

## Research Report

# Digital Embracement of Firms: Measurement, Antecedents, and Financial Consequences

MANY PEOPLE CLAIM THAT FIRMS NEED TO EMBRACE DIGITAL TECHNOLOGIES. YET, WE KNOW LITTLE ABOUT DIGITAL EMBRACEMENT, ITS ANTECEDENTS, AND ECONOMIC CONSEQUENCES. THIS ARTICLE PROPOSES A TEXTUAL APPROACH TO MEASURE DIGITAL EMBRACEMENT AND APPLIES IT IN AN EMPIRICAL STUDY COVERING 2,278 PUBLICLY LISTED U.S. FIRMS OVER 17 YEARS. THE RESULTS OUTLINE A VAST HETEROGENEITY IN FIRMS' DIGITAL EMBRACEMENT IN AND ACROSS INDUSTRIES. REMARKABLY, A HIGHER DIGITAL EMBRACEMENT PREDICTS HIGHER FINANCIAL PERFORMANCE.

Simeng Han

Bernd Skiera

### Introduction

Consultants, politicians, and academics encourage firms to embrace digital technologies because they believe that, by doing so, firms achieve higher economic success. For example, according to Fitzgerald et al. (2013), for many firms, the ubiquity of digital technologies is changing their business landscape, and the effective and quick response to new digital technologies is affecting their survival. In addition, in March 2016, the German Federal Ministry for Economic Affairs and Energy published the Digital Strategy 2025, which involves supporting digital startups and assisting firms to become more digital.

Alexander Hillert

Yet, most of these encouragements are based on anecdotal evidence but lack solid empirical support. As a result, little is known about differences in the embracement of digital technologies across firms and industries, their antecedents, and, most importantly, their economic consequences.

This lack of knowledge is problematic because it does not allow firms to take effective steps towards a digital economy. Without sufficient knowledge, it is challenging for firms to benchmark themselves against their competitors. It is also hard for politicians to make appropriate decisions on whether, where, and how to sup-

port a stronger embracement of digital technologies.

Our vision is to measure the embracement of digital technologies for many firms at many points in time at reasonable costs. More precisely, our aims are (1) to develop and apply a score to measure firm-level digital embracement, (2) to compare the score across firms in various industries at different points in time, (3) to examine the antecedents of the score, and (4) its financial consequences.

### Approach to Measure Score of Digital Embracement

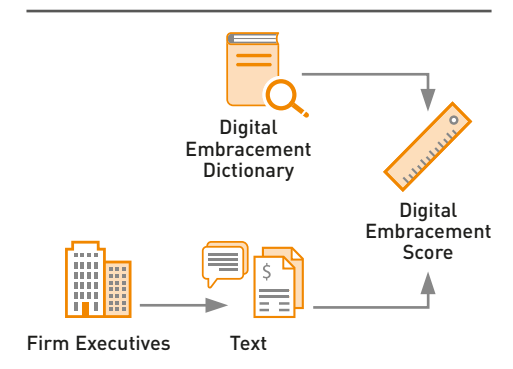
Previous studies show that the attention of a firm's top management substantially shapes the firm's behavior and performance (Ocasio, 1997). Thus, the extent of attendance of the firm's executives to digital technologies can represent how much the firm embraces digital technologies.

Our study proposes the construct of digital embracement as firm executives' strategic attention towards digital technologies. In this definition, the word "attention" indicates that digital embracement is about the attitude and intention towards adopting digital technologies. The word "strategic" implies that the attention should reflect firm executives' enthusiasm towards the opportunities coming with digital technologies instead of the concern about the threats induced by digital technologies. Furthermore, the attention should be forward-looking.

Previous research suggests that language rep-

resents attention so that when one considers a topic, one tends to express the subject in words (Humphreys and Wang, 2018). Analogously, we can use executives' communication to measure their attention towards various topics [Berger et al., 2020].

Therefore, we adopt a textual analysis method and analyze communication from firms' executives to measure digital embracement. Specifically, we look at the share of communication firms' executives devote to discussing plans on adopting digital technologies for their business. To identify such communication reflecting digital embracement, we build a "lexicon" of terms capturing the discussion on intended adoption of digital technologies, namely, a digital embracement dictionary. Figure 1 illustrates the basic idea of our approach.



**Figure 1: Illustration of the Measurement of Digital Embracement**

For building our digital embracement dictionary, we take the digital dictionary from Kindermann

et al. (2021) as a starting point. We use an information systems textbook as our training library (Rainer and Prince, 2019). We expand the previous dictionary by including additional terms capturing digital embracement (e.g., “augmented reality”), removing terms not necessarily digital-related (e.g., “designer”), and removing negative terms (e.g., “malware”).

Our final digital embracement dictionary consists of 702 terms, including 273 single words (e.g., “digital”) and 428 multigram terms (e.g., “data center”, “platform as a service”). In particular, compared to the previous dictionary, our dictionary expands on the bigrams (e.g., “search engine”) and trigrams (e.g., “natural language processing”). Out of the 564 new terms in our dictionary, 384 are bigrams, trigrams, or terms with even more words. These terms help us avoid misclassification and ambiguity caused by homonyms of single words. Furthermore, our dictionary expansion includes numerous terms specific to industries that the previous dictionary fails to capture, such as “facial recognition”.

We use transcripts of firms’ quarterly earnings conference calls as the text source for our measurement. We preprocess the text of each earnings call following a standard procedure. We compute the number of digital embracement terms in each preprocessed text and take the percentage share of digital terms in the preprocessed text as our digital embracement score.

We conduct a series of validations to ensure the internal and external validity of our score. The

results of our validations show that our measurement captures the characteristics of digital embracement.

### Empirical Study

We collect transcripts of earnings conference calls published from 2003 to 2019 from Refinitiv. We obtain firms’ financial data from Compustat and the CRSP stock market database. For each firm in our sample, we require at least three consecutive years of transcripts. The final sample comprises 86,664 quarterly observations from 2,278 firms with around 38.47 quarterly observations per firm.

Figure 2 presents the distribution of digital embracement scores in 2003, 2011, 2019, and across all years. The distribution development shows that the average digital embracement score increased from 0.58 in 2003 to 0.92 in 2019, equivalent to a 50% increase.

We observe that the 25<sup>th</sup> percentile, the median, the 75<sup>th</sup> percentile, and the maximum digital embracement scores increased over time. This development also corresponds to the “flatter” distribution of digital embracement scores in 2019, compared to 2011 and 2003, showing a decreasing share of firms with a digital embracement score close to zero. Thus, such development indicates that, in general, the digital embracement score of firms in our sample increased over time.

Next, we look at how the digital embracement scores vary across industries. Table 1 presents

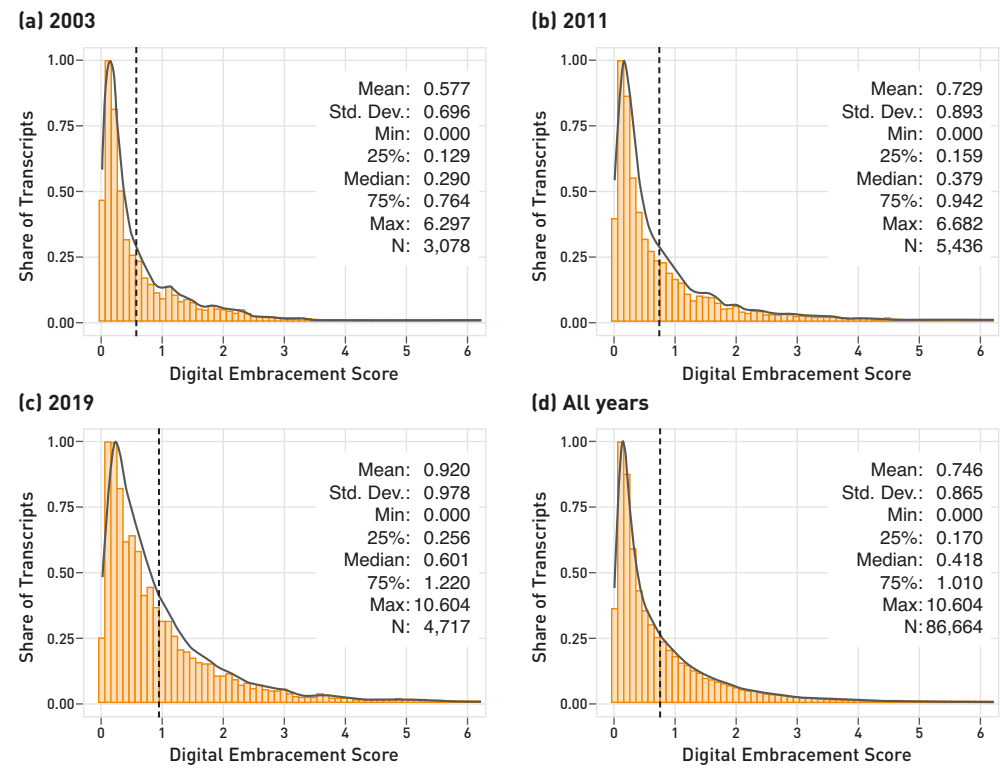


Figure 2: Distribution of Digital Embracement Score

the ranking of industries according to their average digital embracement score in 2003, 2011, and 2019. While business equipment and telecommunication remain the two industries with the highest digital embracement scores, utilities and energy have the lowest average digital embracement scores in all three years. For example, in 2019, business equipment’s average digital embracement score was 1.90, around eight times the average digital embracement score of utilities (0.24).

Such ranking seems intuitive since the business equipment and telecommunication industries include firms advanced in information technologies, such as Oracle. In contrast, firms in the utilities and energy industries typically have fewer opportunities to embrace digital technologies in their operations.

The average digital embracement score of healthcare increased from 0.56 in 2003 to 0.73 in 2019, equivalent to an increase of 30.4%.

2003		2011		2019	
Industrie	DES	Industrie	DES	Industrie	DES
Business Equipment	1.276	Telecommunication	1.704	Business Equipment	1.901
Telecommunication	1.051	Business Equipment	1.512	Telecommunication	1.751
Healthcare	0.562	Other	0.671	Other	0.857
Other	0.462	Healthcare	0.614	Shops	0.777
Consumer Durables	0.410	Shops	0.557	Healthcare	0.733
Shops	0.368	Consumer Durables	0.536	Consumer Nondurables	0.567
Manufacturing	0.306	Consumer Nondurables	0.411	Consumer Durables	0.552
Chemicals	0.251	Chemicals	0.323	Chemicals	0.517
Finance	0.214	Manufacturing	0.303	Manufacturing	0.442
Consumer Nondurables	0.204	Finance	0.245	Finance	0.414
Utilities	0.161	Utilities	0.193	Energy	0.321
Energy	0.155	Energy	0.192	Utilities	0.244

**Table 1: Ranking of Industries According to Digital Embrace-ment Score (DES)**

However, its rank among the industries decreased from the third to the fifth. Similarly, the ranking of consumer durables decreased from fifth to seventh place, although the industry has a 34.1% increase in its average digital embrace-ment score (from 0.41 in 2003 to 0.55 in 2019). In contrast, shops (i.e., wholesale and retail) and consumer nondurables achieved a remarkable increase in their rankings (shops from the sixth to the fourth; consumer non-durables from the tenth to the sixth) by more than doubling their average digital embrace-ment score from 2003 to 2019 (shops from 0.37 to 0.78; consumer nondurables from 0.20 to 0.57).

Then, to investigate the antecedents of digital

embrace-ment more formally, we perform a regression analysis. Our results confirm that large differences across industries in digital embrace-ment scores exist. The year fixed-effects cover a development over time, for which we observe a gradual increase from 2009 to 2019.

In addition, we find that more profitable and lower leveraged firms have higher digital embrace-ment scores. Namely, financial pressure negatively affects firms' digital embrace-ment. Our results also show that larger firms and younger firms have higher digital embrace-ment scores. Furthermore, firms listed on Nasdaq have higher digital embrace-ment scores. Interestingly, book-to-market ratio does not have a

statistically significant effect on digital embrace-ment scores. In other words, the traditional perspective of value versus growth firms cannot explain the extent to which firms embrace digital technologies.

Lastly, we investigate whether the digital embrace-ment score predicts future firm profitability and future firm value. Our results show that a firm's digital embrace-ment score has a significantly positive effect on its future profitability and future firm value.

Based on our estimates, a one standard deviation increase in a firm's digital embrace-ment score predicts a 0.49 percentage points increase in gross profit over total assets twelve months later, corresponding to 8.40% of the average gross profit of the firms in our sample. Furthermore, a one standard deviation increase in a firm's digital embrace-ment score is associated with a 0.08 increase in Tobin's q twelve months later. This effect corresponds to 3.64% of the average Tobin's q (2.25) in our sample. These results suggest that digital embrace-ment has a significant economic impact.

## Conclusion

Our study uses textual analysis to introduce a new measurement of firm-level digital embrace-ment. We apply it to 86,664 transcripts of earnings calls between 2003 and 2019 and investigate digital embrace-ment's antecedents and economic consequences. The positive effect of digital embrace-ment on future firm performance shows that firms should embrace digital tech-

nologies. Thus, politicians should also encourage and support firms' digital embrace-ment.

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