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Short Paper

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Abstract

Organizations need to develop digital competences to utilize digital technologies to succeed in digital transformation. Yet, current efforts on organizational strategies to develop digital competences, i.e., digital M&A or appointing a CDO, have been conducted in isolation. However, following digital ecodynamics, material, organizational and environmental factors are in fact interwoven. We aim to cater to this confluence by taking a configurational perspective on digital competence development and its effect on digital transformation. We integrate prior findings of digital competence on (1) the firm level and the role of knowledge resources, (2) the leadership level and competence of the firm's upper echelon, and (3) the role of contextual complexities in the form of the firm's environment and structure. Subsequently, we employ fsQCA on a unique dataset. Thereby, we disentangle the multifaceted complexity of digital transformation and provide more fine-grained conceptual insights into the phenomena.

Keywords: digital transformation, digital competence, configurational perspective, fsqca

Introduction

In recent years a vast array of studies has been published, contributing toward a better understanding of the potentially relevant elements for digital transformation such as digital resources and capabilities, environmental pressure, and leadership (Hanelt et al. 2021b; Vial 2019). Nonetheless, how firms conduct digital transformation is still a puzzle for research and practice alike. One explanation could be that the aforementioned elements have been examined in isolation so far. Despite the fact that they might be

interwoven and conflated (El Sawy et al. 2010; Hanelt et al. 2021b). Given the complexity of digital transformation, configurational perspectives might be particularly helpful to gain more realistic insights and recipes for managerial practice (Hanelt et al. 2021). Accordingly, this study draws on the idea of digital ecodynamics (El Sawy et al. 2010), and brings together different forms of digital competence, as a key driving force of digital transformation (Chanias et al. 2019).

Prior research portrays several strategies that firms could employ to develop digital competence. While some research focuses on material factors such as acquiring digital technology via digital M&As (Hanelt et al. 2021a) or creating digital human resources (Lou and Wu 2021) others focus on organizational factors and changes in the capabilities and leadership structure for example expressed through the creation of Chief Digital Officer (CDO) positions (Firk et al. 2022). In the spirit of digital ecodynamics, material and organizational factors conflate with environmental circumstances (El Sawy et al. 2010). Relatedly, prior literature highlights that contextual contingencies such as structural complexity and environmental complexity may ultimately determine the degree to which the competence elements contribute to the success or failure of digital transformation (Vial 2019; Soluk et al. 2021).

In this study, we contribute to the digital transformation literature through a configurational perspective and take stock of digital competence development. While the configurational view has been utilized to gain insights into digital business strategy (Park and Mithas 2020) or digital innovation governance (Leonhardt et al. 2018), its potential is yet to be realized with regard to digital transformation. We integrate previous findings on digital competence and capabilities (Lou and Wu 2021; Hanelt et al. 2021a) as well as the required leadership in guiding competence development and alignment (Firk et al. 2022; Vial 2019) and further consider contextual complexity stemming from the firm's environment and structure (Vial 2019; El Sawy et al. 2010). In turn, we advance the literature on digital transformation by building on digital ecodynamics and contributing new configurational theory which integrates long-standing debates in the literature. Based on a unique panel dataset of U.S. firms from 2011 to 2017, we explore digital competence based on material, organizational and contextual factors. We rely on a fuzzy-set qualitative comparative analysis (fsQCA) logic (El Sawy et al. 2010; Bell et al. 2014) and provide initial evidence that there is more than one way to digital transformation. Thus, our explorative study provides an important puzzle piece toward understanding the multifaceted complexity of contemporary digital transformation research.

Theoretical Background

Towards digital competence

Recent research has advocated considering the "multiplicity of digital phenomena" in theorizing (Park et al. 2020), especially for digital transformation (Hanelt et al. 2021). This theoretical multiplicity follows the idea that there are multiple configurations for success (Misangyi and Acharya, 2014). Successful digital transformation may thus be achieved through the combination of various elements and contextual factors, such as appointing a CDO to have a strategic digital leader (Firk et al. 2022) or engaging in digital M&A to acquire new competences (Hanelt et al. 2021a). Because these elements are interwoven, we draw on a configurational perspective and an abductive approach to determine the relevant theoretical concepts (Park et al. 2020). Following El Sawy et al. (2010), we draw on the digital ecodynamics concept and build on the idea of the interplay between material, organizational and environmental factors. We especially also draw on recent advances in the digital transformation literature (Vial, 2019; Hanelt et al. 2021b) and emphasize digital competence, which has been recently described as a key driving force of digital transformation (Chanias et al. 2019). We distinguish digital competence based on the literature into firm and leadership competence and, in the spirit of digital ecodynamics, also include contextual complexity.

Factor	Theoretical Argument	Source
Leadership digital competence	Digital leadership refers to the digital competence of the upper echelon and their knowledge to handle digital technologies. We distinguish between (1) CEOs with digital experience, (2) Chief Digital Officers, and (3) board members with digital experience. As the upper echelon is responsible for the strategic direction of the organization, more digital competence equals better knowledge to steer the organization for digital transformation activities.	(Firk et al. 2022; Vial 2019; Kurzhals et al. 2020)
Firm digital competence	Firm digital competence represents the firm's ability to handle digital technologies for value creation, appropriation, and delivery. We distinguish between (1) digital innovation capability (DIC) as the knowledge to manage,	(Lou and Wu 2021; Hanelt et

	use, and develop digital technologies and (2) digital M&A as externally acquired digital knowledge. Thus, digital competence forms the basis for the use of digital technologies and the subsequent changes in value-creating paths.	al. 2021a; Vial 2019)
Contextual complexity	Contextual complexity represents key contingency factors that influence digital phenomena. We distinguish between (1) environmental complexity as a turbulent environment and (2) structural complexity as internal complexity. The more complex the environment/organization the more challenging transformation will be.	(Soluk et al. 2021; Vial 2019)

Table 1. Overview of theoretical multiplicity

Leadership digital competence

Leadership digital competence refers to the digital competence of those at the upper echelons of the organization), who are responsible for developing a digital mindset (Vial 2019). Upper-echelon theory (UET) has long positioned that those at the very top of the organization to have a crucial impact on strategic decision-making (Hambrick and Mason 1984). The primary inside that is thus far available into how the upper echelons shape digital transformation is derived from the presence or absence of the chief digital/ information officer (CDO) (e.g., Firk et al. 2022). Specifically, Firk et al. (2022) argued that CDOs can better anticipate the need to create new business models, the need to invest in building digital competence, handling threats as well as coordinating change. The CDO, however, does not work in isolation from the CEOs and board of directors. In particular, a CDO without the support of the CEO and the board of directors is merely a symbolic feature (Firk et al. 2022). The CEO, in particular, is ultimately responsible for digital transformation (Siebel 2017). In an ideal world, the board of directors both monitors and advises the firms' upper echelons (Oehmichen et al. 2017; Haynes and Hillman 2010). This may be particularly important when the firm is undergoing digital transformation. Directors, who themselves possess digital competencies are particularly well suited to advise the top management team (TMT) members on how to preside in the future (Oehmichen and van Ees 2019). Overall, when directors have digital competence, they may be more likely to push the idea of digital transformation on the TMT and are less likely to block digital transformation initiatives brought forth by the CEO or CDO. In sum, leadership digital competence allows firms to better steer their digital transformation efforts.

Firm digital competence

For successful digital transformation, firm digital competence is needed to handle digital technologies (Vial 2019; Singh et al. 2019). Firm digital competences functions as knowledge resources that explain firms' ability to utilize digital technologies (Bharadwaj 2000). Prior research highlights two strategies (i.e. internal vs external) that firms can pursue to develop these resources. The first strategy is to source tangible and human resources (Lou and Wu 2021), which subsequently allows firms to create digital innovation capabilities. We adapt the argumentation of Lou and Wu (2021) to conceptualize digital innovation capability (DIC) as the ability to handle, manage, and develop digital technologies, based on human resources and firm patents. Thus, investment in tangible and human resources allows firms to develop digital innovation capability as the basis for digital competence. Second, firms can also get access to digital knowledge resources by acquiring organizations that already possess such knowledge through digital M&A (Hanelt et al. 2021a). In sum, firm digital competence can be developed either through tangible and human resources which facilitate digital innovation capability or by sourcing digital knowledge via digital M&A.

Contextual complexities

Contextual complexities present an important condition that shapes the gestalt of digital transformation of an organization. Contextual complexities broadly relate to (internal) structural (Vial 2019) as well as (external) environmental contingencies (Soluk et al. 2021). First, structural contingencies refer to how the organization is built from the bottom to the top. Among others, the size and complexity of the organization affect how (cross-functional) teams work on challenges and how collaboration between organizational members works Therefore, structural contingencies such as size and complexity, are important factors in determining the "how" of digital transformation. Second, environmental complexity addresses how the outside pressure impact firms to pursue digital transformation. One factor contributing to transformation is the perceived urgency to change (Soluk et al. 2021). Thus, outside pressure from competitors or

customers, e.g., in the form of new entrants in the market, push firms to pursue more digitalization themselves (Soluk et al. 2021; Wang 2010). Such pressure may be distributed unevenly, with some industries having higher pressure). Hence, environmental complexity presents the second key factor that shapes digital transformation.

Methodology

Data

For this study, we rely on a unique and rich database that is based on a variety of data sources, covering the SP500 between 2011 and 2017. For firm digital competence, our data covers among others, data from job postings collected by a US company with similar data being used recently to shed light on human resources (Lou and Wu 2021). Furthermore, we rely on patent data from the USPTO to assess the patent stock of the firm. In addition, we also rely on data from the SDC database, which covers mergers and acquisitions. For digital leadership competence, we rely on data available via the annual proxy statement (DEF14A fillings) and hand-collected data from LexusNexus, Linkedin, and company websites. Moreover, for environmental complexities, we rely on data from the Compustat database as well as Crunchbase. Lastly, the dependent variable of digital transformation is measured through 10k filings.

Variable Description

Leadership digital competence. We measure leadership digital competence based on three dimensions that capture established leadership dimensions in the literature (Kurzhals et al. 2020). First, we capture the *board's digital capabilities*, by following the approach suggested by (Adams et al. 2018) and hand-collected descriptions of directors' capabilities through the firm's DEF 14A filings. Subsequently, we used computer-aided text analysis (CATA) to code whether a director has digital capabilities, or not. Specifically, we regarded directors to have digital capabilities, when they have functional or sector capabilities in relation to information technologies and digital. We then computed the number of directors with digital capabilities for a focal organization *i* in year *t*. Second, the DEF14A fillings also provide information regarding CEO capabilities therefore we followed the same approach to capture the *CEO digital capabilities*. This resulted in a binary variable, which indicates 1 for a CEO with digital capability and 0 when this capability is absent. Third, we capture the presence or absence of a *CDO* by following the logic of Firk et al. (2022). Specifically, we hand collected CDO data by searching through multiple sources such as LinkedIn, LexisNexis, and company websites.

Firm digital competence. We operationalize digital competence based on two dimensions, DIC and digital M&A activities. First, *DIC* is adapted from Lou and Wu (2021) and assessed through the combination of data from employee skills and patent data. For employee data, we rely on job postings, and especially on the skills as a key element of the job and proxy for firm competencies. This approach has been used frequently and allows deep insights into the hiring activity of the focal organization (Lou and Wu 2021). Secondly, we combine this data with patent fillings from the USPTO to assess the organizational knowledge base (Hanelt et al. 2021a). For both measures, we use the number of digital skills and patents and combine them as measures for *DIC (Lou and Wu 2021)*. Second, we assess digital competence through external acquisitions. We extracted all acquisitions of a firm from the Thomas Reuters SDC database and, similar to Hanelt et al. (2021a), manually coded whether the acquired firm was focused on leveraging digital technologies. Agreement between the coders showed a high agreement (alpha > 0.8) and conflicting cases were solved through discussion.

Contextual complexities. We operationalize the previously identified complexities in the following way. For *structural complexity*, we proxy the organizational size as the number of employees. We assume that the bigger an organization is, the more structural complexity is present. Second, for *environmental complexity*, we use the number of digital start-up entries in the industry from the Crunchbase database as a measure of turbulence and urgency to transform.

Digital transformation. We measure *digital transformation* as a text-based measure based on the 10k statements. Because 10Ks are highly formalized statements required for the stock exchange, they provide a good proxy for actual digital transformation. We used a machine learning-based dictionary to measure digital transformation based on five dimensions. Broadly arranged around the SMACIT framework, but we

decided to drop mobile because it already is a standard. Subsequently, we use a word-count measure to determine the degree of digital transformation of the focal organization i in year t.

Analytical strategy

For the analysis, we rely on QCA, which relies on Boolean Algebra to resolve set membership based on necessity and sufficiency tests (El Sawy et al. 2010). First, we calibrate the raw data, subsequently, obtain fuzzy set membership scores, to lastly run the necessary and sufficient condition tests. In the first step, we transformed our panel data into a cross-sectional format by taking the mean of the variables over time (Beynon et al. 2020). Subsequently, we dropped all missing values through list-wise deletion and were left with a sample of N=295 for calibration and analysis. While fuzzy set qualitative comparative analysis (fsQCA) protocols are well established for survey studies Park et al. (2020), archival and continuous data are more complicated to calibrate. We follow Park et al. (2020) and use the 75/50/25 for the anchors. Due to the variety of our data coming from different sources with widely different distributions, we standardized all continuous variables. We subsequently use the population statistics as a basis to select individual cut-off points for each continuous variable. We used fsQCA software 3.0 developed by Ragin and Davey (2016) for both calibration and analysis.

Results

Necessary conditions

In the first step, we conducted a necessary conditions test (Park et al. 2020) as a check to determine whether any of the selected elements are a necessary condition for digital transformation. Typically, consistency scores around 0.90 are seen as the threshold which indicates that a factor is almost always necessary. In our analysis, three variables (turbulence, directors, and DIC) are at or around 0.7, indicating their relatively large importance. Moreover, their coverage value of around 0.7 indicates that they are present in a large share of the outcomes (see Table 2).

Elements	Antecedents	Consistency	Coverage
Leadership digital competence	*Digital CEO*	0.215894	0.528298
	CDO	0.131902	0.388974
	Digital Board	0.708460	0.630405
Firm digital competence	*Digital M&A*	0.541431	0.546228
	Digital Innovation Capability (DIC)	0.736545	0.719956
Contextual complexity	Structural complexity	0.577428	0.463143
	Environmental complexity	0.712546	0.737292

Table 2. Necessary condition analysis

Sufficient conditions

To identify the sufficient conditions for digital transformation, we relied on truth table analysis (Park et al. 2020), which results in an intermediate and a parsimonious solution. We used a frequency cutoff value of 2, such that only solutions 2 or more instances are included in the analysis. Moreover, we applied the commonly accepted raw consistency threshold of 0.8 (Park et al. 2020). We additionally checked for the PRI consistency and found our results to be mainly consistent with the accepted standard of 0.7 (Misangyi and Acharya, 2014), so we did not need to drop cases. While the literature argues that cut-off values have to be context-specific, we also observed a drop in consistency below this threshold. According to the cutoff value, we codified solutions that are higher than the cutoff point as 1 (e.g., leading to digital transformation) and the rest as 0. In the following sufficient condition analysis (see Table 3), the outcomes are based on Boolean expressions and thus either absent or present.

In total, we identified six configurations, with two of them having a sub-configuration. The high solution consistency indicates that the configurations consistently result in high digital transformation. By examining the different configurations, configuration two has the highest consistency and coverage and is, therefore, the most relevant configuration for achieving high digital transformation. From a descriptive

point of view, configuration 1 (a/b), includes two core elements (the presence of digital M&A and the presence of turbulence). Configuration 2 (a/b) also includes turbulence as a core condition and covers the presence of the directors' digital experience as well as the absence of a CDO as other core dimensions. Solution three is characterized by the presence of size and turbulence as core conditions and the absence of a CDO and digital CEO. In configurations 4 and 5, turbulence is a neutral element. While 4 relies on digital innovation capability combined with a CEO as core elements. Configuration 5 relies on directors' digital experience and digital M&A as core elements but also the absence of a digital CEO and the absence of structural complexity. Lastly, configuration 6 again includes turbulence as a core present condition as well as the presence of a CDO combined with the absence of digital directors. In sum, there is a potential substitution effect between different elements of digital leadership as well as digital competence on the firm level as well as environmental complexity is omnipresent.

Configurations									
Elements		**1a**	**1b**	**2a**	**2b**	**3**	**4**	**5**	**6**
Leadership digital competence	*Digital CEO*	⊗	⊗	⊗		⊗	●	⊗	⊗
	CDO	⊗		⊗	⊗	⊗	⊗	⊗	●
	Digital Board		•	●	●		•	●	⊗
Firm digital competence	*Digital M&A*	●	●		•		•	●	⊗
	Digital Innovation Capability	⊗		⊗	•	⊗	●	⊗	⊗
Contextual Complexity	*Structural complexity*		⊗			●		⊗	⊗
	Environmental complexity	●	●	●	●	●			●
Consistency		0.850	0.939	0.867	0.933	0.814	0.892	0.842	0.870
Raw coverage		0.162	0.207	0.308	0.229	0.264	0.104	0.139	0.025
Unique Coverage		0.010	0.031	0.047	0.024	0.040	0.029	0.025	0.025
Overall solution consistency		0.829							
Overall solution coverage		0.596							

Note: *Configurations for high digital transformation. The table presents an overview of the results, using commonly accepted notation. We distinguish between two types of circles: (black filled vs. crossed out), to indicate the presence or absence respectively, and (big vs. small), to indicate whether an element is a core in the parsimonious solution. Lastly, empty boxes indicate neutral permutations and therefore satisfy the requirement for equifinality.*

Table 3. Sufficient condition analysis and truth table

Theoretical Configurational Propositions

Following our exploratory research design, we next discuss the configurations and derive theoretical propositions by integrating empirical observations with relevant literature.

Leadership digital competence. While our analysis reveals that leadership digital competence is a crucial element for successful transformation, we observe two interesting facets. First, digital competence on the board plays a large role in facilitating digital transformation, regardless of contextual complexity. Thereby, the board is a core element in three out of six configurations and among the key elements in necessary condition analysis, indicating its importance in guiding firm decision-making. We know that the importance of the digital board can be derived from two mechanisms. Specifically, in times of turbulence, a digital board may be a source of both monitoring and advising. In absence of turbulence, the board may monitor digital transformation less and can thus focus more on its advising task. Thus, the board as evaluating body has a crucial impact on digital transformation. Thus, we propose:

> *Proposition 1a*: Digital leadership competence in the form of digital board knowledge contributes strongly to digital transformation. It works irrespective of environmental or other firm competences in facilitating digital transformation.

Second, we find a strong substitution effect between different elements of digital leadership competence. While recent literature focused strongly on the role of specific digital leadership such as in the form of a CDO (Firk et al. 2022). We cannot corroborate that finding based on our analysis. Specifically, the CDO is key in only one configuration. Moreover, in two configurations the absence of the CDO is a key requirement. Lastly, the CDO itself substitutes the digital board experience in one configuration. Therefore, theoretically, we challenge the strong trend in the literature toward the importance of a CDO in facilitating digital experience in favor of a broader stance on the importance of digital leadership in other sections of the upper echelon (Kurzhals et al. 2020). This is a particularly interesting finding as UET has long argued that in times of environmental turbulence, those at the very top of the organization have to rely even more on their previous experiences to shape their decisions (Hambrick & Mason 1984). Thereby, indicating that digital transformation for seasoned leaders may not be that different from other previous industry changes. Thus, we propose:

> *Proposition 1b*: Leadership digital competence is substitutable and successful firms can rely on leadership digital competences through different roles. Irrespective of firm competence and contextual factors it promotes digital transformation.

Firm digital competence. We find that firm digital competence is a core condition in 4 out of 6 configurations. Moreover, necessary condition analysis shows the crucial role of digital innovation capability as a key aspect of firm digital competence. The absence of firm digital competence, by contrast, is never a core but only a peripheral element, indicating its crucial role in facilitating transformation. More interestingly, we find a potential substitution between engaging in digital innovation capability as a more "developmental" way on the one, and digital M&A as a "quick fix" on the other hand. The key question is whether digital M&A differs from classical M&A in the sense that it has a better success rate in the long run (Hanelt et al. 2021b). Moreover, we do not find support for the notion that digital competence relies on any specific requirements in terms of digital leadership or contextual factors. Thus, developing digital competence is universally useful for organizations, regardless of contextual factors. Thus, we propose:

> *Proposition 2*: Firm digital competence is a key to achieving digital transformation and can be achieved through various internal and external means. Irrespective of leadership and contextual factors it promotes digital transformation.

Contextual complexities. The necessary condition check (table 2), as well as the truth table (table 3), indicate that of the two complexities, external complexity is a ubiquitous antecedent for digital transformation. Environmental complexity, often conceptualized in terms of turbulence or urgency, has been an important contingency factor in the IS literature (e.g., Mithas et al. 2013). While the literature conceptualized it mostly as a moderating condition (Vial 2019), we can see that perceived urgency and turbulence are antecedent and important factor that promotes digital transformation. Surprisingly, perceived urgency may trigger firms to engage faster in changes and subsequently better engage in digital transformation. For example, past literature, based on institutional theory, found that firms turn to their peers in times of uncertainty and mimic their decision-making (Wang 2010; Mithas et al. 2013). In turn, external pressure may lead to firms copying their more successful peers and thereby viewing digital transformation as an opportunity for value creation. Thus, we propose:

> *Proposition 3:* Environmental complexity shows strong confluence with leadership and firm competence. It is almost always a precondition for digital transformation creating (1) urgency, and (2) encouraging firms to view digital transformation as an opportunity rather than a threat.

Conclusion

Discussion

Our study makes several important contributions to the literature and practice. First, we cater to the need for more configurational inquiries in explaining the socio-organizational complexity of digital transformation (Hanelt et al. 2021b; Park et al. 2020). We build on digital ecodynamics (El Sawy et al. 2010)

and integrate knowledge about material elements and firm digital competence (Lou and Wu 2021; Hanelt et al. 2021a) organizational elements and digital leadership (Firk et al. 2022) and the role of contextual complexities (Vial, 2019). Thereby, we extend existing research on digital transformation by accounting for the confluence of those elements, instead of focusing solely on their isolated role. As such, we overcome the current reductionist perspective in the literature in favor of a configurational perspective that allows more fine-grained conceptual insights.

Second, we challenge existing insights that argue for an either-or approach, oftentimes only considering one or two elements (e.g., only the CDO). We especially expand the digital ecodynamics perspective (El Sawy et al. 2010) and focus on material changes in the form of acquiring IT. Given that materiality in the digital age is of declining relevance, strategic leadership for competence development becomes increasingly important. Our findings corroborate that firm competence and leadership competence, especially in their sub-dimensions, are often substitutable. For example, while leadership is a crucial factor, our findings provide initial evidence that CDOs are being over-hyped and that digital leadership should be thought of more broadly than currently done in the literature (Kurzhals et al. 2020). Moreover, we find that environmental complexity is not only a moderating factor deeply entwined with leadership and firm competence. We encourage researchers to build on our findings to unravel their mechanisms in future studies.

Lastly, our findings are highly important for managers, directors, and investors to better understand the interplay of key digital competence elements. Our configurations allow firms to identify gaps in their digital competence development and to allocate resources more effectively. One of our key findings relates to the overwhelming relevance of digital knowledge on the board. However, directors with digital knowledge are still rare and investors may benefit from ensuring that directors with digital knowledge enter the boardroom of firms.

Limitations and Future Research

Our study has some limitations that should be addressed by further research. First, we focus only on digital transformation as an outcome. Future research may also take into account other firm-level outcomes, in particular, the success of the digital transformation, for example, by relating it to firm performance could further advance our understanding. Second, while we take a broad perspective on digital competence and its sub-elements, there are still other factors not covered in our inquiry. For example, firms may also develop digital competence via internal training (e.g., through consultancies) or external means such as alliances, subsidiaries, or digital labs. Thus, future studies should take a more fine-grained perspective on the role of potential sub-elements of for example firm digital competence. Finally, our use of QCA itself poses some limitations. As QCA cannot handle panel data, we needed to use a cross-section of the data to measure digital transformation. We acknowledged that within the study (between 2011 and 2017) there may be significant differences across the years. In the next iteration of our paper, we will address this shortcoming by studying four different points in time such as early (2011) compared to late (2017) transformation efforts. Moreover, in our initial use of QCA, we used a rather simplistic way of set membership based on the deviation from the mean. In the future, we will also explore other more fine-grained calibration methods (Park et al. 2020). Nonetheless, we strongly believe that the topic's complexity warrants a QCA approach and we encourage future research to follow this approach to create a holistic view of digital transformation. Lastly, while our paper and approach have strengths, the literature can also benefit from other (variance) driven approaches to determine the strength of the relationship and not only the importance.

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