIPO, EPO, WIPO.

Intellectual property right	Type	Jurisdiction	Time	Administration
National Design	Industrial Design Right	National	25 years[b]	National
Registered Community Design (RCD)	Industrial Design Right	EU	25 years	EUIPO
Unregistered Community Design (UCD)	Industrial Design Right	EU	3 years	EUIPO
International Design (Hague system)[a]	Industrial Design Right	National	25 years	WIPO
National Patent	Patent	National	20 years	National
European Patent[a]	Patent	EU	20 years	EPO
Patent (PCT)[a]	Patent	National	20 years	WIPO
National Trademark	Trademark	National	No limit	National
Community Trademark (CTM)	Trademark	EU	No limit	EUIPO
International Trademark (Madrid system)[a]	Trademark	National	No limit	WIPO

Notes: This table presents an overview of different types of industrial design rights, trademarks and patents and the corresponding jurisdictions and administration levels.
[a] Denotes national IPR applied for through a common application process administered by EPO or WIPO.
[b] US design patents are only valid for 14 years.

Nordic countries), or cross-industry and cross-country (e.g. Montresor and Vezzani, 2020, for European firms) survey data. These and other studies demonstrate that design knowledge resulting in successful new features of products and services give rise to competitive advantage in the marketplace. At the same time, this and much other empirical work focus on firm investments in design knowledge and design activities, but not specifically any outcomes that may be granted in terms of IDRs and their potential value as knowledge assets.

2.2.2. IDRs as IPR

In addition to capability-based sources associated with competitive advantages, IPRs serve as important means for appropriating rents from knowledge assets (Grant, 1991; Teece, 2000; Filitz et al., 2015; Filippetti and D'Ippolito, 2017). IPRs are formal devices for appropriating value and protecting against imitation (e.g. Teece, 1986; Arundel, 2001). By providing monopoly right to specific knowledge, IPRs protect its owner against the extraction of transaction value from the innovation by others, thereby allowing for value capture. As illustrated in Table 1, there are different IPRs that also are granted and enforced under varying jurisdictions.

In the case of IDRs as IPRs, a key feature is the conversion of design knowledge into ornamental or aesthetic features of functional products or services that can be illustrated in two-dimensional (2D) or three-dimensional (3D) representations. Theoretically, there are rival arguments when it comes to the relative strength of IDRs as an IPR device for appropriating returns. Due to the product-specificity of IDRs, they can be conceived as strong IPRs, as arguably it is on product markets competition between different value propositions to consumers take place (Roberts, 1999). In comparison to other IPRs emanating from R&D, IDRs differ. Patents cover the right to an invention, that is, a solution to a specific problem in a field of technology and the most important criteria for patentability is usefulness and novelty — not its encapsulation in a product (WIPO, 2004, p. 17). Trademarks, on the other hand, refers to *"any sign that individualizes the goods of a given enterprise and distinguishes them from the goods of its competitors"* (WIPO, 2004, p. 68). Accordingly, trademarks more so than design rights apply more generally to firms.

On the other hand, formally IDRs appear as a rather weak form of IPR. Opportunities for specification of both individual distinctiveness and novelty is limited by its format (also allowing for filing multiple designs in one application). The European IDR system is a registration system where examination of distinctiveness is not scrutinized in relation to prior art. This means that de facto verification is taking place ex post, relying on appeals and infringement litigation as mechanisms. Moreover, in addition to being a relatively expensive, localized and time-consuming process, empirical evidence suggests that it is difficult to uphold IDRs in court (Alcacer et al., 2017; Filitz et al., 2015; Filippetti and D'Ippolito, 2017; Heikkilä and Peltoniemi, 2019). This suggests that while IDRs are being increasingly used their benefits for appropriating rents are highly uncertain. So what is the value of IDRs?

2.2.3. Market value of IDRs

IDRs are observable knowledge assets that firms that when owned by firms whose shares are publicly traded on stock markets are valued – together with its other assets – by shareholders, where expectations about future profits are reflected in stock prices (Griliches, 1981; Hall, 1999; Nesta and Saviotti, 2006). Holdings by a firm of IDRs signal themselves as IPRs (being assessed as stronger or weaker in its potential to appropriate rents). IDRs also signal unobservable design innovation capabilities whose potential both for current value capture as well as for value creation for the future is evaluated and reflected in shareholder expectations about future profits of firms.

In research, IDRs have been used as a proxy for design innovations as an outcome measure (Fjællegaard et al., 2019) or as a measure of specifically "green designs" and their impact on innovation (measured by "green" patents) (Ghisetti et al., 2021). Still, especially in comparison with patents and, more recently, trademarks, empirical evidence collected and analyzed regarding the market value of firms owning IDRs is scarce. There are some exceptions which include studies of UK and Australian IDRs. For instance, Bosworth and Rogers (2001) include IDRs in their study of IPR and the market value of Australian firms in the mid-1990s. Griffiths et al. (2011) investigate profits in relation to IDRs for Australian firms, but find scant evidence of a linkage. Bascavusoglu-Moreau and Tether (2011), in the case of the UK, examine IDRs and firm sales and find a positive relationship especially for national IDRs. Given the recent attention that design has attracted in innovation studies, and the rapidly increasing use of IDRs by firms, the aim of this paper is therefore to examine further how ownership of IDRs relate to firms' market value.

2.3. Estimating market value of firms

To estimate the economic value of IPRs and the returns from innovation-generating activities we use Tobin's q (Montgomery and Wernerfelt, 1988). The first method using values based on Tobin's 1969 formulation of the variable q – the ratio of the market value to the replacement cost – was developed by Lindenberg and Ross (1981). Using this method, the firm's market value includes both its physical and intangible assets. Investors in financial markets evaluate the future returns for various companies and these evaluations form the basis for the valuations reflected eventually in stock prices. On the assumption of an efficient market, the stock price is equal to all future cash flows generated by the company (Fama, 1970). Therefore, the market value can be seen as a leading indicator of the firm's future performance (Hall, 1999). Hall et al. (2007) suggest that the market value approach assumes that firms are composed of assets; this approach, assumes, also, that the company's value is a function of its component assets, determined by the financial markets. These component assets include both physical and intangible assets. According to Griliches

(1981) and Hall (1999) assets can be estimated 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

$$q_{it} = \exp(y_t + m_l + u_{it}) \tag{2}$$

where V_{it} is the value of company i at time t. A is tangible assets and K is knowledge assets. Knowledge assets include R&D, patents, trademarks and IDRs. The value of the company is the sum of the value of its tangible and knowledge assets.[4] σ captures returns to scale and $\sigma = 1$ indicates returns proportionate to scale (Pemberton and Rau, 2011). γ is the marginal contribution value of one additional unit spent on knowledge assets and, if $\sigma = 1$, represents the shadow value of the firm's knowledge assets relative to its tangible assets (Hall and Oriani, 2006). Consequently, the product of q_{it} and γ reflects the absolute shadow value of investors' expectations about knowledge assets. In line with previous studies, despite the loss of accuracy, we keep γ fixed to prevent variation across time (Hall and Oriani, 2006; Sandner and Block, 2011). The shadow value is understood as the implicit market outcome of the interaction between the company and its investment activity and between investors and their evaluation of the company in the financial market. The shadow value should not be understood as a structural parameter (Hall, 1999; Hall and Oriani, 2006). The valuation coefficient, q_{it}, comprises factors that represent the valuation effects of time t, industry l and individual disturbances u_{it}, and captures factors affecting the valuation in a multiplicative way (see Eq. (2)) (Hirsch and Seaks, 1993). These factors may include individual risk as well as the market conditions (Griliches, 1981). The general effects of these factors on the valuation are represented by y_t and m_l.

As already noted, R&D investments and patents can represent knowledge assets K (Hall et al., 1993; Hall and Oriani, 2006) and several studies include both (Cockburn and Griliches, 1988; Griliches et al., 1991; Toivanen et al., 2002; Hall et al., 2005; Hall and MacGarvie, 2010). Hall et al. (2005) found that simple patent counts have less explanatory power than citation-weighted patent stocks, which accounts for much of the unequally distributed values of patents. In the present study we include IDRs, patents and trademarks in the market value equation.

2.4. Adding intellectual property into the market value equation

We include IDRs, patents and trademarks in the market value equation in two ways. First, we assume that IPRs are a type of knowledge assets. In the market value equation, we include a separate term for IPR portfolio, which is in line with previous studies using this method (see Bosworth and Rogers, 2001; Greenhalgh and Rogers, 2007; Hall and Oriani, 2006; Sandner and Block, 2011). In our analysis, IPR portfolios consist of design, patent and trademark assets. Functionally, we assume that all three asset classes can be treated similarly to R&D. In Eq. (3), we include IPR portfolio as an additional additive term, I. Beside IPRs, knowledge assets are not listed on balance sheets. We therefore operationalize knowledge assets as R&D separately from IPRs and let R&D represent K. In Eq. (4), I includes design assets (D), patent assets (P) and trademark assets (TM). Consequently, we reformulate the market value equation by including IPR portfolios.

$$V_{it}(A_{it}, K_{it}, I_{it}) = q_{it}(A_{it} + \gamma_K K_{it} + \gamma_I I_{it})^{\sigma} \tag{3}$$

where

$$I_{it} = D_{it} + P_{it} + TM_{it} \tag{4}$$

By treating the different asset types symmetrically, we assume that the firm can choose to invest in any of these assets. γ_I is the relative shadow value of one additional unit of investment in the IPR portfolio to physical assets. By including logarithms to account for returns to scale, the estimation equation becomes:

$$ln\left(\frac{V_{it}}{A_{it}}\right) = lnq_{it} + (\sigma - 1)lnA_{it} + \sigma ln\left(1 + \gamma_K\frac{K_{it}}{A_{it}} + \gamma_I\frac{I_{it}}{A_{it}}\right) \tag{5}$$

3. Methods and data

3.1. Data

We analyze IDRs and other IPRs owned by Swedish firms. Few, if any, previous studies estimating IPR, and more specifically IDRs, and market value of firms use Swedish data. In general, Sweden repeatedly ranks as one of the world's most innovative countries, with high levels of R&D input, output and efficiency (Cornell et al., 2017). With respect to design, Galindo-Rueda and Millot (2015, p. 11) estimate that the Swedish design industry was the fifth largest in Europe in 2011 (after the UK, Italy, Germany and France, all countries with at least five times the population of Sweden and except for Italy at least five times the size of GDP). Examining RCD registrations and relating them to GDP, Filitz et al. (2015, p. 1196) single out Sweden with Austria, Denmark and Switzerland as particularly strong countries. Moreover, ownership of shares in companies quoted on Swedish stock exchanges is fairly international, the proportion of non-Swedish ownership rose from 34% in 2003 to 41% in 2013 (Statistics Sweden, 2022). To further highlight the relative spread of opportunities for investment in Swedish companies, several of the major Swedish engineering-based multinationals are also listed on overseas stock exchanges. We therefore submit that the Swedish financial context and Swedish firms is suitable for a study of the value of design rights, despite the relative small number of observations that can be obtained.

We collected international patent data from EPO's PATSTAT Online Autumn 2017 edition and use EUIPO's Open Dataset to gather EU-wide IDR and trademark data. For data on Swedish IDRs, patents and trademarks, we obtained information from the Swedish Design Database, the Swedish Patent Database, and the Swedish Trademark Database via the PRV. Firm level and financial accounting data were collected from Thomson Reuters Eikon database, and time-series data on inflation rates were obtained from Statistics Sweden. To further validate our calculated IPR stock, obtain qualitative insight into IPR management and explain the results of the regressions, we conducted five interviews with representatives of some of the companies in our sample.

The market value equation needs input in the form of market value, we therefore consider only publicly traded companies. Eikon is used to identify firms listed as large cap, mid cap, and small cap on the NASDAQ Stockholm Exchange during the years 2003–2013. Since the aim is to represent all companies listed on the NASDAQ Stockholm Exchange, we impose no restrictions on specific industries. More specifically, we extract total revenue, enterprise value, cash and cash equivalents, total assets, total debt, R&D expenditure and the standard industry classification. We conducted a random sample check of company annual reports to validate the Eikon financial data. We deflated SEK (Swedish krona)-values to year 2003 prices imputed from Statistics Sweden's yearly consumer price index.

The data extracted from the PATSTAT and EUIPO databases extend to applications originating in 2017 not all of which had been processed or granted. Since the number of applications in process increases for more recent years, granted registered rights decrease. As we are interested only in granted applications, we truncate the data to include only those applications granted no later than end 2013. We set the end of our observation period to 2013 to minimize the effect of potential truncation bias due to the lag between application submission and grant. PRV and EUIPO data suggest that 97% of submitted applications

[4] If there are important complementarities or synergies between tangible and intangible assets the value can be larger than the sum of the separate assets.

are decided after four years, which results in a negligible effect on the 2013 cohort.[5] This approach has the advantage that it uses actual IPR stocks rather than assumptions for the later years in the observation period, which avoids truncation bias.

The extracted Swedish data reflect all available historically granted IPRs for the firms in our sample, registered at the PRV. Our Swedish IDR data with legal entities as applicants, are from 1993, the first year when these statistics are available. We track patents from 1984, the earliest year when a patent would still be valid in 2003, the start of our observation period. Our Swedish trademark data are from 1884, which is the earliest year in the dataset. Following the rationale applied to Swedish data, we collected European IDR data from the Open Dataset provided by EUIPO starting in 2003. As noted above, the RCD came into force in 2002 and introduced EU-wide IDRs. Thus, there are no IDR data for Europe before 2003. European Community trademarks (CTM) were collected from 1996 onwards; EUIPO began operations in 1996, hence, there are no CTMs prior to that year. Global data on patents from PATSTAT Online is collected from 1984 to 2016 based on the filing date. This allows us to build accurate asset stocks for the companies in our sample.

3.2. Variables

We chose to calculate all assets as stock variables rather than flow variables because stock variables capture all annual inflows into the stock up to a specific point in time t, whereas flow variables capture annual inflows in year t. For instance, if a company's IDR stock in $t-1$ is 50 IDRs, and it files for five more IDRs in year t, the stock in year t will be 55 IDRs. Obsolescence is accounted for by letting the stock of $t-1$ depreciate (Hall, 2007). A company is valued by the discounted future cash flows generated by its assets (Fama, 1970). The knowledge used for current product development is assumed to be based on experience of past investment in, for instance, R&D. Although this experience-based knowledge depreciates over time, it influences investors' estimations of future company performance and valuation. Our approach is in line with Sandner and Block (2011), who use stock variables to account for R&D, patents and trademarks. Observations with no IDRs, patents, trademarks or R&D are coded 0 and accounted for by a corresponding dummy variable.

3.2.1. Tobin's q

Our dependent variable is the natural logarithm of Tobin's q — see Eq. (6), defined as the ratio of the company's market value, V, to the book value of its total assets, A (Greenhalgh and Rogers, 2006; Hall and Oriani, 2006; Sandner and Block, 2011).

$$lnq_t = ln\frac{V_t}{A_t} \tag{6}$$

The firm's market value is the aggregate equity and debt market value. We proxy the equity value by the firm's market capitalization plus preferential stock and minority interests. Market capitalization is defined as the number of shares times the share price. We proxy the market value of debt by the book value of total debt, which is equal to the short-term plus the long-term debt (Blundell et al., 1992, 1999; Hall and Oriani, 2006). The total assets book value is the total assets recorded in the balance sheet.[6]

[5] In general however, trademarks and IDRs are granted much quicker than patents.

[6] Researchers in corporate finance have developed advanced estimates of Tobin's q (e.g. Perfect and Wiles, 1994), but it is always a trade-off between precision and sample size (DaDalt et al., 2003).

3.2.2. Knowledge assets

Knowledge assets are not listed on balance sheets. We operationalize the knowledge assets of interest as both R&D and IPR, but distinct from each other. R&D expenses tend not to be entered on balance sheets due to the uncertain value of many R&D investments (Ross, 1983). However, we estimate knowledge assets based on R&D expenses. We use historical R&D expenditure and a declining-balance formula to calculate knowledge stock (Eq. (7)) (Hall et al., 2005; Hall, 2007). We use a fixed depreciation rate, set to 15%, to account for obsolescence, in line with e.g., Hall (2007).

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

Because our financial data go only to 2002, we assume that R&D stocks grew at a constant annual growth rate, g, of 8% which allows us to compute initial R&D stock for the first observed year (Eq. (8)).

$$RD_0^{stock} = \frac{1}{\delta + g}RD_0^{flow} \tag{8}$$

Disclosure of R&D expenses is loosely regulated (Hall et al., 2007) and the decision to disclose it is arbitrary. Some companies consider that this information should be reserved to internal use and choose not to disclose it (Toivanen et al., 2002), which could cause sample selection bias (Belcher et al., 2002) because the calculation of R&D stocks requires uninterrupted historical data of R&D expenditures. We assign an R&D dummy variable to companies lacking R&D expenditures or with partial R&D histories. Missing values are coded 0 in line with earlier research (Hall, 2007; Sandner and Block, 2011).

3.2.3. Industrial design rights

We use the declining-balance formula to calculate IDR stock, D, (Eq. (9)), and use the IDR application date to define yearly flows. We let IDR stocks depreciate because IDRs have a life span of maximum 25 years. In addition, as mentioned above, an IDR can be related to technical inventions that have become obsolete. No other studies consider depreciating IDR stocks; therefore, there is no agreed appropriate depreciation rate. However, since the underlying innovative activity of IDRs can be said to share similar traits as with R&D and other industrial activities (Walsh, 1996; Filitz et al., 2015), we use the same depreciation rate, δ.

$$D_t^{stock} = D_t^{flow} + (1-\delta)D_{t-1}^{stock} \tag{9}$$

We do not calculate initial stocks since Swedish national IDR data goes back to 1979, but RCDs were introduced only in 2003.

3.2.4. Patents

We use the methodology applied to IDR stocks to calculate patent family stocks (Eq. (10)).

$$F_t^{stock} = F_t^{flow} + (1-\delta)F_{t-1}^{stock} \tag{10}$$

We calculate patent family stocks because they represent the underlying inventions protected by the patents, and apply a 15% yearly depreciation rate to write down this stock (Hall, 2007; Sandner and 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 do not compute initial stocks since the time starts in 2003 and data were collected from PATSTAT starting in 1984. The pure patent stock has limited explanatory power because patent value is not normally distributed (Harhoff et al., 1999, 2003). To ensure that we capture patent quality, we can consider measures such as citations, family size and oppositions. We calculate citations in line with prior research (Bloom and Van Reenen, 2002; Hall et al., 2005; Hall, 2007; Sandner and Block, 2011).

We calculate family-to-family citations in simple families, which comes closest to one invention citing another invention. In this study, we consider citations within three years after publication to capture the bulk of the patent citations during each patent's lifetime (Marco, 2007;

Mehta et al., 2010; Sandner and Block, 2011). Also, a constant time limit of three years reduces the risk of truncation issues regarding year of application. To measure the quality of firm-specific patent stock, we weight each patent by the number of citations. The stock of citations can be written as:

$$C_t^{stock} = C_t^{flow} + (1-\delta)C_{t-1}^{stock} \tag{11}$$

3.2.5. Trademarks

To compute stock of trademarks, we apply the same methodology as used to estimate IDR and patent stocks. We calculate the flow of trademarks in any specific year, based, in most cases, on trademark registration date apart from EUIPO data which do not have registration dates. In this case, we use the date the trademark was filed for registration. Since around 90% of trademarks are published within 11 weeks of filing (EUIPO, 2011), this has little effect on our calculated trademark stock. In contrast to our computation of R&D asset stock, we do not depreciate trademark stock. R&D assets are likely to lose their value over time, due to obsolescence and new technological developments and patents have a restricted lifetime. We therefore apply a depreciation rate when determining the value of knowledge assets and patent stocks (Hall, 2007). However, arguably, trademarks become more valuable as time passes. They have no time limit, that is, the grant period (of trademarks) is infinite if renewal fees are paid continuously, generally every 10 years, and the trademark is used on the market. Therefore, over time, firms can continue to use their trademarks portfolio to generate value which is why we apply no depreciation rate to trademarks.

In this study, we consider a trademark to be 'dead' if the renewal fee is not paid or if the registration office cancels the trademark as the result of a successful termination request from a competing firm. We handle the first type of case by including an estimated renewal rate, r. The average renewal rate of CTMs originating between 1996 and 2007 is about 45% (EUIPO, 2018), so we set r to 45%. The second case has no substantial impact in practice: EUIPO statistics for 2003 to 2013 show only 8,305 trademark applications recorded as cancelled among the 896,169 trademark applications filed during this period (EUIPO, 2018). Eq. (12) provides the estimation of the trademark stock:

$$TM_t^{stock} = TM_t^{flow} - (1-r)TM_{t-10}^{flow} + TM_{t-1}^{stock} \tag{12}$$

As noted earlier, although we do not compute initial trademarks stock, for simplicity we bundle trademark applications filed before 1983. This affects 5% of the trademark applications. We then assume that trademarks are held in infinity after the first renewal. This assumption affects 8.6% of the trademark applications. These two actions have a negligible effect on trademark stocks, so our data provide a full history of Swedish trademarks. Also, as noted earlier, EUIPO trademark data are available only from 1996. However, a substantial number of applications in 1996 refer to international trademarks as firms applied for protection in Europe for pre-existing trademarks (Sandner and Block, 2011).

3.2.6. Control variables

Following prior studies, we include year and industry dummies to control for time and industry effects in the market valuation (Griliches, 1981; Blundell et al., 1999; Hall et al., 2007; Sandner and Block, 2011). We use Standard Industry Classification (SIC) codes as the basis of our industry classifications, and sort all of the sample firms into categories, resulting in : Manufacturing, Paper, Public Utilities, Electronics, Trade, Finance, Transport Equipment and Services. However, 73% of firms are in the Manufacturing group, so to allow for more granularity among manufacturing industries, we subdivide Manufacturing, based on the first two numbers in the SIC code, and obtain: Other manufacturing, Other Metals, Mining & Construction, Machinery and Instruments (see Table 3). Thus, we have a total of 12 industry classes, with the largest class representing 14.6% of firms. Section 5.1 provides more detail on industry characteristics.

3.3. Econometric model

Next, we add the variables, relative to their appropriate bases to measure their respective intensities. IDR stock (D) relative total assets (A), R&D stock (RD) relative total assets (A); patent family stock (F) relative R&D stock (RD); citation stock (C) relative patent family stock (F); and trademark stock (M) relative total assets (A) (Eq. (13)).

$$ln\frac{V_{it}}{A_{it}} = lnq_{it} + (\sigma-1)lnA_{it} + \sigma ln\left(1+\gamma_1\frac{RD_{it}}{A_{it}} + \gamma_2\frac{D_{it}}{A_{it}} + \gamma_3\frac{TM_{it}}{A_{it}} + \gamma_4\frac{F_{it}}{RD_{it}} + \gamma_5\frac{C_{it}}{F_{it}}\right) \tag{13}$$

We do not hold unidentified firm-level components constant. By employing a pooled regression model, we examine the market value of the firms IPRs portfolio for a broad range of firms and industries, which, for our purposes, limits the impact of unidentified firm-level components (Sandner and Block, 2011). Tangible assets, knowledge assets and IPR portfolio change only slightly year on year; thus, were we to apply fixed firm-level effects, we would observe a relatively low degree of variance in the data. 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 Squares (NLLS) regression (Hall et al., 2007; Sandner and Block, 2011; Rahko, 2014). Prior studies using Ordinary Least Squares (OLS) use X as an approximation for $\ln(1+X)$. However, as Hall et al. (2007) suggest, this method of approximating X leads to imprecision when knowledge assets increase relative to physical assets. Instead, the NLLS technique allows accurate estimation of nonlinear functions where the market value equation is such a function. Due to nonlinearity, interpretation of the coefficients is not straightforward and the regressors use different units (e.g., SEK, IDRs, trademarks, patents etc.). To take account of non-linearity and allow easier comparison and interpretation of the coefficients, we apply elasticities to each of the main regressors associated with Tobin's q.

4. Industrial design rights and the market value of Swedish firms, 2003–2013

4.1. Descriptive statistics

For the years 1984 to 2013, we combine IDRs, patents and trademarks at firm level to construct the IP portfolio. National IDR data extracted from the Swedish Design Database yielded 5592 records. We extracted 1,105,811 recorded RCD applications from EUIPO's Open Dataset. We match these records to the financial dataset, which yielded a total of 1,890 records, representing 6609 IDRs from 94 firms. We match patent data to financial data by querying the 16 synonyms in the financial data by the four synonyms available in PATSTAT. This yields 94,207 matched records. These belong to 20,592 patent families and 148 firms. We extracted citation data separately from PATSTAT by matching patent family and citation IDs. We filtered the records by individual family-to-family citations. This results in 29,005 unique family-to-family citations attributable to 122 of the firms in our sample. We extracted 126,743 records of national trademark applications with company owners, from the Swedish Trademark Database. The EUIPO Open Dataset yields 1,478,599 CTM applications from 1996 to 2013. We checked for duplicates and matched 5,909 trademark applications to 270 of the firms in our sample.[7]

We gathered financial data on all publicly listed firms on the NASDAQ Stockholm large, mid and small cap lists, between 2003 and 2013. We account for firms on a month-to-month basis so as not to

[7] The earliest matched trademarks originate in 1885 and belong to Holmen AB and Swedish Match AB.

Table 2
Descriptive statistics.
Source: PATSTAT Online Autumn 2017 edition, EUIPO Open Dataset, Thomson Reuters Eikon database, Swedish Design Database, Swedish Patent Database, and Swedish Trademark Database (PRV).

	mean	sd	min	median	max
Tobin's q	1.736	1.536	.304	1.275	10.05
Market value (billion SEK)[a]	61.76	143.3	.089	13.76	1042.3
Total assets (billion SEK)[a]	77.89	298.6	.062	10.40	2319.9
Total debt (billion SEK)[a]	26.33	116.7	0	1.854	933.8
Revenue (billion SEK)	32.99	50.30	.009	10.60	280.9
R&D stock (billion SEK)[b]	5.450	17.00	.013	1.161	151.3
R&D/Total assets[b]	.207	.309	.003	.094	2.678
Patent stock[b]	83.51	125.3	.039	9.109	542.6
Patent stock/Total assets[b]	5.922	15.11	.018	1.834	142.0
Patent stock/R&D stock[b]	35.81	75.79	.781	19.28	841.5
Citation stock[b]	132.3	355.9	0	9.281	2698.2
Citation stock/Patent stock[b]	1.138	1.537	0	7221	9.101
Trademark stock[b]	37.29	54.50	.45	11.6	242.5
Trademark stock/Total assets[b]	6.303	13.21	.009	1.805	89.22
IDR stock	10.07	19.31	.063	1.991	109.1
IDR stock/Total assets	1.493	2.858	.001	.473	18.09
No R&D dummy	.266	.442	0	0	1
No Patent dummy	.147	.355	0	0	1
No Trademark dummy	.088	.284	0	0	1

Notes: This table provides descriptive statistics for the main variables and the controls used in our analysis. n = 487 observations and n = 73 firms.

[a] Prices deflated to real 2003 year prices using CPI data from Statistics Sweden.

[b] Excludes observations with no reported R&D, patents or trademarks. R&D data are available for 357 observations. Patent data are available for 415 observations. Trademark data are available for 444 observations.

Table 3
Industry characteristics.
Source: PATSTAT Online Autumn 2017 edition, EUIPO Open Dataset, Thomson Reuters Eikon database, Swedish Design Database, Swedish Patent Database, and Swedish Trademark Database (PRV).

	Observations	Observations (%)	Total assets[a]	Tobin's q	Patent stock	IDR stock	Trademark stock
Mining & Construction	22	4.52	48.12	0.66	3.23	0.73	16.75
Other manufacturing	63	12.9	11.92	1.74	57.30	6.13	68.62
Paper	39	8.0	81.32	0.79	83.96	17.17	15.16
Other metals	56	11.5	8.26	1.41	23.57	2.58	14.31
Machinery	71	14.6	31.92	1.70	126.73	14.25	30.02
Electronics	36	7.4	22.39	2.31	58.33	17.98	70.62
Instruments	57	11.7	10.09	2.93	10.30	1.61	7.38
Public utilities	9	1.8	229.66	1.13	225.81	47.86	109.07
Trade	27	5.5	17.36	3.57	0	1.01	26.67
Finance	11	2.3	1982.06	0.44	245.80	35.66	36.65
Transport equipment	41	8.4	94.40	0.97	207.92	12.64	33.91
Services	55	11.3	11.52	1.62	26.13	10.40	34.25

Notes: This table Presents the industry distribution in our data. n = 487 observations from n = 73 firms.

[a] SEK billions in 2003 real prices.

lose firms not observed by the end of each financial year. This initial step yielded 3070 observations attributable to 400 firms. A total of 33,110 IDRs, trademarks and patent families were matched. We adjust for missing values in the components of our dependent variable, Tobin's q, and observations with no knowledge assets or IP, that is, no R&D, patents, trademarks or IDRs. This results in 2059 observations and 269 firms. We adjust the dataset for extreme outliers, which affects 104 observations.[8] This reduces the dataset to 1945 observations and 268 firms. Finally, since this study's main focus is the value of IDRs, we exclude firms with no IDRs. The final dataset consists of 487 observations for 73 firms. Table 2 presents the descriptive statistics. The firms in our sample come from a range of industries. Table 3 shows the industry distribution and shows that Machinery, Other manufacturing and Instruments are the largest industries in the sample.

Certain variables fluctuate across industries. For example, Tobin's q varies considerably across industries, ranging from 0.44 to 3.57, although 8 of the 12 industries (66.7%) have an average Tobin's q above 1. Average patent stock and IDR stock generally show a larger variation across industries compared to average trademark stock. None of the firms in the Trade category owns patents. Average trademark stock shows the lowest variance across industries. IDR stocks are generally small in all industries, with the lowest value in Mining & Construction.

Table 4 presents the sample based on firm size, proxied by total assets. We split the sample into deciles based on total assets. We observe a Pareto distribution in which large firms have disproportionately large total assets compared to the mean. Smaller firms tend to have a higher Tobin's q: the smallest firms in the sample have an average Tobin's q of 2.50 while the largest firms have an average Tobin's q of 0.80. Among our observations, the largest firms contribute to the majority of the patent stocks (deciles 8, 9 and 10).

Unlike patent stocks, IDR stocks and trademarks stocks do not follow a linear relation to firm size. For average trademark stock, the minimum of 2.02 is in the 1st decile while and the maximum average of 75.31 is in the 9th decile; also, mid-sized firms and the largest firms have average trademark stocks. For average IDR stock, the minimum value of 1.53 is assigned to firms in the 2nd decile while the maximum of 39.46 applies to firms in the 10th decile. However, again, mid-sized firms have similar IDR stocks to firms in the 8th and 9th deciles.

[8] Observations in the 1st and 99th percentile of Tobin's q, R&D Stock/Total Assets, Patent Stock/Total Assets, Trademark Stock/Total Assets; IDR Stock/Total Assets were excluded.

Table 4
Characteristics by total assets.
Source: PATSTAT Online Autumn 2017 edition, EUIPO Open Dataset, Thomson Reuters Eikon database, Swedish Design Database, Swedish Patent Database, and Swedish Trademark Database (PRV).

Decile	Observations	Observations (%)	Total assets[a]	Tobin's q	Patent stock	TM stock	Des stock
1	49	10.06	.26	2.50	2.57	4.21	1.76
2	49	10.06	.58	2.29	6.70	8.68	1.53
3	49	10.06	1.24	2.36	8.00	11.11	2.82
4	48	9.86	2.48	1.40	4.95	12.41	1.68
5	49	10.06	5.67	1.39	12.00	13.80	2.20
6	49	10.06	19.44	1.86	76.38	49.99	12.16
7	48	9.86	29.95	1.12	79.45	58.13	7.21
8	49	10.06	43.03	2.37	100.27	51.28	12.57
9	49	10.06	76.27	1.18	182.94	75.31	19.69
10	48	9.86	608.26	.80	240.61	55.52	39.46
Total	487	100	77.89	1.73	71.16	33.99	10.07

Notes: This table displays the distribution of our data by firm size measured as total assets. n = 487 observations from n = 73 firms.
[a] Billion SEK real 2003 prices.

Table 5
Correlation matrix.
Source: PATSTAT Online Autumn 2017 edition, EUIPO Open Dataset, Thomson Reuters Eikon database, Swedish Design Database, Swedish Patent Database, and Swedish Trademark Database (PRV).

	1	2	3	4	5	6	VIFs
Tobin's q							
log Total assets	−0.349***						3.20
R&D/assets	0.271***	−0.286***					1.83
Patents/R&D	0.218***	−0.062	0.030				1.30
Citations/Patents	0.109*	0.114*	0.372***	0.121**			1.68
Trademarks/assets	0.252***	−0.424***	0.223***	0.197***	0.095*		1.68
IDRs/assets	0.321***	−0.567***	0.370***	0.068	0.077	0.343***	1.87

Notes: This table presents the Pearson correlation between our dependent and independent variables. VIFs = variance inflation factors. n = 487 observations from n = 73 firms.
* p<0.05.
** p<0.01.
*** p<0.001.

We compute the correlations among our variables of interest (see Table 5). Statistically significant correlations are denoted with asterisks. All correlations with Tobin's q are statistically significant at the 5% level. With the exception of ln(Total Assets), all the regressors show some degree of a positive correlation to Tobin's q. IDR stock, trademark stock and R&D intensity are correlated negatively to total assets. Both IDR stock and trademark stock are correlated positively to R&D intensity. Finally, IDR and trademark stocks are correlated since they follow similar patterns in terms of firm size (see Table 4). Since some of the correlation coefficients in Table 5 are above 0.3, we calculate the Variance Inflation Factor (VIF) values for all the variables to check for multicollinearity. Although total assets have a higher VIF than the other variables, all are well below the critical value of 10, which indicates no problems of multicollinearity.

4.2. Econometric results

Table 6 presents the results of the NLLS regressions. The natural logarithm of total assets has coefficients that vary between negative and positive in all the models and are significant in only two of the six models. However, there are slight indications of weak economies of scale among our firms and that larger firms are valued more highly. R&D intensity is positively related to Tobin's q in all the models. In Models 3 and 4, the coefficient is above unity. If we include R&D intensity in the regression in Model 2, R2 increases from 0.434 to 0.467 compared to Model 1. The elasticity of R&D intensity is similar to that in Rahko (2014). Sandner and Block (2011) find a considerably lower elasticity, of 2.75%, compared to the 7.50% we obtained. This elasticity can be interpreted as a 100% increase in R&D intensity has a positive impact of 7.50% on the firm's market value. Among all our independent variables, R&D intensity impacts Tobin's q the most. Swedish firms' R&D intensity is similar to that of German and French firms, but it is higher than for Finnish, Danish, UK and Italian firms (Hall and Oriani, 2006). US firms tend to outrival Swedish firms regarding R&D intensity (Hall and Oriani, 2006; Bloch, 2008; Rahko, 2014).

Patent stock is positively related to R&D stock and shows a significant Tobin's q in all the models. Our findings suggest additional gains from of patent families to R&D spendings. It seems as financial markets reward R&D efforts aimed at patentable inventions (Rahko, 2014). The positive relationship between patents based on R&D and market value, supports the idea that patents are used to commercialize products and to secure returns from R&D investments (Saracho, 2002). The patent family yield for R&D is related positively to Tobin's q, which is consistent with the findings in Rahko (2014) and Hall et al. (2005).

Our analysis does not suggest an association of patent value indicators firms' value; rather, the patent citation variable is insignificant or weakly negative which is not in line with earlier research (Hall et al., 2005; Sandner and Block, 2011; Rahko, 2014). The variable used here measures family-to-family citations whereas other studies sometimes rely on aggregate 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 information incorporated to the extent that it does not signal patent value. It might also be an indication that financial markets value absolute patent stock and tend not to distinguish between 'high' or 'low' value patents.

Trademark stock to total assets is included only in Model 6, but shows a positive and significant relation to firm value, controlling for R&D, patents and IDRs. This is in line with Sandner and Block (2011) and Greenhalgh and Rogers (2007). However, Bosworth and Rogers (2001) find no such relationship. The result could be interpreted as showing that trademarks serve a valuable function in hampering

Table 6
The effect of industrial design rights on the market value of firms.
Source: PATSTAT Online Autumn 2017 edition, EUIPO Open Dataset, Thomson Reuters Eikon database, Swedish Design Database, Swedish Patent Database, and Swedish Trademark Database (PRV).

Dependent variable:	Tobin's q					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.402***	−0.557***	−0.764***	−0.765***	−0.730***	−1.016***
	(0.0956)	(0.116)	(0.116)	(0.117)	(0.118)	(0.117)
Log Total assets	−0.0249*	0.00713	0.0208	0.0212	0.0481***	0.0834***
	(0.0139)	(0.0149)	(0.0143)	(0.0144)	(0.0177)	(0.0173)
R&D/assets		0.872**	1.049***	1.052***		0.902**
		(0.351)	(0.387)	(0.387)		(0.387)
Patents/R&D			0.00537***	0.00538***		0.00515***
			(0.000959)	(0.000959)		(0.00105)
Citations/patents				−0.00423		−0.0364***
				(0.0176)		(0.0121)
IDR/assets					0.126***	0.0777**
					(0.0352)	(0.0315)
Trademarks/assets						0.0198***
						(0.00394)
No R&D		0.150*	0.245***	0.243***		0.129*
		(0.0898)	(0.0909)	(0.0922)		(0.0775)
No patents			0.133	0.132		0.00111
			(0.105)	(0.105)		(0.102)
No trademarks						0.404***
						(0.104)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	487	487	487	487	487	487
R^2	0.434	0.467	0.510	0.510	0.479	0.560
Adjusted R^2	0.408	0.440	0.482	0.481	0.453	0.531
Elasticities						
R&D/assets		0.091***	0.095***	0.095***		0.075***
		(0.027)	(0.025)	(0.025)		(0.026)
Patents/R&D			0.082***	0.082***		0.074***
			(0.011)	(0.011)		(0.012)
Citations/Patents				−0.003		−0.026***
				(0.012)		(0.010)
IDR/assets					0.114***	0.060***
					(0.022)	(0.019)
Trademarks/assets						0.056***
						(0.010)

Notes: NLLS regressions. This table displays the effect of different knowledge assets and IPRs on the market value of firms measured as Tobin's q. A full set of year (10 categories) and industry (12 categories) dummies is included in all models. The reference group is Mining & Construction. The reference year is 2003. Robust standard errors in parentheses.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

counterfeiting, infringement and dilution of company brands (Kopp and Suter, 2000). The elasticity of trademarks in Model 6 is similar to the results of earlier studies (Greenhalgh and Rogers, 2007; Sandner and Block, 2011). The effect of trademarks on the market value of firms in Sweden seems to be in line with effects found on other European firms.

Finally, in Models 5 and 6, we include our main variable of interest, ratio of IDRs to total assets. In Model 5, we include it without other IP and R&D. The coefficient of 0.126 is strongly positive and, if interpreted as the shadow value of IDRs, indicates that one additional IDR unit is valued at SEK 126 million. This is comparable to the numbers in Sandner and Block (2011) for trademarks. In Model 6, where we control for patents, trademarks and R&D the coefficient decreases to 0.077 but remains significant at the 5% level.

To make our results comparable to previous research, we calculate elasticities with respect to Tobin's q for all the variables. We find significant elasticities for all the variables except citations to patent stock (Model 4). The elasticity of R&D goes from around 9% in Models 2, 3, and 4, to 7.5% in Model 6. This is higher than in Sandner and Block (2011) and Rahko (2014), but lower than in Hall et al. (2007). The elasticity of patent stock to R&D is of a similar magnitude in all the models. To compare models (Table 6), we use R2 values. Compared to the baseline Model 1, which includes only total assets, the R2 values increase from 0.434 to 0.510 if we include both R&D intensity and patent stock to R&D. The R2 in Model 5, which includes only IDR stock, is slightly lower, but increases to 0.560 for the full model (Model 6) which includes all the variables.

4.3. Robustness checks

To confirm the results of the NLLS regressions, we run the same models, but using a regular OLS framework.[9] Table 7 presents the results of the OLS regressions. The OLS regressions are qualitatively similar to the results for the NLLS regressions. All the signs of the coefficients are similar across both the NLLS and OLS regressions; however, citations to patent stock are not significant in any of the models, pointing, again, to a weak relationship between this variable and the market value of the firms in our sample.

[9] We also estimated the NLLS and OLS regressions on an extended dataset which includes n = 541 observations. This dataset was not adjusted for extreme outliers. The results for the NLLS using the extended dataset show no major differences from the results for the primary dataset.

Table 7
Robustness check — OLS regressions.
Source: PATSTAT Online Autumn 2017 edition, EUIPO Open Dataset, Thomson Reuters Eikon database, Swedish Design Database, Swedish Patent Database, and Swedish Trademark Database (PRV).

Dependent variable:	Tobin's q					
	(1)	(2)	(3)	(4)	(5)	(6)
log Total Assets	−0.0249*	−0.000696	0.0134	0.0130	0.0497***	0.0706***
	(0.0139)	(0.0156)	(0.0154)	(0.0157)	(0.0173)	(0.0172)
R&D/Total Assets		0.468**	0.539**	0.534**	0.464**	0.448*
		(0.230)	(0.234)	(0.240)	(0.228)	(0.235)
Patent Stock/R&D Stock			0.00213***	0.00212***	0.00212***	0.00191***
			(0.000333)	(0.000338)	(0.000293)	(0.000303)
Citation Stock/Patent Stock				0.00318	−0.00702	−0.0234
				(0.0159)	(0.0148)	(0.0145)
IDR Stock/Total Assets					0.0480***	0.0419***
					(0.0141)	(0.0133)
Trademark Stock/Total Assets						0.00902***
						(0.00172)
No R&D (dummy)		0.0810	0.139	0.140	0.153*	0.0698
		(0.0905)	(0.0907)	(0.0912)	(0.0856)	(0.0809)
No Patent (dummy)			0.105	0.106	0.0472	0.0112
			(0.106)	(0.105)	(0.104)	(0.101)
No Trademark (dummy)						0.377***
						(0.106)
Constant	−0.402***	−0.501***	−0.666***	−0.664***	−0.851***	−0.907***
	(0.0956)	(0.116)	(0.116)	(0.117)	(0.122)	(0.114)
Observations	487	487	487	487	487	487
R^2	0.434	0.460	0.498	0.498	0.521	0.549

Notes: OLS regressions. This table displays the effect of different knowledge assets and IPRs on firms' market value, measured as Tobin's q. All the models include a full set of year (10 cats) and industry (12 cats) dummies. The reference group is Mining & Construction; the reference year is 2003. Robust standard errors in parentheses.

* $p < 0.10$.

** $p < 0.05$.

*** $p < 0.01$.

5. Concluding discussion

5.1. Limitations and further research

This study serves as a first attempt to investigate the relationship between IDR ownership and firms' market value and is associated with several limitations that can be addressed in future research. Some of these limitations concerns the empirical data while others are associated with the analytical approach.

Empirically, the IPR data used include only European and Swedish coverage. Therefore, we cannot claim to have complete IPR portfolios for the firms in the study as they might own IPRs in countries outside of Sweden or the EU. However, there is little reason to expect bias in the matching process. Thus, our conclusions about the difference between and relative importance of separate IP stocks should hold. At the same time, future research would benefit from a more global scope (Alcacer et al., 2017) which would allow also for taking into account variegated jurisdictional regulations and procedures with respect to IDRs. The study is also limited to Swedish firms and Swedish stock markets. One drawback of this sample in conjunction with strictly selecting firms that owns three different types of IPR is that the number of observations drop. Using datasets with broader geographical coverage (Ghisetti et al., 2021) could allow for more robust and more fine-grained analyses. Moreover, although arguably Sweden is an interesting context due to its design-intensity, general innovativeness and the international presence of investors, attractiveness and expectations among investors may be biased. Therefore, further studies in other countries and institutional settings are necessary to validate and generalize the findings presented here. Another potential limitation of the study is the unobserved variables. We employ control variables for time, industry, IPR and R&D, but do not consider other potentially important variables such as firm size, firm age and IPR complementarity that might affect firms' market value. The set of variables we use is similar to those used in other studies in the field (Hall et al., 2005, 2007; Sandner and Block, 2011; Rahko, 2014), but using more variables in future studies is desirable.

Analytically, the market value approach introduces some simplifying assumptions. For instance, it treats knowledge assets homogenously and functionally equal, but as our findings indicate knowledge assets at least to some degree are heterogeneous. In particular this should hold with respect to R&D expenditures in relation to IPR, but potentially also between patents, trademarks and IDRs. The advantage of the market value approach is that it makes comparison of results to other similar studies that have omitted IDRs possible (e.g. Sandner and Block, 2011; Rahko, 2014; Dosso and Vezzani, 2020) fairly straightforward. However, to account for knowledge asset heterogeneity, future model specification could use a sequential specification (e.g. Crépon et al., 1998). Such an approach could also allow for analyzing an important feature highlighted in the design literature, namely between design value creation and design value capture (Åman et al., 2017; Montresor and Vezzani, 2020). Further, our study uses IDR data combined with data on patents and trademarks, but we do not analyze complementarities or compositional effects of IPR-bundles (Greenhalgh and Longland, 2005). Since IDRs may overlap with patents for some important features of technological innovations (Filitz et al., 2015), future studies could investigate how IDRs and patents are used in combination. Also, we use only IDR stocks. Future research could extend the scope of indicators to include, for instance IDR quality, such as renewals, Locarno classes and appeals.

5.2. Contributions and implications

The study reveals potential market value of IDRs and contributes to our empirical knowledge of this growing phenomenon. Our findings from the analysis of the impact of R&D intensity patents, trademarks, and IDRs of firms in a design-intensive country as Sweden with ownership of all three types of IPRs demonstrate that financial markets indeed value firms' ownership of IDRs. Our findings hold when we control for R&D, patents and trademarks. Since IDRs capture aspects of innovation not covered or protected by patents and trademarks, this supports the suggestion that IDRs offer a rich and relatively unexplored area for further research (Filitz et al., 2015). By analyzing IDRs in relation to patents, trademarks and R&D in the same dataset, we show that while R&D adds the most to market value, IDRs are (almost) on par with patents and trademarks.

The study also contributes to the theoretical understanding of design knowledge and valuation of design rights by financial markets. When compared to patents, IDRs in theory appear a relatively weak form of IPR which give rise to uncertainty regarding uncontested IDRs as a measure of firm appropriability and value capture (Filippetti et al., 2019; Filitz et al., 2015; Galindo-Rueda and Millot, 2015). This is mainly due to multiple design filings in a single application, ex post determination of novelty, and lacking enforceability when tried in court. Still, the findings of this study show that despite the uncertainty surrounding the quality of IDRs financial markets evaluate them positively.

Drawing upon our conceptual framework, we suggest three explanations to this observation. Explanations that we hope that can be further developed and tested in future research. First, a particular characteristic of IDRs as an IPR is their explicit product connection. The design of a product or service refers to ornamental, often visual, and sometimes tactile features. Such features are crucial to the appearance of the product and the emotions evoked by its user. Accordingly, IDRs operate directly in the market processes in which firms compete with their products, for instance allowing for differentiation strategies (Walsh, 1996). Compared to other IPRs, the holding of IDRs signals potential value capture closely associated with discernible product markets where firms are competing.

Second, assuming that design capability is an unobservable antecedent of IDRs, such innovative capabilities are attributable to firms competitive advantage (as expected by shareholders). While the underlying activities undertaken to allow for IDR registration have not been studied here, drawing upon the knowledge based view of the firm (KBV), our findings lend support to prior theoretical conjectures that design is a distinguishable innovative capability that firms can use to reap competitive advantage (d'Ippolito, 2014; Galindo-Rueda and Millot, 2015; Ghisetti et al., 2021).

Third, and related, underlying knowledge bases differ between IPRs. Patents are associated with underlying scientific principles and technological paradigms that can be applied in a range of products (Pavitt, 1984). Trademarks draws upon market knowledge and are used more broadly for corporate branding to appeal to customers (Castaldi, 2020). In comparison, design is more coupled with embodied aesthetic knowledge (Ewenstein and Whyte, 2007). Arguably, not only do such design capabilities important provide market value in their own right, but they may also serve an important function for firms' ability to innovate as they operate between technological knowledge (as captured in patents) and market knowledge (as measured by trademarks), allowing for "knowledge integration by design" (Åman et al., 2017).

Our findings have some implications for managers and policy makers. In practice, and on a general level, our results indicate that the firm's IPR strategy (Reitzig, 2004; Candelin-Palmqvist et al., 2012) affects shareholder value. However, research and literature on IPR management has until recently by and large been informed by what we know about patents as IPR. While recent research has added to the understanding of trademarks as IPRs and IPR strategies (Castaldi, 2020; Dosso and Vezzani, 2020), design rights to a large extent is unchartered territory. More specifically, while IDRs and patents appear similar, there are important differences both in terms of underlying knowledge base (science vs arts) as well as formal claim procedures, jurisdictions and enforceability. Accordingly, also expectations on what they can provide in terms of competitive advantage and value may differ among stakeholders. For managers, collaborators and investors, managing such expectations in accordance with the "face value" of IDRs will become increasingly important as the use of this specific type of IPR continues to grow. Similar implications should be valid also for economic policy. Additionally, while it has been argued that IDRs lends itself both as an opportunity and indicator for "low-tech" innovation (Filitz et al., 2015; Galindo-Rueda and Millot, 2015; Filippetti et al., 2019), our findings suggest a prevalence of IDRs also in allegedly "high-tech" industries.

CRediT authorship contribution statement

David E. Andersson: Writing – review & editing, Investigation, Formal analysis, Conceptualization, Methodology, Software, Writing – original draft, Supervision. **Anton Ekman:** Writing – review & editing, Conceptualization, Data curation, Writing – original draft, Investigation. **Anton Huila:** Writing – review & editing, Conceptualization, Data curation, Writing – original draft, Investigation. **Fredrik Tell:** Writing – review & editing, Conceptualization, Writing – original draft, Supervision, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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