# Do Markets Value Advanced Service Development?

# DO MARKETS VALUE ADVANCED SERVICE DEVELOPMENT?

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**ABSTRACT**

**Purpose:** Markets have a proven propensity for valuing research and development (R&D) intensity of manufacturing firms. This paper investigates whether coupling R&D intensity with advanced services (ADS) yields even higher market performance effect.

**Design/Methodology/Approach:** The longitudinal financial and annual report data covered a period from 1994 to 2020 (n = 164, N = 2 844). Panel regression (fixed effects estimator) was used to investigate the relationships between market performance (regressand), R&D intensity (regressor) and annual report-level discourse related to ADS (moderator).

**Findings:** The findings confirm that markets do in fact value R&D intensity of manufacturers more if the manufacturer publicizes ADS. However, in alignment with extant research the direct relationship between market performance and ADS discourse proved to be negative and significant.

**Originality/Value:** The current study shows that ADS publicizing adds to the R&D-driven market value of manufacturing firms. Thus, the study contributes to the literature on financial consequences of servitization. However, it also highlights the challenging nature of ADS strategies.

**KEYWORDS:** Service innovation, Advanced services (ADS), Financial consequences of servitization, Research and development (R&D), Digital servitization, Market performance

## 1. INTRODUCTION

Studies show that markets merit the R&D efforts of manufacturing firms (Chan, Martin & Kensinger, 1990; Ho, Keh & On, 2005). Indeed, R&D investments allow manufacturers to innovate new and improve the existing products. However, service-enthusiastic firms (Raddats & Kowalkowski, 2014) may also research and develop novel ways of integrating value-adding service elements to create product-service systems (Tukker, 2015). Incidentally, another aspect that the markets seem to value is the service business of manufacturers. For example, Fang et al. found that although services require a certain critical mass (20–30 % of sales revenues), they contribute positively to firm value nonetheless (2008). Servitizing companies typically progress gradually from basic (e.g., spare parts provision) to ADS (e.g., outcome-based services; Dmitrijeva et al., 2022), latter of which have been found to be an advantageous strategy for manufacturer profitability in many instances (Nowicki, Kumar & Steudel, 2008; Eggert et al., 2014; Patra et al., 2019; Korkeamäki, Kohtamäki & Parida, 2021).

On the flipside of that coin, manufacturers take notably higher risks by offering ADS (Josephson et al., 2016). Hou and Neely (2018), for example, identified 23 endogenous risk factors related to outcome-based services which can result in the materialization of commercial and operational risk. Subsequently, in their recent paper Karatzas et al. (2022) found that shareholders tend to be risk-averse and react indifferently to announcements related to such high-risk service deals in the short term. Nevertheless, ADS offerings are often characterized by long-termism which also provides security for the manufacturers to make respective investments (Visnjic et al., 2017). Thus, instead of chasing quick wins, the more long-term-oriented investors may expect the manufacturer to become committed to hedging against the many risks associated with ADS. For example, by complementing condition-based maintenance with adaptive preventive maintenance AS providers can prolong service intervals by 5-10% on average and avoid overservicing (Öhman, Finne & Holmström, 2015). Not only does that contribute to their margins, but also extends the useful life of the equipment. Both long-termism and sustainability are endemic traits of ADS that have also been shown to affect firm value (Woolridge & Snow, 1990; Griffin & Sun, 2013). Thus, the current paper investigates if markets value R&D intensity of manufacturers more when the manufacturer publicizes ADS simultaneously.

Based on the analysis on a sample consisting 2 844 observations of 164 US manufacturing firms we found significant evidence that the markets do indeed value R&D efforts of a manufacturer more if the firm actively publicizes ADS in their annual reports. However, our findings also indicate that above-average ADS publicizing only becomes credible after manufacturer's R&D intensity exceeds a threshold of about 20% relative to sales revenues. Thus, it seems that the markets expect that the manufacturers not only "talk the talk" but walk it as well. The current paper contributes to two strands of literature. First, it provides novel insights about the relationship between manufacturing firm value and R&D intensity (Ho, Keh & On, 2005). Second, it contributes to the strand of servitization literature that discusses the associated financial consequences (Fang et al., 2008; Neely, 2008), particularly from the perspective of ADS development (Baines & Lightfoot, 2014).

## 2. THEORETICAL BACKGROUND AND RESEARCH DESIGN

### 2.1 Variables and Hypotheses

Manufacturing firms' market values have been shown to be associated with their R&D investments (Ho, Keh & On, 2005). Services have also been shown to add to the market value of manufacturing firms (Fang et al., 2008). However, where announcements related to base services (e.g., spare parts provision) contribute to abnormal stock returns in the short-term, Karatzas et al. (2022) found no corresponding evidence related to announcements concerning ADS. We argue that knowledgeable markets appreciate both riskiness and long-termism related to ADS offerings (Ziaee Bigdeli et al., 2018; Fallah-Fini et al., 2012) and thus do not necessarily expect them to yield quick profits or competitive edge. What is expected from the manufacturers providing ADS instead is commitment to research and develop practices by which the many associated risks and challenges can be best mitigated (Baines & Lightfoot, 2014). Based on the above discussion, we formulated three hypotheses:

H1: There is a positive relationship between R&D intensity and manufacturer firm value.
H2: There is a negative relationship between ADS discourse and manufacturer firm value.
H3: The ADS discourse positively moderates the relationship between R&D intensity and firm value.

We used Tobin's *q* as a proxy for firm value. Commonly known as *q*, it is a forward-looking market performance measure (Bharadwaj, Bharadwaj & Konsynski, 1999). Given that our inquiry targets pioneering R&D of servitizing firms, the measure seems suitable for the purposes of the study. We calculated $q$ accordingly: $Tobin's\ q = \frac{Total\ Assets + Market\ Value - Common\ Equity}{Total\ Assets}$ which corresponds to the approximations of Coles, Naveen and Lalitha (2008), and Ahern and Dittmar (2012), just to name a few. R&D intensity, on the other hand, is the ratio of R&D investments to sales (mean = 14.91, std. dev. = 79.10) whereas ADS discourse is the sum of ADS-related mentions in the annual reports (mean = 18.34, std. dev. = 51.31). To control for the differences in industry innovativeness, we included a continuous by categorical variable interaction where the continuous variable was the number of patents (mean = 88.27, std. dev. = 501.97) and the categorical variable was the SIC code. There was also a technical reason why the SIC code could not be modelled alone, namely, the fixed effects (FE) estimator does not allow modelling time-invariant categorical variables.

Furthermore, because the degree of internationalization can affect firm value (Riahi-Belkaoui, 1999), we controlled for it using the ratio of foreign sales to total sales (mean = 39.10, std. dev. = 25.72). Next, we controlled for firm's operational performance which was measured as return on assets (ROA; mean = -5.14166, std. dev. = 124.7179). Lastly, in accordance with the Schumpeterian hypothesis that R&D investments correlate positively with firm size (Shefer & Frenkel, 2005), we controlled for size as in market capitalization (mean = ~$10 900 000, std. dev. = ~$63 500 000). The pairwise correlations between the variables are reported in the Figure 1. Only weak correlations existed between the independent variables with an exception of a moderate correlation between patents and market cap (0.3146***). However, the variance influence factors of neither the patents (VIF = 4.35) or market cap (VIF = 1.60) were not alarming (e.g., VIF > 10). On a minor note, one should consider that the reported correlation matrix does not reflect the panel structure of the data.

Table 1: Correlation matrix

| | Tobin's *q* | R&D | ADS | SIC | Patents | Foreign sales to total sales | ROA | Market cap |
|---|---|---|---|---|---|---|---|---|
| Tobin's *q* | 1 | | | | | | | |
| R&D | 0.2436*** | 1 | | | | | | |
| ADS | -0.0108 | -0.0048 | 1 | | | | | |
| SIC | 0.1135*** | 0.1474*** | 0.1232*** | 1 | | | | |
| Patents | -0.0091*** | -0.0177 | 0.2411*** | 0.0477** | 1 | | | |
| Foreign sales to total sales | -0.1189*** | -0.0974*** | 0.0883*** | -0.0295 | 0.1167*** | 1 | | |
| ROA | -0.6798*** | -0.2136*** | 0.0162 | -0.1056*** | 0.0203 | 0.0977*** | 1 | |
| Market cap | 0.0264 | -0.0179 | 0.0973*** | 0.0437* | 0.3146*** | 0.1088*** | 0.023 | 1 |

*, **, and *** indicate significance at 95%, 99%, and 99.9%, respectively.

### 2.2 Data and Methods

The data used in the current study (1994–2020) is from Eikon financial market database by Refinitiv. The discourse concerning ADS was extracted from the database-provided annual reports of the US manufacturers included in the dataset using Python. The ADS-related terms were chosen based on whether they were something that (1) the customers want manufacturers to do for them (Baines & Lightfoot, 2014) and (2) requires more complex (especially digital) capabilities from the manufacturers than basic services (Sousa & da Silveira, 2017). The used ADS-related terms and categories are displayed in the Figure 1. As demonstrated in the figure, the adoption of ADS-related terminology in corporate discourse has clearly been on the rise during the latest decades (note especially autonomous services that have surged from 2014 onwards). The firm value (as in Tobin's *q*) estimate was based on 2 844 observations of 164 firms. To ensure that the studied firms were relevant, their websites were examined manually. Two firms along with 33 observations were excluded from the sample because their website information indicated that despite a SIC codes starting with "35" the firms were not manufacturers. Similar inaccuracies with database industry codes have been reported before by, for instance, Neely (2008). Because the data used in the current study consists of time series of observations from 164 firms panel regression was used as the estimation method. There are, however, multiple panel regression methods that differ primarily in the manner in which they use pooling techniques to produce estimates. First, a pooled ordinary least squares estimator pools all observations and thus assumes that there is no firm-specific variance, which is possible but rare. As expected, a Breusch-Pagan test proved that this was not the case (p-value = 0.0000). Thus, we proceeded to decide between FE and random (RE) estimators. FE and RE differ in that where RE uses partial pooling technique, the FE produces estimates for each panel separately (Gelman & Hill, 2007). As a firm's market value and its drivers surely depend greatly on the firm in question, it was clear from the outset that the FE estimator would be the optimal choice. However, instead of assuming the estimation method a priori, a Hausman specification test (Hausman, 1978) was conducted to determine the suitable estimator. The test confirmed (p-value = 0.0000) that RE estimator was not consistent due to endogenous regressors. Thus, FE estimator was to be used.

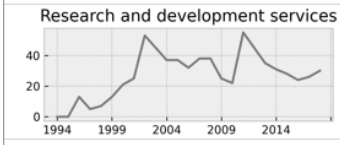
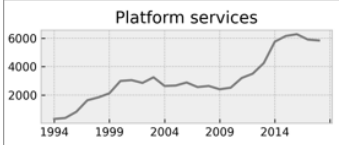
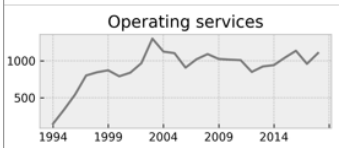
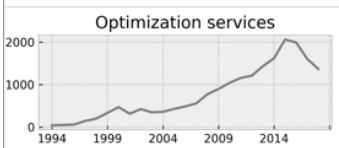
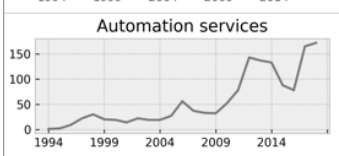
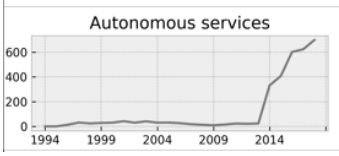
| Advanced service categories | Keywords |
|---|---|
|  | research and development service, R&D service, technical development service, prototype design, product-tailoring service |
|  | mobile app, mobile application, desktop app, desktop application, cloud, e-commerce, webshop, platform, b2b marketplace, marketplace ecosystem, service marketplace, digital marketplace, multi-supplier platform, multi-vendor platform, online marketplace |
|  | operations and maintenance, service contract, service package, lifetime service, lifecycle service, full service, O&M, operating contract, operating agreement, operator agreement, operator contract, pay per, as-a-service, performance guarantee, pay for performance, pay for results, power by the hour, operational availability, service-level agreement, SLA, operational availability, performance-based contract, performance-based logistics, performance service, outcome-based contract, outcome-based service, value-based contract, value-based pricing |
|  | energy saving service, carbon reduction solution, cloud computing, edge computing, data center, optimization, optimisation, optimizing, optimising, fuel efficiency service, system tuning, parameter tuning |
|  | process automation, process simulation, machine to machine communication, automated control, artificial intelligence, connected products |
|  | autonomous services, autonomous operation, self-diagnosis, self-governing, autonomous system, smart system, autonomous robot, autorobot, autobot, intelligent automation, industry 4.0, internet of things, IoT, intelligent optimization, intelligent optimisation |

Figure 1: Advanced service categories and keywords.

## 3. RESULTS

Surprisingly, only inconclusive support for H1 (i.e. there is a positive relationship between R&D intensity and manufacturer firm value) was found (p-value = 0.617). In terms of H2 and H3, however, statistically significant and concurring evidence was found. That is, our findings confirmed that although the direct relationship between manufacturing firm value and ADS publicizing is negative (p-value = 0.001), the latter positively moderates the relationship between firm value R&D intensity (p-value = 0.018). Looking at the controls, there were 12 out of 38 SIC codes for which the interaction with the number of patents was positive. The effect of foreign sales to total sales ratio proved to be negative but statistically insignificant (p-value = 0.231). Counterintuitively, the coefficient of ROA revealed to be negative and significant (p-value = 0.020). Lastly, albeit small, the effect of market cap was positive and significant (p-value = 0.002). The fraction of variance explained by the individual term (rho) increased by about 1.05 percentage points when the R&D*ADS interaction was included. Also the within (from 0.3816 to 0.4120), between (from 0.6775 to 0.6926) and overall (from 0.4316 to 0.4486) $R^2$ increased when the interaction was modelled.

To visualize the interaction we plotted the predictive margins of R&D intensity (from 0 to 100%, incremented by 10 percentage points) by three values of ADS: mean (18.3), mean plus one standard deviation (69.6), and mean plus two standard deviations (121.0). The margins were statistically significant (p-value < 0.05) except for the highest degree of ADS at R&D = 0%, which was marked with a cross. Rather interestingly, it seems that manufacturers must invest at least around 20% of their sales revenues in R&D in order that their above average ADS publicizing becomes credible for the markets. We also investigated the interaction the other way around (i.e., if R&D intensity moderates the negative relationship between firm value and ADS) but found that the margins were statistically insignificant throughout. The regression coefficients and the panel-wise clustered standard errors can be found in the Table 2. The linear moderation effect is successively reported in the Figure 2.

Table 2: Regression results

| **Tobin's *q*** | **Model 1** | **Model 2** |
|---|---|---|
| **R&D** | 0.0090611 | 0.0045018 |
| | (*0.0110978*) | (*0.0089733*) |
| **ADS** | -0 .0056901* | -0.0212965*** |
| | (*0.0024337*) | (*0.0065528*) |
| **R&D*ADS** | | 0.0009748** |
| | | (*0.0004087*) |
| **Patents*SIC** | | |
| **3510 (Baseline)** | 1.968951*** | 1.944256*** |
| (Engines & turbines) | (*0.5966299*) | (*0.5814898*) |
| **3519** | -1.965494*** | -1.938665*** |
| (Internal combustion engines, n.e.c.) | (*0.5963210*) | (*0.5814006*) |
| **3523** | -1.968851*** | -1.943962*** |
| (Farm machinery & equipment) | (*0.5964987*) | (*0.5813818*) |
| **3533** | -1.967224*** | -1.943414*** |
| (Oil & Gas Field Machinery & Equipment) | (*0.5961307*) | (*0.5809151*) |
| **3541** | -1.959457*** | -1.915516*** |
| (Machine tools, metal cutting types) | (*0.5956915*) | (*0.5825551*) |
| **3548** | -1.964292*** | -1.939244*** |
| (Welding apparatus) | (*0.5966284*) | (*0.5815274*) |
| **3550** | -1.963421*** | -1.938284*** |
| (Special industry machinery) | (*0.5987119*) | (*0.5836204*) |
| **3564** | -1.964855*** | -1.940902*** |
| (Blowers & fans) | (*0.5944800*) | (*0.5793926*) |
| **3568** | -1.818532*** | -1.791693** |
| (Power transmission equipment, n.e.c.) | (*0.6055259*) | (*0.5904353*) |
| **3570** | -1.968719*** | -1.943745*** |
| (Computer & office equipment) | (*0.5966168*) | (*0.5815041*) |
| **3579** | -1.965210*** | -1.942852*** |
| (Office machines, n.e.c.) | (*0.5964492*) | (*0.5810829*) |
| **3585** | -1.960884*** | -1.936348*** |
| (Refrigeration & heating equipment) | (*0.5966002*) | (*0.5814514*) |
| **Foreign sales to total sales** | -0.0112081 | -0.0107408 |
| | (*0.0088521*) | (*0.0089384*) |
| **ROA** | -0.0223999* | -0.0220922* |
| | (*0.0096204*) | (*0.0093701*) |
| **Market cap** | 3.10e-09*** | 3.00e-09** |
| | (*9.32e-10*) | (*9.65e-10*) |
| **Constant** | 2.970202*** | 3.049143*** |
| | (*0.3402034*) | (*0.3018217*) |
| **$R^2$** | | |
| Within | 0.3816 | 0.4120 |
| Between | 0.6775 | 0.6926 |
| Overall | 0.4316 | 0.4486 |
| **rho** (fraction of variance due to u_i) | 0.6914 | 0.7019 |

*Clustered standard errors* are reported in parentheses.
*, **, and *** indicate significance at 95%, 99%, and 99.9%, respectively.
To save space, the results of the continuous by categorical interaction (Patents*SIC) were reported only for the SICs for which the effect was positive. The results for the omitted SICs (26) can be provided upon request.

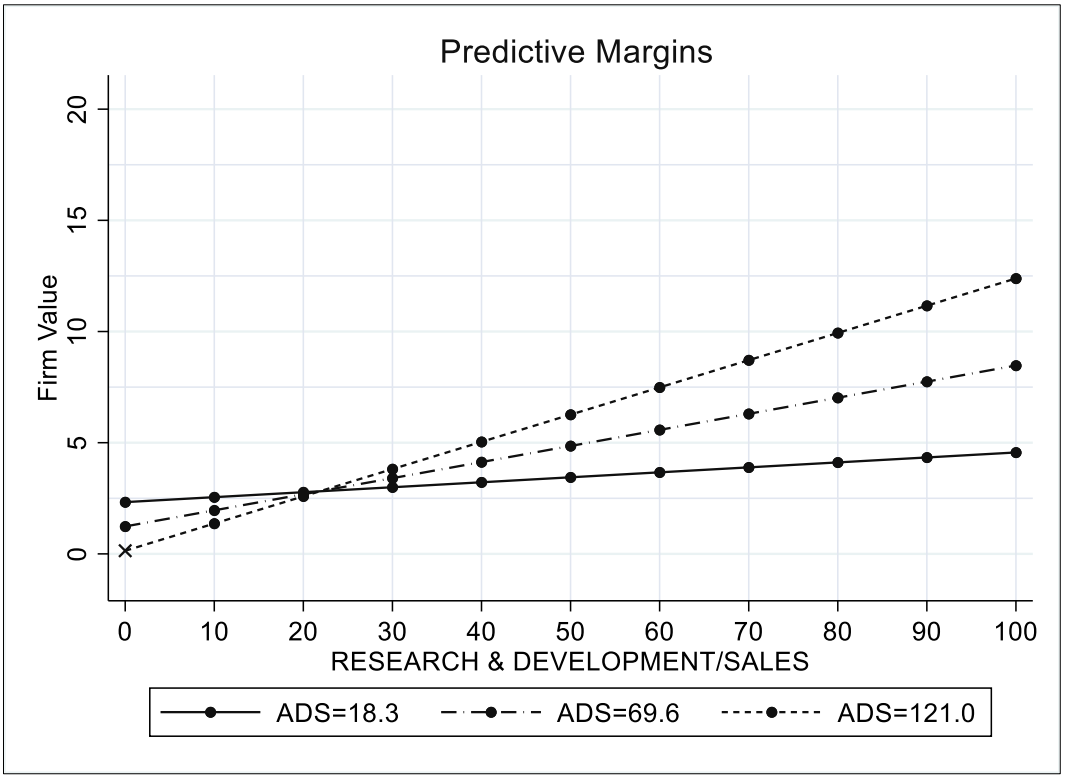



Figure 2: Linear moderation effect of ADS publicizing on the firm value-R&D intensity relationship

## 4. DISCUSSION AND CONCLUSIONS

### 4.1 Theoretical Contributions

The theoretical contributions of the current study stand at a crossroads. On one hand, the study reveals new insights regarding the relationship between R&D intensity and manufacturer market performance (Ho, Keh & Ong, 2005). On the other hand, it adds to the literature concerning the financial consequences of servitization, majority of which has focused on accounting-based performance metrics such as profitability and sales growth (e.g., Neely, 2008; Kohtamäki et al., 2013; Eggert et al., 2014; Kohtamäki et al., 2015). More specifically, the current study shows that publicizing ADS offerings together with R&D investments increases the R&D-driven market value of manufacturing firms. Thus, we argue that it is not R&D intensity per se that influences higher market performance. Rather, successfully convincing the markets that the R&D investments will foster the manufacturer's capabilities (Huikkola & Kohtamäki, 2017; Story et al., 2017) needed to manage high-risk but high-reward competitive strategies is key in terms of R&D-driven market performance. In the context of this study, such competitive strategies refer to ADS offerings (Baines & Lightfoot, 2014).

ADS offerings are packed with forward-looking characteristics that modern capital markets have been shown to value, namely, sustainability (Griffin & Sun, 2013) and long-term orientation (Woolridge & Snow, 1990). Yet, possibly for the same reasons, announcements of medium- to high-risk service deals have been shown to evoke no abnormal stock reactions in the short-term (Karatzas et al., 2022). Unfortunately, our findings converge by revealing that the direct relationship between ADS and long-term firm value is negative. Thus, more diverse empirical evidence is needed to convince the markets of the added value of ADS offerings. In this respect, it is paramount that the broad servitization community (Rabetino et al., 2018) continues to purvey the resource-consciousness related to industrial ADS (Randall, Nowicki & Hawkins, 2011; Szász & Seer, 2018) and explicate means by which the associated risks can be offset. We suggest that dedicated R&D is one such mean.

### 4.2 Managerial Implications

This study includes tangible managerial implications. Although it advocates talking publicly about ADS, managers in manufacturing firms should be advised that using ADS as mere rhetoric can actually have

an adverse effect on R&D-related market performance. ADS publicizing should rather be coupled with adequate level of R&D investments. In particular, our findings posit that above average ADS publicizing in annual reports only starts to add to the R&D-driven firm value (as measured by Tobin's *q*) after the manufacturer invests about 20% or more of the sales revenues to R&D. Below this threshold, the effect of overenthusiastic ADS publicizing on R&D-related market performance may well be negative. These findings stress the necessity of becoming committed to the provision of ADS. Without the demonstrated willingness of the manufacturer to commit to and invest in the R&D related to ADS strategies the markets can find it difficult to buy in to the added value of the risky service strategy (Karatzas et al., 2022).

This raises the question: what are the key targets for R&D investments regarding ADS provision? Fortunately, there is a dedicated stream of literature focused on the requirements of successful ADS deliveries (Schaefers, Ruffer & Böhm, 2021). In terms of technical assets, the manufacturers' success in ADS provisioning has been argued to depend on information and communication technology (Baines & Lightfoot, 2014), spare parts inventory management (Nowicki, Kumar & Steudel, 2008), solution modularization (Korkeamäki, Kohtamäki & Parida, 2021) and component reliability (Selçuk & Ağralı, 2013). On the softer side of things, relational features such as service orientation (Gebauer, Edvardsson & Bjurko, 2010) and legitimacy management (Korkeamäki & Kohtamäki, 2020) have been emphasized as means to build and sustain arms-length ADS relationships.

### 4.3 Limitations and Suggestions for Future Research

Like all research, the current one has its limitations too. The study contrasts others that use accounting-based financial performance measures as dependent variables. Market performance measures such as Tobin's *q* overcome some inherent weaknesses of the commonly used accounting-based measures. For example, profit ratios typically reflect past performance and they can be manipulated by creative accounting. Market-based measures, by contrast, incorporate ex ante valuations of future risks and profits among other things (Bharadwaj, Bharadwaj & Konsynski, 1999). On the other hand, alike profit ratios, market performance measures may also be susceptible to manipulation as firms can, at least to some degree, choose what information to disclose with the markets and how to present it (Gentry & Shen, 2010). Nonetheless, given the finding that too eager ADS publicizing without corresponding R&D intensity did not lead to higher R&D-driven market value, it can be argued that also the markets possess a healthy level of source criticism. However, our approximation of firm value is only one of many ways to measure it. For example, economic value added (EVA) measures the true economic profit made by a firm (Fabozzi, 2003). Moreover, market value added (MVA) measures the created shareholder wealth (Lee & Kwon, 2019) as the difference between market value and the invested capital. Thus, future research could replicate our tests using firm value measures other than Tobin's *q*.

Furthermore, we measured ADS categories displayed in Figure 1 aggregately as the sum of the terms across all categories. Such bundling is aligned with the equifinality argument associated with servitization-related performance outcomes (i.e., different configurations can lead to similar outcomes; Forkmann et al., 2017). Nevertheless, future research could investigate what kind of effect differences and convergence there is in between the categories. Techniques such as confirmatory factor analysis (CFA) and principal component analysis (PCA) may prove useful in this effort depending on whether one wishes to treat ADS as a latent variable or weigh certain ADS categories more than others, respectively. Finally, it should be mentioned that the list of the ADS-related terms used in the current study does not by any means intend to be exhaustive. Rather, it is based on the researchers' experience, readings and interpretation of what passes as an ADS offering.

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