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Do we put all eggs in one basket? A polynomial regression study of digital technology configuration strategies

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Abstract

Digital technologies like social media, mobile, analytics, cloud computing and internet-of-things seem to provide organizations with a plethora of options to construct and configure their technology portfolios for enhancing firm performance. Due to seemingly low-cost, subscription-based, easy-to-adopt, easy-to-use nature of digital technologies, organizations are tempted to diversify their technology portfolios to thrive in the hyper-competitive dynamic markets. Using data gathered from chief information officers representing 177 organizations, this research investigates the effect of four digital technology portfolio configuration strategies that leads to firm performance.

Keywords: Digital technology, Firm performance, IT portfolio, polynomial regression, response surface analysis

Introduction

Traditionally, there is a strong recognition of the role of technology as an important asset for innovation and it is also considered that innovation positively influences firm performance (Bharadwaj 2000; Sirmon et al. 2011). Today, with the advent of digital technologies[1] like social media, mobile, analytics, cloud computing and Internet-of-things (IoT) (commonly known as SMAC-IoT), firms are provided with even greater opportunities to trigger and enable organizational innovations (Nylén and Holmström 2015; Yoo et al. 2012). Certainly, the advent of digital technologies has provided greater capabilities for firms to maintain a stable, yet configurable portfolio of technologies to face challenges of the hyper-competitive dynamic markets (Nambisan et al. 2017). Consequently, there are a plethora of examples of start-ups, entrepreneurs and even traditional brick-and-mortar businesses engaging in highly innovative and competitive behaviors using digital technologies, ultimately leading to better firm performance (Svahn et al. 2017; Tumbas et al. 2015). For example, the advance of firms such as Uber, Airbnb, and Alibaba.com are strongly attributed to the developments in digital technologies (Sedera et al. 2016; Tan et al. 2016; Tan et al. 2017). Such examples epitome characteristics of digital technologies such as availability, accessibility, scalability and ease-of-use and ease-of-deployment (Henfridsson et al. 2014; Nylén and Holmström 2015). More importantly, the digital technologies provide the contemporary firms to innovate with low levels of technology sophistication (Yoo et al. 2012), less capital investment (Nylén and Holmström 2015) and less specialized skills and knowledge within the firm (Zittrain 2006). Digital

[1] The collective term 'digital technologies' has been used to consolidate technologies such as cloud, wearables, mobile, social media, and business analytics. Similar notions are presented in recent research (Sedera et al. 2016; Yoo et al. 2012). The use of an overarching term allows the study to distinguish this new wave of technologies with similar fundamental characteristics.

technologies also allow firms to take advantage of the ecosystem that allows innovations to be outsourced (Ceccagnoli et al. 2012; Tilson et al. 2010). Such characteristics of digital technologies necessitate that we reconsider their value propositions, strategies and the impact on firm performance.

While the ability to innovate with digital technologies has been recognized in past studies (e.g., Lokuge et al. 2019; Nylén and Holmström 2015; Sedera et al. 2016), most research has investigated the role of digital technologies at the firm level (Svahn et al. 2017; Tan et al. 2017). Such studies do not explain the underlying question of 'how firms innovate with commonly available digital technologies?' An insightful discourse with the aforementioned question is underpinned with the fact that competitive advantage and firm performance are unlikely to occur when such technologies are available to competitors (Nevo and Wade 2010). However, competitive advantage and firm performance can be achieved through asset configuration which provides one of the salient mechanisms of innovation (Sirmon et al. 2011; Tan et al. 2014). The investigation of the question above therefore requires a careful disintegration of the firm's digital technology portfolios (henceforth referred to as the DT portfolio), to better understand the role of technologies, yielding firm performance. As such, investigation of such question requires the unit of observation to go beyond firm level.

As such, the objective of this paper is to explore the underlying configurations of digital technologies through the dimensions of technology 'depth' and 'breadth' (i.e. of the DT portfolio). The DT portfolio configurations are investigated through the disaggregation of technology 'depth' and 'breadth' and similar work has been conducted for tangible and intangible assets of a firm (e.g., Grewal et al. 2008; Prabhu et al. 2005). The consideration of tangible assets such as digital technologies leading to firm performance assumes that the assets provide competitive advantage. As such, one of the main theoretical foundations of this paper is the application of the resource-based view (RBV) (Barney 1991). The investigation of the DT portfolio configuration requires the investigation of how the arrangement of organizational assets (the internal fit) align with the environment (external fit) to provide firm performance. As such, this research also applies the configuration theory (Siggelkow 2002; Vorhies and Morgan 2003) lens to understand the DT portfolio configurations and their alignment with the external environment that provides firm performance. The study builds on these two strong theoretical foundations to develop and test a model that proposes how DT portfolio assets interact to provide firm performance. The DT portfolio depends on both depth and breadth of technology assets, as these dimensions reflect whether the assets are likely to create appropriate value when deployed. Thus, the overarching research question of the study is "how does a firm's configuration of digital technology assets influences the firm's performance?" Consistent with extant research, we posit that the DT portfolio depth and breadth provides a basis for understanding the research question (e.g., Grewal et al. 2008; Prabhu et al. 2005). The theoretical framework and the conceptualization proposed in this research advocate that the DT assets must be viewed from a configuration or portfolio perspective that identifies the underlying configuration types of these technology assets. Further, it also considers their internal arrangements as well as their alignment with the environment which influences firm performance.

To investigate this research question, we test our model using a survey. We gathered responses from chief information officers (CIOs) representing 177 companies, which increases confidence in the underlying theoretical rationale of our predictions. The paper proceeds in the following manner. First, the study provides the theoretical foundation and derives the a-priori model of the study. Next, the paper introduces the data collection and the sample employed to test the a-priori model. Subsequently, the data analysis is presented. The results of the study are described next, drawing conclusions for research and practice, finally, summarizing the limitations and the future research areas of the study.

Linking DT portfolio and firm performance through the application of RBV and configuration theory

Prior research has highlighted that a firm's technology assets – that is, any technology related items of value, owned or controlled by a firm that create value (Henfridsson et al. 2014; Weill 1992; Weill and Vitale 2002) – having a positive influence on financial outcomes (Nevo and Wade 2010). However, it is also acknowledged that focusing solely on the outcome variables like firm performance is less meaningful for the firm (Fang et al. 2011). For the firm's survival, performance and growth, one must understand *how* technology portfolio assets can provide competitive advantage (Grover and Kohli 2013; Nylén and Holmström 2015). A technology is an important asset that firms utilize to obtain favorable organizational outcomes such as innovation and competitive advantage (Bharadwaj et al. 2013). The relationship between resources and organizational outcomes is well-established in the literature (e.g., Bakos and Treacy 1986; Collis and Montgomery 1995; Grant 1991; Sirmon and Hitt 2009). A prominent school of thought in this regard is derived from organizational economics known as the 'resource-based view of the firm' (Barney 1991; Grant 1991; Prahalad and Hamel 1990; Wernerfelt 1984). RBV possesses that the potential for attaining competitive advantage exists when a firm manages assets that are valuable, rare, inimitable and non-substitutable (VRIN) (Barney 1991).

Wade and Hulland (2004, p. 123) note that "resources rarely act alone in creating or sustaining competitive advantage," and commonly available technology assets, according to RBV, cannot provide competitive advantage. However, through various utilizations (i.e. configurations) of the technology assets (i.e. the DT portfolio) firms can exploit opportunities for attaining competitive advantage (Kor and Mahoney 2005; Sedera and Lokuge 2017; Sedera et al. 2016). The RBV of the firm, which indicates how organizational assets deliver sustainable competitive advantages (Barney 1991), provides the theoretical argument between the technology assets and firm performance. Specifically, with the digital technologies in modern DT portfolio, firms have the potential to configure DT portfolio assets to make them as VRIN assets, which in-turn yield competitive advantages and above-average financial performance (Lokuge et al. 2018; Sedera et al. 2016). We note that the characterization of digital technologies especially challenges the extant RBV research, where the technology assets are unlikely to have a positive effect on firm performance, *as stand-alone assets* (Lokuge et al. 2016b; Sedera et al. 2016; Wade and Hulland 2004). Only through unique configurations that they could meet the VRIN criteria. As such, the DT portfolio as a technology asset should be disaggregated across *breadth* and *depth* dimensions to isolate its underlying value-generating mechanisms and relative effects on firm performance.

Technology depth refers to the extent to which a firm possesses profound understanding of the DT portfolio, their capabilities individually, as well as in an amalgamated portfolio. The technology depth encapsulates the focus and intensity of a technology asset or of the asset portfolio. Technology depth is important for providing value to a firm as high depth technology assets are considered to be sporadic, unique, and irreplaceable (Szulanski 1996). The depth of digital technologies also relates to how entrenched the technologies are in delivering products and services through the business processes (Lokuge and Sedera 2014; Nylén and Holmström 2015). Moreover, when a firm consist of high depth technology assets, they are (i) armed with unique knowledge in their innovation, (ii) inherent with technology expertise (Sedera and Dey 2013), (iii) hold relatively low risks technology channel failure leading to product / service denials (Benitez et al. 2018), and (iv) include a substantial presence of technology in core business offers and services (Prabhu et al. 2005; Schenk 2015). Such technology-specific knowledge and expertise make it impossible for competitors to offer substitutes (Dierickx and Cool 1989; Dobbs et al. 2015; Lokuge and Sedera 2017; Lokuge and Sedera 2018). However, too much depth (focus and intensity to technology assets) could lead to dependency risks of the (i) technologies, (ii) knowledge and (ii) skills (Alavi and Leidner 2001b). Moreover, too much depth of technology assets would also lead to (iv) high costs of replacement, upgrade or renewal costs (Alavi and Leidner 2001a; Lokuge and Sedera 2016).

Technology breadth encapsulates the diversity and the extent of the scope of the DT portfolio. While the concept technology breadth captures the value creation of diverse DT portfolio, it is also considers capturing value over time as high breadth of technology assets offer extensive and diverse contexts for gaining value from unique configurations (Bierly and Chakrabarti 1996). Especially in DT portfolio, firms have the ability to increase the presence of SMAC-IoT with minimal costs and disruptions (Yoo et al. 2012). As such high technology breadth can be attained by a firm by combining variety of technology assets, knowledge or capabilities. Moreover, the breadth of technologies could include (i) the existing products and services to be delivered using new technologies, (ii) offer new technologies to attract tech-savvy customer segments, (iii) derive efficiencies through cost-effective technologies and (iv) derive better insights through technologies for new product / service offers (Nambisan 2013). However, increasing the breadth of DT portfolio assets to yield positive outcomes is not a foregone conclusion either. Broadening assets without a clear rationale could lead firms to (i) hold unproductive assets that do not contribute to performance, (ii) introduce undue complexity, (iii) increase expenditure, skills and resources and (iv) arise confusion about strategic goals and alignment (Hajli et al. 2015; Weill 1992).

Moreover, while a firm's technology assets can be uniquely configured to transform them as VRIN assets, technology breadth maybe critical in terms of increasing the firm performance. For example, a firm can create a technology configuration with multiple technologies which provides a unique combination with VRIN characteristics. Thus, disaggregating technology assets across technology depth and technology breadth, highlights that these dimensions are important for a firm for firm performance and provides an explanation of how these dimensions work together in providing organizational value creation. For example, if we consider technology depth and technology breadth as fundamentals that provide value, configuration theory postulates that firm performance is contingent on the asset arrangement (Siggelkow 2002). However, the fit among the technology assets and the fit between the internal and external environment is also critical for value creation.

The research model and hypotheses

Figure 1 depicts the research model. The focus of this research is not on understanding whether the digital technology depth and breadth impacts firm performance, rather it is on developing a nuanced view on what combinations of digital technology depth and breadth creates the highest impact on firm performance. As such, the dotted square in the middle depicts the possible DT depth and breadth combinations.

Figure 1 highlights four asset configuration possibilities, arising through 'low' and 'high' combinations of digital technology depth and breadth. For example, it is possible that a firm maintains a 'low' breadth in digital technologies combined with a 'high' degree of depth in digital technologies. Similarly, a firm could maintain a 'high' degree of breadth and a 'low' degree of depth in digital technologies. Using Figure 1, this research develops four hypotheses on DT portfolio asset configuration strategies: (1) DT portfolio concentration strategy, (2) DT portfolio diversification strategy, (3), DT portfolio optimization strategy, and (4) DT portfolio leveraging strategy. Further, we also note that technology depth and breadth are continuous variables. As such, neither the breadth nor the depth is conceived out of an absolute number.

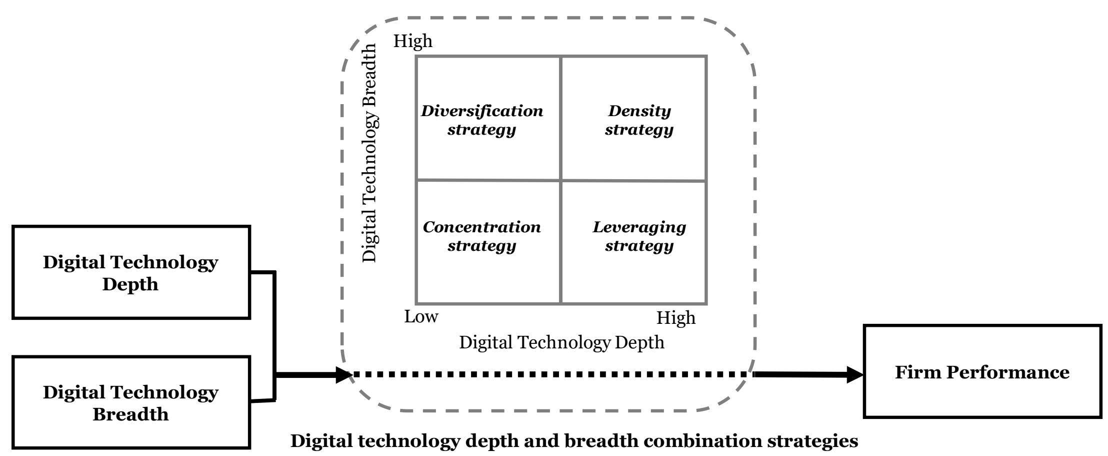

Figure 1. The conceptual model

Furthermore, there is no imposition here to suggest that a *specific strategy is innately better than the other*. Each of the four strategies have the potential to provide a unique advantage to the firm. The following discussion provides further details of the four strategies and introduces the four hypotheses tested in this study.

DT portfolio diversification strategy (Low Depth – High Breadth)

Research supports the premise that firm performance has a positive significant impact as the firm broadens its technology assets (Bharadwaj 2000). In such strategies the firm hedges its risks through diversification of the technology assets (Kim et al. 2016). A salient argument herein is that the digital technologies can balance the weaknesses of another. In other words, a weakness in one digital technology can be mitigated by introducing another technology. However, we extend this argument of Kim et al. (2016) by suggesting that firms gain benefits, when they substitute different asset bases (as opposed to keeping the same asset base and having to improve depth). As such, since this strategy employs the strengths of broadening the breadth of assets, we term it as *the DT portfolio diversification strategy*. When responding to dynamic markets, the *DT portfolio* diversification strategy may support firm performance, where the innovations through the advent of digital technologies are more likely to be compensatory, as compared to utilizing the same technology assets (Chari et al. 2008; Kim et al. 2016). However, this strategy could run into the risk of over-diversification, leading to low levels of appropriate internalization (Lubatkin and Chatterjee 1994). The aforementioned discussion can be empirically tested using the following hypothesis.

H1: The low digital technology depth and high digital technology breadth have a significant positive impact on firm performance.

DT portfolio concentration strategy (Low Depth – Low Breadth)

The *DT portfolio* concentration strategy is proposed to capture the premise that with digital technologies, a firm has a potential to maintain a low technology base with concentrated efforts of technology acquisition, maintenance and management. It argues that the low-cost involvement in acquiring and utilizing digital technologies would lead to higher firm performance (Nylén 2015). The extant literature suggests that digital technologies provide firms with the options of outsourcing (Ceccagnoli et al. 2012), resorting to subscription-based acquisitions as operating expenses (Weill 1992) and maintain minimum know-how within the firm (Oshri and Kotlarsky 2013). Moreover, digital technologies allow (and encourage) experimentation of solutions, through which various digital technologies are tried-and-tested with relatively minimum risk and costs (Lokuge et al. 2019). On the other hand, the *DT portfolio* concentration strategy may compromise the long-term organizational knowledge capital and continuity of solutions (Veugelers 1997; Veugelers and Cassiman 1999), yielding a negative effect on firm performance. Furthermore, placing less emphasis on in-house technology assets, coupled with the low levels of know-how may leave the firm vulnerable to the technology market forces (Cha et al. 2008), creating uncertainty in the firm as well as with the customers. The aforementioned discussion can be empirically tested using the following hypothesis.

H2: The low digital technology depth and low digital technology breadth have a significant positive impact on firm performance.

DT portfolio leveraging strategy (High Depth – Low Breadth)

Increasing technology depth provides firms with more knowledge and expertise regarding future trends, which helps them to enhance their decision making process by forecasting (Sedera and Dey 2013; Sedera and Lokuge 2019; Srivastava et al. 1998). Moreover, low breadth of technology mean that a firm can direct its resources to increase depth – making a reciprocal relationship between high depth and low breadth. However, deep insight into the existing technology offer no protection against unforeseen changes in a dynamic market. As such, even with high depths, a firm could remain susceptible to dramatic performance and market shifts. Moreover, such changes in a high depth firm would make it difficult and costly to change deeply engraved technologies and shift to new ones (Sarker et al. 2005). By reducing risk through the provision of high depth focus to a smaller number of technologies, the firm can anticipate and reduce the impact of change. However, a major change in the DT portfolio may have a negative impact on firm's performance, and the compensatory diversification potentially affects the firm's ability to serve the existing base. The aforementioned discussion can be empirically tested using the following hypothesis.

H3: The high digital technology depth and low digital technology breadth have a significant positive impact on firm performance.

DT portfolio density strategy (High Depth – High Breadth)

When a firm maintains a high degree of know-how and have a range of digital technologies, it is likely that the firm would be able to successfully react to the dynamic market conditions, facing the uncertainties through better anticipation, adaptation (Lokuge et al. 2019; Svahn et al. 2017). In turn, such capabilities will improve firm performance (Christensen 1997). As such, it is expected that the interactive effect of high-depth and high-breadth DT portfolio assets will have a significant positive impact on firm performance (Cui and Pan 2015). From the outset, the asset density strategy may look like a 'silver-bullet' for all firms. However, this is not the case. For instance, with the increasing breadth of DT portfolio (i) increases the complexity of portfolio management, (ii) increases cost of maintaining idle assets and (iii) increases cost of retaining diversity of knowledge (Hall et al. 2013; Roberts and Grover 2012).

H4: The high digital technology depth and high digital technology breadth have a significant positive impact on firm performance.

The instrument and the sample

A survey instrument was designed to test the hypotheses derived earlier and the implied paths of the research model. The instrument included 15 items in total. The complete instrument, items arranged under each sub-construct, descriptive statistics at the sub-construct level and the lineage of each of the items is presented in Appendix A. A pilot test was conducted with a sample of 4 senior IT managers who attended a monthly CIO business seminar series organized by a co-author. The pilot survey analysis resulted in introducing some explanatory statements. For example, the IT managers raised the question whether the study explanations adequately provide information on whether the survey was *only* about digital technologies. As such, new explanatory instructions were inserted, stating the following: "The focus of the study is to assess the capabilities of *digital technologies* in your organization. The scope of digital technologies is limited to systems based on social media, mobile, analytics, could and internet-of-things. The survey is not concerned about traditional legacy systems like enterprise systems."

Employing the stratified sampling method, the survey instrument was then distributed among nearly 200 CIOs (or equivalent designated person such as chief technology officer, chief digital officer) at a renowned international CIO forum in April 2018. The event organizers indicated that all participating firms were large and were representative of all industry sectors. Further, the survey instrument gathered demographic details to assert that the firms considered for the analysis possessed the following criteria: (i) the firm had a dedicated CIO/chief technology officer and a team of staff that managed the digital technology portfolio, (ii) the firm had used a collection of digital technologies for the past 5 years, and (iii) at the time of the data collection, the CIO had been in the position for at least 6 months, was not in the last 6 months of their appointment[2], and was participating in regular meetings with the executive leadership team (e.g., Chief Executive Officer and Chief Finance Officer).

The sample of CIOs was appropriate for the study objectives, as these personnel are able to comment knowledgeably on behalf of the firm with regard to strategic initiatives using DT portfolio (Grover et al. 1993). The CIOs are involved in managing the information resources that influence organizational strategy and have the direct responsibility for planning of the IT initiatives. The study received responses from 177 organizations. The 177 respondents provided answers to all questions of the survey.

The survey employed a seven-point Likert scale items, anchored by "strongly disagree" (1) to "strongly agree" (7), to assess digital technology depth and breadth. The dependent variable, firm performance was measured using performance and performance variability employing a seven-point Likert scale items, anchored by "very low" (1) to "very high" (7). The study considered firm size as the control variable.

Data analysis

For the analysis, partial least squares (PLS) structural equation modeling (SEM) method (Benitez et al. 2018; Benitez et al. 2017) and polynomial regression (Edwards and Parry 1993) with response surface methodology (Box and Draper 1987; Khuri and Cornell 1987) were employed. The model validation and construct validation were evaluated using content validity, construct validity, investigating common-method bias, and polynomial regression and response surface analysis. It is considered that PLS-SEM is a technique that is commonly employed to evaluate complex research questions by estimating a complex

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[2] Determining that the IT leadership was not "in transit" is an important consideration as it has been argued that firms with in-transit CIOs do not embark on strategic initiatives.

research model, modeling latent variables, and estimating several types of measurement errors. PLS-SEM is therefore well suited for highly complex predictive models, which supports the mapping of formative observed variables (Becker et al. 2012; Henseler and Sarstedt 2013; Sedera et al. 2003; Wold 1989). Further, to test the structural models, ADANCO 2.0.1 software was employed (Dijkstra and Henseler 2015) with the bootstrap resampling method (4,999 resamples). Following the guidelines of Dijkstra (2010), the sub-constructs were estimated by using the regression weights (mode B). When conducting polynomial regression and response surface methodology, guidelines of Shanock et al. (2010) were followed.

Content validity

Since digital technology depth and breadth (and their corresponding items) were derived through a strong theoretical basis, the establishment of content validity was not a priority. Yet, guidelines of McKenzie et al. (1999) were followed for establishing content validity. This consists of four steps[3]: (i) preparing an initial draft of the survey instrument by canvassing the related literature to derive its measures (Lynn 1986); (ii) identifying a panel of respondents to review and evaluate the possible survey questions, ensuring that the panel had the necessary training, experience, and qualifications (American Educational Research Association 2002); (iii) the panel proving an evaluation of the survey measures; and (iv) panel assessing how well each item represented each of the sub-constructs. The panel of experts included six respondents. In this fourth step, a quantitative assessment was made, thus establishing the content validity ratio (CVR) for each item/question using the formula of Lawshe (1975). Based on the pilot tests, a minimum CVR value of 0.713 was observed at a statistical significance of $p<0.05$. Feedback from the pilot-test respondents resulted in minor modifications to the wording of the survey items and endorsement of the research model and its sub-constructs and associated measures (Lawshe 1975; Lynn 1986; McKenzie et al. 1999).

Construct validity

Using the average variance extracted (AVE), construct validity was determined for each construct. All the constructs demonstrated satisfactory convergent and discriminant validities, with the AVE for all three constructs measuring above 0.5 (Cenfetelli and Bassellier 2009; Fornell and Larcker 1981). The AVE of each construct was greater than the variance shared between the construct and the other constructs in the model, thus indicating strong discriminant validity. Table 1 presents the results of the AVE analysis.

Table 1. Construct correlation matrix

	1	2	3
Digital Technology Depth (1)	0.852		
Digital Technology Breadth (2)	0.187	0.877	
Firm Performance (3)	0.364	0.148	0.901

Measurement and structural model results

Following the guidelines (e.g., Cenfetelli and Bassellier 2009; Diamantopoulos and Siguaw 2006; Diamantopoulos and Winklhofer 2001; Dijkstra and Henseler 2015; Henseler 2017), the eight items were then tested for multi-collinearity using variance inflation factors (VIF). The VIF from a regression of all the two constructs ranged between 1.265 and 2.59, indicating that multi-collinearity is not a problem in the study sample (Diamantopoulos and Siguaw 2006). The convergent validity of the constructs conformed to the heuristics with all the t-values of the outer model weights exceeding the one-sided[4] cut-

[3] The four-step approach followed here is analogous to the Q-sort approach for attaining content validity (Kendall et al. 1987; Tractinsky and Jarvenpaa 1995).
[4] The one-sided test was appropriate because we only hypothesized a positive contribution of the formative components of expertise. The two-sided cut-off of 1.96 was used otherwise.

off of 1.645 levels[5] significant at the 0.05 (*) alpha protection level (Benitez et al. 2017; Henseler 2017; Henseler et al. 2016).

Next, the structural model analysis investigated the relationship between DT depth and DT breadth on firm performance as the dependent variable. The path coefficient for DT depth was 0.593 and the path coefficient for DT breadth was 0.522, with an R^2 (of firm performance) was of 0.38. Moreover, the model fit indicators were also established using SRMR, d_{ULS} and d_G. The SRMR of the model was 0.017, d_{ULS} = 0.119 and d_G = 0.028, demonstrating good model fit (Dijkstra and Henseler 2015; Hu and Bentler 1999). The results confirm the overarching theoretical foundations (Figure 1), encouraging further investigation into the associations with DT configurations and firm performance.

Common method bias

Sharma et al. (2009) advise against the common practice of gathering perceptual data on both independent variable and the dependent variable from the same respondent, as it may create common method variance (CMV). However, recent literature suggests that composite models are highly unlikely to suffer from common method bias (see Rönkkö and Ylitalo 2011; Rueda et al. 2017). Nevertheless, paying attention to the traditions of demonstrating that CMV is unlikely, the items for depth and breadth were not grouped under their construct headings in the survey. Next, employing the Harman (1976) one-factor test, we found that not all the measures lead to a single factor solution; thus confirming that CMV was unlikely.

Polynomial regression

Polynomial regression is a technique to model the relationship between multiple independent variables (X and Y) in relation to a dependent variable (Z) through a non-linear relationship (Shanock et al. 2010). Similar to polynomial regression (Edwards and Parry 1993), response surface methodology (Box and Draper 1987; Khuri and Cornell 1987) is a common technique that analyze non-linearities. Moreover, these two techniques together provide the basis for testing and interpreting the features of surfaces corresponding to polynomial quadratic regression equations. Especially, these techniques are popular in micro and macro organizational literature to investigate congruence and/or discrepancies between variables (Shanock et al. 2010) allowing researchers to examine the extent to which the combinations of two predictor (independent) variables relate to an outcome (dependent) variable. Further, this method has been widely used in multi-source feedback research (Shanock et al. 2010). For example, Venkatesh and Goyal (2010, p. 282), state that "*…research in IS in particular is limited to linear models. Linear models fail to reveal complexities that are anticipated in theories of congruence…"* Failure to adhere to the non-linear assumptions compromise research and practical explanations of the research, compromising the credibility and insightful findings. Moreover, such linear models assume that there is a similar effect for multiple independent variables on the dependent variable (Venkatesh and Goyal 2010). Therefore, when in fact the relationship between the component measures and the outcome measure is curvilinear and are interrelated, a linear model would oversimplify the relationship and mask the true relationships among the variables (Edwards 2002; Edwards and Cooper 1990).

In the case of digital technology depth and breadth, this paper reports the observations of the tri-partite relationship between the variations of depth, breadth on firm performance. As hypothesized earlier, digital technology depth and breadth is observed at 'high – low' combinations as the two predictor variables. Firm performance is the outcome variable, where variations of both depth and breadth *in combination* influence its behavior. As such, the two techniques, polynomial regression and response surface method are ideal to explore the hypotheses stated above.

In this example, digital technology depth and digital technology breadth are the two predictor variables and firm performance is the outcome variable. As such, we label digital technology depth as X variable, digital technology breadth as the Y variable, whilst firm performance is labeled as the outcome variable Z.

[5] The t-values of the loadings are equivalent to t-values in least-squares regressions. Each measurement item is explained by the linear regression of its latent construct and its measurement error (Diamantopoulos and Winklhofer 2001).

We then employed the following polynomial equation to test the aforementioned tripartite relationship between digital technology depth, breadth and firm performance:

Firm Performance = *f* (digital technology *depth* *, digital technology breadth **) (1)

$$\mathbf{Z = \beta_0 + \beta_1\, DTDepth^{*} + \beta_2\, DTBreadth^{**} + \beta_3\, DTDepth^2 + \beta_4\, (DTDepth \times DTBreadth) + \beta_5\, DTBreadth^2 + e}$$

Where,

* **DTDepth** = Digital technology *depth*

** **DTBreadth** = Digital technology *breadth*

Shanock et al. (2010) provide the four surface properties, a_1, a_2, a_3 and a_4. The test value a_1 corresponds to the slope of the surface alone the line of perfect agreement between two predictor variables ($PV_1 = PV_2$ or X=Y) where it is related to the dependent variable Z. Where $a_1 = (b_1+b_2)$, and b_1 and b_2 are the non-standardized beta coefficients for the scale centered PV_1 and PV_2 (X and Y), respectively. Meanwhile the test value a_2 corresponds to the curvature along the line of perfect agreement between two predictor variables ($PV_1 = PV_2$ or X=Y) as related to the dependent variable Z. It is given by $a_2 = (b_3+b_4+b_5)$, where b_3, b_4 and b_5 are the non-standardized beta coefficients for the scale-centered DV_1 squared (X^2), cross-product (DV_1 * DV_2 or XY) and DV_2 squared (Y^2), respectively to incorporate non-linearity. Similarly, the test value a_3 corresponds to the slope of the line of incongruence between two predictor variables (PV_1 = negative PV_2 or X= negative Y) as related to the dependent variable Z. The value $a_3 = (b_1-b_2)$, where b_1 and b_2 are the non-standardized beta coefficients for the scale-centered PV_1 and PV_2, respectively. This line explains the changes in DV (Z) as related to the direction and magnitude of the discrepancy between two predictor variables (IV_1 is higher than / lower than IV_2). Alternatively, the test value a4 corresponds to the curvature along the line of disagreement between two predictor variables (PV_1 = negative PV_2 or X= negative Y) as related to the dependent variable Z. It is given by $a_4 = (b_3-b_4+b_5)$, where b_3, b_4 and b_5 are the non-standardized beta coefficients for the scale-centered DV_1 squared (X^2), cross-product (DV_1 * DV_2 or XY) and DV_2 squared (Y^2), respectively. As such it is possible for a_1, a_2, a_3 and a_4 to be independently be significant or non-significant as they are related to the two different properties of the two different lines of the resultant response surface. We followed the procedure outlined in Shanock et al. (2010) to run the polynomial regression analysis on the data collected from 177 respondents to create the response surface as shown in Figure 2.

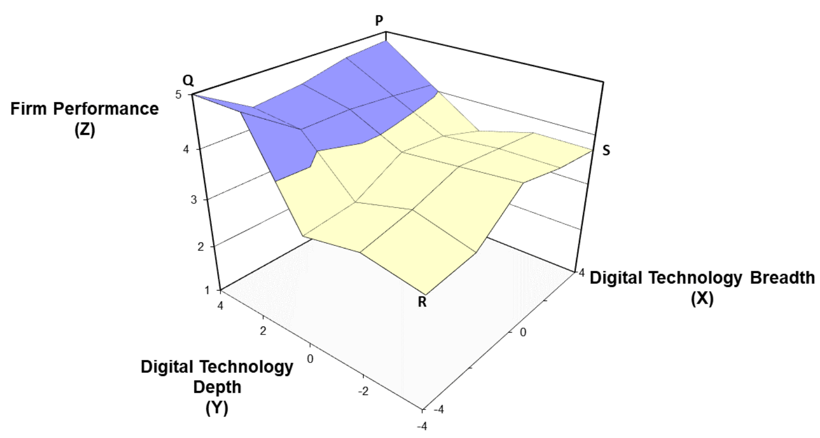

Figure 2. Response surface of DT depth and breadth and firm performance

Table 2. Properties of the response surface between depth, breadth and firm performance					
Effect	**Coefficient**	**Standard error**	**Test stat (t)**	**P value**	**Significance**
a_1: Slope along X=Y (as related to Z)	0.59	0.11	5.507	0.000	Significant
a_2: Curvature on X=Y (as related to Z)	0.49	0.09	4.081	0.000	Significant
a_3: Slope along X=-Y (as related to Z)	-0.46	0.01	-12.152	0.000	Significant
a_4: Curvature on X=-Y (as related to Z)	0.00	0.04	-0.119	0.905	Non-significant

The solid line on the bottom of the graph represents the line P to R on the three-dimensional surface of Figure 2, where it depicts the perfect agreement between the two predictor variables, where depth and breadth are balanced (i.e. X=Y). As hypothesized, this scenario highlights the 'DT portfolio density strategy,' where the depth and breadth are both increased to influence firm performance. Our results indicate, that the high depth-high breadth (DT portfolio density strategy) (X=Y) has a positive slope through the line from P to R (see Figure 2). Hence, with the increasing depth and breadth, there is a strong likelihood of firm performance increasing. However, it is noted in Figure 2 that the firm performance is lowest at the front corner (point 'R'), where the depth and breadth remain the lowest. As seen in Table 2, the slope along the P-R line is significant (a_1).

The line perpendicular to the (X = Y) depicts the line of disagreement or contract between the X and Y variables. They highlight the low depth – high breadth (DT portfolio diversification strategy) and high depth – low breadth (DT portfolio leveraging strategies) of digital technologies. Therein, the X and Y variables are not in agreement, (i.e. X = negative Y) and it represents the surface along the line Q to S points in Figure 2. Observing high-low combinations of depth and breadth finds that firm performance has a significant positive impact with the combinations of low breadth and high depth of digital technologies. As presented in Table 2, the slope along the line of incongruence (Q-S) is significant (a3), while the curvature along the Q-S line remains non-significant.

Conclusion

The objective of this study was to investigate the digital technology portfolio configurations that firms possess to improve their firm performance. The study commenced with the premise that contemporary firms are provided with low-cost, easy-to-adopt and being largely subscription-based digital technologies for value creation (Nambisan 2013; Nylén and Holmström 2015). Using these technologies firms can develop various types of digital technology portfolio configurations – with a combination of depth and breadth. The study proposed four theoretically based hypotheses that were tested using data from 177 chief information officers, each representing one organization. Having established the content and construct validity in a rigorous assessment, polynomial regression and response surface methodology (Shanock et al. 2010) was employed to test the effectiveness of the four DT portfolio strategies on firm performance.

Overall, the study made the following observations through the polynomial regression and response surface methodology:

- As proposed in the overarching study design, the study observed that there is substantial variation of firm performance in relation to the varying degree of digital technology depth and breadth. In other words, the four strategies hypothesized above yielded varying degrees of firm performances.
- The analyses observed that the lowest firm performance is recorded for the combination of low depth - low breadth of digital technologies. This strategy – termed herein as the *DT portfolio concentration strategy* – theoretically argued that the lowest amount of assets would yield lesser positive outcomes.

- The analyses revealed the *highest* firm performance for the combination of high depth - low breadth of digital technologies. The *DT portfolio leveraging strategy* demonstrates that a firm is likely to benefit more through high depth, rather than spreading it 'too thin.' A high depth – low breadth technology configuration mirrors Mark Twain's risk-reduction advice: "Put all your eggs in one basket and—watch that basket" (Stevenson 1948, p. 672).
- The polynomial analyses also revealed favorable results for the combination of high depth – high breadth, where the firm performance for the *DT portfolio density strategy* was high, yet lower than the *DT portfolio leveraging strategy*.
- Similarly, low depth – high breadth *DT portfolio diversification strategy* too demonstrated significant and substantial impact on firm performance in the sample.

Table 3 presents the results of the testing of the four hypotheses. In summary, the digital technology configurations certainly influence the firm performance in our sample. Yet, only certain combinations of depth and breadth of digital technologies seem to have a significant positive impact on firm performance.

Table 3. Summary of the hypotheses

Hyp.	**Path**	**Result**
H1	The interaction between low digital technology depth and high digital technology breadth have a significant positive impact on firm performance.	Supported
H2	The interaction between low digital technology depth and low digital technology breadth have a significant positive impact on firm performance.	Not supported
H3	The interaction between high digital technology depth and low digital technology breadth have a significant positive impact on firm performance.	Supported
H4	The interaction between high digital technology depth and high digital technology breadth have a significant positive impact on firm performance.	Partially supported

Our analysis also demonstrated the use of configuration theory as a lens for viewing the influence of various configurations of digital technologies that affects firm performance. For example, in our sample we demonstrated that a high depth – low breadth *DT portfolio leveraging strategy* has a greater impact on firm performance. Further, the *DT portfolio density strategy* has a relative low effect on firm performance. These results suggest the effects of some configuration strategies on firm performance specifically in relation to the digital technologies. Finally, our research extends extant literature on role of digital technologies on firm performance (Bharadwaj et al. 2013; Tallon 2007), organizational strategy (Grover and Kohli 2013; Henfridsson and Lind 2014; Nylén and Holmström 2015) and resource-based view of the firm (Seddon 2014; Sedera et al. 2016) by providing specific technology (i.e. digital technologies) orchestration strategies for firm performance. Our results revealed the importance of disaggregating the IT portfolio into a discussion of depth and breadth to better understand how they affect firm performance.

Implications for Research

The digital technology configuration strategies derived through this study and the approach followed in its development address several areas of uncertainty in past information systems research. The prevalent view suggests that various resources can be bundled to provide value to the firm (Nevo and Wade 2010). Literature on asset orchestration (Sirmon et al. 2011), resource bundling (Sirmon et al. 2008; Sirmon et al. 2007) and CRBT (Aragon-Correa and Sharma 2003; Brush and Artz 1999; Sedera et al. 2016) have all contributed to this discussion. We aim to fill the gap of "how" firms can create value by configuring digital technologies. The study derived four specific digital technology configuration strategies through which value can be created in firms. To-date there are no specific digital technology configuration strategies presented in IS literature. As such, the four digital technology configuration strategies – DT portfolio diversification, DT portfolio concentration, DT portfolio leveraging and DT portfolio density – provide a commencing point for researchers to examine how different digital technology configuration strategies can assist firms. For researchers, this study provides the foundation to define how multiple digital technologies can be configured using four configuration strategies. These mutually exclusive digital technology configuration strategies have distinct objective, the role of each configuration, risk, the time it takes to formulate, additional resource requirements, imitability and its value proposition.

Overall, this study contributes to the broad body of knowledge of IS and strategic management. Though there is a wealth of literature on strategy and resource management that spans for decades (Gerow et al. 2014), firms still require new and renewed attention to formulate and execute management of IT. Furthermore, this study demonstrates that generalized strategies can be derived beyond the context specificity. For most strategy related studies, conclusions are left at the point where it needs to be determined by the context and that makes it nearly impossible for researchers to engage in detailed research on specific strategies. The use of configuration theory as the theoretical foundation provides a unique perspective of the activity of digital technology configurations. It also makes it possible to make contributions to research on resources and their utilization to attain positive organizational outcomes. Finally, further adding to the continuous debate of whether IT adds value to firms, this study manifests a positive association between IT and organizational outcomes.

Implications for Practice

The study offers several practical implications as well. First, the study provides a framework to understand digital technology portfolio based on two related concepts; DT depth and DT breadth. Such a classification would provide firms with an easy-to-understand view of compartmentalizing the digital technology portfolio (and potential future investments too). While these terms, depth and breadth are relative terms, such a discussion will raise awareness of how an IT strategy could be formed using digital technologies. This would provide an essential discussion for IT managers to form their IT portfolio, given the relative ease of accessing digital technologies and the natural temptation to increase the breadth of applications.

Second, the study provided four actionable digital technology-based strategies that firms can use to gauge their digital technology portfolio. Here, firms can evaluate various assemblies of digital technologies that are configured for the same business proposition through the lenses of depth and breadth. Therein, while some strategies were not favorable for firm performance (or partially supported), we would encourage firms to take an open investigation into all four strategies.

Limitations and Future Research

We recognize several limitations of the study requiring attention beyond the scope of this study and paper. First, the model was developed and validated with a sample of 177 organizations, may be perceived as small at the global scale. This raises questions about whether the a-priori model was complete, whether it was representative of contemporary IS in general, and whether the final list of measures and constructs are, indeed, generalizable. Thus, although the initial findings are encouraging, further research is necessary to extend generalizability. Specifically, generalizability could be strengthened through re-testing the model in diverse settings of various systems, contexts and timelines.

Second, while the snap-shop approach of establishing the DT configuration strategies having a significant positive impact on firm performance is precisely what was sought, future studies could benefit from a longitudinal study that will allow researchers to understand how the formation of the strategies will lead to gradual changes (especially, improvements) in firm performance.

Appendix – The survey instrument

Firm size (control variable)

1. Number of employees

Firm Performance (adapted from Fang et al. 2011)

During the last five years, how do you rate your firm's overall level of performance in: ("low/high")

1. Profit margin
2. Return on assets

3. Return on equity

During the last five years, how do you rate your firm's stability (reverse coded) of performance in:

1. Profit margin
2. Return on assets
3. Return on equity

Digital Technology Breadth during the last five years… (adapted from Fang et al. 2011)

1. Our firm has developed a diverse technology portfolio.
2. Our firm has established a broad knowledge base of new technologies.
3. Our firm has accumulated extensive know-how regarding new product and service development using new technologies.
4. Our firm has developed extensive knowledge of using new technologies across different industries.

Digital Technology Depth during the last five years… (adapted from Fang et al. 2011)

1. Our firm has developed a deep understanding of using new technology portfolio.
2. Our firm has accumulated profound understanding of our existing technologies.
3. Our firm has established thorough know-how regarding our product and service offerings through using new technologies.
4. Our firm has developed deep understandings of new technologies in our industry.

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