Innovation and Firm Value Revisited: Evidence from a DCF Valuation Approach across the Entire Firm Size Spectrum

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ABSTRACT

In this study, we leverage the Discounted Cash Flow (DCF) valuation methodology to re-examine how innovation links to economic value estimates of firms, and how firm size moderates this relationship. As DCF valuation can be applied to a complete spectrum of firm sizes, ranging from small privately-held to large publicly-listed firms, our study provides more compelling evidence on the link between innovation and economic firm value across all of firm sizes. This contrasts prior studies that typically draw inferences based on market valuations of publicly listed firms. We show that innovation is not uniformly positively associated with economic value across all firm sizes. Rather, this relationship is strongly affected by firm size, with a negative moderating effect. Notably, the positive association between innovation and economic value estimates is more pronounced for small firms than for larger ones. These findings are robust to various controls, alternative operationalisations, including survey-reported innovation in the Community Innovation Survey (CIS), and a battery of robustness tests for the DCF valuation approach.

Keywords: Innovation; Economic Value, Firm Size; Discounted Cash Flow; DCF Valuation;

JEL-classification: **O34; G32**

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1. Introduction

Governments spend sizable financial resources to stimulate firms' creation of economically valuable innovations, e.g., through R&D tax credits and innovation project grants (Hall and Van Reenen, 2000; Czarnitzki, Hanel and Rosa, 2011; Dechezleprêtre *et al.*, 2020; Mina *et al.*, 2021). As resources are scarce, allocation of funds is often prioritized towards firms that can achieve relatively higher economic returns on their R&D investments and innovations. Therefore, innovation policymakers are concerned with assessing how corporate innovation associates to economic value in firms (OECD, 2019), and more relevantly, how firm characteristics moderate this relationship.

Firm size has long been one of the most debated factors thought to moderate the economic returns to innovation, as discussed in decades of literature (Schumpeter, 1942; Arrow, 1962; Cohen, 2010). Specifically, the direction of the moderating effect of size is highly contested in prior literature. Large firms have enhanced capacities to develop and extract economic value from their innovations, such as increased cost-spreading advantages (Cohen and Klepper, 1996a, 1996b), access to internal complementary assets or external licensing opportunities (Teece, 1986; Arora, Cohen and Walsh, 2016; Arora *et al.*, 2022), access to stable financing (Hall, 1990; Hottenrott and Peters, 2012), and valuable knowledge capital (Kerr and Lincoln, 2010). Yet, empirical evidence also shows that small firms develop innovations more productively, and often are of both higher qualitative and scientific value (Lerner, 2006b; Lerner, Sorensen and Strömberg, 2011; Bernstein, 2015). Prior literature examining the link between corporate innovation and economic firm value is typically limited to the segment of publicly-listed firms, citing limited availability of economic value estimates for publicly-held firms (see Cohen, 2010), despite that privately-held firms make up to about 90% of firm population[1].

In this paper, we bridge a gap in the literature by examining the relationship between innovation and firm value across the full spectrum of firm sizes, including both privately held and publicly traded firms. We do so by pioneering the use of the Discounted Cash Flow (DCF) valuation methodology in innovation research. Furthermore, we are the first to investigate how firm size moderates the relationship between corporate innovation and economic value. In line with prior literature documenting a positive link between innovation and firms' economic value (Griliches, 1981; Blundell, Griffith and Van Reenen, 1999; Toivanen, Stoneman and Bosworth, 2002; Kogan *et al.*, 2017), we predict that innovation associates positively to the economic value of both publicly-listed and (smaller) privately-held firms (Hypothesis 1). Furthermore, we argue that firm size moderates the extent to which innovation associates to the economic value of these firms (Hypothesis 2). We test these hypotheses on a sample of Belgian firms in the manufacturing industry, active during the years 2000 through 2020. In order to obtain economic value estimates of firms, we use the DCF valuation methodology[2]. Further, we capture firms' innovations through publicly available data on active granted patents, and survey-reported innovations captured through the Flemish Community Innovation Survey (CIS). Data from CIS contains a wide range of firms responses on the presence of innovation, and various other responses related to firms' innovation activities.

Our main results provide evidence that innovation is positively linked to firms' economic value estimates. Furthermore, we show that firm size negatively moderates the link

[1] Small and medium-sized enterprises (SMEs) are major contributors to the prosperity and growth of national economies, representing about 90% of businesses worldwide and about 99% of all businesses in the EU according to the World bank (see https://www.worldbank.org/en/topic/smefinance; https://ec.europa.eu/growth/smes/sme-definition_en). Furthermore, SMEs' activities account for about 50% of the economic value added in the OECD countries (OECD, 2019).

[2] The most common implementation of DCF valuation requires estimates of future free cash flows. In this study, however, we make use of DCF calculations, *in hindsight*, using actually observed free cash flows of the firm, allowing us to make use of fewer assumptions in the DCF methodology (Green, Hand and Zhang, 2016).

between innovation and firms' economic value estimates. Specifically, we show that particularly for small firms rather than for larger ones, innovation is linked to the economic value of the firm. Notably, the results are robust for alternative specifications of how we operationalise firm innovation: patented innovation-derived and survey-reported firm innovation; various operationalisations of firm size: including total assets, tangible fixed assets, and the total number of employees. Additionally, the results are robust for variations in the DCF estimation methodology, and the DCF methodology is validated using observed market valuations of publicly-listed firms in the sample, and implied target valuations from minority share stake acquisitions (<50% final stake) derived from M&A activity in the Bureau Van Dijk Zephyr database.

Our study contributes to literature in several ways: First, we pioneer the use of the DCF valuation methodology in innovation research, to estimate the economic value of firms across the entire size spectrum. As such, we are the first to document the link between innovation and economic value estimates in small and privately-held firms, since prior research is typically restricted to observations in large and publicly-listed firms (see call in Arora et al. 2022). We fill the blind spot of the economic value of innovation in privately-held firms, in a long line of empirical work examining the link between firms' innovation and their economic value (Griliches, 1981; Jaffe, 1986; Trajtenberg, 1990; Blundell, Griffith and Van Reenen, 1999; Toivanen, Stoneman and Bosworth, 2002; Hall, Jaffe and Trajtenberg, 2005; Kogan *et al.*, 2017).

Second, we leverage an economic value estimation methodology, widely established in practice (financial investment professionals) and in university curricula, and contribute to literature examining the value of innovation in small firms by relying on various proxies. For instance, firm revenues (Crepon, Duguet and Mairesse, 1998; Lööf *et al.*, 2001; Hashi and Stojčić, 2013), firm survival probability (Mowery, 1983; Cefis and Marsili, 2006), or firms' credit ratings (Czarnitzki and Kraft, 2004); and indicators of scientific value such as patent citation counts or novelty (Lerner, 2006a; Lerner, Sorensen and Strömberg, 2011).

Lastly, we contribute to the long strand of literature examining how size influences firms' ability to extract financial benefit from their innovations (see review in Cohen, 2010). Evidence in Arora *et al.* (2022) suggests that innovations originating from larger firms are more economically valuable than innovations from smaller firms, on average. However, this notion provides limited insight into the marginal contribution of innovation, across small and large firms. Furthermore, the authors in Arora *et al.* (2022) point out that their empirical approach relies only on observations from publicly listed firms, and call for validation studies examining the link between innovation and economic value in small and privately-held firms.

The remainder of the paper is organised as follows: in the following section, we describe relevant literature and develop our two main hypotheses; Section 3 discusses our empirical methodology; we present our main results, robustness tests and sensitivity tests in section 4; and we conclude the study in section 5.

2. Background Literature and Hypotheses

The positive link between innovation and firms' economic value is robustly observed over the past decennia for large and publicly-held firms, typically using hedonic value regressions[3]. In such analyses, one of the most widely adopted proxies for firm innovation is derived from patent data. Specifically, patented inventions constitute, on the one hand, novel and inventive steps with industrial applicability and, on the other hand, costly legal exclusive rights to facilitate the commercialisation of the underlying invention. As such, patents closely mirror the paradigm that innovation is the commercialisation of invention.

[3] Typically, an operationalization of firms' market valuation, such as Tobin's Q (ratio of market value over the book value of the total assets) is used.

Griliches (1979, 1981) pioneered the large-scale use of patent data to evaluate the link between innovation and firms' economic value, and shows that patent counts, proxying for innovative output, associate significantly to the market value of publicly listed firms. Citation counts of patents are furthermore shown to contain incremental explanatory power for listed firms' market valuation (Jaffe, 1986; Trajtenberg, 1990; Toivanen, Stoneman and Bosworth, 2002; Hall, Jaffe and Trajtenberg, 2005). More recent work shows the presence of significantly positive abnormal market reactions at the moment of publication of new patent applications and patent grants. Such market reactions are hence indicative of the economic market value of the patented invention itself (Kogan *et al.*, 2017). A notable exception is a study that examines the link between firms' economic value and innovation derived from other sources than patent data is Blundell, Griffith and Van Reenen (1999). The authors find a robust and statistically significant positive relation between market share, stock market value and counts of 'technologically significant and commercially important' innovations, as tracked by the U.S. Science Policy Research unit (SPRU).

Small firms, in contrast, are typically privately-held and often lack an observable economic valuation. Studies that examine the economic benefits of innovation in small firms consequently resort to proxies of financial performance: firstly (1), short-term measures such as total revenues (Crepon, Duguet and Mairesse, 1998), or innovation-related revenues reported in survey evidence (Klomp and Van Leeuwen, 2001; Lööf *et al.*, 2001; Lööf and Heshmati, 2006; Hashi and Stojčić, 2013). These studies typically report a significantly positive association between innovation and financial returns. Secondly (2), measures that provide an indication of the more long-term economic benefits of innovation. For instance, Mowery (1983) and Cefis and Marsili (2006) find a significantly positive link between small firms' innovation activities and survival probability. Czarnitzki and Kraft (2004) further show that innovation activities are statistically significantly positively related to firms' credit ratings.

We extend the hypothesis from prior literature—that innovation is positively associated with firm economic value—by explicitly examining this relationship across the entire firm size spectrum. Our use of the DCF valuation approach enables us to assess the economic value of both publicly listed and privately held firms. Accordingly, we formulate our first hypothesis as follows:

H1: *Innovation is positively associated with the economic value of firms across the entire size spectrum.*

For our second hypothesis, we are interested in how firm size affects the link between innovation and the economic value of firms. There is ongoing and substantial debate in the literature about how firm size moderates the relationship between innovation and a firm's economic value (Cohen, 2010; Akcigit and Kerr, 2018; Arora *et al.*, 2022; Stoffman, Woeppel and Yavuz, 2022). A prevalent argument for a stronger link between innovation and economic value in large firms stems from the embodiment assumption, which posits that economies of scale and cost-spreading advantages enable larger firms to derive greater financial returns from innovation (Cohen and Klepper, 1996b, 1996a). Specifically, the mechanisms that manufacturing firms commonly use to protect the profits generated by their innovations are often highly scalable across total output. These include, for example, well-developed supply chain infrastructures that support first-mover advantages, established legal teams that safeguard corporate secrecy measures (Cohen, Nelson and Walsh, 2000), and other complementary assets such as marketing channels and financial planning teams (Teece, 1986; Levin *et al.*, 1987). Besides economies of scale, empirical evidence from the pharmaceutical sector suggests that economies of scope particularly benefit large firms to profitably develop innovations. Specifically, large firms with a broad scope of distinct research projects are substantially more productive in drug discovery due to internal knowledge spill-overs (Henderson and Cockburn, 1996; Cockburn and Henderson, 2001).

Notably, the embodiment assumption need not be confined to firms' internal capabilities. Access to external markets for technology—such as the out-licensing of innovations—also enables firms to extract greater financial returns from their innovations. Arora, Cohen and Walsh (2016), and Arora *et al.* (2022) demonstrate that more developed external technology markets (i.e., sectors with a higher prevalence of technology licensing) are associated with greater economic value of innovations. Moreover, these authors emphasize that large firms typically have more developed access to such markets, enabling them to derive substantially greater financial benefits from their innovations—a dynamic that reinforces the argument that firm size strengthens the innovation–value relationship.

Another argument resides in the observation that large firms have advantages in securing financing for high risk/return R&D projects, or have increased access to stable and internally generated funds. Hall (1990) shows that substantial corporate restructuring events that increase leverage are significantly linked to decreases in R&D activity for a sample of U.S. manufacturing firms. Furthermore, financial constraints are amongst the most frequently cited barriers that hamper innovation development within a firm (Pellegrino and Savona, 2017; Bloom, Van Reenen and Williams, 2019; Dechezleprêtre *et al.*, 2020; Stoffman, Woeppel and Yavuz, 2022). Arguably, larger firms have increased access to funds or have more stable access to financing, and can initiate innovation projects with higher risk/reward levels leading to more economically valuable innovation outcomes.

Large and established firms are also shown to be better able to attract high quality personnel than small firms (Kerr and Lincoln, 2010; Vinokurova and Kapoor, 2020). Particularly by an increased ability to offer benefits such as, e.g., higher pay, job security, promotion opportunities, qualitative resources and equipment, the opportunity to collaborate with other talented individuals and scientists (Bennett and Levinthal, 2017; Popkin, 2019; Roach and Sauermann, 2023). Elevated levels of knowledge capital are robustly shown to associate positively to innovative performance outcomes, and the scientific and economic value of innovation (Cohen and Levinthal, 1990; Cassiman and Veugelers, 2006; Frenz and Ietto-Gillies, 2009; Roper, Love and Bonner, 2017).

However, there are also counterarguments suggesting that the link between innovation and economic value may be stronger in smaller firms. A commonly cited rationale is the decreasing marginal productivity of R&D projects, which implies that smaller firms may achieve higher returns on their innovative efforts. Specifically, if firms of different sizes face a similar set of R&D projects, larger firms will realize a lower average return per unit of R&D investment since they have the capacity to profitably undertake innovation projects further down the marginal productivity schedule as compared to smaller firms (Cohen and Klepper, 1996a, 1996b; Cohen, 2010). Empirical evidence further shows that small firms are more productive in terms of innovation counts and their scientific and economic importance. For instance, Lerner (2006) shows that small firms in the financial sector account for the majority of innovations that were covered by the Wall Street Journal. Bernstein (2015) further shows that after Initial Public Offerings (IPOs) on the stock market, novelty of firm innovation decreases by approximately 40% and innovation efforts shift towards more conventional and incremental projects. Analogously, firms that are taken out of the public market, through Leveraged Buy-Outs (LBOs), develop patented inventions that are cited significantly more often (Lerner, Sorensen and Strömberg, 2011).

Lastly, large firms often experience higher degrees of bureaucracy and hierarchy, stifling innovation activities (Schumpeter, 1942; Sah and Stiglitz, 1988). Coordination costs and agency issues rise disproportionately with firm size due to diminishing returns to the managerial function. Holmstrom (1989) shows that increased agency costs lead to decreased innovation counts. Furthermore, management in larger firms tend to focus disproportionately on developing incremental innovations and improving existing product versus expansion, arguably due to limitations in managerial scope (Lucas, 1978; Henderson, 1993).

Given that arguments from literature support both directions of the moderating effect of firm size on the extent that innovation associates to economic value, we formulate our second hypothesis non-directionally:

H2: *The association between innovation and firm value varies by firm size*

3. Empirical approach

Regression model

To examine covariates of firms' economic value, we use a hedonic regression specification of the Cobb-Douglass model[4], in line with prevalent prior literature examining the link between firm innovation and their economic value (Griliches, 1981; Toivanen, Stoneman and Bosworth, 2002; Hall, Jaffe and Trajtenberg, 2005). We estimate the economic value of a firm in function of its innovations and the size of the firm. The current present economic value of a firm should, namely, be reflective of its size and of the expected success of its innovations.

For our main analyses, we operationalize firms' economic value ($Value$) as the natural log of the valuation obtained through the DCF methodology (see discussion of the DCF valuation methodology further). Firm innovation ($Innovation$) is captured as the natural log of the total count of patented inventions. Since not all firm innovations are patented, we perform

[4] Notably, Griliches (1981) uses the Cobb-Douglass function to estimate the economic value of firms in function of their conventional assets (e.g., plant, equipment, financial assets) and their knowledge assets (stock of patents). Specifically, firm value (V) is estimated in function of their (T) and knowledge capital (I), controlling for a scale component (σ) assumed to approximate unity, and a valuation coefficient (q) as follows: $V(T, I) = qT^{\sigma-\alpha}I^{\alpha}$. Subsequently, log-linear transformation is used to obtain an additive model: $\log(V) = \log(q) + (\sigma - \alpha)\log(T) + \alpha\log(I)$.

robustness testing using survey-reported evidence of firm innovation using data from the Flemish Community Innovation Survey[5] (CIS). For the variable firm size ($Firm\ Size$), we use the log total assets of the firm. Additional robustness tests are in place using the log total number of firm employees, and the log total tangible fixed assets of the firm. Additionally, we include control variables ($\sum controls$) to control for various effects, such as firm age, debt/equity ratio, and the presence of a corporate group. Lastly, we include fixed effect controls ($\sum FEs$) at the year level (year FEs), two-digit industry NACE Rev. 2 level (industry FEs), and at the firm-level (firm FEs). Formal definitions for all variables can be found in Appendix Table A1.

For our first hypothesis, we are interested in examining the link between innovation and the economic value of firms. Hence, we estimate regression equation (1). Analogously for our second hypothesis, we are interested in the moderating effect of firm size on the link between innovation and economic firm value, and estimate regression equation (2) where firm size is interacted with firm innovation.

$$Value = \beta_0 + \beta_1 Innovation + \beta_2 Firm\ Size + \sum controls + \sum FEs + \varepsilon \tag{1}$$

$$\begin{aligned} Value = \beta_0 + \beta_1 Innovation + \beta_2 Firm\ Size + \beta_3 Innovation \times Firm\ Size \\ + \sum controls + \sum FEs + \varepsilon \end{aligned} \tag{2}$$

Discounted Cash Flow (DCF) Valuation Methodology

To estimate the value of all firms (privately-held as well as publicly listed), we make use of the Discounted Cash Flow (DCF) methodology. This methodology is a framework[6] to assess the value of investments based on their future returns. Furthermore, the present value of

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[5] See our discussion in the robustness section.
[6] A comprehensive survey of the DCF methodology can be found in Parker (1968), and a study of its use and pitfalls by financial analysts can be found in Green, Hand and Zhang (2016).

the future returns is obtained by applying a discount rate (i.e., the cost of capital). The DCF methodology is widely employed in, first of all, plethora of university-level curricula in the fields of financial valuation and corporate finance given its validity and theoretical rigour (Imam, Barker and Clubb, 2008; Heinrichs *et al.*, 2013; Green, Hand and Zhang, 2016), and secondly, in practice by investment professionals and regulators given its accuracy and robustness in comparison to proxy or valuation methods using a financial multiple such as Return on Assets (ROA) or Equity (ROE) (Demirakos, Strong and Walker, 2010; Patatoukas, Sloan and Zha, 2015).

In particular, we estimate firms' DCF value in hindsight, using the actual observed free cash flows of the respective firms up to the latest observation. In order to calculate the DCF value of privately-held firms, we require two elements: a firm's *free cash flows* (A), representing the cash generated after accounting for outflows to maintain operations; and the appropriate discount rate i.e. the *cost of capital* (B), representing the required rate of return for incurring the idiosyncratic risk of investing in the operations of the firm.

We (A) obtain firms' Free Cash Flows (FCFs) using the following methodology: the FCF of a firm in a year can essentially be calculated as the Earnings Before Interest and Taxes (EBIT) minus the income tax (Tax) plus the depreciation and amortisation (D&A) minus the capital expenditures (CAPEX) and minus the change in working capital (ΔW) (Green, Hand and Zhang, 2016). The FCF calculation methodology is formally described in Appendix Table A2.

To estimate (B) the Cost of Capital (COC), we follow the intuition of the production-based asset pricing model, developed in (Cochrane, 1991, 1996). Notably, the model was further validated and deemed to be applicable to estimate the COC for privately-held firms in a production economy/manufacturing sector (Liu, Whited and Zhang, 2009; Cooper and Priestley, 2016; Zhang, 2017). In essence, the production-based asset pricing model uses producers' first order conditions to investment demand: assuming that producers have access to financial markets, producers will source financial capital to invest in their firm up until the marginal cost of capital is equal to the marginal return on invested capital of the firm (first order condition).

Ultimately, COC can be estimated using firms' return on invested capital (Cooper and Priestley, 2016). The Belgian context, however, does not allow for an exact replication or calibration of the methodology to estimate the COC using market data (few Belgian manufacturing firms are publicly-listed). Hence, we rely on the median return on invested capital observed Belgian manufacturing industry, by industry and year, as presented in Appendix Table A3. Here, we observe that the estimated COC for Belgian manufacturing firms ranges in the median between 5.2% and 17.1%. The observed cost of capital estimates are in line with estimations of the cost of capital for privately-held firms in Cooper and Priestley (2016), and the perceived cost of capital rates for publicly-listed firms (Gormson and Huber, 2023).

Notably, the DCF valuation methodology is subject to various assumptions in its estimation procedure and likely sensitive to these. As such, we implement various robustness tests related to the hyperparameters in the Appendix. we include robustness tests for the following: (1) exclusion of the terminal DCF component; (2) three-year forward rolling DCF calculations instead of using all observations up to the last observed one; (3) variations in the terminal growth rate; and (4) variations in the COC calculation (Gormson and Huber, 2023), and a default COC of 10%. Furthermore, we include validation tests of the DCF calculation using publicly listed Belgian manufacturing firms and assess the explanatory power of the DCF estimation - including variations in the estimation methodology - for firms' observed market valuations.

Data

To conduct our analyses, we use data from several sources. Firstly, we obtain financial statement data of Belgian firms from Moody's Analytics (Historical financial statements from Bureau Van Dijk Orbis Global and Belfirst). Here, we obtain historical balance sheet and income statement data for both publicly-held and privately-held firms. Secondly, we link Belgian firms' financial data to patent data using the Orbis IP database, allowing us to obtain historical data on the number of active granted patents, and link the patent data further to the worldwide Patent Statistical Database (PATSTAT) to retrieve patent portfolio characteristics for further sensitivity testing.

Table 1 reports the sample selection procedure. We initially start out with the set of Belgian manufacturing firms active during the years 2000 to 2020 (287,734 firm-year observations). Subsequently, we exclude 42,098 observations with a negative DCF valuation. Negative DCF value observations are excluded since these constitute instances where the DCF valuation methodology arguably fails to accurately capture the economic value of the firm (limited liability suggests that firms' economic value cannot be negative). Notably, we include robustness tests in the Appendix where observations with negative DCF value are kept in the analyses and their value replaced by zero (Appendix Table B8). Lastly, we exclude 115 observations with missing values for any of the variables. We obtain a final regression sample of 243,266 observations (28,266 unique firms). We observe a non-empty patent portfolio for 16,722 observations of the final sample.

<<<INSERT TABLE 1 ABOUT HERE>>>

Descriptive statistics for the regression sample is shown in Table 2. The mean DCF value of firms in regression sample amounts to EUR 11.11 million (median 1.7 million). Notably, the observed Cost of Capital (COC) for firms in our sample ranges between 4-16%, closely mirroring cost of capital estimates for privately-held firms (Cooper and Priestley, 2016) and the perceived cost of capital rates of publicly-listed firms (Gormson and Huber, 2023). The total assets account of observations in our sample account on average for EUR 6.05 million (median 0.91 million), suggesting that the economic value of firms (DCF value) is on average higher than the value of firms recorded by total assets in financial statements. We further observe that firms in the final regression sample have on average 21.46 (median 6) employees, suggesting the bulk of the sample concerns micro and small-sized companies. Since we only observe a non-empty (active & granted) patent portfolio for about 6.9% of the sample (16,722/243,266), the descriptive statistics of the patent-related variables are highly skewed.

<<<INSERT TABLE 2 ABOUT HERE>>>

Additionally, we present the Pearson correlations for the relevant regression variables in the final sample in Table 3. We observe that the patent portfolio size (innovation proxy) correlates significantly positively with firms' economic value estimate (DCF valuation).

<<<INSERT TABLE 3 ABOUT HERE>>>

4. Results

Main Analyses

We present the main regression results for the first hypothesis (H1) in Table 4. The results show that firm innovation (proxied by the natural log of the total patent count, i.e., $Patents$) is a positive and statistically significant covariate for the economic value of firms. Specifically, the link between innovation and firms' economic value estimate appears robust for the inclusion of various fixed effect controls (column 3: Patents coefficient = 0.0779, $p < 0.01$), proxy controls for firm size using tangible and intangible fixed assets (column 4: Patents coefficient = 0.0391, $p < 0.1$), and the employee count (column 5: coefficient Patents = 0.0442, $p < 0.1$). However, the variable $Patents$ loses its statistical significance when using the total assets as a proxy for firm size (columns 6 and 7). The absence of a significant effect when controlling for size using total assets may suggest that the association between innovation and firm value is not uniform, but instead differs across firm size categories.

<<<INSERT TABLE 4 ABOUT HERE>>>

We delve deeper into the moderating role of firm size in the relationship between innovation and firms' economic value estimates. In Table 5, we include interaction terms between firm innovation and various proxies for firm size to examine our second hypothesis (H2). The coefficient of the variable $Patents$ is positive and statistically significant in all specifications with firm size proxies and interaction terms included. For instance when we use total assets as a proxy, the main test variable $Patents$ is significantly positively related to firm value (column 3: coefficient Patents = 0.5772, $p < 0.01$) and the coefficient of the interaction term $Total\ Assets \times Patents$ is negative and statistically significant (column 3: coefficient Patents x Total Assets = -0.0334, $p < 0.01$). The results using other specifications of firm size are fully in line with this finding, suggesting that firm size negatively moderates the link between innovation and firm value. Further robustness tests including several additional control terms, e.g., the debt/equity ratio, firm age, intangible assets, and group membership, are also in line with our main findings (Appendix Table B3 and B4).

<<<INSERT TABLE 5 ABOUT HERE>>>

To further assess whether the link between innovation and economic firm value is stronger for small firms than for larger firms, we implement split sample analyses in Table 6. Here, we split the sample above and below both the median and mean total assets. We estimate specifically the regression equation (1) excluding and including a proxy for firm size (total assets). We find that firm innovation is positively and statistically significantly related to economic firm value only in the subset of small firms. Specifically, the coefficient for variable $Patents$ is positive in the subset of observations where the total assets is below the median observed total assets of EUR 0.91 mil (column 1: coefficient Patents = 0.2504, $p < 0.05$) and below the mean observed total assets of EUR (column 5: coefficient Patents = 0.2343, $p < 0.01$). Further split sample robustness tests, using sample quintiles, show that innovation is linked to firms' economic value particularly in the smallest size quintile (Appendix Table B1 and B2).

<<<INSERT TABLE 6 ABOUT HERE>>>

Validation of the DCF Valuation Approach

The DCF methodology is subject to various assumptions. Hence, we test how sensitive our results are to variations in the specifications of the DCF estimation methodology. Firstly, the DCF estimation methodology can produce negative valuation estimates for firms. Since the limited liability paradigm restricts the economic value of firms to be bound by zero, we include robustness tests where we include the observations with a negative DCF value (excluded in the main regression sample, see Table 1) and replace all negative DCF values with a zero (log(1)). Appendix Table B5 shows the main regression results including the negative DCF value observations. The results are fully in line with the results in Table 5: the coefficient of the main test variable $Patents$ is positive and statistically significant (column 3: coefficient Patents = 2.905, $p < 0.01$), and the coefficient of the interaction effect $Patents \times Total\ Assets$ is negative and statistically significant (column 3: coefficient Patents x Total Assets = -0.1715, $p < 0.05$).

Secondly, we include robustness tests of our main results using variations in the DCF estimation methodology in Appendix Table B6. Specifically, we test the sensitivity of our results to the following variations instead of the original DCF valuation: (column 1) the DCF valuation excluding the terminal component term; (column 2) the DCF valuation at a three-year forward rolling window - instead of the full hindsight estimation using all observed FCFs; (column 3) column 2 excluding the terminal component; (column 4) the DCF valuation using a 1% terminal growth rate; (column 5) the DCF valuation using a 5% terminal growth rate; (column 6) the DCF valuation using the two-digit industry median estimated COC; (column 7) the DCF valuation using the two-digit industry median ROE as COC; (column 8) the DCF valuation using a default 10% as the COC. Notably the results relevant for hypothesis 1 and 2 remain unchanged.

Thirdly, we perform validation tests of the DCF valuation methodology assessing its explanatory power for observed market valuations, in Appendix Table B7. Specifically, we restrict the sample to only include observations of publicly-listed firms and regress the natural log of the market value of the firm in function of the natural log of the DCF valuation[7]. We incorporate all variations in the DCF estimation methodology as discussed in the paragraph above, including firm and year fixed effects. We find that the estimated DCF valuations have statistically significant explanatory power in firms' market valuations, suggesting the validity of the DCF estimation as a measure of firms' economic value.

Lastly, we perform validation tests of the DCF valuation methodology, assessing its validity using observed valuations from minority share acquisitions, in Appendix Table B8. Specifically, we link the sample to observations of minority share acquisitions (<50% final stake), recorded in Bureau Van Dijk's Zephyr database logging M&A activity across both

[7] Specifically, we estimate the following equation: $\log(Market\ Value + 1) = \log(DCF\ Value + 1) + \sum FE + \varepsilon$

publicly-held and privately -held firms. Notably, we estimate the natural log of the implied target valuation of the firm in minority share transactions (a market transaction-based valuation of a firm) in function of the natural log of the DCF value estimation[8], including firm and year-fixed effect controls. We notably include several variations of the DCF estimation methodology as discussed in the prior sections, and find that economic value estimations derived from the DCF valuation methodology contain significant explanatory power for firms' valuations as shown by implied target valuations in minority share transactions. Both the validation tests using the market valuations of publicly-listed firms and the implied target valuations in minority share transactions in M&A activity suggest the validity of the DCF valuation methodology as a measure of firms' economic value.

Robustness analyses using Community Innovation Survey (CIS) data

Since not all firm innovation is captured through patents, inferences based solely on patent data may lead to biased results. Hence, we introduce validation tests for the innovation measure using survey-reported evidence of firm innovation. Specifically, we use historical data from the Flemish Community Innovation Survey (CIS). The CIS is commissioned on a biannual basis by the European Commission (Eurostat) since the early 90s, in order to map the innovation activities of European firms on a scale much broader than patented innovation. In CIS, firms are surveyed about the presence of innovation activities without restriction to patented innovations. We make use of the Flemish CIS that is administered by the Center for R&D Monitoring (ECOOM[9]) since 2005, such that the respondents in the survey are identifiable and linkable to their relevant financial statement information.

[8] Specifically, we estimate the following equation : $\log(Implied\ Target\ Value + 1) = \log(DCF\ Value + 1) + \sum FE + \varepsilon$

[9] See https://www.ecoom.be/nodes/cisenrd/en

Instead of using the natural log of the total patent count of the firm, reliance on CIS data allows for the use of binary indicators of the presence of innovation (product- or process-related innovation). Specifically, we operationalise the $Innovation$ variable discussed in the empirical model section of our paper using the CIS variable $Innovation$. Furthermore, respondents of the Community Innovation Survey were additionally asked to indicate whether they engaged in innovation projects that were later abandoned or aborted (CIS: $Aborted\ Innovation$), or innovation projects that were not completed but still ongoing at the time of the survey response (CIS: $Ongoing\ Innovation$). These variables allow for relevant counterfactual controls for the indicators for innovation in our tests. Formal variable definitions can be retrieved in Appendix Table A1.

In Appendix Table C1, we show the sample selection procedure for the CIS sample. We start out with an initial set of firm-CIS wave observations of 9,073. The CIS are collected biannually, in the years 2005, 2007, 2009, 2011, 2013, 2015, 2017 and 2019. We exclude 1,258 observations with a negative DCF value and 3,338 observations where any of the relevant values were missing. We obtain a final regression set of 4,477 observations (2,433 unique firms). Here we observe a non-empty patent portfolio in 1,228 observations, whereas we observe a CIS-reported innovation in 2,916 observations. We observe the presence of CIS-reported firm innovation in about 65% of the instances, whereas only 27.43% of the observations concern patented innovations. This supports the notion that not all innovations are patented and suggests that relying on patent data, solely, results in an underrepresentation of true counts of firm innovation. Descriptive statistics (Appendix Table C2) and the correlation structure (Appendix Table C3) are in line with those of the main regression. Firms in the CIS regression sample appear to be larger on average (mean Total assets of 6.049 EUR mil. in main sample, vs. 16.145 EUR mil. in CIS sample), and have more patented innovations on average (percentage of observations with an active patent portfolio: 6.83% in main sample, vs. 27.43% in CIS sample).

The robustness tests of Hypothesis 1 using the CIS sample are somehow in line with those of the main tests, as can be seen in Appendix Table C4. The coefficient for CIS-reported innovation is positive and statistically significant when controlling for industry and year FEs (column 2: coefficient Innovation = 0.9534, $p < 0.05$). However, the statistical significance of the main test variable disappears when including firm fixed effects (column 3) and control variables for size (columns 4,5, 6 and 7). Again, the absence of a significant effect when controlling for size could suggest that the relationship between innovation and firm value is not uniform, but instead varies across firm size categories.

Further robustness tests of Hypothesis 2 using CIS data are shown in Appendix Table C5. We find statistically significant evidence that firm size is a negative moderator for the link between firm innovation and firm value. Notably, the coefficient of the main test variable $Innovation$ is positive and statistically significant (column 3: coefficient Innovation = 0.7368, $p < 0.1$), and that of the interaction term $Innovation \times Total\ Assets$ is negative and statistically significant (column 3: coefficient Innovation x Total Assets = -0.0.490, $p < 0.05$), with regression estimations including fixed effect controls at the year and firm-level. We include further robustness tests by making use of counterfactuals for the presence of innovation. Specifically, in Appendix Table C6 we restrict our analyses to observations where we observe CIS-reported innovations, aborted innovations or ongoing innovations. Furthermore in Appendix Table C7, we restrict our sample to only include observations with a CIS-reported innovation or aborted innovation. The findings using the counterfactual restricted samples are fully in line with our main findings for our second hypothesis.

Sensitivity analyses related to innovation novelty

Lastly, we evaluate the sensitivity of our results to heterogeneity in the type of innovations, specifically related to the degree of novelty of the innovations. Specifically, small firms are often credited with pursuing more novel and radical innovation, whereas larger firms are thought to pursue particularly more incremental types of innovation. Hereto, we execute robustness tests including parameters proxying for the degree of novelty of the innovations[10].

Firstly with respect to the main regression sample, we include novelty scores and interaction terms based on patent novelty scores introduced in Verhoeven, Bakker and Veugelers (2016) to assess how sensitive our results are to the inclusion of novelty measures for the patented innovation in Appendix Table D1. The main results appear not to be driven by heterogeneity in the degree of novelty in the patent portfolios. With respect to the robustness tests using CIS-data, we proxy for the novelty of the degree of novelty of the self-reported innovations by introducing controls for the presence of government-supplied funding and financing for innovation, since such funds are typically awarded competitively and for more novel types of innovation in Appendix Table D2. Notably, the regression results show that our findings are not driven by heterogeneity in the degree of novelty of innovations in small and large firms.

5. Conclusion and limitations

In this study, we apply the Discounted Cash Flow (DCF) methodology to estimate the economic value of both publicly listed and privately held manufacturing firms, covering the full firm size spectrum, including micro-, small-, and medium-sized firms. We find that innovation is positively and significantly associated with economic value, but this relationship is significantly negatively moderated by firm size—innovation contributes more strongly to the

[10] We estimate (1) $Value = \beta_0 + \beta_1 Innovation + \beta_2 Firm\ Size + \beta_3 Novelty\ Score + \sum controls + \sum FEs + \varepsilon$, and (2) $Value = \beta_0 + \beta_1 Innovation + \beta_2 Firm\ Size + \beta_3 Novelty + \beta_4 Novelty \times Innovation + \sum controls + \sum FEs + \varepsilon$, respectively.

economic value of smaller firms than of larger ones. Additional analyses show that the positive association between innovation and firm value persists only within the smallest size quintile.

Our findings are in line with the strand in the literature suggesting that the link between innovation and economic value may be stronger in smaller firms (as opposed to larger firms). Lerner (2006) shows that the majority of innovation covered in the financial sector originated from small firms. Bernstein (2015) examines firms' Initial Public Offerings (IPOs) since these are size-increasing, and shows that firms decrease their innovation output rate following an IPO. Lerner, Sorensen and Strömberg (2011) further show that firms taken out of the public market, i.e., decrease in size, develop inventions of higher scientific value.

Our study is of relevance to policymakers allocating financial incentives to firms, across the entire size spectrum, to stimulate the development of economically valuable innovation. Specifically, we are the first to examine the link between innovation and company valuations across the entire firm size spectrum, and show that size negatively and statistically significantly moderates the extent to which innovation links to economic value. Our findings suggest that the marginal contribution of innovation to economic value appears more substantial in small firms than in larger firms, implying that higher marginal economic returns to innovation are achieved in small firms compared to larger ones.

Our study is subject to several limitations. First of all (1), DCF valuation methodologies are rarely used in empirical academic contexts. Although the general methodology is widely agreed upon (i.e., the discounting of Free Cash Flows), empirical limitations and a substantial number of assumptions is required to obtain economic value estimates. These limitations should be kept in mind when interpreting the results of this study. Although we perform several robustness checks, validation tests and sensitivity testing, further empirical adoption of the DCF methodology is arguably warranted to assure a more exhaustive validation of the approach.

Secondly (2), firms are reluctant to develop or implement innovations that might be unprofitable such that our sample contains an overrepresentation of economically valuable innovations. It is therefore difficult to substantiate the claim that any innovation is positively related to the economic value of firms. Some concern can be alleviated by the inclusion of firm-specific fixed effects, since these can accommodate some unobserved heterogeneity. Specifically, firm-fixed effects address to an extent omitted variables at the firm-level that are time-invariant. We additionally include robustness tests using data from the Community Innovation Survey (CIS), where we can use firms with aborted or ongoing innovation projects as a more appropriate counterfactual for examining the association between innovation and economic firm value. Notably, our main results remain largely unchanged in these robustness tests.

Thirdly (3), our sample consists of Belgian manufacturing firms due data availability and relevant assumptions in the DCF valuation methodology (production economy). As such, it is unclear how and to what extent our results are generalizable to settings other than manufacturing sectors, such as service-oriented sectors. Here, firms might operate under substantially different environments that could affect the conditions to invent, or commercialise innovations due to different institutional frameworks (sectorial conventions in the commercialisation process of inventions, enforceability of Intellectual Property (IP) regulations and legislation, competition, …).

We pioneer the use of the DCF methodology, in academic research on the economic value of innovation to firms, to obtain economic value estimates for a broad spectrum of manufacturing firms, including publicly-listed and privately-held firms. We show, for both large and small privately-held firms that innovation is significantly positively linked to firms' economic value. Notably, we show that firm size significantly negatively moderates this link, suggesting that innovation is more closely tied to economic value in small firms than large firms. Prior literature examining how innovation associates to the economic value in firms and how firm size moderates this link, have typically resorted to either the subset of publicly listed firms, or to proxies of the economic value of innovations (patents' citation counts, measures of novelty). The results of this study bridges the gap between both strands, and is the first to provide empirical evidence on the economic value of innovation in small firms, and how size moderates the innovation-value link in a representative sample of firms.

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Tables

Table 1 Sample selection procedure

	Less	Total observations (unique firms)	Total observations with patent (unique firms)
Belgian manufacturing firms active between 2000 and 2020		287,734 (30,871)	20,418 (1,492)
Less observations with negative DCF value	-42,098	245,636 (28,269)	16,779 (1,392)
Less observations with missing values for any of the variables	-115	245,521 (28,266)	16,772 (1,392)
Final sample		245,521 (28,266)	16,772 (1,392)

Table 2 Descriptive statistics

Variable	N	Mean	SD	Min	P25	P50	P75	Max
DCF Value (EUR mil.)	245,521	11.108	29.268	0.057	0.595	1.701	5.789	157.74
DCF Value	245,521	14.497	1.799	10.952	13.296	14.347	15.571	18.876
DCF Main Component (EUR mil.)	245,521	1.538	4.175	-0.237	0.072	0.237	0.779	22.482
DCF Terminal Component (EUR mil.)	245,521	4.762	12.806	-0.471	0.179	0.675	2.478	68.947
Cost of Capital (CoC) estimation	245,521	0.077	0.012	0.04	0.064	0.079	0.086	0.155
Total Assets (EUR mil.)	245,521	6.049	16.191	0.066	0.348	0.91	2.857	86.875
Total Assets	245,521	13.947	1.674	11.098	12.761	13.721	14.865	18.28
Tangible Fixed Assets (EUR mil.)	245,521	1.219	2.975	0.002	0.063	0.236	0.752	15.772
Tangible Fixed Assets	245,521	12.307	1.954	7.767	11.051	12.373	13.53	16.574
Intangible Fixed Assets (EUR mil.)	245,521	0.044	0.163	0	0	0	0.003	0.926
Intangible Fixed Assets	245,521	3.28	4.784	0	0	0	8.039	13.739
Employees (no logscale)	245,521	24.939	55.156	1	2	6	17	288
Employees	245,521	2.194	1.287	0.693	1.099	1.946	2.89	5.666
Firm Age	245,521	21.457	16.445	1	10	18	29	157
Debt/Equity	245,521	2.94	6.01	-11.172	0.567	1.574	3.743	26.43
Group	245,521	0.011	0.104	0	0	0	0	1
Listed	245,521	0.003	0.054	0	0	0	0	1
Patents (no logscale)	245,521	1.564	52.062	0	0	0	0	5,336
Patents	245,521	0.081	0.454	0	0	0	0	8.582
NR Novelty score	245,521	0.05	0.117	0	0	0	0	0.8
NTO Novelty score	245,521	0.15	0.211	0	0	0	0.333	0.875

Notes:
- Winsorization is applied at the 2.5-97.5% levels for all variables (except group and patent-related variables due to high skewness).
The results of the analyses remain unchanged without winsorization and at different levels (1-99%, 5-95%).
- Variable definitions can be found in Appendix Table A1.

Table 3 Correlation structure (N=245,521)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) DCF Value											
(2) Total Assets	0.83*										
(3) Tangible Fixed Assets	0.76*	0.78*									
(4) Employees	0.71*	0.83*	0.67*								
(5) Intangible Fixed Assets	0.34*	0.37*	0.30*	0.36*							
(6) Firm Age	0.26*	0.35*	0.23*	0.33*	0.04*						
(7) Debt/Equity	0.04*	0.03*	0.06*	0.00*	0.06*	-0.11*					
(8) Group	0.22*	0.25*	0.21*	0.26*	0.19*	0.11*	-0.01*				
(9) Listed	0.12*	0.14*	0.11*	0.14*	0.11*	0.10*	-0.01*	0.51*			
(10) Patents	0.30*	0.34*	0.24*	0.33*	0.24*	0.14*	-0.02*	0.29*	0.29*		
(11) NR novelty score	0.11*	0.12*	0.06*	0.10*	0.12*	0.03*	0.01	0.09*	0.09*	0.30*	
(12) NTO novelty score	0.19*	0.21*	0.13*	0.17*	0.15*	0.04*	0.03*	0.10*	0.11*	0.48*	0.57*

Notes:
- Variable definitions can be found in Appendix Table A1.
- * $p<0.05$

Table 4 Effect of innovation (log patent count) on DCF firm value

Dep. Variable	(1) Value	(2) Value	(3) Value	(4) Value	(5) Value	(6) Value	(7) Value
Patents (H1)	**1.174*** (0.0388)**	**1.071*** (0.0383)**	**0.0779*** (0.0243)**	**0.0391* (0.0218)**	**0.0442* (0.0226)**	**0.0058 (0.0205)**	**0.0065 (0.0206)**
Tan. Fixed Assets				0.2896*** (0.0134)			
Intan. Fixed Assets				0.0046*** (0.0010)			
Employees					0.3797*** (0.0250)		
Total Assets						0.6339*** (0.0240)	0.6338*** (0.0239)
Firm Age							-0.0411* (0.0235)
Debt/Equity							-0.0005 (0.0003)
Group							0.1433** (0.0642)
Listed							0.0214 (0.1499)
Constant	14.40*** (0.0146)						
Fixed Effects:	No	Year, Industry	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm
Observations	245,521	245,521	245,521	245,521	245,521	245,521	245,521
R2	0.08754	0.16664	0.83952	0.85314	0.84379	0.85555	0.85557
Within R2	--	0.07667	0.00013	0.08501	0.02672	0.09998	0.10012

Notes:
- This table shows the results of the OLS regressions estimating the association between firm innovation (proxied by the log total patent count) on DCF firm valuations.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- **** p<0.01, ** p<0.05, * p<0.1*

Table 5 Firm size moderating the effect of innovation (log patent count) on DCF firm value

Dep. Variable	(1) Value	(2) Value	(3) Value
Patents (H1)	0.2585*** (0.0697)	0.7372*** (0.1220)	0.5772** (0.2287)
Employees	0.3838*** (0.0249)		
Patents x Employees (H2)	**-0.0479*** (0.0143)**		
Tan. Fixed Assets		0.2948*** (0.0137)	
Patents x Tan. Fixed Assets (H2)		**-0.0464*** (0.0077)**	
Total Assets			0.6356*** (0.0240)
Patents x Total Assets (H2)			**-0.0334** (0.0132)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm
Observations	245,521	245,521	245,521
R2	0.84381	0.85317	0.85556
Within R2	0.02688	0.08518	0.10007

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by the log total patent count), firm size proxies, their interaction term, on DCF firm valuations.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table 6 Firm size split – the effect of innovation (log patent count) on DCF firm value

	Below Median Total Assets (≤ 0.91 m. EUR)		Above Median Total Assets (> 0.91 m. EUR)		Below Mean Total Assets (≤ 6.05 m. EUR)		Above Mean Total Assets (> 6.05 m. EUR)	
Dep. Variable	(1) Value	(2) Value	(3) Value	(4) Value	(5) Value	(6) Value	(7) Value	(8) Value
Patents (H2)	**0.2504** **(0.1041)**	**0.2035** **(0.0912)**	**0.0363** **(0.0244)**	**-0.0178** **(0.0211)**	**0.2343***** **(0.0581)**	**0.0544** **(0.0471)**	**0.0294** **(0.0254)**	**-0.0087** **(0.0220)**
Total Assets		0.5902*** (0.0202)		0.6616*** (0.0210)		0.6399*** (0.0239)		0.6396*** (0.0314)
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm
Observations	122,779	122,779	122,742	122,742	207,406	207,406	38,115	38,115
R2	0.70288	0.72758	0.77601	0.79054	0.75263	0.77809	0.67220	0.69028
Within R2	8.84e-5	0.08320	4.96e-5	0.06493	0.00025	0.10314	8.02e-5	0.05523

Notes:
- This table shows the results of the split sample OLS regressions estimating the association between firm innovation (proxied by the log total patent count) on DCF firm value. The sample is split by median and mean total assets.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Appendix A Clarifying tables

Table A1 Variable definitions

Variable	Definition
Value (DCF Value)	Natural log of the firm valuation following Discounted Cash Flow (DCF) methodology in hindsight.
DCF Main Component	Main component of the DCF Valuation methodology, i.e., the sum of the discounted free cash flows, observed in hindsight, only.
DCF Terminal Component	Terminal component of the DCF Valuation methodology
Cost of Capital	Median return on invested capital, by year and industry.
Total Assets	Natural log of the total assets of the firm.
Tan. Fix. Assets	Natural log of the Tangible Fixed Assets of the firm.
Intan. Fix. Assets	Natural log of the Intangible Fixed Assets of the firm.
Employees	Natural log of the number of employees of the firm.
Firm Age	Age of the firm in years.
Debt/Equity	Ratio of Debt to Equity of the firm.
Group	Binary indicator equal to one if the firm is part of a group, zero otherwise.
Listed	Binary indicator equal to one if the firm is publicly-listed, zero otherwise.
Patents	Natural log of the total number of active granted patent families of the firm, grouped by DOCDB Family ID.
NR Novelty score	Ratio of patents in the active granted patent portfolio with a non-zero 'Novelty in Recombination' novelty score (Verhoeven, Bakker and Veugelers, 2016).
NTO Novelty score	Ratio of patents in the active granted patent portfolio with a non-zero 'Novelty in Technological Origin' novelty score (Verhoeven, Bakker and Veugelers, 2016).
Community Innovation Survey (CIS) variables	
Innovation	CIS indicator equal to one if the firm engaged in either product innovation (the firm brought to market a new or significantly improved product), or process innovation (innovation in any business processes), zero otherwise. (equal to one if INPD or INPS equal to one, zero else)
Innovation aborted	CIS indicator set equal to one if the firm engaged in innovation that was stopped, aborted or abandoned, zero otherwise. (equal to one if INABA equal to one, zero else)
Innovation ongoing	CIS indicator set equal to one if the firm engaged in innovation that was not yet completed, zero otherwise. (equal to one if INONG equal to one, zero else)
R&D expenditures	Natural log of the CIS-reported internal Research and Development (R&D) expenditures. (natural log of EXPIM)
Local/Regional Support	Indicator equal to one if the company received local/regional government support for the development of innovation, typically awarded competitively, zero otherwise.
National Support	Indicator equal to one if the company received national government support for the development of innovation, typically awarded competitively, zero otherwise.
EU Support	Indicator equal to one if the company received EU support for the development of innovation, typically awarded competitively, zero otherwise.

Table A2 Discounted Cash Flow (DCF) valuation methodology

			Year								
			$\ldots$	Y_{-3}	Y_{-2}	Y_{-1}	Y_0	Y_1	Y_2	$\ldots$	Y_N
Discounted Cash Flow (DCF) Valuation	Free Cash Flow (Components)	Earnings before Interest and Taxes (EBIT)					$EBIT_0$	$EBIT_1$	$EBIT_2$	$\ldots$	$EBIT_N$
		Income taxes					Tax_0	Tax_1	Tax_2	$\ldots$	Tax_N
		Depreciation & Amortization					$D\&A_0$	$D\&A_1$	$D\&A_2$	$\ldots$	$D\&A_N$
		Capital expenditures					$Capex_0$	$Capex_1$	$Capex_2$	$\ldots$	$Capex_N$
		Δ Working capital					ΔW_0	ΔW_1	ΔW_2	$\ldots$	ΔW_N
		Free Cash Flow (FCF)					FCF_0	FCF_1	FCF_2	$\ldots$	FCF_N
	Cost of Capital (COC)						COC_0	COC_1	COC_2	$\ldots$	COC_N
	Discounted Cash Flow (DCF)						DCF_0				

Notes:

- $FCF_i = EBIT_i - Tax_i + D\&A_i - CAPEX_i - \Delta W_i$
- $DCF_0 = Main\ Component\ DCF_0 + Terminal\ Component\ DCF_0$
- $Main\ Component\ DCF_0 = \sum_{t=0\ldots N} \frac{FCF_t}{\prod_{i=0\ldots t}(1+COC_i)}$
- $Terminal\ Component\ DCF_0 = \frac{1}{\prod_{t=0\ldots N}(1+COC_t)} \frac{FCF_N}{(COC_N - growth\ rate)}$
- $growth\ rate = 0.03$, following conservative rule-of-thumb (Green, Hand and Zhang, 2016)
- N the index of the latest observed fiscal year (2021)
- Capital expenditures ($CAPEX$) calculated as the net acquisitions of tangible fixed assets less the net sales of tangible fixed assets
- Δ Working capital (ΔW) in year t calculated as the net working capital (current assets-current liabilities) in year t less the net working capital in year $t-1$

Table A3 Cost of Capital (CoC) estimates

NACE Rev. 2 Manufacturing sectors (2-digit level) - Manufacturing of:	Unique firms	Cost of Capital (CoC) estimate: median return on invested capital												
		'00	'01	'02	'03	'04	'05	…	'16	'17	'18	'19	'20	Med.
10 - Food products	5,348	8.6	8.9	9.1	9.9	10.9	9.6	…	7.7	7.8	6.3	6.1	6.1	8.6
11 - Beverages	319	7.1	5	7.4	10.3	6.3	10.6	…	7	5.8	5.4	4.2	3.6	7.4
12 - Tobacco products	37	31.2	13.3	14.1	26.3	18.2	18.4	…	31	20.5	24.1	11.7	31.8	17.1
13 - Textiles	1,230	8.3	7.2	7.5	7.6	7.4	6.3	…	8.2	5.6	6.1	5	5.2	6.4
14 - Wearing apparel	702	11.6	11.7	9.1	9.9	14.3	15.6	…	9	7.1	9.3	5.3	6.1	9.3
15 - Leather and related products	108	6.2	4.7	11.7	7	8	6.7	…	9.8	9.7	6.4	0	1.9	5.7
16 - Wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1,572	6.9	6.5	6.7	6.3	9.4	8.8	…	7.2	5.8	6.7	8.5	7.2	7.2
17 - Paper and paper products	401	8.3	8.8	7.5	12.5	9	5.7	…	7.1	5.9	5.8	8.8	8.1	7.3
18 - Printing and reproduction of recorded media	2,369	7.6	5.8	7.3	10.6	9.9	7.8	…	4.8	7.4	5.2	6.1	3.8	6.1
20 - Chemicals and chemical products	36	9.1	9.3	6.1	5.4	10.1	10.7	…	13.3	9.3	8.8	12	7.3	9.3
21 - Basic pharmaceutical products and pharmaceutical preparations	925	8.8	9.1	9.9	10.1	8.7	10.8	…	8.9	8.2	7.8	7.6	7.8	8.8
22 - Rubber and plastic products	267	10.4	8.4	8.4	10.2	8.6	7.2	…	7.6	8.8	8.6	7.8	6.8	7.8
23 - Other non-metallic mineral products	897	10.8	8.7	10.6	9.8	9	9.8	…	6.5	7.5	7.1	8.1	9.9	8.1
24 - Basic metals	1,582	8	7.6	7.1	7.3	8.3	8	…	4.7	4.4	6.3	5.5	6.4	6.4
25 - Fabricated metal products, except machinery and equipment	555	9.6	7.1	8.8	6.8	11.9	8.6	…	5.8	8.5	6.1	5.6	6.7	6.9
26 - Computer, electronic and optical products	5,365	8.9	8.8	8.4	9.1	10.8	10.2	…	8.2	6.9	8	6	8.2	8.4
27 - Electrical equipment	736	15.1	12.4	8.1	11.5	14.1	12.1	…	9.4	9.7	10.2	12.2	8.1	9.9
28 - Machinery and equipment n.e.c.	691	11.6	9.7	9.8	6.9	10.5	12.7	…	9.4	10.7	10	5.5	9.2	9.7
29 -Motor vehicles, trailers and semi-trailers	1,617	11.2	10.2	7.2	7.4	11.2	14.6	…	6.8	8.8	7.6	8.5	6.4	8.6
30 - Other transport equipment	395	10	8.8	10.1	8.2	13	13.2	…	9	9.8	6.2	6.1	3.4	8.2
31 - Furniture	161	9.2	12.1	5	7.5	8.9	23.4	…	11.7	9.4	6.1	4.3	-0.3	8.4
32 - Other manufacturing	1,414	9.6	6.5	7.7	6.1	7.4	7	…	5.2	3.7	6	3.5	5.1	5.2
33 - Repair and installation of machinery and equipment	1,230	16	9.5	14.8	9.7	9.7	10.8	…	9.7	6.6	11.1	8.4	6.8	9.7

Notes:

- This table presents cost of capital (%) estimates for Belgian firms active in the manufacturing sector (NACE Rev. 2: 10-33). The estimates show the median return on invested capital by year (2000-2020). Observations after sample selection procedure were used to obtain the estimates in the sample.
- Column 'Median' represents the median return on invested capital across years by manufacturing 2-digit subsector. Return on Invested Capital (ROIC) is calculated as the ratio of the Net Operating Profits After Taxes (NOPAT) over the total invested capital.

Appendix B Robustness tests for the covariate and variate

Table B1 Firm size split by quintile – the effect of innovation (log patent count) on DCF firm value

	Quintile 1 [P0, P20[	Quintile 2 [P20, P40[	Quintile 3 [P40, P60[	Quintile 4 [P60, P80[	Quintile 5 [P80, P100]
Dep. Variable	(1) Value	(2) Value	(3) Value	(4) Value	(5) Value
Patents (H2)	**0.5436*** **(0.3039)**	**0.0806** **(0.1424)**	**0.2231** **(0.1534)**	**0.1117** **(0.0903)**	**0.0222** **(0.0253)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm
Observations	49,061	49,131	49,114	49,108	49,107
R2	0.73217	0.66695	0.63207	0.61412	0.70634
Within R2	8.89e-5	1.02e-5	0.00012	7.64e-5	3.85e-5

Notes:
- This table shows the results of the split sample OLS regressions estimating the association between firm innovation (proxied by the log total patent count) on DCF firm value. The sample is split by quintiles.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table B2 Firm size split by quintile (observations with a non-empty patent portfolio) – the effect of innovation (log patent count) on DCF firm value

	Quintile 1 [P0, P20[	Quintile 2 [P20, P40[	Quintile 3 [P40, P60[	Quintile 4 [P60, P80[	Quintile 5 [P80, P100]
Dep. Variable	(1) Value	(2) Value	(3) Value	(4) Value	(5) Value
Patents (H2)	**0.2256**** **(0.0864)**	**-0.0397** **(0.0838)**	**0.1050** **(0.0658)**	**-0.0393** **(0.0487)**	**-0.0007** **(0.0235)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm
Observations	3,079	3,080	3,079	3,079	3,080
R2	0.67260	0.55405	0.53857	0.51410	0.41591
Within R2	0.00686	0.00022	0.00199	0.00053	3.91e-7

Notes:
- This table shows the results of the split sample OLS regressions estimating the association between firm innovation (proxied by the log total patent count) on DCF firm value. The sample is split by quintiles.
- The sample only concerns observations of firms that had at least one active granted patented in any of the years 2000-2020.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table B3 Firm size moderating the effect of innovation (log patent count) on DCF firm value – Additional controls

Dep. Variable	(1) Value	(2) Value	(3) Value
Patents (H1)	**0.2624*** (0.0702)**	**0.7444*** (0.1223)**	**0.5862** (0.2292)**
Employees	0.3744*** (0.0244)		
Patents x Employees (H2)	**-0.0498*** (0.0145)**		
Tan. Fixed Assets		0.2920*** (0.0135)	
Patents x Tan. Fixed Assets (H2)		**-0.0471*** (0.0077)**	
Total Assets			0.6333*** (0.0234)
Patents x Total Assets (H2)			**-0.0340** (0.0133)**
Debt/Equity	0.0045*** (0.0004)	0.0013*** (0.0003)	-0.0006 (0.0003)
Firm Age	-0.0183 (0.0252)	-0.0165 (0.0232)	-0.0411* (0.0235)
Intangible Fixed Assets	0.0079*** (0.0012)	0.0045*** (0.0010)	0.0024** (0.0010)
Group	0.0794 (0.0579)	0.0871 (0.0576)	0.1387** (0.0629)
Listed	0.0010 (0.1449)	-0.0353 (0.0977)	0.0270 (0.1496)
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm
Observations	287,596	287,596	287,596
R2	0.34783	0.35976	0.35579
Within R2	0.00381	0.02204	0.01599

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by the log total patent count), firm size proxies, their interaction term and various control fixed effects, on DCF firm valuations.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table B4 Firm size moderating the effect of innovation (log patent count) on DCF firm value – Negative Debt /Equity observations excluded

Dep. Variable	(1) Value	(2) Value	(3) Value
Patents (H1)	**0.2358*** (0.0691)**	**0.6946*** (0.1320)**	**0.4705** (0.2205)**
Employees	0.3915*** (0.0245)		
Patents x Employees (H2)	**-0.0443*** (0.0142)**		
Tan. Fixed Assets		0.3002*** (0.0137)	
Patents x Tan. Fixed Assets (H2)		**-0.0438*** (0.0084)**	
Total Assets			0.6730*** (0.0231)
Patents x Total Assets (H2)			**-0.0275** (0.0127)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm
Observations	226,048	226,048	226,048
R2	0.84275	0.85173	0.85459
Within R2	0.02670	0.08225	0.09997

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by the log total patent count), firm size proxies, their interaction term, on DCF firm valuations.
- The sample excludes negative debt to equity value observations.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table B5 Firm size moderating the effect of innovation (log patent count) on DCF firm value – Negative DCF observations included and replaced by 0 economic value

Dep. Variable	(1) Value	(2) Value	(3) Value
Patents	**0.1126**	**1.702****	**2.905****
(H1)	**(0.4112)**	**(0.7001)**	**(1.109)**
Employees	0.8258*** (0.0491)		
Patents x	**-0.0094**		
Employees (H2)	**(0.0908)**		
Tan. Fixed Assets		0.8368*** (0.0283)	
Patents x		**-0.1120****	
Tan. Fixed Assets (H2)		**(0.0464)**	
Total Assets			1.463*** (0.0656)
Patents x			**-0.1715****
Total Assets (H2)			**(0.0657)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm
Observations	287,596	287,596	287,596
R2	0.34783	0.35976	0.35579
Within R2	0.00381	0.02204	0.01599

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by the log total patent count), firm size proxies, their interaction term, on DCF firm valuations.
- The sample is extended using observations where the negative DCF value estimations are included and replaced by zero.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table B6 Robustness of DCF valuation methodology specifications

Dep. Variable	(1) Value, excl. terminal component	(2) Value, 3y forward DCF	(3) Value, 3y forward DCF excl. terminal component	(4) Value, 1% terminal growth rate	(5) Value, 5% terminal growth rate	(6) Value, CoC = median CoC (by industry)	(7) Value, CoC = median Return on Equity ROE (by industry)	(8) Value, CoC = Default rate of 10%
Patents (H1)	**0.0636** (0.0236)**	**0.0386** (0.0137)**	**0.0400** (0.0180)**	**0.0539*** (0.0138)**	**0.0534*** (0.0144)**	**0.0595*** (0.0163)**	**0.0506*** (0.0144)**	**0.0564*** (0.0137)**
Total Assets	0.0398*** (0.0019)	0.0301*** (0.0018)	0.0259*** (0.0024)	0.0433*** (0.0015)	0.0412*** (0.0016)	0.0430*** (0.0016)	0.0411*** (0.0016)	0.0430*** (0.0015)
Patents x Total Assets (H2)	**-0.0038** (0.0014)**	**-0.0022** (0.0008)**	**-0.0022** (0.0010)**	**-0.0031*** (0.0008)**	**-0.0031*** (0.0008)**	**-0.0037*** (0.0010)**	**-0.0030*** (0.0008)**	**-0.0033*** (0.0008)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm
Observations	245,521	229,128	222,048	245,521	238,506	239,114	245,521	245,521
R2	0.71919	0.87502	0.84204	0.85072	0.83676	0.80840	0.83383	0.84700
Within R2	0.04052	0.05680	0.03084	0.10714	0.08267	0.07578	0.09018	0.10408

Notes:
- This table shows the OLS regressions of the robustness analyses of variations in the DCF estimation methodology, specifically: (1) excluding the terminal component; (2) using a three-year rolling window; (3) using a three-year rolling window and excluding the terminal component; (4) using a 1% terminal growth rate; (5) using a 5% terminal growth rate; (6) using the median two-digit industry COC estimate; (7) using the median two-digit industry ROE estimate; and (8) using a default 10% rate as the cost of capital.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table B7 Validation DCF methodology using market valuations – Sample of publicly listed Belgian manufacturing firms (2000-2020)

Dep. Variable	(1) MV	(2) MV	(3) MV	(4) MV	(5) MV	(6) MV	(7) MV	(8) MV	(9) MV
Value	0.3647** (0.1437)								
Value, excl. terminal component		0.2086* (0.1167)							
Value, 3y forward			0.3439** (0.1273)						
Value, 3y forward excl. terminal component				0.0318 (0.0222)					
Value, 1% terminal growth rate					0.4979*** (0.1493)				
Value, 5% terminal growth rate						0.4689*** (0.1503)			
Value, CoC = median CoC (by industry)							0.3793** (0.1361)		
Value, CoC = median Return on Equity ROE (by industry)								0.2942** (0.1312)	
Value, CoC = Default rate of 10%									0.4086*** (0.1246)
Fixed Effects:	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year
Obs.	679	637	729	729	684	645	677	679	682
R2	0.89993	0.89599	0.89548	0.88992	0.90264	0.90109	0.90056	0.89878	0.90052
Within R2	0.05324	0.02404	0.05680	0.00656	0.08192	0.07215	0.06126	0.04516	0.06665

Notes:
- This table shows OLS regression results of the validation analyses of the DCF valuation methodology on the log market value of publicly listed firms. The dependent variable constitutes the natural logarithm of the market valuation of the firms: MV = log(Compustat PRCCD*CSHOI+1).
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table B8 Validation DCF methodology using minority share acquisitions – Sample of deals with Belgian manufacturing firm targets (final ownership < 50%)

Dep. Variable	(1) MV	(2) MV	(3) MV	(4) MV	(5) MV	(6) MV	(7) MV	(8) MV	(9) MV
Value	0.8540*** (0.2896)								
Value, excl. terminal component		0.3657 (0.4363)							
Value, 3y forward			0.7211*** (0.2421)						
Value, 3y forward excl. terminal component				0.0645 (0.0386)					
Value, 1% terminal growth rate					0.9573*** (0.2306)				
Value, 5% terminal growth rate						0.7925** (0.3492)			
Value, CoC = median CoC (by industry)							0.7631*** (0.2178)		
Value, CoC = median Return on Equity ROE (by industry)								0.7864** (0.2921)	
Value, CoC = Default rate of 10%									0.6439* (0.3646)
Fixed Effects:	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year	Firm, Year
Obs.	431	414	471	471	431	422	428	432	432
R2	0.93174	0.93024	0.92567	0.91899	0.93236	0.92904	0.93212	0.93168	0.93104
Within R2	0.04147	0.01047	0.10028	0.01940	0.04942	0.03859	0.04597	0.03975	0.03084

Notes:
- This table shows OLS regression results of the validation analyses of the DCF valuation methodology on the target valuation implied by minority share acquisitions (<50% final stake) in the Bureau Van Dijk Zephyr Database. The sample is obtained by matching the final regression sample with deals listed in the Bureau Van Dijk Zephyr database listing all M&A activity for both publicly-listed and privately-held firms. The dependent variable constitutes the natural logarithm of the implied target valuation of the firm.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Appendix C Validation tests using Community Innovation Survey (CIS) data

Table C1 Sample selection procedure – CIS data

	Less	Total observations (unique firms)	Total observations (unique firms): With patent	With CIS-reported innovation	With CIS-reported aborted or ongoing innovation
Belgian Manufacturing firms in CIS waves 2005, 2007, 2009, 2011, 2013, 2015, 2017 or 2019		9,073 (3,857)	2,201 (613)	5,502 (2,536)	4,056 (1,915)
Less observations with negative DCF value	-1,258	7,815 (3,537)	1,838 (565)	4,749 (2,314)	3,465 (1,735)
Less observations with missing values for any of the variables	-3,338	4,477 (2,433)	1,228 (458)	2,916 (1,589)	2,196 (1,203)
Final sample		4,477 (2,433)	1,228 (458)	2,916 (1,589)	2,196 (1,203)

Table C2 Descriptive statistics – CIS data

Variable	N	Mean	SD	Min	P25	P50	P75	Max
DCF Value (EUR mil.)	4,477	106.414	282.809	0.313	3.629	12.446	55.451	1,503.689
DCF Value	4,477	16.514	2.003	12.654	15.104	16.337	17.831	21.131
DCF Main Component (EUR mil.)	4,477	15.659	40.269	-2.441	0.516	1.877	9.36	210.786
DCF Terminal Component (EUR mil.)	4,477	44.769	126.542	-11.137	0.857	4.224	21.117	678.988
Cost of Capital (CoC)	4,477	0.079	0.013	0.04	0.071	0.079	0.086	0.155
Total Assets (EUR mil.)	4,477	57.175	139.718	0.448	2.456	8.871	35.018	725.028
Total Assets	4,477	16.145	1.828	13.014	14.714	15.998	17.371	20.402
Tan. Fix. Assets (EUR mil.)	4,477	9.49	22.759	0.027	0.431	1.511	6.037	117.986
Tan. Fix. Assets	4,477	14.296	1.967	10.213	12.974	14.228	15.613	18.586
Intan. Fix. Assets (EUR mil.)	4,477	1.325	5.113	0	0	0.003	0.134	29.331
Intan. Fix. Assets	4,477	6.431	6.126	0	0	7.97	11.806	17.194
Employees (no logscale)	4,477	157.167	308.939	5	17	46	136	1645.1
Employees	4,477	4.005	1.386	1.792	2.89	3.85	4.92	7.406
Firm Age	4,477	30.415	19.122	1	17	27	39	135
Debt/Equity	4,477	2.355	3.12	-1.435	0.553	1.306	2.783	14.852
Group	4,477	0.048	0.214	0	0	0	0	1
Listed	4,477	0.016	0.126	0	0	0	0	1
Patents (no logscale)	4,477	13.124	126.658	0	0	0	0	3,301
Patents	4,477	0.453	1.124	0	0	0	0	8.102
NR Novelty score	4,477	0.059	0.114	0	0	0	0.081	0.667
NTO Novelty score	4,477	0.178	0.211	0	0	0.017	0.333	0.833
Innovation	4,477	0.651	0.477	0	0	1	1	1
Innovation aborted or ongoing	4,477	0.491	0.5	0	0	0	1	1
Innovation aborted	4,477	0.166	0.372	0	0	0	0	1
Innovation ongoing	4,477	0.47	0.499	0	0	0	1	1
R&D exp. (EUR mil.)	4,477	640.458	1,872.731	0	0	10	250	10,000
R&D exp.	4,477	2.891	3.078	0	0	2.398	5.525	9.21
Local/Regional Support	4,477	0.191	0.393	0	0	0	0	1
National Support	4,477	0.162	0.369	0	0	0	0	1
EU Support	4,477	0.051	0.22	0	0	0	0	1

Notes:

- Winsorization is applied at the 2.5-97.5% levels for all variables (except group and patent-related variables due to high skewness). The results of the analyses remain unchanged without winsorization and at different levels (1-99%, 5-95%).
- Variable definitions can be found in Appendix Table A1.

Table C3 Correlation Table (N=4,477) – CIS data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) DCF Value																	
(2) Total Assets	0.86*																
(3) Tangible Fixed Assets	0.79*	0.84*															
(4) Employees	0.79*	0.89*	0.80*														
(5) Intangible Fixed Assets	0.46*	0.50*	0.44*	0.50*													
(6) Firm Age	0.26*	0.30*	0.25*	0.29*	0.14*												
(7) Debt/Equity	-0.06*	-0.06*	-0.03	-0.03*	0.03*	-0.11*											
(8) Group	0.29*	0.31*	0.31*	0.38*	0.28*	0.15*	-0.03										
(9) Listed	0.23*	0.24*	0.23*	0.28*	0.21*	0.13*	-0.03*	0.57*									
(10) Patents	0.45*	0.50*	0.39*	0.47*	0.38*	0.16*	-0.06*	0.34*	0.38*								
(11) NR novelty score	0.17*	0.18*	0.13*	0.16*	0.13*	0.03	-0.06*	0.08*	0.12*	0.30*							
(12) NTO novelty score	0.25*	0.28*	0.22*	0.24*	0.14*	0.06*	-0.02	0.08*	0.09*	0.45*	0.60*						
(13) R&D expenditures	0.48*	0.54*	0.45*	0.56*	0.44*	0.13*	-0.04*	0.27*	0.19*	0.50*	0.16*	0.21*					
(14) Innovation	0.26*	0.29*	0.27*	0.31*	0.27*	0.04*	-0.01	0.13*	0.09*	0.22*	0.06*	0.06*	0.57*				
(15) Innovation aborted or ongoing	0.28*	0.33*	0.29*	0.34*	0.30*	0.07*	-0.02	0.16*	0.12*	0.29*	0.07*	0.12*	0.63*	0.50*			
(16) Local/Regional Support	0.27*	0.28*	0.24*	0.28*	0.27*	0.08*	-0.01	0.17*	0.18*	0.34*	0.07*	0.07*	0.48*	0.30*	0.35*		
(17) National Support	0.26*	0.29*	0.24*	0.28*	0.26*	0.08*	-0.03	0.12*	0.11*	0.28*	0.09*	0.07*	0.45*	0.27*	0.31*	0.29*	
(18) U Support	0.21*	0.23*	0.19*	0.23*	0.22*	0.10*	-0.04*	0.21*	0.22*	0.40*	0.13*	0.16*	0.33*	0.15*	0.21*	0.34*	0.23*

Notes:
-Variable definitions can be found in Appendix Table A1.
-* $p<0.05$

Table C4 Effect of innovation (CIS response) on DCF firm value

Dep. Variable	(1) Value	(2) Value	(3) Value	(4) Value	(5) Value	(6) Value	(7) Value
Innovation (H1)	**1.086*** (0.1433)**	**0.9534*** (0.1013)**	**-0.0517 (0.0421)**	**-0.0587 (0.0392)**	**-0.0741 (0.0403)**	**-0.0571 (0.0352)**	**-0.0354 (0.0426)**
Tan. Fixed Assets				0.3082** (0.1112)			
Intan. Fixed Assets					0.2464*** (0.0419)		
Employees					0.0009 (0.0059)		
Total Assets						0.6082*** (0.0637)	0.5973*** (0.0527)
Firm Age							-0.1331 (0.1497)
Debt/Equity							-0.0082 (0.0116)
Group							0.2438 (0.1465)
Listed							1.171** (0.4103)
R&D Expenditures							-0.0112 (0.0107)
Constant	15.81*** (0.1862)						
Fixed Effects:	No	Year, Industry	Year, Firm	Year, Firm	Year, Firm	Year, Firm	Year, Firm
Observations	4,477	4,477	4,477	4,477	4,477	4,477	4,477
R2	0.06684	0.19435	0.91965	0.92044	0.92152	0.92397	0.92437
Within R2	--	0.05051	0.00042	0.01024	0.02370	0.05416	0.05920

Notes:
- This table shows the results of the OLS regressions estimating the association between firm innovation (proxied by survey-reported innovation) on DCF firm valuations.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- **** $p<0.01$, ** $p<0.05$, * $p<0.1$*

Table C5 Firm size moderating the effect of innovation (CIS response) on DCF firm value

Dep. Variable	(1) Value	(2) Value	(3) Value
Innovation (H1)	0.2177 (0.1316)	0.6313 (0.3641)	0.7368* (0.3247)
Employees	0.3585** (0.1130)		
Innovation x Employees (H2)	**-0.0681* (0.0305)**		
Tan. Fixed Assets		0.2826*** (0.0437)	
Innovation x Tan. Fixed Assets (H2)		**-0.0490* (0.0240)**	
Total Assets			0.6455*** (0.0651)
Innovation x Total Assets (H2)			**-0.0490** (0.0193)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm
Observations	4,477	4,477	4,477
R2	0.92052	0.92163	0.92405
Within R2	0.01131	0.02507	0.05525

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by survey-reported innovation), firm size proxies, their interaction term, on DCF firm valuations.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Table C6 Firm size moderating the effect of innovation (CIS response) on DCF firm value – (Control group: observations with aborted/ongoing innovation)

Dep. Variable	(1) Value	(2) Value	(3) Value
Innovation	0.4101	1.274*	1.592**
(H1)	(0.2184)	(0.6179)	(0.6449)
	0.4868**		
Employees	(0.1448)		
Innovation x	**-0.1071***		
Employees (H2)	**(0.0503)**		
		0.3331***	
Tan. Fixed Assets		(0.0570)	
Innovation x		**-0.0914***	
Tan. Fixed Assets (H2)		**(0.0417)**	
			0.7391***
Total Assets			(0.0802)
Innovation x			**-0.0996****
Total Assets (H2)			**(0.0390)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm
Observations	3,153	3,153	3,153
R2	0.91334	0.91397	0.91726
Within R2	0.01624	0.02338	0.06076

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by survey-reported innovation), firm size proxies, their interaction term, on DCF firm valuations.
- The sample is restricted to the set of observations where we observe an innovation, or aborted or ongoing innovation.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table C7 Firm size moderating the effect of innovation (CIS response) on DCF firm value – (Control group: observations with aborted innovation)

Dep. Variable	(1) Value	(2) Value	(3) Value
Innovation	1.145*	3.761**	3.480
(H1)	(0.5715)	(1.057)	(1.815)
	0.6501**		
Employees	(0.2339)		
Innovation x	**-0.2970***		
Employees (H2)	**(0.1500)**		
		0.4926***	
Tan. Fixed Assets		(0.1088)	
Innovation x		**-0.2632****	
Tan. Fixed Assets (H2)		**(0.0803)**	
			0.8389***
Total Assets			(0.1319)
Innovation x			**-0.2199**
Total Assets (H2)			**(0.1136)**
Fixed Effects:	Year, Firm	Year, Firm	Year, Firm
Observations	2,963	2,963	2,963
R2	0.91142	0.91209	0.91512
Within R2	0.01470	0.02225	0.05593

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by survey-reported innovation), firm size proxies, their interaction term, on DCF firm valuations.
- The sample is restricted to the set of observations where we observe an innovation, or aborted innovation.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1

Appendix D Sensitivity of innovation-value link to novelty

Table D1 Sensitivity to novelty of innovation in patenting sample (patent portfolio novelty indicators)

Dep. Variable	(1) Value	(2) Value	(3) Value	(4) Value	(5) Value
Total Assets	0.8640*** (0.0126)	0.8639*** (0.0126)	0.8638*** (0.0126)	0.8640*** (0.0126)	0.8640*** (0.0126)
Innovation (Patents – H1)	0.0741*** (0.0127)	0.0763*** (0.0132)	0.0660*** (0.0181)	0.0742*** (0.0137)	0.0779*** (0.0209)
NR Novelty Score		-0.0830 (0.1078)	-0.2284 (0.1720)		
Innovation x NR Novelty Score			**0.1164 (0.1191)**		
NTO Novelty Score				-0.0020 (0.0846)	0.0143 (0.1126)
Innovation x NTO Novelty Score					**-0.0138 (0.0567)**
Fixed Effects:	Year, Industry	Year, Industry	Year, Industry	Year, Industry	Year, Industry
Observations	15,397	15,397	15,397	15,397	15,397
R2	0.71680	0.71683	0.71687	0.71680	0.71680
Within R2	0.67562	0.67565	0.67571	0.67562	0.67562

Notes:
- This table shows the results of the OLS regression estimating the link between firm innovation (proxied by the log total patent count), interacted with novelty indicators based on the observed patent portfolio, and DCF firm valuations. The estimations include fixed effect controls for the year and the industry.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table D2 Sensitivity to novelty of innovation in CIS sample (government support)

Dep. Variable	(1) Value	(2) Value	(3) Value	(4) Value	(5) Value	(6) Value	(7) Value
Innovation (CIS-H1)	0.9534*** (0.1013)	0.7392*** (0.1012)	0.7374*** (0.1013)	0.7370*** (0.1263)	0.7749*** (0.1263)	0.8764*** (0.1016)	0.8701*** (0.0978)
Local/Regional Support		0.9673*** (0.1405)	0.9381** (0.3674)				
Innovation x Local/Regional Support			**0.0315 (0.3361)**				
National Support				0.9948*** (0.0791)	1.744*** (0.2681)		
Innovation x National Support					**-0.8069** (0.2763)**		
EU Support						1.349*** (0.2590)	0.4753 (0.8827)
Innovation x EU Support							**0.9037 (0.9484)**
Fixed Effects:	Year, Industry	Year, Industry	Year, Industry	Year, Industry	Year, Industry	Year, Industry	Year, Industry
Observations	4,477	4,477	4,477	4,477	4,477	4,477	4,477
R2	0.19435	0.22561	0.22561	0.22375	0.22505	0.21466	0.21496
Within R2	0.05051	0.08736	0.08736	0.08517	0.08670	0.07445	0.07480

Notes:
- This table shows the results of the OLS regression estimating the association between firm innovation (proxied by CIS-reported innovations), interacted with novelty indicators based on the presence of local/regional, national and European-level support of the development of innovation (typically awarded to highly novel or promising innovation), and DCF firm valuations. The estimations include fixed effect controls for the year and the industry.
- Standard errors, clustered at the firm and year-level, given between brackets.
- Variable definitions can be found in Appendix Table A1.
- *** p<0.01, ** p<0.05, * p<0.1