// NO.25-061 | 11/2025

DISCUSSION PAPER

// BASTIAN KRIEGER, STEFANIA SCROFANI
AND LINUS STRECKE

Firms' Disclosure of University Ties on Their Website: An Explorative Analysis of Its Role for Innovation Performance

Leibniz Association

ZEW

Firms' Disclosure of University Ties on Their Website: An Explorative Analysis of Its Role for Innovation Performance

Bastian Krieger[a], Stefania Scrofani[b], Linus Strecke[c]

November 2025

Abstract

This paper explores a novel web-based indicator to examine how firms' disclosure of university ties on their websites shapes their innovation performance. First, using data from the German Community Innovation Survey 2023 and the Tenders Electronic Daily database, combined with firms' discloser of university ties on their website provided by ISTARI.AI, we investigate the indicator's properties by comparing the most frequently disclosed types of university ties: innovation collaborations, university customers, and employee education, with firms' survey responses and their procurement contracts. Second, we analyze how website disclosure of university ties relates to firms' revenues from new or significantly improved products or services, applying Ordinary Least Squares, a Control Function, and Lewbel Instrumental Variable approach. In sum, the website disclosure of ties with universities is significantly associated with its related survey items and procurement contracts. Moreover, website disclosures show no consistent association with revenues from innovations new-to-the-firm. A consistent statistically significant relationship emerges only for small firms, where website disclosures are associated with higher revenues from market novelties. These findings suggest that our web-based indicator captures ties between firms and universities and that disclosing these ties on firms' websites may influence the market success of their novel products.

Keywords University-Industry Transfer – Innovation Performance – Signaling
JEL code O31 - 032 - O36

[a] Corresponding author.
Affiliation: ZEW – Leibniz Centre for European Economic Research, L7 1, 61861 Mannheim, Germany
E-mail: bastian.krieger@zew.de

[b] Affiliation: Scuola Superiore Sant'Anna, stefania.scrofani@santannapisa.it
[c] Affiliations: ZEW Mannheim, TU Berlin, linus.strecke@zew.de

---

Acknowledgments: We thank the ZEW Mannheim and ISTARI.AI for providing their data. This research was funded by the German Federal Ministry of Education and Research (BMBF), grant number 16WIT013A. Stefania Scrofani acknowledges financial support from PagoPA S.p.A and Sant'Anna School of Advanced Studies.

1 Introduction

Universities play an important role in shaping how firms develop and communicate their innovation capabilities. Ties to universities, whether through research collaborations, funding relationships, or the educational background of managers and employees, provide firms with privileged access to advanced knowledge, specialized expertise, and complementary resources (Veugelers, 2016; Stephan, 1996; Grimpe, Hussinger, & Sofka, 2023). Such ties are known to strengthen absorptive capacity, facilitate exposure to transformative technologies, and stimulate interdisciplinary exchange (Laursen & Salter, 2006; García-Vega & Vicente-Chirivella, 2020; Mulligan et al., 2022). In these ways, university ties constitute a significant enabler of firms' innovation performance.

The importance of such ties, however, extends beyond their direct contribution to innovation. Firms operate under pronounced information asymmetries, as customers, investors, and other stakeholders rarely observe the scope or quality of firms' internal R&D processes (Merton, 1987). In this context, university ties can serve as credible signals that reduce uncertainty about firms' innovative capacity. Thus, by simultaneously providing substantive resources and symbolic legitimacy, university ties fulfill a dual role as they not only enhance firms' ability to generate innovations but also shape external perceptions of their credibility and potential (Rao, Chandy & Prahbu, 2008; Maier et al., 2024).

Prior research has emphasized patents and scientific publications as central signaling mechanisms, as they i) provide verifiable evidence of firms' innovative capabilities to peers and investors (Baruffaldi, Simeth, & Wehrheim, 2024; Liu, Du, & Pennings, 2024), and ii) are widely available (Schubert, Darold, & Kroll, 2025). Yet these forms of disclosure are narrowly defined (Schubert, Darold, & Kroll, 2025), and limited in both audience and accessibility. Scientific publications require technical expertise to interpret, while patents entail extensive disclosure of proprietary knowledge and expose firms to the risk of imitation (Polidoro & Theeke, 2012). Consequently, such mechanisms are less effective for engaging broader stakeholder groups, particularly customers, who depend on accessible and easily interpretable signals to evaluate product quality and innovation credibility.

This paper examines an alternative and underexplored signaling mechanism: *firms' website mentions of universities*, such as references to innovation collaborations, customer references, or employee education. Websites provide a cost-effective platform for communicating such ties in ways that are accessible to broad audiences (Dahlke et al., 2024) and less costly than patents or publications, both financially and in terms of knowledge disclosure (Blind, Krieger, & Pellens, 2022). By highlighting university ties in broad, non-technical terms, website disclosures increase transparency while limiting the risks associated with detailed knowledge sharing.

This study combines data from the German Community Innovation Survey 2023 and the Tenders Electronic Daily database with web-based indicators from ISTARI.AI to i) assess how the most frequently disclosed ties to universities correspond to related measures in the survey and procurement data, and ii) analyze how firms' disclosed ties to universities on their websites are associated with innovation performance. For this purpose, we i) descriptively compare our web-based indicators with our alternative data sources, and ii) estimate relations between mentioning university ties and innovation performance using Ordinary Least Squares, a Control Function approach, and a Lewbel Instrument.

We find that the three most frequently disclosed types of university ties on firms' websites, innovation collaborations (27 percent), universities as customers (22 percent), and employee education (18 percent), are significantly associated with their corresponding survey measures using three separate probit estimations. Moreover, firms that report an innovation collaboration with a university in the Community Innovation Survey mention such a collaboration on their website about 4.5 times as often (14 percent) as firms that do not report such a collaboration (3 percent). Firms with a higher share of employees holding a higher education degree are more likely to reference universities in the context of employee education: only 0.4 percent of firms with a zero share of employees with a higher education degree mention universities in relation to employee education, whereas restricting to firms with a positive share, 1 percent of firms in the lowest quartile and 9 percent of firms in the highest quartile mention universities as part of their employees' education. Finally, firms that win a larger procurement contract from a university in the Tenders Electronic Daily database are approximately four times as likely to list universities as customers on their website (8

percent) as firms that do not win such a contract (2 percent). Thus, while being significantly associated in general, the results demonstrate a limited number of firms to report their ties on their website, indicating both i) the strategic use of their website, as well as ii) a concentration on university ties perceived as substantive.

For our analysis on innovation performance, we distinguish between products and services new to the firm and those new to the market. Moreover, due to the previously described properties of our web-based indicator, we specifically control for i) the intensity of university collaboration, highly educated employees, and procurement contracts from universities, as well as ii) firms' general capability to use their website strategically, proxied by their marketing intensity. The analysis shows that website mentions of universities have no relation with firms' overall likelihood of introducing product innovations of either type. Their association arises only for market novelties, and only at the commercialization stage. Specifically, for firms with fewer than 50 employees, the point estimates indicate that disclosing university ties on their websites is associated with an increase in revenues from market novelties of between EUR 94,000 to EUR 127,000 for the median firm, despite having no statistically significant relationship with the probability of introducing such novelties.

This study makes two main contributions:

First, it advances research that uses website information as a data source (e.g., Dahlke et al., 2024, 2025) by conceptualizing firms' own website disclosures of university ties as a scalable, firm-side indicator of engagement with the science system. In contrast to prior work that relies on universities' websites or broad web traces such as hyperlinks (Schubert, Darold, & Kroll, 2025; Schmidt et al., 2025; Arifi et al., 2023; Kenekayoro, Buckley, & Thelwall, 2014), we distinguish between specific types of ties, thus capturing firm–university interactions at a more granular level and on a larger scale from the perspective of the firm.

Second, we contribute to research on signaling and innovation performance by conceptually introducing website mentions of university ties as a low-cost, customer-facing signal that complements traditional, high-cost signals such as patents and publications (Baruffaldi, Simeth, & Wehrheim, 2024; Liu, Du, & Pennings, 2024; Polidoro & Theeke, 2012), and by empirically demonstrating that such website disclosures are not broadly related to the

introduction of innovations, but are specifically associated with higher revenues from market novelties among small firms.

The remainder of the paper is structured as follows: Section 2 conceptualizes firms' incentives to disclose their university ties on their websites, and discusses the discloser's relevance for firms' innovation performance. Section 3.1 describes our used databases, Section 3.2 covers the construction of our used variables, and Section 3.3 demonstrates their descriptive statistics. In particular, Section 3.3 extensively describes our measure of website mentions of university ties, and explores its link with related survey and tender measures to explore their joint properties. Section 4.1 describes our estimation model to investigate the association between website mentions and firms' innovation performance, whereas Section 4.2 motivates our use of subsamples. Section 5 presents the results of the analysis described in its preceding section. Finally, Section 6 concludes, extending the short discussion of our results provided above, particularly with regard to their implications for research, policy makers, and managers.

2 Conceptual framework

The commercialization of innovation is a lengthy and uncertain process. The commercialization can determine the innovation's success (Slater & Mohr, 2006) and with that the success or survival of the innovating firm (Cefis & Marsili, 2006; Ipinnaiye et al., 2025). However, such processes depend on a multitude of factors, ranging from marketing to network, from market environment to positioning strategies. Among the many challenges that firms face in the commercialization process, one of the most important ones is demonstrating and communicating the quality of the innovation. The presence of consistent information asymmetries between the firm and its potential investors, as well as between the firm and its potential consumers or users requires the firms to fill this gap providing a credible narrative of the innovation.

Patents and scientific publications have long been widely used as signals to convey a firm's innovative capabilities and the outcomes of its R&D collaborations (Baruffaldi, Simeth, & Wehrheim, 2024; Liu, Du, & Pennings, 2024; Grimpe, Kaiser, & Sofka, 2018). However, these traditional signals are associated with limitations. Patents and publications primarily target investors and peers as they provide technical and verifiable evidence of innovation. Yet, they

come with substantial costs, both financially and in terms of knowledge disclosure (Blind, Krieger, & Pellens, 2022). Patents require an explicit description of the technical details of an innovation, potentially exposing firms to competitive risks (Polidoro & Theeke, 2012). Similarly, scientific publications involve sharing research findings that often provide competitors with insights into a firm's technological advancements (Gans, Murray, & Stern, 2017). These signaling mechanisms are also less effective for engaging customers who typically lack the technical expertise to interpret complex scientific or technical information (De Vries et al., 2016; Block et al., 2015).

In contrast, website disclosures offer a less costly yet powerful and more versatile signaling mechanism, particularly suited for targeting customers and other non-expert audiences (Boulland, Bourveau, & Breuer, 2025; Dahlke et al., 2024; Macchioni, Prisco, & Zagaria, 2024).[1] Thus, we argue, firms can craft a narrative about their innovations on their websites, highlighting ties with universities in broad and accessible language, without the need for the technical detail required by patents or academic publications. Using this form of communication, firms can indicate not only that their innovations resulted from partnerships with universities, but also showcase team characteristics, such as prestigious educational backgrounds. Similarly, firms can share that they are university spin-offs or reference university researchers as experts in their field, which may positively influence potential consumers' perceptions of their innovative products. Therefore, website disclosures offer a less costly yet powerful and more versatile signaling mechanism, particularly suited for targeting customers and other non-expert audiences (Dahlke, et al., 2025; Dahlke et al., 2024; Macchioni, Prisco, & Zagaria, 2024).

This flexibility and possibility of creating a more comprehensive narrative make website signaling an attractive option for firms seeking to enhance the perceived quality of their innovations without compromising proprietary information. However, opposed to open knowledge disclosure mechanisms such as patents or scientific publications, signaling theory typically emphasizes costly, hard-to-imitate signals that reliably differentiate high-quality

[1] Boulland, Bourveau, & Breuer (2025) show that corporate communication has increasingly shifted toward firms' websites and that the disclosure of non-financial information to diverse stakeholders (e.g. investors, suppliers, customers, and employees) is strongly related to website content. Moreover, the findings indicate that website disclosure is negatively associated with investors' information asymmetry, underscoring that websites represent a meaningful and economically significant channel of corporate disclosure.

actors from low-quality ones (Spence, 1973; Connelly et al., 2024). However, Farrell and Rabin (1996) demonstrate that cheap talk, costless, non-binding, and potentially unverifiable communication, can still be informative under certain conditions, particularly when the interest of senders and receivers are sufficiently aligned or when reputational concerns exist.

Building on this foundation, Connelly et al. (2024) underline that the efficiency of a signal depends on its credibility, meaning that a signal must be relatively less costly for high-quality signalers and more costly for low-quality signalers. Signaling credible universities ties can therefore be an efficient communications mechanism to foster innovation success, even when the signaling strategy is symbolic or low-cost in nature. In particular, website-based signals that might otherwise resemble cheap talk can acquire informational value when they are repeated over time (Farrell & Rabin, 1996), embedded within reputable institutional affiliations (Fiss & Zajac, 2006; Zott & Huy, 2007), and prominently and publicly observable to key external stakeholders such as customers, investors, and regulators (Rao, Chandy, & Prabhu, 2008). Through strategic broadcasting of such affiliations, firms can enhance the perceived legitimacy, credibility, and innovation competence of their products and services, without bearing the costs of full disclosure associated with patents or scientific publications. Moreover, firms can leverage the credibility of universities to build costumer trust and differentiate their offerings in competitive markets (Maier et al., 2024).

Although website disclosures are less costly than scientific publications or patents, they still entail significant risks and organizational commitments. Harris et al. (2023), examining nonprofit organizations' use of social media, reveal that the ostensibly low-cost nature of online disclosures masks the involvement of multiple professional roles and the necessity for a coherent strategic approach. The process of disseminating information via a website or social media platform requires careful planning, coordination of content publication, and professional writing. Consequently, not all organizations (whether nonprofit or for-profit) choose to establish and actively maintain a website or to allocate substantial resources toward online disclosures (Harris et al., 2023). Wells et al. (2011) show how website quality can work as a credible signal for product quality, thanks to the display of useful and readily available information that most potential clients can evaluate without technical knowledge. In particular, Wells et al. (2011) demonstrate that the website quality acts as a credible signal for

product quality. Its credibility stems from the acknowledgment of the upfront and continuous substantial investments required by the development and maintenance of a high quality website. Such investments would not be justified for organizations lacking valuable products, as the returns on these investments would not materialize. Therefore mentioning university ties on the firm's website extends beyond the mere publication of news, but it reflects a series of previous long term strategic choices and investments.

Drawing on these insights, website mentions of university ties can function as relatively low-cost yet credible signals of innovation capacity. The signaling value of such disclosures is amplified depending on the information available, as greater the information asymmetry faced by potential customers, the more they rely on information conveyed through the website.

In the case of market novelties, defined as innovations that are new not only to the firm but to the market, the information asymmetry is particularly pronounced due to the absence of prior customer experience with similar products or services. In such cases, publicly mentioning university ties can provide relevant information to prospective customers, accelerating stakeholder acceptance. Nevertheless, the novelty of such innovations may address previously unmet needs, compelling them to experiment with the innovation even in the absence of comprehensive information. Also, early users of market novelties might possess specialized technical knowledge, enabling them to assess the value of an innovation through alternative signals, such as firms' patents or scientific publications, if they are available (Colombo et al., 2023).

In contrast, firm novelties often involve modest improvements of existing products and services, making it difficult for costumers to directly perceive their added value. By signaling university ties, firms can emphasize the quality and legitimacy of their products and services, encouraging customers to perceive them as superior to similar alternatives. Website disclosures could therefore be effective for firm novelties, where the differentiation from competitors may not be immediately apparent to external audiences, too. Then consumer's reliance on external indicators of scientific legitimacy can specifically transform signaling universities ties into a strategy to build costumer trust in competitive markets (Maier et al., 2024). This signaling strategy also aligns with the growing importance of digital communication channels in shaping consumer perceptions and purchasing decisions

(Pellegrino, 2024). On the other side, customers of a product only marginally innovated may have already experience with the functioning of the product, thus they are better suited to evaluate the importance, necessity and quality of the innovation.

In conclusion, website disclosures of university ties have the potential to be leveraged by firms as credible signals of innovation quality. Their credibility rests less on technical verification than on the reputational value of universities, their visibility to non-expert audiences, and the organizational investments required to sustain them. The relevance of such signals varies with the type of innovation.: For market novelties, where uncertainty is high and customer experience is absent, university ties can accelerate acceptance but are likely complemented by more technical signals. For firm novelties, where improvements are incremental and less readily observable, website references to universities can be particularly effective in strengthening perceptions of product differentiation and legitimacy. In this way, university-related website disclosures refine the understanding of how signaling mechanisms operate across different innovation contexts, complementing traditional accounts of costly, technical signals.

3 Data

3.1 Databases

The empirical analysis relies on cross-sectional data for 2,480 firms from the German Community Innovation Survey 2023 owning a website, enhanced with data on firms' website content in December 2021 and December 2022 from ISTARI.AI, patent information stemming from PATSTAT covering the period from 1974 to 2023, as well as public procurement contract information from the Tenders Electronic Daily Database - TED - for the years 2006 to 2022. PATSTAT and TED are merged with the Community Innovation Survey using the name-address matching according to Doherr (2023) provided by the ZEW Mannheim. The data from ISTARI.AI is added to the Community Innovation Survey using firms' web addresses available in both datasets.

The German Community Innovation Survey is organized by the ZEW Mannheim on behalf of the German Federal Ministry of Education and Research. The survey is representative of firms with five or more employees in the German business sector. It focuses on questions about

firms' innovation activities, whereas it covers further characteristics, such as revenues, industries, and age, too (Peters & Rammer, 2023).

ISTARI.AI is a science start-up rooted in the work of Kinne & Lenz (2021) and Kinne & Axenbeck (2020) on web-based innovation indicators, and its website data are increasingly used as a resource for research (e.g.; Dahlke et al., 2024; Abbasiharofteh et al., 2023). In general, ISTARI.AI co-develops the most recent state-of-the-art to extract organization web data through a multi-step pipeline (Dahlke et al., 2025). In short, it adheres to the following steps:

A) *Identify websites:* Organization URLs are collected from registries and databases; missing URLs are added via automated search and matching, wherever possible. The most important source for organization URLs is the ORBIS database.[2]
B) *Scrape content:* Text and hyperlinks from organization websites are crawled, covering up to 25 subpages per organization URL (Kinne & Axenbeck, 2020).[3]
C) *Process text:* HTML is cleaned, and textual content is analyzed with keyword searches, machine-learning or large-language models to extract information.
D) *Validate indicator:* Web-based indicators are validated against external data.

The data provided by ISTARI.AI corresponds to all paragraphs on firms' websites mentioning a specific university worldwide or having a hyperlink to a specific university worldwide in December 2021 or December 2022. Paragraphs are identified by first detecting all hyperlinks to universities and keyword-based mentions of universities. ISTARI.AI then extracted the surrounding text by collecting the content from the two preceding and two subsequent HTML tags in the website's HTML code. In large, the data covers all firms in Germany, Austria, and Switzerland having a website (Dahlke et al., 2024). We validate the reliability of the resulting mentions of university ties with our survey, and tender data.

PATSTAT stems from the European Patent Office and covers information on firms' patent applications at the office. TED is freely available from the European Commission. It covers

[2] ISTARI.AI's database is further extended by diverse national commercial registers, as well as open source databases, such as OpenStreetMap.

[3] *„A website is the overall internet presence of a firm. A website consists of a number of webpages (e.g. "www.firm-name.com", "www.firm-name.com/products"). The highest level webpage is called the homepage or the main page (e.g. "www.firm-name.com"), while lower level webpages are called subpages (e.g. "www.firm-name. com/products"), if a distinction has to be made. The first webpage downloaded from a website (the webpage corresponding to a URL in the user given list of URLs; this is usually the website's homepage) is referred to as the start page."* (Kinne & Axenbeck, 2020; p. 2015)

information on public procurement tenders awarded in the European Economic Area whose monetary value exceeds the legal thresholds for securing a transparent and competitive procurement process (Krieger & Zipperer, 2022).

3.2 Variable construction

Innovations performance – We are interested in the determinants of firms' product innovation performance. We focus on two different measures of innovation performance in our analysis:

Firm novelties – Firms' revenues with new or significantly improved products or services. This measure comprises the performance of firms' product innovations in general. It covers the revenues of products and services new to the firm, as well as new to the market.

Market novelties – Firms' revenues with new or significantly improved products not existing on the market. This measure specifically targets the performance of firms' more novel product innovation.

Each revenue is generated in 2022, whereas the implemented products and services the revenues refer to have been implemented between 2020 and 2022.

Website mentions – Firms' signaled university ties are measured by the presence of at least one paragraph mentioning a specific university on a firm's website in December 2021 or December 2022. The variable takes the value 0 if no such paragraph is present, and 1 if at least one paragraph is identified. Because firms may mention universities for different reasons, we manually classified all identified paragraphs into ten categories, such as innovation collaboration, employee background, or expert reference. Paragraphs whose meaning could not be determined were excluded, so that only interpretable and meaningful references contribute to the website mention variable.

Firms' websites are a robust source of data for inferring their activities. Prior research demonstrated that they serve as comprehensive self-representations of firms, primarily targeting investors, customers, and the press. Moreover, unlike traditional mass media, such as print and broadcast media, websites allow firms to convey their identities, and activities comprehensively to all stakeholders (Dahlke et al., 2024).

Control variables – We build a variety of control variables to investigate the properties of our website mention indicator, as well as to tackle omitted variable bias in our empirical analysis of innovation performance. All control variables refer to the year 2022, if not specified differently.

University collaboration scope – To disentangle the relevance of collaborating with universities, and signaling ties with them on a firm's website, we measure if a firm actively collaborated with universities on innovation as an ordinal variable. The Community Innovation Survey allows to identify firms' collaborating with i) universities from their German region, ii) German universities from outside their region, iii) European universities outside of Germany, iv) Universities from the United States, v) Asian Universities, as well as vi) Universities from further countries between 2020 and 2022. We defined our variable as the number of regions from the previous list, from which firms' university collaborators stem.

University customers – Moreover, to differentiate between signaling universities as customers on a firm's website and having universities as customers, we identify firms' number of received public procurement contracts awarded by universities within the TED. For this, we i) run a keywords search covering the different terms for "university" across the European Economic Area across the names of the awarding procurer, and ii) sum the number of contracts identified by the search at the level of the firm.

General innovation efforts – First, we control for the share of highly qualified employees, measured as the proportion of employees with tertiary education or equivalent qualifications, which, besides controlling for innovation efforts, additionally allows to differentiate between actually having highly educated employees, and signaling employee education on firms' websites. Moreover, we include R&D intensity, measured as R&D expenditures over revenues, and a firm's patent stock, adjusted annually using a 15 percent depreciation rate, to reflect accumulated innovation capacity.

External innovation efforts – Further external innovation efforts are captured through collaboration breadth (e.g.; Laursen & Salter, 2014), measured as the number of distinct types of innovation collaboration partners excluding universities between 2020 and 2022, and the

external R&D share, calculated as external R&D expenditures over total R&D expenditures. These variables reflect firms' general reliance on and diversity of external knowledge sources.

Firm structure – Firm structure is represented by firm age in years, the number of employees in full-time equivalents, and a binary variable for company group membership. In addition, we include a binary variable for public funding, equal to one if the firm received public financial support between 2020 and 2022. These variables account for resource availability, experience, and access to broader markets (e.g.; Krieger & Zipperer, 2022).

Firm strategies – To account for firms' market orientation and ability to utilize its website efficiently to attract customers for their innovative products and services, we include marketing intensity, measured as marketing expenditures over revenues, as well as two binary variables indicating whether a firm considered focusing i) on existing customers or ii) on acquiring new customers as at least medium important competition strategy.

Market environment – We account for industry-specific differences by including binary variables for high-tech, medium-high-tech, medium-low-tech, and low-tech manufacturing, as well as knowledge-intensive services and all remaining industries, based on the NACE Rev. 2 classification of Eurostat.

3.3 Descriptive statistics

Table 1 provides an overview of the key variables used in the analysis, offering insights into the characteristics of the firms included in the dataset. The sample comprises 2,480 firms owing a website drawn from the German Community Innovation Survey 2023.[4] The descriptive statistics highlight the diversity of firms in terms of size, innovation activities, and collaboration with universities, providing a foundation for exploring the relationship between signaling university ties on firms' websites and innovation performance.

[4] We removed firms whose R&D intensity, marketing intensity, or number of employees exceeded the 99th percentile.

Table 1 – Descriptive sample statistics

	Mean	Median	SD	Min	Max
University website mention (0/1)	0.05	0.00	0.22	0.00	1.00
Firm novelty (0/1)	0.45	0.00	0.50	0.00	1.00
Market novelty (0/1)	0.14	0.00	0.35	0.00	1.00
Revenue with firm novelty (in mio. €)	4.79	0.00	37.99	0.00	1193.06
Revenue with market novelties (in mio. €)	1.28	0.00	24.98	0.00	1193.06
University collaboration scope (0-6)	0.30	0.00	0.62	0.00	4.00
Public procurement contracts by universities	0.07	0.00	0.65	0.00	21.00
Collaboration breath (0-9)	1.02	0.00	1.79	0.00	9.00
External R&D expenditures share	0.05	0.00	0.17	0.00	1.00
R&D intensity	0.03	0.00	0.07	0.00	0.63
Patent stock	0.42	0.00	4.91	0.00	176.26
Share of highly qualified employees	0.28	0.16	0.29	0.00	1.00
Public funding (0/1)	0.36	0.00	0.48	0.00	1.00
Marketing intensity	0.01	0.00	0.01	0.00	0.10
Strategy on existing customers (0/1)	0.86	1.00	0.35	0.00	1.00
Strategy on new customer group (0/1)	0.69	1.00	0.46	0.00	1.00
Firm age in years	33.20	26.50	28.03	1.50	266.50
Number of employees as FTE	102.98	28.00	227.89	0.50	2596.00
Part of a company group (0/1)	0.42	0.00	0.49	0.00	1.00
High-tech manufacturing (0/1)	0.07	0.00	0.25	0.00	1.00
Medium-high-tech manufacturing (0/1)	0.15	0.00	0.36	0.00	1.00
Medium-low-tech manufacturing (0/1)	0.16	0.00	0.37	0.00	1.00
Low-tech manufacturing (0/1)	0.12	0.00	0.32	0.00	1.00
Knowledge-intensive services (0/1)	0.28	0.00	0.45	0.00	1.00
Other industries (0/1)	0.23	0.00	0.42	0.00	1.00

Note: Number of observations = 2,480

Innovation performance – The mean turnover generated from new or significantly improved products or services is €4.79 million, with considerable variability across firms (standard deviation: €37.99 million). This variability reflects the heterogeneity in firms' innovation performance, ranging from those with no innovative activities to outliers with substantial revenues from innovation. When disaggregated, turnover from market novelties averages €1.28 million. These figures suggest that firms tend to generate more revenue from incremental improvements than from radical innovations, highlighting the importance of understanding the mechanisms driving the success of these two innovation types separately.

Website mentions – In total 128 firms from our sample (5.1%) have at least one paragraph on their website in December 2021 or December 2022 mentioning a tie with a specific university according to ISTARI.AI. Moreover, we find 765 unique paragraphs on the websites of these

128 firms. Therefore, firms mentioning university ties on their website, mention those ties on average in 5.6 paragraphs. However, this distribution is skewed with a maximum value of 49, and a median of 4. We classified all 765 paragraphs manually into ten classes as demonstrated in Table 2. Anonymized examples for each category are provided in Appendix A.

Table 2 – Types of university website mentions

	# of paragraphs	Share of Paragraphs	# of firms	Share of firms
Collaboration	207	27%	61	48%
Customer	168	22%	29	23%
Education	141	18%	36	28%
Expert	45	6%	22	17%
Sponsorship	34	4%	9	7%
Studies	16	2%	8	6%
Spinoff	9	1%	6	5%
Region	4	1%	3	2%
Others	93	12%	21	16%
None	48	6%	17	13%

Note: Share of paragraphs calculated based on the 765 paragraphs found on the firms' websites. Share of firms represent the share of the 128 firms mentioning a specific university tie.

The three largest types of mentioned ties with universities are collaboration, customer, and education. Collaboration with universities is the most frequent type, accounting for 207 paragraphs (27%) and appearing on the websites of 61 firms (48% of the 128 firms). These paragraphs describe cases where firms and universities jointly work on innovations or projects. Customer ties, where universities are presented as customers of the firm's products or services, represent 168 paragraphs (22%) and occur in 29 firms (23%). Education-related ties, referring to employees' educational background or training at universities, cover 141 paragraphs (18%) and are mentioned by 36 firms (28%).

The remaining types are mentioned less frequently. Expert mentions (45 paragraphs, 6%; 22 firms, 17%) describe endorsements, statements, or contributions by university-affiliated experts, such as professors or researchers. Sponsorship (34 paragraphs, 4%; 9 firms, 7%) captures financial or non-financial support of universities by firms, for example sponsoring professorships, events, or scholarships. Mentions classified as studies (16 paragraphs, 2%; 8 firms, 6%) refer to universities as active partners in employee training. Spinoff ties, where firms present themselves as originating from a university or being founded by university members, account for 9 paragraphs, corresponding to a share of 1% (6 firms, 5%). Region

mentions (4 paragraphs, 1%; 3 firms, 2%) highlight universities as part of the firm's regional environment. A further 93 paragraphs (12%; 21 firms, 16%) fall into an "other" category, capturing heterogeneous and less frequent forms of ties. Finally, 48 paragraphs (6%; 17 firms, 13%) are grouped under "none", as they contain unspecific references to universities that cannot be clearly identified as a tie, or represent a wrongful identification of a university.

As a first validity check, we examine the cross-industry distribution of firms that mention universities. As expected, the frequency of mentions varies across industries, reflecting their differing degrees of dependence on knowledge generated by universities in Table 3. Firms mention university most frequently in knowledge-intensive services (10%) and high-tech manufacturing (6%), while medium-low- and low-tech manufacturing displays significantly lower rate with 3% and 1% respectively.

Table 3 – Share of firms mentioning universities on their website by industry

Industry	Mentioning university ties	Observations
High-tech manufacturing (0/1)	6%	166
Medium-high-tech manufacturing (0/1)	4%	376
Medium-low-tech manufacturing (0/1)	3%	403
Low-tech manufacturing (0/1)	1%	288
Knowledge-intensive services (0/1)	10%	689
Other industries (0/1)	3%	558

Next, we analyze if a firm's actual engagement in a university tie is related to the likelihood of the tie being mentioned on the firm's website. Due to data limitations, we focus this part of the analysis on the three most frequently mentioned ties: A) Collaboration, B) Customer, and C) Education. First, for each of the three categories, we generate a variable equal to one if a firm mentioned the category on its website, and zero otherwise. Next, we regress each of the generated variables, as well as our general website mentions indicator on our set of controls reflecting i) the actual engagement of a firm within a university tie, as well as ii) firms' general capability to use their website strategically, proxied by their marketing intensity. We measure firms' actual engagement with a dichotomous variable for having an innovation collaboration with a university within the last three years, firms' share of employees with higher education degree, and a dichotomous variable for having won a procurement contract from a university

in the past. The estimates demonstrated in Table 4 base on a probit model and represent average marginal effects.[5]

Table 4 – Linking engagement and disclosure of university ties

	(O) Mention (0/1)	(A) Collaboration (0/1)	(B) Customer (0/1)	(C) Education (0/1)
Collaboration with university (0/1)	0.64***	0.66***	0.34***	0.41***
	(0.10)	(0.09)	(0.13)	(0.12)
Share of highly qualified employees (0-1)	0.97***	0.82***	0.95***	0.55***
	(0.17)	(0.16)	(0.23)	(0.21)
Public procurement contract by university (0/1)	0.50**	0.32*	0.61**	0.15
	(0.20)	(0.19)	(0.24)	(0.26)
Marketing Intensity	1.15	-4.88	-5.73	-2.29
	(2.96)	(3.16)	(4.25)	(3.92)
Pseudo R-squared	0.16	0.11	0.12	0.13

Note: The number of observations is 2,480. Estimates represent average marginal effects. Industry dummies, and constant term included. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 shows that engaging in innovation collaborations with universities is positively and statistically significantly associated with mentioning any university tie on the website, with the largest effect observed for collaboration mentions (Column A). Having won a procurement contract from a university is likewise positively associated with customer mentions (Column B) and, to a lesser extent, collaboration mentions (Column A), while it is not significantly related to education mentions (Column C). The share of employees with higher-education degrees is positively correlated with all three mention types; somewhat unexpectedly, the smallest magnitude emerges for education mentions (Column C). By contrast, marketing intensity does not exhibit a statistically significant association with any of the mention types. Using the overall indicator of university mentions as the dependent variable (Column O) yields positive and statistically significant associations with all three engagement measures, with magnitudes broadly comparable to the largest ones reported in Columns A to C. In sum, website mentions are significantly aligned with their corresponding engagement measures in the extensive margin, yet multiple engagements simultaneously predict each mention type

[5] Even though Table 4 is descriptive, we include industry dummies to net out first-order industry differences in engaging and disclosing university ties, ensuring that the reported estimates reflect within-industry partial correlations rather than mechanical cross-industry composition effects.

indicating that the disclosure of and engagement in different types of university ties is strongly intertwined.

Next, we compare the shares of firms mentioning a specific type of university tie across different levels of engagement intensity. Firms that report an innovation collaboration with a university in the Community Innovation Survey are about 4.5 times more likely to mention such a collaboration on their website (14 percent) than firms without a reported collaboration (3 percent). Among collaborating firms, this propensity increases with the geographical scope of collaboration: the probability of mentioning collaborations is 12 percent for firms collaborating with universities in one region, 15 percent for those collaborating in two regions, and 22 percent for those collaborating in three or more regions.[6]

A similar pattern emerges with respect to the educational composition of the workforce. Firms with a higher share of employees holding a higher education degree are more likely to reference universities in the context of employee education. Only 0.4 percent of firms with no employees holding a higher education degree mention universities in relation to education, compared to 1 percent in the lowest quartile and 9 percent in the highest quartile among firms with a positive share.

Finally, firms that win a larger procurement contract from a university in the Tenders Electronic Daily database are roughly four times as likely to list universities as customers on their website (8 percent) as firms without such a contract (2 percent). Among firms winning at least one contract, the probability of mentioning universities as customers rises from 8 percent to 11 percent as the number of won contracts increases up to three, but drops to zero for the remaining ten firms with four or more contracts.[7]

Taken together, these patterns suggest that website disclosure of university ties is an increasing, but highly selective, function of engagement intensity. Even among strongly engaged firms, many do not disclose such ties, and the relationship might be non-linear at high

[6] Collaborating with universities in one region corresponds to the median regional breadth among collaborating firms, while collaborating in two regions corresponds to the 75th percentile.

[7] In total, 75 firms won at least one larger award from a university. The 25th, 50th, and 75th percentiles of the number of awards per firm are 1, 2, and 3, respectively. Ten firms obtained four or more awards with an average and median of 5 awards in this group and a maximum of 21.

engagement levels of specific ties, consistent with a strategic rather than mechanical use of website disclosure.

4 Empirical strategy

4.1 Estimation model

To investigate the relationship of signaling university ties with the performance of firm innovation, we employ the following empirical model:

$$I_i = \beta_0 + \beta_1 SigUni_i + \boldsymbol{Controls_i \beta_2} + \gamma + \epsilon_i$$

where I_i is the revenue of firm i with new or significantly improved products and services, and $SigUni_i$ is our measure for mentioning university ties. The vector $Controls_i$ represents the described firm controls, and γ the described fixed effects differentiating between industries. Finally, ϵ_i is the error term.

We use three alternative specifications to estimate the parameters of the model. Throughout, identification of β_1 hinges on two central assumptions:

- ***(A1) Exogeneity of signaling:*** conditional on observed controls and industry fixed effects, mentioning university ties on the website, $SigUni_i$, is uncorrelated with the unobserved determinants of innovation revenues.
- ***(A2) No selection on unobservables into earning innovation revenues:*** the fact that a firm does or does not generate revenues from new or significantly improved products or services does not depend on unobserved factors that also affect the level of those revenues, after conditioning on observables.

Ordinary Least Squares provides an estimate of the conditional linear relationship between mentioning university ties and innovation revenues (Wooldridge, 2010). This specification quantifies whether, holding observable characteristics constant, firms that mention universities on their websites report higher revenues from new or significantly improved products or services.

In our context, OLS requires both (A1) and (A2):

Under (A1), unobserved characteristics such as managerial ability, website quality, or product appeal do not jointly drive signaling behavior and innovation revenues once we condition on controls and industry fixed effects.

Under (A2), the selection into having positive innovation revenues is assumed to be fully captured by observables and thus ignorable.

Given our setting, both assumptions are demanding: unobserved manager-, website-, or product-specific factors may simultaneously increase a firm's propensity to highlight university ties and its ability to generate innovation revenues, violating (A1). Moreover, firms that become innovators are plausibly positively selected on unobservables that also raise revenues, violating (A2).

The ***Control Function Approach*** extends Ordinarily Lest Squares by explicitly addressing non-random selection into earning innovation revenues, i.e. it is designed to relax assumption (A2) while maintaining (A1).

Only firms that introduce new or significantly improved products or services can generate corresponding revenues. Therefore, firms with zero innovation revenues systematically differ from those with positive revenues. Ignoring this, even if the sample is restricted to innovators only, mixes selection and performance since firms that end up as innovators are positively selected on unobserved characteristics that affect both signaling and revenues, biasing β_1.

The control function corrects for this non-random selection in two steps. We first estimate a probit model for the probability that a firm introduces any new or significantly improved product or service. From this first stage, we compute the inverse Mills ratio, which summarizes the part of the innovation-entry decision that is driven by unobserved factors. We then include this inverse Mills ratio as an additional regressor in the revenue equation. Intuitively, this term controls for the correlation between the unobservables in the selection equation and those in the revenue equation, purging the selection bias.

In doing so, the Control Function Approach:

- **Relaxes (A2):** selection into earning innovation revenues is no longer required to be random conditional on observables; instead, it is modeled explicitly via the selection equation and its correlation with the outcome equation.
- **Maintains (A1):** after controlling for observables and the inverse Mills ratio, $SigUni_i$ is still assumed exogenous with respect to the remaining error in the revenue equation.

At the same time, it introduces the following new main assumptions:

(C1) Correct parametric specification of the selection and outcome equations, including the functional form of the probit and the linear revenue equation.

(C2) Joint normality of the selection and outcome errors, which underlies the use of the inverse Mills ratio as a sufficient control for selection on unobservables.

If these assumptions are violated, for example when the determinants of introducing innovations differ systematically from the determinants of earning revenues from them in ways not captured by observables, the correction may itself be misspecified.

Lewbel Instrumental Variable Estimator (Lewbel, 2012) addresses a different concern: it is designed to relax (A1) by allowing for endogeneity of signaling, while leaving (A2) unchanged.

As described previously, unobserved characteristics may affect both the decision to signal university ties on the website and the ability to generate innovation revenues. In this case, $SigUni_i$ is correlated with the error term, violating (A1) and rendering Ordinary Least Squares biased even in the absence of selection.

The Lewbel approach uses heteroskedasticity to construct internal instruments for $SigUni_i$. In our setting, it:

- **Relaxes (A1):** $SigUni_i$ is allowed to be endogenous; identification of β_1 comes from variation in instruments generated from the covariance between mean-centered exogenous regressors and the heteroskedasticity of the error term in the first-stage equation.

- **Maintains (A2):** even if the estimation is restricted to firms with positive innovation revenues, the method still assumes that selection into this sample is ignorable conditional on observables.

In turn, Lewbel IV adds the following main assumptions:

(L1) Exogeneity of the original controls: all non-constructed regressors used to build instruments must be uncorrelated with the structural error in the outcome equation.

(L2) Presence and correct use of heteroskedasticity: there must be sufficient heteroskedasticity in the error term of the first-stage equation, and the resulting covariance restrictions must hold (i.e. the constructed instruments are correlated with $SigUni_i$ but uncorrelated with the outcome error).

Together, these three specifications allow us to assess the robustness of the estimated relationship under different relaxations of the key assumptions (A1) and (A2), while imposing an alternative set strong assumptions (C1) and (C2), or (L1) and (L2). The control function approach relaxes the assumption of no selection on unobservables into earning innovation revenues at the cost of stronger functional form and distributional assumptions about the joint error structure. The Lewbel estimator relaxes the exogeneity assumption for signaling by exploiting heteroskedasticity to construct instruments but relies on additional moment conditions and the exogeneity of the remaining regressors. Given the strength of these different sets of assumptions, we ultimately interpret our findings as *strictly* correlational.

4.2 Subsample selection

We concentrate on different measures of innovation revenues as dependent variables. Therefore, as we focus on the performance of innovation (What makes firms successful with their innovation?), and not their introduction (What makes firms innovative?), we estimate our empirical model for different subsamples of firms.

Firm novelties – We use all 1,108 firms responding to the 2023 Community Innovation Survey *introducing new or significantly improved products or services at least new to the firm* between 2020 and 2022. Thus, we limit the variation captured by I_i to changes in the magnitude of innovative

revenues (intensive margin), and effectively remove the variation related to the number of firms generating them (extensive margin).

Market novelties – Furthermore, to separately investigate the relationship between signaling university ties and revenues from market novelties, we further reduce the previous subsample. More precisely**,** we use only the 346 firms introducing new or significantly improved products or services *new to the market* between 2020 and 2022. While this stratification reduces statistical power, it enables a more detailed investigation into the types of innovation revenues and their relationship with university-based website signals at the intensive margin.

Employee numbers – As presented in the next section, we find no relationship between website mentions of university ties and the performance of firm or market novelties across the full samples of innovators. We therefore turn our focus to small and medium-sized enterprises, which face stronger information asymmetries and resource constraints than larger firms (Baumol, 2022; Mumi et al., 2019), and profit more strongly from ties with universities (Johnston & Prokop, 2025; Bellini et al, 2019). These firms might particularly profit from referencing universities on their website at relatively low cost to enhance their credibility. Accordingly, we investigate subsamples of firms with fewer than 250 employees and, even more narrowly, small firms with fewer than 50 employees.

5 Results

This section investigates the relationship between signaling university ties on firms' websites and the performance of market novelties. Table 5 reports Ordinary Least Squares estimates, Table 6 shows Control Function estimates, and Table 7 presents Lewbel Instrumental Variable estimates. The results indicate that website mentions of university ties are statistically significantly and positively related to the revenues from market novelties of small firms with fewer than 50 employees. For the broader set of firms, no significant association is observed. As shown in Appendix B, the results for firm novelties indicate that website mentions are generally unrelated, with all estimates remaining statistically insignificant. We interpret this as evidence for the absence of a consistent statistically significant relationship.

In the Ordinary Least Squares estimations (Table 5), the coefficient on website mentions of university ties is neither statistically significant for the full sample ($\hat{\beta}$ = 0.09, p = 0.53), nor for firms with fewer than 250 employees ($\hat{\beta}$ = 019, p = 0.15). For firms with fewer than 50 employees, the coefficient is positive and marginally significant ($\hat{\beta}$ = 0.22, p = 0.08). Hence, the Ordinary Least Squares results provide first indications that website mentions of university ties are positively related to market-novelty revenues, but only in small firms.

Table 5 – Ordinary Least Squares estimates

Dependent variable: Ln(turnover with market novelties + 1)	(1) All firms	(2) <250 employees	(3) < 50 employees
Website mention of university ties (0/1)	0.09	0.19	**0.22***
	(0.15)	(0.13)	**(0.12)**
Ln(university cooperation scope +1)	0.12	0.00	0.05
	(0.11)	(0.09)	(0.10)
Share of highly qualified employees (0-1)	0.80***	0.52***	0.43***
	(0.24)	(0.16)	(0.16)
Ln(university pp contracts +1)	0.19	0.29	-0.06
	(0.16)	(0.18)	(0.22)
Ln(collaboration breath +1)	-0.16**	-0.14**	-0.09
	(0.08)	(0.07)	(0.06)
External R&D expenditures share	0.61**	0.73**	0.93***
	(0.30)	(0.30)	(0.25)
R&D intensity	-0.80**	-0.96***	-0.87***
	(0.37)	(0.34)	(0.29)
Ln (patent stock + 1)	0.06	0.27*	0.44***
	(0.09)	(0.14)	(0.12)
Public funding (0/1)	-0.15	-0.03	0.02
	(0.10)	(0.09)	(0.09)
Marketing intensity	3.47	3.34	0.05
	(2.36)	(2.10)	(1.71)
Strategy on existing customers (0/1)	0.20*	0.23**	0.11
	(0.11)	(0.10)	(0.10)
Strategy on new customer group (0/1)	-0.07	-0.12	-0.13
	(0.10)	(0.10)	(0.10)
Ln(age + 1)	0.01	-0.01	-0.05
	(0.06)	(0.05)	(0.05)
Ln(number of employees as FTE + 1)	0.48***	0.34***	0.19***
	(0.05)	(0.05)	(0.06)
Part of a company group (0/1)	0.15*	0.18**	0.13
	(0.08)	(0.08)	(0.08)
Export revenues (0/1)	0.09	0.05	0.15**
	(0.12)	(0.10)	(0.07)
Observations	346	286	184
Adjusted R-Squared	0.49	0.34	0.33

Note: Robust standard errors in parentheses. Industry dummies, and constant term included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The Control Function estimates (Table 6) confirm this pattern and strengthen the results for small firms. For the full sample ($\hat{\beta}$ = 0.03, p = 0.84) and the subsample of firms with fewer than 250 employees ($\hat{\beta}$ = 0.12, p = 0.44), the coefficients on website mentions remain positive but are statistically insignificant. For firms with fewer than 50 employees, the coefficient is positive and becomes statistically significant at the five percent level ($\hat{\beta}$ = 0.27, p = 0.04). The Inverse Mills Ratio enters positively but is not statistically significant. Appendix C reports the first-stage probit estimates used to calculate the Inverse Mills Ratio. These indicate no statistically significant relationship between website mentions and the probability of introducing market novelties. By contrast, conducting collaborations with universities is highly statistically significant in the first stage, highlighting its importance for the introduction of new products and services. Taken together, these results suggest that while university collaborations matter for the likelihood of generating market novelties, website mentions become relevant primarily for the subsequent commercial performance of such innovations.

Table 6 – Control Function Approach estimates

Dependent variable: Ln(turnover with market novelties + 1)	(1) All firms	(2) <250 employees	(3) <50 employees
Website mention of university ties (0/1)	0.03	0.12	**0.27****
	(0.16)	(0.16)	**(0.13)**
Ln(university cooperation scope +1)	0.41	0.41	0.33
	(0.35)	(0.48)	(0.31)
Share of highly qualified employees (0-1)	1.34**	1.01*	0.71**
	(0.66)	(0.60)	(0.33)
Ln(university pp contracts +1)	0.33*	0.54*	0.04
	(0.18)	(0.32)	(0.26)
Ln(collaboration breath +1)	-0.04	-0.05	-0.07
	(0.14)	(0.12)	(0.07)
External R&D expenditures share	0.78**	1.01**	1.36***
	(0.35)	(0.45)	(0.46)
R&D intensity	1.15	1.09	0.29
	(2.07)	(2.31)	(1.16)
Ln(patent stock + 1)	0.16	0.56	0.71**
	(0.12)	(0.35)	(0.27)
Public funding (0/1)	-0.18	-0.08	-0.05
	(0.11)	(0.11)	(0.12)
Marketing intensity	7.21*	7.83	4.70
	(4.36)	(5.42)	(5.10)
Strategy on existing customers (0/1)	0.49	0.48	0.31
	(0.33)	(0.30)	(0.22)
Strategy on new customer group (0/1)	0.16	0.15	0.02
	(0.27)	(0.30)	(0.18)
Ln(age + 1)	0.01	-0.04	-0.14
	(0.06)	(0.07)	(0.11)
Ln(number of employees as FTE + 1)	0.54***	0.41***	0.29**
	(0.09)	(0.10)	(0.11)
Part of a company group (0/1)	0.15*	0.17**	0.18*
	(0.08)	(0.08)	(0.10)
Export revenues (0/1)	0.65	0.67	0.64
	(0.61)	(0.68)	(0.49)
Inverse-Mill-Ratio	1.27	1.43	0.91
	(1.34)	(1.58)	(0.89)
Observations	346	286	184
Adjusted R-squared	0.49	0.34	0.33

Note: Robust standard errors in parentheses. Industry dummies, and constant term included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The Lewbel Instrumental Variable estimates (Table 7) confirm the results for small firms, too. For the full sample ($\hat{\beta} = 0.07$, p = 0.48) and firms with fewer than 250 employees ($\hat{\beta} = 0.04$, p = 0.65), coefficients remain insignificant. For firms with fewer than 50 employees, the coefficient is positive and statistically significant ($\hat{\beta} = 0.21$, p = 0.01). Instrument strength is supported by a Kleibergen–Paap F-statistic of 41.55 and higher, and the Hansen J-test ($\hat{p} < 0.55$) does not reject the validity of the over-identifying restrictions. The Breusch–Pagan χ^2 statistic of >92 ($p < 0.01$) confirms the presence of heteroskedasticity for the estimations in the first stage.

Table 7 – Lewbel Instrumental Variable estimates

Dependent variable: Ln(turnover with market novelties + 1)	(1) All firms	(2) <250 employees	(3) <50 employees
Website mention of university ties (0/1)	0.07 (0.10)	0.04 (0.09)	0.21** (0.08)
Observations	346	286	184
R-squared	0.52	0.38	0.39
Kleibergen-Paap LM statistic	44.30	46.44	41.55
Kleibergen-Paap LM p-value	0.00	0.00	0.00
Kleibergen-Paap Wald F-statistic	42.32	30.91	29.54
Hansen Chi-squared	17.50	14.02	17.62
Hansen J test (p-value)	0.56	0.78	0.55
Breusch–Pagan χ^2 statistic	218.81	156,70	92,33
Breusch-Pagan (p-value)	0.00	0.00	0.00

Note: Robust standard errors in parentheses. Control variables, industry dummies, and constant term included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In total, these results indicate a statistically significant positive association between mentioning ties with universities on a website and firms' revenues from market novelties. Applying the log–linear transformation ($\exp(\hat{\beta}) - 1$) implies that, for firms with fewer than 50 employees, website disclosures of university ties are associated with revenue levels from market novelties that are about 23–31 percent higher. Evaluated at the median revenue from market novelties for this group (EUR 410,000), this corresponds to an increase of roughly EUR 94,000 to EUR 127,000.

6 Conclusion

Summary – This study *exploratively* examined how i) disclosed ties with universities on firms' websites relates to firms' actual ties with universities measured by survey and tender data, and ii) how disclosing ties with universities is related with firms' performance of innovations, specifically, revenues from firm novelties (new-to-the-firm) and market novelties (new-to-the-market). Thus, it builds and tests a novel measure for firms' ties with universities based on firms' discloser of information on their website, conceptually discusses firms' incentives to disclose such information on their website, and directly demonstrates the measures applicability in an empirical setting.

Contribution – With this, the study contributes to two streams of research: First, adding to research on using website information as data source (e.g., Dahlke et al., 2025), it extends the discussion on the potential of using website data to investigate interactions between firms and

universities at a more granular level, and a larger scale by i) focusing on *firms' website mentions*, instead of on universities' website mentions (e.g., Schubert et al., 2025), and ii) differentiating between *specific types of university ti*es, instead of using broader indicators of potential ties, such as hyperlinks (e.g. ; Schmidt et al., 2025; Arifi et al., 2023; Kenekayoro, Buckley, & Thelwall, 2014). Second, it conceptually introduces and empirically analyzes website mentions of universities ties as a potential *low-cost, customer-facing* signal that complements traditional, *high-cost signals such as patents and publications* (e.g., Baruffaldi, Simeth, & Wehrheim, 2024; Liu, Du, & Pennings, 2024).

Insights for research – Four main insights emerge for its use as a data source. First, *website mentions of universities allow for an identification of a large number of different ties with universities*, such as innovation collaboration, customer relationships, employee education, expert endorsements, sponsorships of universities, or being a university spinoffs, which is – to the best of our knowledge – not observable in any alternative single data source, besides – and even in these cases only for a smaller number of ties – targeted surveys, such as specific waves of the Community Innovation Survey (e.g., Rammer & Schubert, 2022, pp. 168-175). Second, the *mentioned university ties seem to present reliable information*, as indicated by the three most commonly mentioned ties, namely innovation collaboration, universities as customers, and firms' employee education, having a statistically significant relationship with a firm's actual ties as measured by the German Community Innovation Survey and the Tenders Electronic Daily database. Third, our results suggest *that firms are more likely to mention ties that are particularly relevant to them*, as the probability of our most commonly mentioned ties being disclosed largely increases with the firm's actual engagement in a specific tie. However, this result implies *a large number of firms not disclosing their ties with universities*, even though they exist, too. Fourth, these properties pose particular risks in using website mentions to analyze the average effects of signaling, as well as engaging in specific ties on firms' performance, as *mentions likely present high levels of engagement, leading to the overestimation of effects*, if not i) controlled for, or ii) interpreted accordingly.

Three main insights emerge for the relation of mentioning university ties on a website with firms' innovation performance i) using three different estimation methods based on varying assumptions on firms' selection into innovating, and the exogeneity of our mention indicator

conditional on the included controls, and ii) strictly controlling for firms actual engagement in the most commonly mentioned ties. First, across the full samples of innovators, website mentions of university ties are not systematically associated with revenues from either firm novelties or market novelties. *For firm novelties in particular, we interpret our results as generally null*. Second, the relationship between website mentions and market novelties differs by firm size. *Among small firms, website disclosures are positively associated with revenues from market novelties*. More precisely, based on the point estimates of our different estimation methods, disclosing university ties results in an increase of revenues from market novelties of between EUR 94,000 to EUR 127,000 for the median firm. This pattern is consistent with website mentions acting as accessible, customer-facing credibility cues when evaluative benchmarks are scarce and uncertainty is high (Spence, 1973; Wells, Valacich, & Hess, 2011; Mavlanova, Benbunan-Fich, & Koufaris, 2012), as well as with evidence that highlighting university ties can raise perceived product attractiveness (Maier et al., 2024).[8] Third, compared with traditional signals such as patents and publications, which primarily target expert audiences and involve higher costs and disclosure risks (Gans, Murray, & Stern, 2017; Baruffaldi, Simeth, & Wehrheim, 2024; Liu, Du, & Pennings, 2024; Polidoro & Theeke, 2012), website disclosures represent a low-cost, broadly visible signal that appears relevant for the commercialization of market novelties by smaller firms with typically limited resources (Mumi, Obal, & Yang, 2019; Baumol, 2022; Macchioni, Prisco, & Zagaria, 2024).

Insights for practitioners – These findings for innovation performance offer *tentative implications*. For managers of small firms commercializing market novelties, carefully designed website disclosures of university ties can complement broader strategies by enhancing perceived credibility at relatively low cost (Wells et al., 2011; Maier et al., 2024). By contrast, for firm novelties and for larger firms with most likely stronger brand capital, the incremental value of such website signaling appears limited. Therefore, communication resources should be aligned with innovation type and existing reputation assets (Gans et al., 2017; Polidoro & Theeke, 2012). For policymakers, support for university–industry collaboration could be complemented by light measures that help small firms to communicate these ties effectively on their websites (e.g., guidance, templates, recognition programs), thereby lowering barriers

[8] Moreover, the stronger effects among smaller firms align with empirical evidence on small firms benefit the most from ties with universities ((Johnston & Prokop, 2025; Bellini et al., 2019).

to credible, low-cost signaling without inducing excessive disclosure (Mumi et al., 2019; Macchioni et al., 2024).

Future research – Several limitations set directions for future research.

First, our results on innovation performance are correlational. The analysis relies on cross-sectional data; establishing temporal ordering and causality will require panel designs that track website content and subsequent revenues over time or quasi-experimental approaches that exploit exogenous shocks. Moreover, we cannot distinguish the relevance of different *types* of website-mentioned ties because i) statistical power is limited, in particular for market innovators, and ii) we have no information on firms' actual engagement in a number of individual types of ties. Thus, a sharper differentiation between the mechanisms of signaling and the engagement of firms in specific university ties, would require i) a larger database to provide the statistical power for analyzing the relevance of the individual types of mentioned university ties, and ii) further firm-level control variables, optimally covering all types of mentioned ties, and firms' level of engagement in each of them.

Second, more research is needed for a better empirical understanding of the indicator, in particular, the association between less frequently mentioned ties, and firms' actual engagement in them, has the potential to further verify the informativeness' of the measure. In addition, our manual classification of university ties poses a major limitation for the measures scalability. Thus, follow on research developing an automated procedure for identifying the different types of university ties is needed to leverage the measures demonstrated potential.

Third, the focus on Germany may constrain external validity for our findings on the properties of our measure, as well as for our findings on innovation performance; comparative studies across countries would clarify the boundary conditions of our findings.

References

Abbasiharofteh, M., Krüger, M., Kinne, J., Lenz, D., & Resch, B. (2023). The digital layer: alternative data for regional and innovation studies. *Spatial Economic Analysis, 18*(4).

Arifi, D., Resch, B., Kinne, J., & Lenz, D. (2023). Innovation in hyperlink and social media networks: Comparing connection strategies of innovative companies in hyperlink and social media networks. *PloS one, 18*(3).

Baruffaldi, S., Simeth, M., & Wehrheim, D. (2024). Asymmetric Information and R&D Disclosure: Evidence from Scientific Publications. *Management Science, 70*(2), 1052-1069.

Baumol, W. (2022). Entrepreneurship, Innovation and Growth: The David-Goliath Symbiosis. *Journal of Entrepreneurial Finance and Business Ventures, 7*(2), 1-10.

Bellini, E., Piroli, G., & Pennacchio, L. (2019). Collaborative know-how and trust in university–industry collaborations: empirical evidence from ICT firms. *Journal of Technology Transfer, 44*, 1939–1963.

Blind, K., Krieger, B., & Pellens, M. (2022). The interplay between product innovation, publishing, patenting and developing standards. *Research Policy, 51*(7).

Block, J. H., Fisch, C. O., Hahn, A., & Sandner, P. G. (2015). Why do SMEs file trademarks? Insights from firms in innovative industries. *Research Policy, 44*(10), 1915-1930.

Boulland, R., Bourveau, T., & Breuer, M. (2025). Company Websites: A New Measure of Disclosure. *Journal of Accounting Research*.

Cefis, E., & Marsili, O. (2006). Survivor: The role of innovation in firms' survival. *Research Policy, 35*(5), 626-641.

Colombo, M. G., Guerini, M., Hoisl, K., & Zeiner, N. M. (2023). The dark side of signals: Patents protecting radical inventions and venture capital investments. *Research Policy, 52*(5).

Connelly, B. L., Certo, S. T., Reutzel, C. R., DesJardine, M. R., & Zhou, Y. S. (2024). Signaling Theory: State of the Theory and Its Future. *Journal of Management, 51*(1), 24-61.

Crawford, V. P., & Sobel, J. (1982). Strategic Information Transmission. *Econometrica, 50*(6), 1431-1451.

Dahlke, J., Beck, M., Kinne, J., Lenz, D., Dehghan, R., Wörter, M., & Ebersberger, B. (2024). Epidemic effects in the diffusion of emerging digital technologies: evidence from artificial intelligence adoption. *Research Policy, 53*(2).

Dahlke, J., Schmidt, S., Lenz, D., Kinne, J., Dehghan, R., Abbasiharofteh, M., . . . Rammer, C. (2025). The WebAI Paradigm of Innovation Research: Extracting Insight From Organizational Web Data Through AI. *ZEW Discussion Paper No. 25-019*.

De Vries, G., Pennings, E., Block, J. H., & Fisch, C. (2016). Trademark or patent? The effects of market concentration, customer type and venture capital financing on start-ups' initial IP applications. *Industry and Innovation, 24*(4), 325-345.

Doherr, T. (2023). The SearchEngine: a Holistic Approach to Matching. *ZEW - Centre for European Economic Research Discussion Paper No. 23-001*.

Farrell, J., & Rabin, M. (1996). Cheap Talk. *Journal of Economic Perspectives, 10*(3), 103–118.

Fiss, P. C., & Zajac, E. J. (2006). The Symbolic Management of Strategic Change: Sensegiving via Framing and Decoupling. *The Academy of Management Journal, 49*(6), 1173-1193.

Gans, J., Murray, F., & Stern, S. (2017). Contracting over the disclosure of scientific knowledge: Intellectual property and academic publication. *Research Policy, 46*, 820-835.

García-Vega, M., & Vicente-Chirivella, Ó. (2020). Do university technology transfers increase firms' innovation? *European Economic Review, 123*.

Grimpe, C., Hussinger, K., & Sofka, W. (2023). Reaching beyond the acquirer-target dyad in M&A - Linkages to external knowledge sources and target firm valuation. *Long Range Planning, 56*.

Grimpe, C., Kaiser, U., & Sofka, W. (2018). Signaling valuable human capital: Advocacy group work experience and its effect on employee pay in innovative firms. *Strategic Management Journal, 40*, 685-710.

Harris, E. E., Neely, D. G., & Saxton, G. D. (2023). Social media, signaling, and donations: testing the financial returns on nonprofits' social media investment. *Review of Accounting Studies, 28*, 658–688.

Ipinnaiye, O., Lenihan, H., Mulligan, K., Doran, J., & Roper , S. (2025). Innovation success in small and larger firms: Does persistence and diversity in R&D matter when building a unique knowledge base? *The Journal of Technology Transfer*.

ISTARI. (2024). *Client Stories.* Von istari.ai: https://www.istari.ai/client-stories?filter-sector=Public%20sector abgerufen

Johnston, A., & Prokop, D. (2025). Collaborations between universities and entrepreneurial ventures: a micro-firm perspective. *Journal of Small Business and Enterprise Development, 32*(5), 1055–1080.

Kenekayoro, P., Buckley, K., & Thelwall, M. (2014). Hyperlinks as inter-university collaboration indicators. *Journal of Information Science, 40*(4), 514-522.

Kinne, J., & Axenbeck, J. (2020). Web mining for innovation ecosystem mapping: a framework and a large-scale pilot study. *Scientometrics, 125*, 2011-2041.

Kinne, J., & Lenz, D. (2021). Predicting innovative firms using web mining and deep learning. *PLoS ONE, 16*(4). doi:https://doi.org/10.1371/journal.pone.0249071

Krieger, B., & Zipperer, V. (2022). Does green public procurement trigger environmental innovations? *Research Policy, 51*(6).

Laursen, K., & Salter, A. (2006). Open for Innovation: the role of opennes in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal, 27*, 131-150.

Laursen, K., & Salter, A. J. (2014). The paradox of openness: Appropriability, external search and collaboration. *Research Policy, 43*(5), 867-878.

Lewbel, A. (2012). Using Heteroscedasticity to Identify and Estimate Mismeasured and Endogenous Regressor Models. *Journal of Business & Economic Statistics, 30*(1), 67-80.

Liu, Z., Du, Y., & Pennings, E. (2024). Open knowledge disclosure and firm value: a signalling theory perspective. *Industry and Innovation, 31*(4), 475-500.

Macchioni, R., Prisco, M., & Zagaria, C. (2024). The value relevance of voluntary disclosure through social media platforms: Evidence from European Union listed firms. *Socio-Economic Planning Sciences, 93*.

Maier, L., Schreier, M., Baccarella, C., & Voigt, K.-I. (2024). University Knowledge Inside: How and When University–Industry Collaborations Make New Products More Attractive to Consumers. *Journal of Marketing, 88*(2), 1-20.

Mavlanova, T., Benbunan-Fich, R., & Koufaris, M. (2012). Signaling theory and information asymmetry in online commerce. *Information & Management, 49*(5), 240-247.

Merton, R. (1987). A simple model of capital market equilibrium. *The Journal of Finance, 42*(3), 483-510.

Mulligan, K., Lenihan, H., Doran, J., & Roper, S. (2022). Harnessing the science base: Results from a national programme using publicly-funded research centres to reshape firms' R&D. *Research Policy, 51*(4).

Mumi, A., Obal, M., & Yang, Y. (2019). Investigating social media as a firm's signaling strategy through an IPO. *Small Business Economics, 53*, 631-645.

Pellegrino, A. (2024). Consumer Perceptions. How Digital Marketing Has Changed Consumer Perceptions. In A. Pellegrino, *Decoding Digital Consumer Behavior. Bridging Theory and Practice* (S. 31-53). Springer Nature.

Peters, B., & Rammer, C. (2023). Chapter 5: Innovation panel surveys in Germany: the Mannheim Innovation Panel. In F. Gault, A. Arundel, & E. Kraemer-Mbula, *Handbook of Innovation Indicators and Measurement* (S. 54-87). EE Elgar online.

Polidoro, F., & Theeke, M. (2012). Getting competition down to a science: The effects of technological competition on firms' scientific publications. *Organization Science, 23*(4), 1135-1153.

Rammer, C., & Schubert, T. (2022). *Dokumentation zur Innovationserhebung 2017 bis 2021.* Mannheim and Karlsruhe: ZEW Documentation.

Rao, R. S., Chandy, R. K., & Prabhu, J. C. (2008). The Fruits of Legitimacy: Why Some New Ventures Gain More from Innovation than Others. *Journal of Marketing, 72*(4), 58-75.

Schmidt, S., Kanilmaz, U. N., Abbasiharofteh, M., & Resch, B. (2025). Analysing the spatial manifestation of sustainability-engaged inter-firm networks in Germany, Austria and Switzerland. *Spatial Economic Analysis*, 1-20.

Schubert, T., Darold, D., & Kroll, H. (2025). Knowledge and technology transfer in German universities: An exploratory study leveraging information from university websites. *Socio-Economic Planning Sciences, 102*.

Slater, S. F., & Mohr, J. J. (2006). Successful Development and Commercialization of Technological Innovation: Insights Based on Strategy Type. *Journal of Product Innovation Management, 23*, 26-33.

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics, 87*(3), 355–374.

Stephan, P. (1996). The Economics of Science. *Journal of Economic Literature, 34*(3), 1199 - 1235.

Veugelers, R. (2016). The embodiment of knowledge: universities as engines of growth. *Oxford Review of Economic Policy, 32*(4), 615–631.

Wells, J. D., Valacich, J. S., & Hess, T. J. (2011). What Signal Are You Sending? How Website Quality Influences Perceptions of Product Quality and Purchase Intentions. *MIS Quarterly, 35*(2), 373-396.

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data.* The MIT Press.

Zott, C., Huy, Q. N. (2007). How Entrepreneurs Use Symbolic Management to Acquire Resources. *Administrative Science Quartelry, 52*(1), 70-105.

Appendix A – Example paragraphs of mentioning university ties on firms' websites

In the following, we provide anonymized website paragraphs directly taken from the data provided by ISTARI.AI as examples for firms' website mentions of each identified university type. Paragraphs are translated from German to English using DeepL, and shortened to their most relevant parts as indicated by […]. If within the shortened paragraphs specific parts are particular important to identify the type of tie, it is highlighted in bold.

A1 Collaboration

> ***The A-project is led by B-Company and supported by C-Initiative and D-University.*** The aim of the project is to prove that continuous, multi-level stress monitoring can be implemented using largely automated processes and, when combined with learning strategies, can enable a personalized and sustainable stress management system for people in the workplace. […]

> *A-Product* is our unique TTR microscope, which you can also test in our application laboratory. We have added THz lasers and THz detectors to our latest product range. ***Not to mention our in-house development in collaboration with B-University: a TTR-ATR waveguide.***

A2 Customer

> ***A-Company about our client: The B-Graduate School of Management […] is an internationally recognized business school.*** 700 students from 56 countries and more than 2,500 alumni speak for the popularity of this educational institution. […] Our collaboration with *B-Graduate School*: Our work for *B-Graduate School* is also top notch. […] We also provided *B-Graduate School* with comprehensive SEO support for the relaunch of their website, including keyword strategy, technical implementation, SEO workshops, and more.

A3 Education

> *A-Employee*
>
> Place of birth: *B-City* Year of birth: *19XX* ***Attorney at law, LL.M. (A-University)***, specialist lawyer for commercial and corporate law, specialist lawyer for insolvency law […] Foreign languages: English

A4 Expert

A-Associate Professor, B-University: In Europe, *A-Project* is working within the program [...] to develop potential antibiotics against certain bacteria. The scientists who want to combat these bacteria have already found new ways to fight drug-resistant bacteria, convinced a pharmaceutical company to join them, and recently selected their first antibiotic candidate. [...]. Researchers at B-*University* have already demonstrated the efficacy and safety of this drug in animal models for various infections [...].

A5 Sponsorship

Scholarships for the 2019/20 winter semester***. To promote young academics, A-GmbH has once again provided financial support for the scholarship program this year***. For the 2019/20 winter semester, 59 Germany Scholarships were awarded by the B-*University*.

A6 Studies

We are a practice partner of A-University in the Practical Computer Science degree program and of *B-University* for Study-Practice […]

A7 Spinoff

Through the development of our own *A-software* and projects in a wide range of industries, we have built up a wealth of experience that enables our highly qualified team to successfully solve your problems. *A-software* over time: ***The partners met at B-University in the Department of Aerospace Engineering under C-Prof.***, who played a key role in developing and designing the finite element method. The company founders developed and programmed the *A-software* [...]. 19XX Foundation ***of the D-company as a spin-off for the further development and marketing of the nonlinear solver.***

A8 Region

Our location is in the heart of the cybersecurity center of *A-City*, with the appropriate infrastructure and network and good public transport connections. *A-City* has been recognized as a digital city by *B-Initiative*, is a science city, and is the digital hub for cybersecurity in Germany. ***Proximity to research: Spatial and scientific proximity to the directly adjacent C-Institute C, D-TU, and E-University.*** […]

A9 Others

Geological excursions through *A-Region*. As part of the *A-Region:* Geoscience Evenings organized by the Society for Sedimentology, ***lecture "Geological excursions through A-Region" by B-Person, at C-University, Geology Lecture Hall*** - The groundwater balance in *A-Region* - Lecture: Sustainability inventory for the *C-city* - Awarded: *D-Project* is committed to equal treatment of men and women. […]

Appendix B – Estimation results for firm novelties

Table B1 –Ordinary Least Squares estimates for firm novelties

Dependent variable: Introducing firm novelty (0/1)	(1) All firms	(2) <250 employees	(3) < 50 employees
Website mention of university ties (0/1)	-0.07	-0.01	0.03
	(0.07)	(0.07)	(0.07)
Ln(university cooperation scope +1)	-0.03	-0.11	-0.10
	(0.08)	(0.07)	(0.07)
Share of highly qualified employees	0.57***	0.49***	0.28***
	(0.11)	(0.10)	(0.08)
Ln(university pp contracts +1)	0.36***	0.25**	0.31*
	(0.13)	(0.12)	(0.17)
Ln(collaboration breath +1)	0.06	0.02	0.00
	(0.04)	(0.04)	(0.04)
External R&D expenditures share	0.05	0.12	0.40**
	(0.17)	(0.17)	(0.16)
R&D intensity	-0.46*	-0.31	-0.43*
	(0.25)	(0.24)	(0.22)
Ln(patent stock + 1)	0.23***	0.23**	0.34**
	(0.08)	(0.10)	(0.14)
Public funding (0/1)	-0.09	-0.08	-0.01
	(0.06)	(0.05)	(0.05)
Marketing intensity	0.90	0.42	0.34
	(1.35)	(1.19)	(1.10)
Strategy on existing customers (0/1)	-0.01	-0.03	-0.04
	(0.08)	(0.07)	(0.07)
Strategy on new customer group (0/1)	0.05	0.03	-0.05
	(0.06)	(0.06)	(0.05)
Ln(age + 1)	0.03	0.03	-0.03
	(0.04)	(0.04)	(0.04)
Ln(number of employees as FTE + 1)	0.53***	0.46***	0.35***
	(0.03)	(0.03)	(0.03)
Part of a company group (0/1)	0.03	0.02	0.05
	(0.06)	(0.05)	(0.05)
Export revenues (0/1)	0.24***	0.26***	0.24***
	(0.06)	(0.05)	(0.05)
Observations	1108	965	664
Adjusted R-Squared	0.53	0.39	0.27

Note: Robust standard errors in parentheses. Industry dummies, and constant term included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B2 –First-Stage Control Function estimates for firm novelties

Dependent variable: Introducing firm novelty (0/1)	(1) All firms	(2) <250 employees	(3) <50 employees
Website mention of university ties (0/1)	0.09	0.09	0.08
	(0.13)	(0.13)	(0.16)
Ln(university cooperation scope +1)	0.18*	0.18*	0.08
	(0.10)	(0.11)	(0.13)
Share of highly qualified employees	0.39***	0.34***	0.29**
	(0.12)	(0.13)	(0.14)
Ln(university pp contracts +1)	0.02	0.03	-0.09
	(0.13)	(0.16)	(0.21)
Ln(collaboration breath +1)	-0.00	-0.03	-0.06
	(0.05)	(0.05)	(0.07)
External R&D expenditures share	0.40***	0.47***	0.99***
	(0.15)	(0.17)	(0.27)
R&D intensity	2.07***	2.04***	1.73***
	(0.56)	(0.56)	(0.59)
Ln(patent stock + 1)	0.19**	0.13	0.42
	(0.08)	(0.14)	(0.27)
Public funding (0/1)	0.01	0.02	0.08
	(0.06)	(0.06)	(0.08)
Marketing intensity	6.79***	6.83***	8.17***
	(2.05)	(2.18)	(2.57)
Strategy on existing customers (0/1)	0.23***	0.21***	0.15
	(0.08)	(0.08)	(0.10)
Strategy on new customer group (0/1)	0.26***	0.28***	0.28***
	(0.06)	(0.06)	(0.07)
Ln(age + 1)	-0.06	-0.06	-0.11**
	(0.04)	(0.04)	(0.05)
Ln(number of employees as FTE + 1)	0.05**	0.04	0.04
	(0.02)	(0.03)	(0.05)
Part of a company group (0/1)	-0.03	-0.04	0.01
	(0.06)	(0.06)	(0.08)
Export revenues (0/1)	0.19***	0.22***	0.21***
	(0.06)	(0.07)	(0.08)
Observations	2480	2208	1522
Pseudo R-squared	0.09	0.09	0.10

Note: Estimates are based on probit regressions. Coefficients are presented as average marginal effects. Robust standard errors in parentheses. Industry dummies, and constant term included.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B3 –Second-Stage Control Function estimates for firm novelties

Dependent variable:	(1)	(2)	(3)
Introducing firm novelty (0/1)	All firms	<250 employees	<50 employees
Website mention of university ties (0/1)	-0.02	0.03	0.06
	(0.08)	(0.08)	(0.07)
Ln(university cooperation scope +1)	0.07	-0.03	-0.05
	(0.11)	(0.10)	(0.08)
Share of highly qualified employees	0.84***	0.65***	0.44***
	(0.20)	(0.17)	(0.13)
Ln(university pp contracts +1)	0.36***	0.27**	0.28
	(0.13)	(0.12)	(0.17)
Ln(collaboration breath +1)	0.06	0.01	-0.03
	(0.04)	(0.04)	(0.04)
External R&D expenditures share	0.31	0.32	0.88**
	(0.23)	(0.23)	(0.34)
R&D intensity	0.59	0.37	0.26
	(0.67)	(0.61)	(0.53)
Ln(patent stock + 1)	0.32***	0.28***	0.49***
	(0.10)	(0.11)	(0.18)
Public funding (0/1)	-0.08	-0.06	0.04
	(0.06)	(0.05)	(0.06)
Marketing intensity	4.94*	3.11	4.37
	(2.74)	(2.62)	(2.98)
Strategy on existing customers (0/1)	0.15	0.07	0.04
	(0.12)	(0.11)	(0.09)
Strategy on new customer group (0/1)	0.24*	0.16	0.11
	(0.13)	(0.13)	(0.12)
Ln(age + 1)	-0.01	-0.00	-0.08
	(0.05)	(0.05)	(0.06)
Ln(number of employees as FTE + 1)	0.57***	0.48***	0.37***
	(0.04)	(0.03)	(0.04)
Part of a company group (0/1)	0.01	0.00	0.06
	(0.06)	(0.06)	(0.05)
Export revenues (0/1)	0.38***	0.37***	0.37***
	(0.11)	(0.11)	(0.10)
Inverse-Mill-Ratio	1.07	0.70	0.86
	(0.66)	(0.62)	(0.59)
Observations	1108	965	664
Adj. R-squared	0.53	0.39	0.27

Note: Robust standard errors in parentheses. Industry dummies, and constant term included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B4 – Lewbel Instrumental Variable estimates for firm novelties

Dependent variable: Introducing firm novelty (0/1)	(1) All Firms	(2) <250 employees	(3) <50 employees
Website mention of university ties (0/1)	0.05 (0.08)	0.09 (0.07)	0.08 (0.06)
Observations	1108	965	664
R-squared	0.54	0.40	0.29
Kleibergen-Paap LM statistic	129.08	127.55	85.10
Kleibergen-Paap LM p-value	0.00	0.00	0.00
Kleibergen-Paap Wald F-statistic	55.22	58.94	55.00
Hansen Chi-squared	20.39	20.09	21.76
Hansen J test (p-value)	0.43	0.45	0.35
Breusch–Pagan χ^2 statistic	0.28	0.91	0.51
Breusch-Pagan (p-value)	0.59	0.34	0.47

Note: Robust standard errors in parentheses. Control variables, industry dummies, and constant term included.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix C – First-Stage Control Function estimates results for market novelties

Dependent variable: Introducing market novelty (0/1)	(1) Full Sample	(2) < 250 employees	(3) < 50 employees
Website mention of university ties (0/1)	-0.08	-0.06	0.07
	(0.14)	(0.15)	(0.18)
Ln(university cooperation scope +1)	0.31***	0.39***	0.42***
	(0.12)	(0.13)	(0.16)
Share of highly qualified employees	0.53***	0.44**	0.38*
	(0.17)	(0.18)	(0.22)
Ln(university pp contracts +1)	0.21	0.26	0.18
	(0.15)	(0.20)	(0.27)
Ln(collaboration breath +1)	0.12*	0.08	0.03
	(0.06)	(0.07)	(0.09)
External R&D expenditures share	0.18	0.27	0.66**
	(0.19)	(0.21)	(0.27)
R&D intensity	2.12***	1.99***	1.76***
	(0.48)	(0.49)	(0.56)
Ln(patent stock +1)	0.15*	0.30**	0.50*
	(0.08)	(0.14)	(0.26)
Public funding (0/1)	-0.04	-0.05	-0.11
	(0.08)	(0.08)	(0.11)
Marketing intensity	4.02*	4.33*	7.00**
	(2.23)	(2.36)	(2.91)
Strategy on existing customers (0/1)	0.29***	0.23**	0.28*
	(0.11)	(0.11)	(0.15)
Strategy on new customer group (0/1)	0.24***	0.24***	0.21*
	(0.08)	(0.09)	(0.11)
Ln(age + 1)	-0.00	-0.02	-0.13*
	(0.05)	(0.06)	(0.08)
Ln(number of employees as FTE + 1)	0.06*	0.06	0.12
	(0.03)	(0.04)	(0.08)
Part of a company group (0/1)	-0.00	-0.01	0.09
	(0.08)	(0.08)	(0.11)
Export revenues (0/1)	0.54***	0.54***	0.68***
	(0.09)	(0.09)	(0.11)
Observations	2480	2208	1522
Pseudo R-squared	0.18	0.17	0.22

Note: Estimates are based on probit regressions. Coefficients are presented as average marginal effects. Robust standard errors in parentheses. Industry dummies, and constant term included.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Download ZEW Discussion Papers:

https://www.zew.de/en/publications/zew-discussion-papers

or see:

https://www.ssrn.com/link/ZEW-Ctr-Euro-Econ-Research.html
https://ideas.repec.org/s/zbw/zewdip.html

IMPRINT

ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH Mannheim
ZEW – Leibniz Centre for European Economic Research

L 7,1 · 68161 Mannheim · Germany
Phone +49 621 1235-01
info@zew.de · zew.de