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THE CASE FOR OFFENSIVE STRATEGIES IN RESPONSE TO DIGITAL DISRUPTION

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iCite Working Paper 2017 - 021

iCite - International Centre for Innovation, Technology and Education Studies

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The case for offensive strategies in response to digital disruption

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WORKING PAPER FOR DISCUSSION

This version: February 2017

Abstract

Digitization is claimed to disrupt a growing number of industries, even if to date, limited empirical evidence is made available to assess both the magnitude of this phenomenon and recommend the best incumbent firms' responses. Leveraging a unique global survey cutting across multiple countries, industries and firms, we provide robust statistical evidence that: (a) digitization fits the concept of disruptive innovation. Empirically, digitization already threatens to cut a major part, up to 12%, of the profit growth profile of the non-responding incumbent. (b) For companies responding to the threat of digitization, an offensive corporate strategy with coherent digital actions, has by far the largest pay-off and may potentially offset the depressive effect of digital disruption. The empirical results are robust to many sensitivity tests, including instrumental variables regressions to test reverse causation from firm performance to strategic posture.

Keywords: *Digital disruption, Digital transformation, Digital strategy, Information technology, Firm dynamics.*

Acknowledgements

The authors wish to thank Laura LaBerge at McKinsey, as well as Dan Lavallo, at Sydney Business School, Paul Michelman at MIT Sloan for fruitful discussions and comments, as well as McKinsey/Digital for supplying the data. All errors and omissions remain ours alone.

1. Introduction

Digitization, however complex as a phenomenon,[1] has multiple facets. First, digitization marks the diffusion of a wide range of digital technologies (such as the internet, web 2.0, internet of things, analytics, or still cloud technologies), into the core of organisations, for the benefit of improved performance (Koellinger, 2008). Second, "digitization" is claimed to belong to the set of disruptive innovations (Christensen, 1997), whereby a) entrants use digital technologies to build new business models as detriment to market incumbents [2], while b) incumbents would be better off, either by not reacting at all, or by aggressively embracing the disruption (Downes and Nunes, 2013; Wessel and Christensen, 2012).

The typical industry case of such digital turbulences is media. In music for example, P2P, then downloading and recently, streaming digital technologies have all been eroding the CD technology, with new business models such as all-you-can-eat subscription models being pushed by new entrants to disrupt the incumbent record companies (see Moreau, 2013). As a response to stop the pressure on their revenue shrinkage, most of the major record labels had to significantly reinvent themselves and jump on streaming aggressively as their new major source of revenue. Warner among others was the first to announce that streaming was the primary revenue platform recently and that streaming revenue growth over-compensated for the fall of other music distributions[3]

However, if the widespread view of digitization as a disruptive innovation seems to make intuitive sense, it still lacks broad empirical support, across multiple industries. Specifically, few scholarly works – if any – have tried to quantify the magnitude of the effect of digitization on firm performance, absent any reaction by incumbents. Empirically, the effect should be large enough if digitization is disruptive, i.e. destroying the mass-market segment space of traditional incumbents. Continuing with our example, the traditional music recording industry shrunk by 25% in 5 years, or by 4.7% a year from 2010-2015 (Rogers, 2013)[4], which provides a lower bound to the extent of how digital disruption has affected music companies under no reaction of their part. The magnitude of revenue dislocation remains however not known, for many industries.

Similarly, limited efforts have been devoted to a comprehensive empirical investigation as to how incumbent firms react to digital turbulence in their industry, and if those reactions match the prescriptions of the literature on disruption. Christensen (1997) proposes the two choices of not responding, or responding but only boldly. Charitou and Markides (2003) proposed a wider range of responses between those two extremes. Gilbert et al. (2012) suggest a dual transformation path of fixing the core and offensively diversifying, even if the authors only offer case study examples as validity of reactions to digital disruption. In their work on the music industry, Geurts et al. (2016) show that Dutch music companies have responded both defensively and offensively, but the

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[1] See e.g. Thomas Davenport's famous 2014 post in the Wall Street Journal, available at http://blogs.wsj.com/cio/2014/11/12/what-the-heck-is-digitization-anyway/.

[2] Digitally-suited business models include platform play (Zhu and Iansiti, 2012), crowdsourcing (Busarovs, 2011), or new product versioning (Bakos and Brynjolfsson, 2000; Bhargava and Choudhary, 2008, or Bughin, 2015).

[3] http://www.forbes.com/sites/cheriehu/2016/10/15/the-record-labels-of-the-future-are-already-here/#7abf12a87802

[4] Another media subs-segment example, is newspapers, which one source of revenue, advertising classifieds, has been claimed to be the subject of major disruption via online and price per click models (Karimi and Walter, 2015). The global newspaper industry revenue was down by 10% from 2012-2015, or roughly a reduction of 3,5% a year. See http://www.pwc.com/gx/en/industries/entertainment-media/outlook/segment-insights/newspaper-publishing.html

question whether the offensive strategy has larger pay-offs than the defensive strategy is neither addressed, nor measured. We deduct from the literature that a large array of strategies may be possible, but that one lacks empirical evidence as to the types of strategy played by incumbents, and their relative merits to counter the effect of digital innovation.

In this paper, we aim to fill this gap by providing a first empirical look at digital disruption as well as the payoffs of incumbent firms' corporate and digital responses to overcome the disruption and restore revenue or profit growth. We do this thanks to a unique worldwide sample that cuts across many types of firms, industries, and countries, and through the robust estimation of an econometric model linking performance of a focal firm, to the type of strategic responses to multiple digitization shocks.

Our econometric analysis generates three important stylized facts:

First, digitization is consistent with the concept of disruptive innovation. Our measure of disruption, is an econometric estimate of how incumbent firms face the prospect of large revenue/EBIT growth cut by not responding to multiple digital shocks. On average, we find that digital disruption exerts a negative and economically significant impact on growth. For instance, profit growth is cut by 5 percentage points on average, and can be as dramatic as a drop of 15 percentage points in revenue growth for the weakest, non-reacting firms. Such evidence of digital turbulence gives us the clearance to analyse the responses of firms at the light of the disruptive innovation theory.

Second, bold at scale, offensive, strategic reactions, aimed at developing or acquiring new products or services rather than at defending legacy business lines, and complemented with larger investments than competition in digital technology, generate the most promising growth trajectory. Empirically, such strategies are associated with a) twice as large pay-offs as any other category of reaction, while b) warrant a better growth profile after digitization than before digitization turbulence.

Third, such offensive reactions maximize returns when there is strong consistency, i.e. digital strategy and investments need to be strongly aligned and integrated with the corporate strategy and be placed at its heart rather than at its periphery. Such a result generalizes early technology literature that technology strategy must be aligned with corporate strategy for generating positive returns (Henderson and Venkatraman, 1993).[5]

Our empirical analysis relies on a global survey conducted on a panel of some 12,000 firms worldwide. This panel is maintained by TNS, a global research firm, on behalf of McKinsey & Company. The panel is mostly composed of C-suite executives, who have been trained by TNS to answer 3-4 global surveys a year. The panel is confidential with an easy opt-out so as to ensure quality of responses. The results hereafter are of course to be understood in the context of this panel, but we contend that the panel is powerful enough, as it covers more than 60 countries, and crosses over all industries. It also offers a diversified set of companies in terms of location, size distribution, ownership, and business unit diversification. Questionnaires applied to this panel have served for already multiple scholarly works. For example, Bloom and Van Reenen (2007) exploited it to measure management practices and their relation to firm performance; Brynjolfsson et al. (2011) examined returns on analytics; and Bughin (2016a) used it to estimate productivity enhancement of

[5] Note that these are statements about the integration of digital within the firm's strategy, but they do not inform about organizational arrangements or forms such as keeping digital new ventures separate as suggested by the literature on corporate entrepreneurship.

big data investments. Our final sample regarding digitization contains close to 2000 firms, or a decent answer rate of about 15%.

The paper is organised as follows: section 2 introduces our conceptual model of the impact of digital disruption on firm reactions and performance. Section 3 presents the survey data our empirical analysis relies on. Section 4 uses a discriminant analysis to highlight the distinctive characteristics of bold strategic reactions. Our empirical strategy is presented in section 5, the results of which are reported and discussed in section 6. Section 7 concludes.

2. Theoretical framework

2.1. Predictions regarding digitization as a disruptive technology

As highlighted in the introduction, our work is anchored mostly in the theory of disruptive innovation. In his seminal work, Schumpeter (1942), defined creative destruction as the "*process of industrial mutation […] that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism*."

Forty years later, Bower and Christensen (1995) and subsequent works of Christensen (e.g. Christensen, 1997) drew attention on the concept of disruption technologies and disruptive innovation. Their starting point was the recurring observation that many incumbent firms fail to adapt to radically new technologies and business models (Bower and Christensen, 1995).[6] The theory posits that disruption occurs when a technology that is superior on a new dimension that appeals to a niche, surely improves on another dimension that meet the needs of the mass market. The inferiority of the technology leads to incumbent not to be aware or bothered by it, and ultimately, starts to be disrupted, with the disruptive technology upgrading its business model to attack the full mass market segment of the incumbent.

Since then, a large literature on disruptive innovation has provided prescriptions in terms of strategic *reactions* to be adopted by incumbent firms in such situations. We focus our attention on four predictions in the face of (possible) digital disruption.

1. First, if disruptive, digital technology should have significant negative effects on incumbent performance. This first prediction is *by definition* of disruption. By the theory, however, the effect on incumbents should only be visible when disruption truly bites in reaching mainstream.

2. Second, in general, there should be sluggish strategic reaction to digital disruption by incumbents. This derives from the idea that incumbents will have difficulty both to anticipate the threat associated with digital disruption (as digital disruption usually carves out a niche, only then to scale to attack the full mass-market) and to overcome internal obstacles to the adoption of an appropriate reaction.

3. Third, the best strategic reaction should either be no reaction, or one driven by offensive strategies embracing the disruptive innovation (Christensen, 1997). In the alter case, this would imply substantial changes to the core business (i.e. changes to the strategic portfolio or business model) and investment in the source of disruption (i.e. investment in digital technology). There are hence two elements in the dominant reaction:

- A transformation of the strategic portfolio ("strategic transformation" henceforth)
- Significant investment in the source of disruption ("digital investment" henceforth)

[6] See also Christensen et al. (2002) and Christensen (2006), Christensen (2012), Wessel and Christensen (2012).

4. And finally, the pay-off of a reaction should be maximised if it is accompanied by consistency between new digital initiatives and corporate strategy. Early technology literature suggested indeed already that technology strategy must be consistent with broader strategy to succeed (see Henderson and Venkatraman, 1993).

2.2. Possible responses to digital disruption

The third prediction is less straightforward and more disputed in the literature than the others. Charitou and Markides (2003) summarize the strategic challenge that incumbent firms face: "*The leading companies were facing a dilemma: Their attackers utilized strategies that were both different from and in conflict with their own. Thus, if the established companies were to respond by adopting the strategies of their attackers, they would run the risk of damaging their existing business and undermining their existing strategies. However, they couldn't simply ignore the disruptions*."

The pioneering work of Christensen (1997) offers two alternative strategies: ignoring the disruption (i.e. sticking to the core strategy) or embracing the disruption, preferably in a separate business. Charitou and Markides (2003) however challenge this dichotomy and offer a richer range of possibilities: to the two extreme scenarios (ignoring or embracing the disruption) they add the possibilities of investing in the existing business to defend it, playing both games in parallel (i.e. maintaining the existing business in parallel with a new business based on the disruptive element), or attacking back by disrupting the disruption (a strategy Ghemawat (2009) called "leapfrogging"). The authors claim that the optimal response depends on the incumbent firm's ability and motivation to respond.

Adner and Snow (2010a,b) and Adner and Kapoor (2016) stress one more possible response, which they call a "bold retreat". It is a defensive strategy consisting in refocusing the business on a defensible niche in which the old market proposition can still dominate the new one. This however seems possible only to the extent that digitization leads to a new demand heterogeneity. Yet, Chandy and Tellis (2000), Christensen and Overdorf (2003) and Charitou and Markides (2003) suggest that incumbents would be wise to adopt an *offensive* response, capturing new products and segments, usually by accessing new resources via alliances and/or acquisitions. Kane et al (2015) concede as well that the most appropriate digital strategy is to transform original businesses via new offensive business models.

Concluding from the above, the possible optimal strategy remains uncertain even if the literature favors more often than not a more offensive reaction than any other, or no, reaction. The question remains thus to be assessed empirically, and for this sake, we propose in our paper to rank strategic reactions along the two axes: level of investment in the source of disruption (i.e. digital technology in our case) and extent of the change in corporate or business strategy (i.e. strategic transformation).

We develop a simple taxonomy of possible reactions, summarized in figure 2, along the horizontal axis of *digital investment* intensity versus competition ("higher, at par, or lower"), and along the vertical axis of *strategic transformation*. Strategic transformation can be qualified as "bold" (offensive responses by changing corporate strategy up to being the disruptor), "medium" (defensive responses but within the same current strategy), or "weak" (no change, or limited ad hoc/tactical response, with no reference to strategy). We organised the possible combinations into 4 specific clusters:

- Weak (or inexistent) reactions: the focal firm acts low on both dimensions. This is a plausible posture, if indeed, digitization is not disruptive with attackers only able to carve out a niche.

This grouping can be however suboptimal if there is real threat of disruption, and would thus be composed of companies with limited perception of, or capabilities to react to, disruptive threat. This corresponds therefore to the "ignore the disruption" strategy (Christensen, 1997; Charitou and Markides, 2003).

- Medium reactions: the focal firm acts medium-scored on one dimension, low to medium on the other. This cluster of companies is composed of those perceiving the threat of digital disruption, but nevertheless deciding to defend their original strategy. Under certain demand conditions, this is a plausible defensive strategy as highlighted by the work of Adner and Snow (2010a,b).
- Semi-bold reactions: the firm adopts a strong response along one dimension only, either through a bold change to its corporate strategy, or by overinvesting in digital technology, but not the two. These combinations may cover "escape" strategies (shifting the core business to avoid the disruption) or attempts to digitize the existing core business. Both moves can be qualified as bold, but not at scale.
- Bold-at-scale reactions: the last cluster corresponds to the most offensive strategy, as predicted by the theory of disruption: a bold transformation of the corporate strategy combined with overinvestment in digital technology. In contrast to semi-bold strategies, bold-at-scale one will provide a test of the joint importance of large digital investment with substantial changes in corporate strategy. Under the theory of disruption, we expect bold strategies to be associated with superior firm performance. To some extent, this category – by combining strategic change with digital investment – overlaps with the widespread notion of digital transformation among firms and likely captures the "digital masters" highlighted by Westerman et al. (2014).

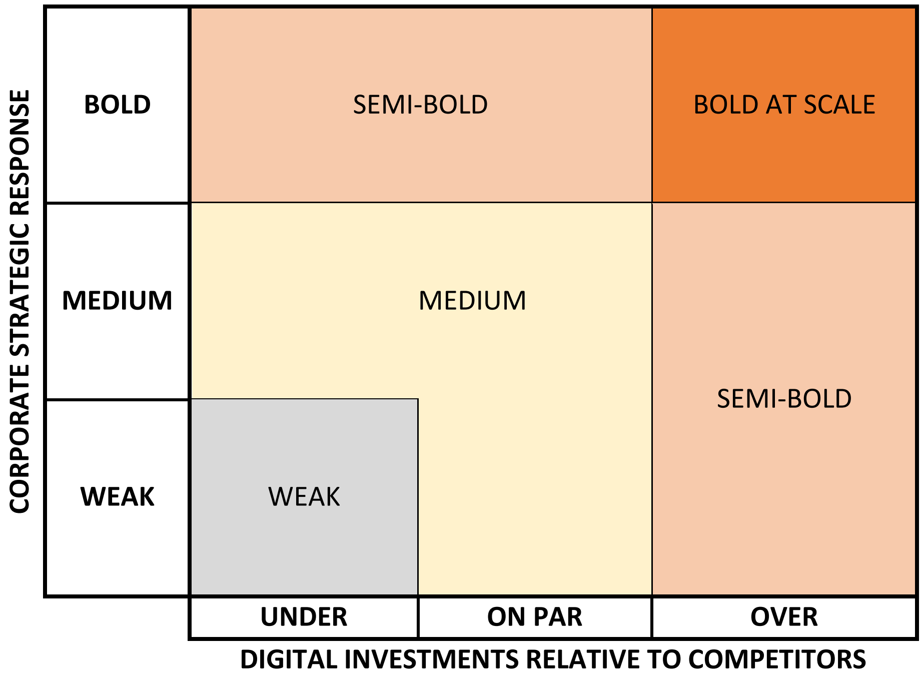

Figure 2 – A matrix of digital strategy

The offensiveness of bold-at-scale strategies can obviously take different forms. Based on our data,[7] we note that bold-at-scale players bring substantial changes to their *corporate* strategies. Such changes involve 3 types of strategies: the acquisition or development of new businesses and/or customer segments, the introduction of new (disruptive) business models – even at the risk of cannibalizing existing revenues –, and the redefinition of the value chain. In contrast, they generally exclude the downscaling of the company's cost structure by automating, digitizing, or virtualizing its core operations (even if process automation is as frequently reported as last digital initiative as for other players).

2.3. Conceptual framework

Any firm faces the twin prospect of *direct* disruptive innovation from entrants as well as of *indirect* competition, as a result of likely reactions of other incumbents.[8] This matches recent models of red queen competition (e.g. Giachetti et al., 2016) where firms engage in technology imitation as a reaction of competitor innovation and vice-versa, in a self-reinforcing process. Likewise, game theory predicts that credibility of strategies depends on level of sunk investments—hence, leading companies facing threat of entry are likely to be investing above their peers (Etro, 2006).

Based on the above, our conceptual framework can be summarized as in Figure 1:

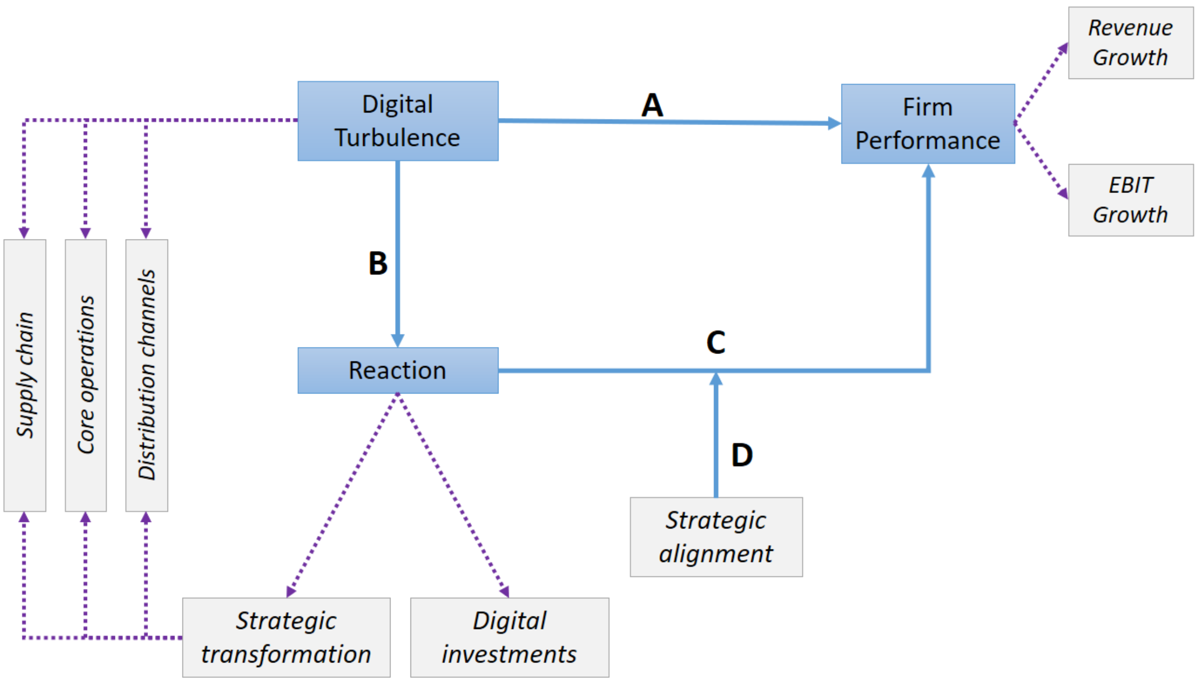

Figure 1 – Conceptual Framework

We posit the following:

- A. Digital technology creates a (threat of) disruption at the industry level with a detrimental effect on the performance of existing firms. We therefore expect the negative effect to be stronger in industries with higher levels of disruption.

[7] These patterns extend beyond the scope of the present paper and are investigated at length in a companion paper.

[8] In this work, we do not distinguish between the threat from new entrants and the threat from competitors adopting the disruptive model. Instead, we base our empirical analysis on the self-reported reactions of players to the changes to their competitive landscape, supply chain, operations or distribution channels, no matter their origin.

- B. Such disruption, in turn, will trigger certain types of reaction among incumbent firms. Because the theory of disruptive technology suggests that many firms do not perceive the threat of disruption or cannot overcome internal obstacles, there should be a substantial heterogeneity in the incidence and strength of reactions among firms. A number of more astute firms, however, should react in a way that is consistent with the prescriptions of the literature, i.e. with bold strategic moves and above competition investments in digital.
- C. In turn, reactions would lead to mitigate the risk of disruption, especially for companies choosing bold strategies which could help them reinvent themselves and be put on a higher growth trajectory or profit rate than their peers.
- D. Reaction pay offs are maximized by a strong integration of corporate strategy with digital strategy and investments. Strategic alignment between digital and corporate will therefore be a key mediating factor of the positive contribution of strategic reactions to firm performance.

Our framework also acknowledges that digitization can affect multiple aspects of value chains – at the supply chain, firm operations or distribution levels. Firms may also choose to react in any (or several) of these channels. How these different channels of digitization differ in their impact on firm performance is mostly an empirical question.

3. Data

Our data come from a major survey conducted by one of the authors within McKinsey & Company, on a large representative panel of companies across regions and industries. This panel has been built by TNS, a global research firm, which polls C-suite executives on a variety of business matters, for about 8 years. The sample size is roughly 12,000 respondents from more than 60 countries, and is confidential in nature to ensure unconstrained answers by the executive.

The panel has been checked for validity and has thus been used in multiple scholarly studies already. Examples of technology surveys conducted on this panel include the adoption and use of analytics (Brynjolfsson et al., 2011); investment in big data (Bughin, 2016a) or still adoption and integration of web 2.0 technologies into companies' processes, Bughin (2016b).

The survey conducted for this study involves questions about company perception of digital threat and how they responded to it. This survey is described at length in Bughin et al. (2017). Figure 3 provides the 10 types of questions raised in the survey. The collected sample of answers to those questions is 2135 firms of which 1719 have fully exploitable responses on *all* dimensions we are interested in, and hence form our analysis sample. This also implies a rather material response rate around 15%. Table 1 reports descriptive statistics of our analysis data.

Question type	Examples of data collected
1 Company features	• Revenue, industry, public / private, industry, location
2 Company performance	• Revenue growth, EBIT growth last 3 years
3 Company digital performance	• ROI from digital initiatives, share of revenue linked to digitization, digital capabilities captured in absolute and versus competition
4 Company perception of digital disruption	• Digital disruption in the form of distribution, product, competitive landscape, core operations, and ecosystem / supply chain
5 Company response to digital disruption	• Corporate strategy change, business strategy change
6 Company digital strategy focus	• Strategic dimensions – DOT matrix • Strategy priority – big data analytics, creation of digital channels, digital engagements of customers, digital engagements of suppliers, etc
7 Scale of digital investment	• Scale versus competition
8 Capabilities digital	• Speed, reallocation of resources, cannibalization, digital metrics, etc
9 Organization of digital strategy	• Tight versus loose strategy with respect to corporate strategy
10 Typical organizational challenges	• Silos in organization, risk averse culture, limited financial support to digital, etc
11 Management support	• CEO boards of directors support, etc

Figure 3—questionnaire taxonomy

As is usual with survey data, there may be concerns related with common method bias (see e.g. Podsakoff et al., 2003). The data, except for firm-level controls that were added by the surveying company, all come from the same respondent and were obtained through a single questionnaire. Certain procedural choices were made in order to limit the potential bias due to common method (and common respondent), such as randomizing the order of the possible responses across respondents, using different scales across questions, and guaranteeing the anonymity of the respondents (even the name of the focal firm is not known to us, which prevents us from matching the data to external sources).

Nonetheless, we have run a Harman single factor test on the full survey as well as on the specific subset of variables that we use in the present analysis. In both cases, the single factor retained explains less than the commonly-accepted value of 50% of the variance (10.6% over the entire survey[9] and 40.2% over the subset of variables used in the present analysis). These figures do not fully exclude the possibility of common-method biases (see Podsakoff et al. 2003), but are at least not indicative of such bias in the data.

Note that the survey includes (self-reported) measures of revenue and profit growth as well as several firm-level elements such as geography, size, industry and portfolio of products or services. Those later dimensions are important correlates of company evolution patterns (see Delmar et al., 2003), and will then be used as control variables when we estimate a possible link between digitization responses and firm growth. Roughly 43% of companies have their headquarters in Europe, for 30% in the US. Likewise, 1/3 generate more than $1 billion in sales; 38% are publicly quoted, 35% operate in B2C industries, and the most represented sectors are high tech (22%), financial services (20%), and professional services (20%). While 75% of answers are from C-suite, half of those answers are directly from CEO, then from COO (20%), CMO (15%).

3.1. Measures of firm performance

We measure firm performance growth of revenues and profit. These two indicators are measured as ranges, spanning from -50% or more to +50% or more. 78% of the sample firms report a revenue

[9] I.e. including all responses provided by the respondent in the survey, which means excluding variables (firm-level observables) that were added by the surveying company.

growth in between the [-4%;0%] and [15%;24%] ranges. For EBIT growth, the share is 84%. Both distributions have a unique mode at the [5%;9%] range. In the data, ranges are numbered in ascending order from 1 to 12. A one unit change in these variables therefore reflect a jump of one range. At the mean, such a jump reflects a lift from the [1%;4%] to the [5%;9%] range, which corresponds to an increase of about 4.5 percentage points in the latent measure of performance.

We checked plausibility of those figures (for instance, the average of US corporate profits was nearly flat, about +0.6%, between Q2:2014 and Q2:2016, but with a large recovery, +6%, in 2016)[10]. This is in line with the two modes of reported EBIT figures between [-4%;0%] and [5%;9%] for US respondents in our sample. Likewise, China corporate profit has been growing at just less than 10 % in last three years, again in line with our reported EBIT figures with mode in [9%;15%] for the Chinese companies.[11]

3.2. Measures of reactions

As mentioned earlier, the reactions at the focal firm level are measured along two dimensions: digital investments and strategic transformation.

The former is a self-reported measure of investments in digital technologies compared with the firm's competitors, which is reported on a 5-levels scale ranging from "*We are significantly underinvesting relative to competitors*" to "*We are significantly overinvesting relative to competitors*" (the middle value reads as "*We invest the right amount relative to competitors*"). Likewise, strategic transformation is captured on a 5-levels scale through the following responses to the question: "Which of the following statements best describes your organization's posture in addressing digital disruptions [12]:

- *We have not yet responded.*
- *We have responded through ad hoc initiatives and actions.*
- *We have developed a coordinated plan to respond to the disruption but have not changed our longer-term corporate strategy.*
- *We have changed our longer-term corporate strategy to address the disruption.*
- *We initiated the disruption.*

In each of these two dimensions (strategy/investment), we classify the first two levels as "weak/below par", the middle level as "medium/at par", and the two higher levels as "bold/above par". Figure 4 computes the four sub-groups of our previous taxonomy. 22% of the firms in our sample adopted a weak reaction at best, 28% reacted in a medium way, 34% reacted in a semi-bold way (either strategically bold or through overinvestment in digital), and 16% reacted in a bold-at-scale way.

Category of reactions	**Obs.**	**Share**
Weak	417	22%
Medium	524	28%
Semi-bold	630	34%
Bold-at-scale	289	16%
Total	**1860**	**100%**

[10] See http://www.tradingeconomics.com/united-states/corporate-profits
[11] http://www.tradingeconomics.com/china/corporate-profits, last accessed January 17, 2017.
[12] The same question is asked for each of the three levels on which digital can be deployed: sources of supply, core operations and distribution channels. Empirically, our measure of reaction is the simple average of those three levels.

Figure 4 – Distribution of firms among the four categories of digital reaction

The balance of responses, together with enough observations in each subgroup, provides a good basis for our empirical analyses on disruption and reaction thereof on firm performance. Also, we should seek for such a wide range of postures- in effect, our sample cuts across multiple industries some with major digital turbulence observed such as high-tech, and some with more limited turbulence, e.g. manufacturing. Likewise, by design of the theory of disruption, incumbents might have a difficult time to react, or still a low awareness, to disruption—while some other will aggressively play. Forms of demand heterogeneity (Adner and Snow, 2010a,b), or dynamic capabilities such as culture and organizational leadership (Geurts et al, 2016) may condition the choice of reactions.

3.3. Measures of digital turbulence

Digital turbulence should be measured *at the industry* level. For each firm, we thus compute the average degree of digital reaction among all firms active in the same industry, excluding the focal firm. We further compute a similar measure of industry-level turbulence for each of the three levels: supply chain, core operations and distribution channels. These measures reflect the degree of digital transformation observed within the focal firm's industry (outside of the focal firm).

The average firm in our sample has a score of digital turbulence in its industry of 3.16, which suggests that in the average industry, firms have developed a coordinated plan but haven't changed their longer term strategic plan as yet. Note that we did not find any substantial heterogeneity in the level of digital turbulence across the three levels: supply chain; core operations and distribution channels. The resulting variables are very strongly correlated with each other (correlations are around 0.97). A factor analysis (not reported here) retains indeed only one factor and leaves less than 4% of uniqueness to each of the three areas. This suggests that digital disruption tends to hit in all three areas together and rarely in a selective way. Non-reported regressions with each of the 3 areas of turbulence separately yields no significant differences in the effects of digital turbulence on firm performance across areas.

Industry group	**Firms**	**Share of firms**	**Mean turbulence**	**SD Turbulence**
Financial Services	341	16%	3,02	0,17
High Tech & Telecom	403	19%	3,76	0,12
Manufacturing	453	21%	2,83	0,24
Public, Social, Healthcare and Other Services	353	17%	3,05	0,12
Services: Prof., Media, Transport & Retail	585	27%	3,14	0,18
Total	**2135**	**100%**	**3,16**	**0,36**

Figure 5 – Levels of digital turbulence by industry group

There is evidently, difference by industry—for illustration, see figure 5, where we provide some aggregation of firms into 5 segments. As expected, the average digital turbulence is the highest for the industry grouping of high-tech and telecom industries. The level of disruption is close to 4, which corresponds to the level at which firms in the industry have "changed their longer-term corporate strategy to address the disruption". In contrast, the level of turbulence appears significantly lower in manufacturing and extracting industries, with an average of value of 2,83, which is in between ad-hoc responses and coordinated plans without any change to the long-term strategy. The resulting ranking of industries according to their current degree of digital disruption is broadly consistent with that of Grossman (2016), which also shows high tech (and media) at the forefront of disruption, and industrial (i.e. manufacturing) at the low end of the disruption scale.

Interestingly, the mean of digital turbulence is inversely related to its standard deviation, with standard deviation the double of high-tech and telecom in manufacturing. In the later, there is still some uncertainty and the cognitive bias may still rule as emphasized by Christensen (1997). In high-tech for instance, digitization is being played in full, and the question of awareness should be of less relevance.[13]

3.4. Measures of strategic alignment

Respondents were further asked the extent to which their digital strategy relates to their overall corporate strategy. Responses range (on a 6-level scale) from "*We have some digital initiatives that are fully planned and executed within the specific function or business unit that owns them, with minimal coordination across the company*" to "*The digital strategy and the overall corporate strategy are one and the same*" (which we consider "fully-integrated" strategies). 25% of the firms in our analysis sample report that their digital strategy is fully integrated in their corporate strategy, whereas 35% of respondents self-report themselves on the level of integration just below: "*The digital strategy is one of several sections or chapters in the overall corporate strategy but does not drive all business decisions*". The remaining 40% are spread across the four lower levels.

4. Empirical implementation

4.1. Empirical model

Our primary objective is to estimate the impact of digital turbulence and reactions on firm performance. We first translate the 4 main relationships in our conceptual framework into 4 equations to be estimated. Relationship A in Figure 1 represents the direct effect of digital turbulence on firm performance, which yields equation 1 (with error term omitted).

$$Y_{ij} = c_1 + \beta T_{ij} + X_i \qquad (1)$$

Where: Y_{ij} is the performance of firm i in its industry j. T_{ij} is the level of turbulence faced by firm i in its industry j; and X_i is a set of controls at the firm level[14]. Our conceptual framework suggests $\beta<0$. As a reference, remember that for some industries, like music, which have been already claimed to be disrupted, the net blended effect was negative and up to -4 points lower growth a year.

Relationship B is a test of $\theta>0$ in equation 2 (with error term omitted as well), with other words, we expect firm strategic reactions to increase in intensity or likelihood as digital turbulence grows.

$$Z_i = c_2 + \theta T_{ij} + X_i \qquad (2)$$

Where: Z_i is the strategic reaction of firm i. Our conceptual framework predicts $\theta>0$. Furthermore, we should expect that $c_2 < 0$. That is, companies on average can have sluggish reaction to turbulences, and in absence of disruption will prefer more than anything to commit to their original strategic posture.

Relationship C is a test of $\gamma>0$ in equation 3.

$$Y_{ij} = c_3 + \gamma Z_{ij} + X_i \qquad (3)$$

However, this equation is incomplete as it misses out the effect of digital turbulence. We therefore combine equations 1 and 3 to form equation 4, with Y as *observed* performance.

[13] Note in passing that we will perform general statistical analyses on the full sample, as well as the level of the 5 segments as laid out in Figure 5. A more disaggregate picture can be possible but quickly reduces the set of companies in sub sample for enough degrees of statistical freedom

[14] See infra for the set of variables included as part of the vector X.

$$Y_{ij} = c_3 + \beta T_{ij} + \gamma Z_{ij} + X_i \quad (4)$$

Equation 4 forms our main empirical specification. It is of course subject to concerns over the multicollinearity and the endogeneity of T_{ij} and Z_{ij}. We first estimate equation 4 ignoring these potential concerns but run a battery of tests (including instrumental variables regressions) to assess the sensitivity of our results to a relaxing of this assumption.

Finally, we introduce a term A_i reflecting the degree of integration of digital into the corporate strategy as in equation 5 to assess the mediating role that strategic integration plays on the reaction-performance relationship. Adding the error-term, we obtain equation 5, in which our conceptual framework predicts δ>0.

$$Y_{ij} = c_4 + \beta T_{ij} + \gamma Z_{ij} + \delta Z_{ij} A_i + X_i + \varepsilon_i \quad (5)$$

Equations 4 and 5 are our main equations to be estimated. They altogether provide scope for a structural test of β<0, γ>0, δ>0 (and c_2<0). We focus in our results on the estimates of these last 2 equations but report estimates for each equation separately in appendix.

4.2. Dealing with within- and between-industry differences

As we pool multiple industries together, we are also concerned about potential sources of unobserved heterogeneity at the industry level (Koellinger, 2008)[15]. Ideally, we would thus include industry fixed-effects, which should pick-up most of these potential sources of bias in our estimation. This strategy falls unfortunately short in our case. The reason lies in the way our measure of turbulence is computed. As explained here above, we measure turbulence through industry averages of firm reactions excluding the focal firm (T_{ij} in the above equations). By definition, this means that the only source of variation in this term within a given industry is the reaction of the focal firm that was excluded. As a result, should we include industry fixed effects in the regressions, they would pick up the industry average, which would be differenced out from the T_{ij} term. Consequently, T_{ij} would only capture the effect of the focal firm's own reaction.

In order to address this issue, we recode all dependent and explanatory variables as differences with respect to the industry average.[16] Y_{ij} for instance is replaced with Y^*_{ij} as in equation 6. Z_{ij} is replaced with Z^*_{ij} in a similar way (Nj is number of companies in the j-th industry).

$$Y^*_{ij} = Y_{ij} - \frac{1}{N_j}\sum_{k=1}^{N_j} Y_{kj} \quad (6)$$

In so doing, equations 1 to 6 will be estimated as within-industry differences, which mitigates the risk of unobserved heterogeneity biases at the industry level. Nevertheless, given the cross-sectional nature of our data, the source of identification will rest on cross-firm (within-industry) differences.

We therefore need to control for firm characteristics, which may affect either firm performance itself or its sensitivity to digital disruption. We control for things that are known to influence firm performance: firm size,[17] ownership structure (private or public) and geographical area (i.e. continent) where the headquarters are located. In all our regressions, the reference firm is a privately-owned one, with revenues under a billion dollars, headquartered in the Asia-Pacific region.

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[15] Like Koellinger (2008), we must assume that firm-level un-observables are not correlated with our core measures of digital reaction, otherwise their effect would not be identified. We however discuss below the limits to this assumption and their implication for the interpretability of our results.

[16] For the sake of robustness, table A3 in appendix nonetheless reports the estimates of equation 3 using nominal values of the treatment and dependent variables with industry fixed-effects.

[17] This is measured through a dummy equal to 1 when revenues are larger than a billion dollars.

We further control for 2 key characteristics of firms' activities, which may determine their level of exposure to digital disruption: its dominant customer focus (B2C v. B2B), whether it offers products or services,[18] and whether is offers a single product/service or rather a portfolio. Our choice of controls is of course constrained by the observables in our data.

Note however that our reduced form model deliberately abstracts from reverse causalities: in practice, there may be arguments in support of the idea that superior performance at the firm level generates margins for more investments and bolder strategies, not to mention that a firm's strategic posture will itself influence the strategic reactions of its competitors until some sort of equilibrium is reached. This leads us to relax the main exogeneity assumption our model relies upon.

4.3. Addressing the endogeneity of strategic reactions

As per equation (2), we expect the reaction of firms to be strongly driven by the level of reaction of their peers, which we use as a measure of the degree of digital turbulence in the industry. This assumption implies that our core explanatory variable (reactions to digital) can hardly be taken for exogenous and that our estimation of equation 4 could potentially be affected by multicollinearity. We explore the sensitivity of our results to these potential concerns in different ways.

First, given that our aim is to disentangle the effect of T and Z on Y, we need a measure for Z that is cleaned of the influence of T. To obtain this cleaned – independent – measure, we resort to estimate equation 2 to first derive $\hat{Z}$, and replace strategic reactions Z in equation 4 with their residuals as in equation 7. This way, γ_2 will capture the effect of strategic reactions in excess of the level of digital turbulence in the industry (weaker or stronger reactions than predicted by the level of turbulence).

$$Y_{ij} = c_4 + \beta T_{ij} + \gamma_2 (Z_{ij} - \hat{Z}_{ij}) + X_i \quad (7)$$

In this specification, the measure of reaction is by construction independent of the measure of digital turbulence, which should eliminate any multicollinearity between them. It does however not make the measure of reaction independent of potential sources of unobserved heterogeneity at the firm level.

We test the robustness of our results to this potential endogeneity concern using instrumental variable regressions. Specifically, we specify a set of instruments that are expected to drive the reactions but are assumed to be uncorrelated with the unobserved component of firm performance that is affected by digital reactions. Recent research (Tambe and Hitt, 2011) has suggested that firm-level factors facilitating or inhibiting the adoption of IT investments, such as organizational culture or senior management support, may be used as instruments for investments in digital technology. Karimi and Walter (2015b) show that dynamic capabilities play a strong role in responding to digital disruption. Elsewhere, the same authors (Karimi and Walter, 2015a) observe that autonomy, risk-taking, and proactiveness are positively associated with the adoption of disruptive business model innovation. Along these lines, we look for organizational specificities which may facilitate or hinder the adoption of strategic transformations and digital investments in response to digital disruption.

Such measures are present in our survey. In a set of questions, respondents were asked about the cultural or behavioural challenges that are most likely to interfere with their organization's ability to achieve its digital objectives. In particular, among the different options, three features echo the recent literature. They involve the degree of risk aversion of the organization ("*Our culture is averse to risk and experimentation*") and (lack of) agility in decision making ("*We take a long time to make a*

[18] Our control dummy is set to 1 if the firm's portfolio includes at least more than one product. The reference in our regressions is therefore a service-only firm.

decision based on the data we have"). Both measure organizational idiosyncrasies, which cannot be changed in the short run and are likely to be independent of digital turbulence or other industry-level characteristics. These characteristics nicely fit within the definition of first-order dynamic capabilities of Karimi and Walter (2015a,b). Following Tambe and Hitt (2011), we also consider the impact of senior management support to digital initiatives ("*What level of support, if any, is your organization's digital program receiving from the CEO?*"). To these measures of organizational culture and structure, building on Bynjolfsson and Hitt (2003), we add a measure of digital capabilities ("*In your opinion, how do your organization's digital capabilities compare with those of your industry peers?*"). We acknowledge, however, that these instruments have their own limitations and that their case for exogeneity is criticisable. We therefore view these regressions as adding more confidence to the causal interpretation of our results without constituting a strong case.

To operationalize our instrumental variables regressions, we recode our reaction variable as a categorical one on a 0-3 value scale. Zero corresponds to weak reactions, medium reactions take value 1, semi-bold reactions are coded as two and bold-at-scale reactions as three. Our core (non-IV) estimates are robust to this alternative coding of our explanatory variable.

5. Results

We estimate all equations by default using OLS with robust standard errors. As in some specifications our dependent variable is either categorical or binary, we use alternatively (ordered) logit models. The results are statistically similar to OLS. Our measure of firm performance is a (categorical) measure of revenue growth, which we express in differences with respect to the industry average, as explained in section 3. However, we report estimates of our main specifications using an analogous measure of EBIT growth (see below). Our results are qualitatively consistent across the two dependent variables and specification changes. Results for the estimates of the intermediate equations (1 to 3) are reported in Tables A1, A2 and A3 in appendix.

We first estimate our main equation (4). The results are reported in table 3 (table A3 in appendix reports robustness estimates of the same, including a specification as in equation 7, using residuals for reactions). The first column of table 3 uses measures of reactions in nominal terms (strategic transformation and digital investments), the second uses our 4 categories of digital reactions introduced as dummy variables (weak reactions serve as the reference).

Looking at control variables, it is worth noticing (from table 3) that only firm ownership and diversification of the portfolio seem to yield different growth trajectories. Specifically, public firms seem on average handicapped with respect to privately-owned firms by a factor of about 0.25, which means a quarter of a growth category. Since a category corresponds to a 5% range, this suggests that private firms exhibit on average a one percentage point higher top-line growth. Similarly, diversified companies (i.e. those reporting that their activities include more than a single product or service) exhibit on average a growth rate that is almost 0.5 categories below mono-product or mono-service firms, which implies an average 2.5 percentage points difference in growth rates. To a lesser extent, larger firms (those with revenues in excess of $1 billion) are associated with a 0.2 growth gap compared with smaller firms. This effect is however statistically weaker. In contrast, we do not observe any significant difference based on focus (B2C v. B2B) or activity (product v. service).

5.1. How do digital turbulence and reactions affect firm performance?

Looking now at the impact of digital turbulence and reactions on performance (in column 2 of table 3, which forms our baseline estimates), two important messages stand out. First, we find overwhelming evidence that $\gamma>0$, which means strong reactions to digital turbulence pay off. The picture is furthermore that bold-at-scale reactions pay off twice as much as semi-bold reactions, and 3 times as much as medium reactions. What is more, whatever the specification, only bold at scale reactions have a marginal effect of more than one category jump (1.36 in column 2). Since categories are measured as ranges of 5 points of revenue growth, this means that the jump at the margin is as large as 1.36*5=6.8 points – or roughly the same size as the average revenue growth of the full sample. This is a very large effect, and it is robust to any specification.

Second, the effect of disturbance on performance is consistently negative ($\beta<0$), but statistically weaker in some specifications. In our baseline estimates (column 2 of table 3), the effect of digital turbulence is -0.47. Given that the average level of turbulence in the regression sample is 3.17, this implies a 1.49 decrease in the dependent variable. In raw terms, this translates into a 7.5 percentage points decrease in top-line growth for the average firm (since one value unit of the dependent variable corresponds to a 5% growth range). As we can see, only bold-at-scale reactions yield large-enough differences to nearly offset this depressive effect (1.36-1.49=-0.13). In contrast, medium reactions still lead to a 1.02 cut in the dependent variable, which corresponds to about 5% fewer percentage points in top-line growth.

This result however hides substantial heterogeneity. Digital affects indeed firms differently at different ends of the performance distribution. We uncover these non-linearities by running quantile regressions estimated at the 25^{th} and 75^{th} percentiles, as reported in columns 3 to 6 of table 3. It turns out that digital turbulence has a strong negative and significant impact on the performance of firms at the lower end of the distribution. Looking at column 5 for instance, these firms suffer a performance loss of 2.27 on the performance scale (the coefficient of digital turbulence is -0.73 and the average level of turbulence for firms in the first quartile of performance is 3.11), which corresponds to a drop by two growth categories (i.e. the cost of digital turbulence to them is 11 percentage points in revenue growth. In contrast, in the top quartile of performance, digital turbulence does not significantly affect performance (as indicated in column 6).

Note that table A1 in appendix offers additional insights into the turbulence-performance relationship (ignoring the effect of reactions as in equation 1). Columns 2 to 5 in this table report estimates of equation 1 with subsamples cut by category of digital reactions: Weak reactions in column 2, Medium reactions in column 3, Semi-bold reactions in column 4, and Bold-at-scale reactions in column 5. It appears that the effect of digital turbulence is strongly negative and significant on weakly-reacting and medium-reacting firms, but not significant for semi-bold and bold firms. This provides further confidence that failure to react to digital turbulence damages firm performance.

The coefficient for the non-reacting group is particularly interesting as it is the group with the least response to turbulence and thus its coefficient is the closest to the true β. The estimated coefficient is -1.14. Given that firms in this group face an average level of digital turbulence of 3.05, the marginal contribution of digital turbulence on the dependent variable is -3.47. This means that the average firm in this group will experience a revenue growth that is 3 to 4 categories lower than the average firm facing no turbulence in the same industry: from an average [1%;4%] range to the [-10%;-14%] range. It means digital turbulence could cut the top-line growth of firms by up to some 15 percentage points. To the best of our knowledge, this figures provides for the first time an order of magnitude of the effect of digital on firm performance when firms do not react. Note that table A3 in appendix provides further estimates of equations 3, 4 and 7. They are all consistent with our baseline results.

5.2. Instrumental variables

In an attempt to evaluate the sensitivity of our results to the endogeneity of our core treatment variable (digital reaction), we report the results of instrumental variables regressions. Table 4 reports the first stage and Table 5 the second stage. We use two-stage least squares with each instrument separately then with the full set of instruments. We also estimate the full system using limited information maximum likelihood (LIML) as well as structural equation modelling with maximum likelihood. The results are robust to all these specification changes and estimate methods.

Before turning to the results of these instrumental variables estimates, we comment on classical diagnostics. As with any IV estimate, we are of course concerned about weak instrument bias or overidentification bias. Classical tests provide confidence in our results by rejecting these hypotheses. Specifically, we reject the null hypothesis that the reaction variable is exogenous at the 0.1% probability level. Next, we reject the null hypothesis that our instruments are weak. The partial R^2 of the first stage (including the instruments only) is still 0.16 (against an adjusted R^2 of 0.21 with controls included), and the F-Stat of the first stage (71.7) is high enough as it exceeds the threshold of 10 suggested by Stock et al. (2002) and the test statistic is significant at the 0.1% probability level. The Cragg and Donald (1993) and Stock and Yogo (2005) statistics also lead us to reject the null hypothesis of weak instruments at the 0.1% probability level. Finally, Wooldridge's robust score test of overidentifying restrictions confirms the validity of our instruments (with a p-value of 0.52 we cannot reject the null hypothesis that our instruments are valid and correctly specified).

Turning now at the results of the first stage, one may observe that risk aversion and lack of agility in decision making are indeed very strong obstacles to strong reactions (their coefficients in the first stage are negative and strongly significant). CEO support to digital initiative also shows up as a very strong predictor of bold reactions. This result is consistent with a vast literature on strategic transformation, which stresses the vital importance of top management support. In line with the literature (e.g. Karimi and Walter (2015b), Geurts et al. (2016)), our measure of digital capabilities is also positively associated with bold-at-scale reactions.

These instrumental variables regressions also offer a direct test of equation 2, since the level of digital turbulence is also included as an exogenous variable in all first stage regressions. The results confirm the very strong and positive influence of digital turbulence on strategic reactions. This is supportive of our view that digital transformation is significantly triggered by digital disruption. Note that this relationship is explored in more details in table A2 in appendix, which provides further estimates of the impact of digital turbulence on strategic reactions. It shows that digital turbulence leads to both superior digital investments and with higher intensity of strategic transformation. Columns 3 to 6 of table A2 use a logit model to estimate the incidence of each category of reaction. It appears that digital turbulence is negatively associated with weak and medium reactions, and positively associated with semi-bold and even more with bold-at-scale reactions. These results are consistent with equation 2 and suggest that firms do indeed invest in digital and engage in strategic transformation in reaction to digital threats and opportunities. On average also, the first two columns of table A2 suggest that reactions are economically significant. Given an average level of turbulence of 3.16, a 1 unit increase in the level of digital turbulence would lead to an increase of nearly 2 (1.81) in the level of digital investment, enough to jump from the "somewhat underinvesting" category to the "somewhat overinvesting one". Yet, we confirm that the tendency is to resist—e.g. the constant term of strategic response is statistically negative ($c_2<0$), while the constant estimate on the probabilities to respond weak or medium are positive in contrast with the probabilities of stronger responses that are both statistically negative.

The second stage of our instrumental variables regressions provides support to a causal interpretation of our main findings: digital turbulence has a strong and significant negative impact on firm performance. According to column 6 of table 5, the coefficient associated with digital turbulence is -0.85. Given that the average level of turbulence in the regression sample is 3.15, its average impact on firm performance is -2.69, a 2 to 3 categories (10 to 15 percentage points) drop in revenue growth. For firms who adopt a weak (or no) reaction, this represents a net effect. This depressive effect is however mitigated by stronger reactions with a strongly positive coefficient of .95. Firms who react in a medium way (whose value of the reaction variable is 1) therefore bring the depressive effect down to -1.74 (-2.69+0.95), placing the depressive effect in the -5 to -10 percentage points category. Firms reacting in a semi-bold way (whose value of the reaction variable is 2) cut the depressive effect by another 0.95 categories. For these firms, the net effect of digital is -0.79, still a drop of about one category (5 percentage points). Here again, only firms adopting a bold-at-scale reaction manage to fully offset the negative effect of digital to recover their growth trajectory.

5.3. Should digital be integrated into and aligned with corporate strategy?

We now turn to the mediating effect of strategic alignment on the reaction-performance relationship by estimating equation 5. The results are reported in table 6 (table A4 in appendix reports robustness estimates of the same using a specification as in equation 7, using residuals for reactions). In columns 1 and 2, the level of integration of digital into the corporate strategy is introduced as a standalone term. In both cases (as a level in column 1 and as a dummy signaling full integration in column 1), its coefficient is strongly positive and significant, $\delta>0$. This is supportive of the argument that digital pays off significantly more when it is fully integrated into the corporate strategy.

In columns 3 and 4, the dummy measuring full integration is interacted with the dummies characterizing each type of strategic posture. As a result, the coefficient associated with the standalone terms are reduced, suggesting that even bold strategies pay less when they are not fully integrated, and the coefficient of the interacted terms with semi-bold and bold-at-scale are all positive and significant, showing that strong strategic reactions pay significantly more when digital is fully integrated into the corporate strategy. Compared with a medium reaction, a bold-at-scale reaction yields an extra revenue growth of half a range (about 2% extra revenue growth) if not integrated, and an almost 2-range upgrade (revenue growth higher by about 8 percentage points) when fully integrated with the corporate strategy.

It should be stressed, however, that our measure of strategic alignment is agnostic about the type of organizational arrangements where digital initiatives should be hosted. It does not inform for instance about the trade-off between developing and growing digital projects inside firm boundaries or as new ventures.

5.4. Where and when do digital reactions pay off more?

The results above clearly support the idea of categorizing digitization as a disruptive innovation ($\beta<0$). Further, it provides substance that reactions are necessary ($\theta>0$ and $\gamma>0$), but the ones with large pay offs, -even reverting the curse of digitization for an opportunity to re-concentrate growth-, are to be only found in bold at scale strategies, with consistent digital and corporate strategies ($\gamma>0$). Defensive strategies barely hedge- as are half baked strategies (see also Bughin et al., 2017).

We report a set of sensitivity tests hereafter, which confirm those results in large. We first look at the importance of scope of digital playgrounds, we then experiment with more disaggregated views, contrasting sectors like high-tech with others, and finally report results based on EBIT growth rather than revenue growth.

To explore potential differences in the reaction-performance relationship, we have run our core estimates with a set of variables capturing the distinctive efforts of the focal firm in the three different digital areas: distribution channels, core operations, and supply chain. The results are reported in table 7. They first show (in columns 1 and 2) that reactions pay more when firms play the digital game in different areas simultaneously. Firms who engage in digital transformations in more than one of these playgrounds enjoy an extra premium on their revenues.

Columns 3 to 6 provide estimates similar to column 1 of table 3 with separate measures for digital investments (constant across specifications) and strategic transformation in each digital area specifically. When introduced one by one, each of the digital area seems to matter: all three coefficients are positive and significant and in roughly the same orders of magnitude, albeit a bit larger for distribution channels (0.35) than for supply chain (0.25). When introduced altogether, however, only the coefficient associated with distribution channels remains statistically and economically significant, suggesting that this dimension slightly dominates the other two. Overall, successful firms however need to invest in at least two of these dimensions.

Digitization does also not hit all industries in the same way or with the same intensity. Certain businesses, such as banks and media companies, are more amenable to digitization than others.[19] We therefore explore industry patterns in the digital turbulence-reaction-performance relationship. Table 8 reports the results of our main estimates of equation 4, for the 5 broad industry groups as shown in Figure 5: financial services, high tech and telecom industries, manufacturing industries, public and other services (including social and healthcare), and for-profit (non-financial) services (including professional services, media, transport and retail).

While the aggregation is likely too large,[20] it allows at least to contrast high tech with other sectors, as a large part of disruptive innovation literature has concentrated on high tech (see e.g. McAfee and Brynjolfsson, 2012). The general pattern remains that (a) bold strategies have the highest pay-off, (b) the pay-off tends to be twice larger than other reactions, and (c) digitization has a depressive effect on growth trajectories (although hardly significant at conventional levels).

In terms of industry differences, the two for-profit services clusters (financial and non-financial for-profit) exhibit fairly similar patterns, consistent with our main observations. The high-tech sector is the one that exhibits the largest and strongest effect of digital turbulence and reactions, still in line with our main findings. Perhaps not surprisingly, this is also the industry that exhibits the highest level of disruption overall. Manufacturing and public services, which are yet to enter the (perception of) digital disruption, exhibit the lowest effect of digitization: there seems to be no significant difference in performance across the different categories of reaction (except for semi-bold reactions paying off slightly more in the manufacturing sector). The fact that the industry cluster (manufacturing) experiencing the lowest level of digital turbulence (see figure 5) is the only one in

[19] Porter and Millar (1985) proposed a framework to predict the potential for digitization of industries, which was based on the information content of products or services on the one hand, and information intensity of the value chain on the other. The higher the information content of products and the information intensity of the value chain, the higher the potential for leveraging information technology. This framework puts obviously services much higher on the digital targets list.

[20] E.g. media and transport face evidently very different dynamics and digital threats, the former facing Netflix and Spotify, the latter Uber and Booking.com or Expedia.

which bold-at-scale reactions do not pay off more provides – in our view – further support to the disruptive nature of digitization.

5.5. Do digital disruption and reaction affect profitability as well?

We finally run our main estimates using an alternative dependent variable instead of the revenue growth: the rate of EBIT growth. The main results are reported in table 9. Table A5 in appendix reports results split by industry group as in table 9. All these results are completely consistent with the above results. This is an interesting observation by itself. It suggests indeed that digital technology affects profitability as well as growth and that bold reactions overcome its eroding effect not just on revenues but also on profits.

6. Discussion and conclusions

How do firms face the current trends of digitization? Enabled by technological advances and their convergence, summarized with the SMACIT acronym (social, mobile, analytics, cloud computing and Internet of things, see Ross et al. (2016)), new business models unfold and firm digitally transform themselves.

These opportunities, if seized by disruptors to enter and attack unaware or unprepared incumbents, can have dramatic effect on the performance trajectory of those firms. However, if anticipated correctly, incumbents can react (in a defensive or offensive, or even disruptive way) to rebuild an even better growth trajectory.

Many case studies back up such perceptions of digital disruption (such as Apple upstaging Sony in digital music players, Netflix leading to the demise of Blockbuster or still Kodak being unable to adapt to digital photos) and highlight the successful reactions of several high-profile incumbents (e.g. Schibsted by early investing in online classifieds internationally, or Charles Schwab overtaking E-Trade, the pioneer entrant in online brokerage (Ansari and Krop, 2012).

Up until now, these claims were only backed up by anecdotal evidence and speculative reasoning. The present paper provides – to the best of our knowledge – the first piece of empirical evidence of the raw depressive effect of digital technology on the growth and profitability of incumbent firms and of the counterbalancing effect of different types of responses. Using a unique dataset from a global survey of executives, it shows that digital turbulence at the industry-level is associated with substantially lower profit and revenue growth in the absence of reaction.

Firms which take notice and do react to the disruption can overcome the effect of the disruption, provided (1) they react boldly in terms of strategic transformation and digital investments and (2) integrate their digital efforts into their corporate strategy. Such successful moves require a focus on innovation and new business development leveraging digital capabilities, rather than on defending existing business lines against the odds through cost cutting, automation or existing customer service improvements. The present empirical study therefore finds itself consistent with Christensen’s theory of disruption, advocating for bold and offensive reactions, embracing the source of disruption. These results are also consistent with the anecdotal evidence reported in Westerman et al. (2014), which suggests that digital transformation leads to superior performance.

It should be noticed, however, that we have not considered the factors that hinder or facilitate the adoption of bold responses, such as capabilities, organizational agility, or motivation. Many scholars have examined the relationship between digital capabilities and firm performance (e.g. Aral and Weill, 2007; Bharadwaj, 2000; Bhatt and Grover, 2005; Lu and Ramamurthy, 2011; Stoel and Muhanna, 2009). These works and many others have led to contrasted if not contradictory observations (see e.g. Chae et al., 2014). One conclusion from this literature, nonetheless, is that digital capabilities mediate the ability of firms to profit from their investments in digital technology. It would therefore be important in the future to incorporate this mediating effect in a structural model based on ours.

Our results indicate overall that bold-at-scale responses have better returns for the average firm in the average industry. Industries however exhibit substantial heterogeneity in their rate of digitization and our results tend to hold only in industries with higher degrees of digital turbulence. This suggests that excellence in core capabilities may still yield better outcomes in low turbulent environments. From this perspective, our results for the forerunning industries (high-tech and telecoms, financial institutions and services) may provide some advanced notice to the other industries about the potentially upcoming wave of digital disruption.

As with any empirical study, our results however need to be considered with a pinch of salt. Although we present a converging array of evidence pointing at a causal interpretation, the cross-sectional and self-reported nature of all our observables has its limitations. In addition, our firm-level controls are rough and hardly able to capture all potential sources of heterogeneity. Likewise, our industry decomposition is lacking granularity, and we wish we could have a larger sample for analysis of industries.

Another limitation in our study is that we treat digital disruption as a whole. Clearly, the effect of digital disruption will vary not just across industries and along a wider range of firm characteristics, but also according to the actual nature of the disruption. Ansari and Krop (2012) stress that these three dimensions interact to determine the economic outcome of the disruption. More detailed data would be needed to provide a more nuanced view on the effect of different types of digital disruptions.

Those caveats notwithstanding, our results do guide some managerial prescriptions. In the face of digital turbulence, firms should indeed seek ways to adapt their strategic portfolio in innovative and ambitious ways and place digital at the heart of their corporate strategy rather than at the periphery. They also raise an important question for managerial practice and scholarly research: what are the organisational capabilities and resources and the cultural features that enable firms to detect digital threats and opportunities and to adopt the right strategic response? This question will deserve more research attention in the near future.

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Tables

Table 1. Comparative statics of bold players v. others

Variable	Obs	Mean	St. Dev.	Min	Max
Dependent variables					
Revenue Growth	1952	7,85	2,24	1,00	12,00
EBIT Growth	1807	7,90	2,24	1,00	12,00
Digital turbulence					
Degree of digital turbulence in industry (excl. focal firm)	2135	3,16	0,36	2,31	3,82
Firm responses					
Digital Investments	2048	2,71	1,08	1,00	5,00
Firm's level of strategic transformation	1929	3,17	1,10	0,00	4,00
Reaction is weak or inexistent	1860	0,22	0,42	0,00	1,00
Reaction is medium	1860	0,28	0,45	0,00	1,00
Reaction is semi-bold (strong in only one dimension)	1860	0,34	0,47	0,00	1,00
Reaction is bold at scale	1860	0,16	0,36	0,00	1,00
Nb of areas in which reaction is bold	2135	1,24	1,60	0,00	4,00
Firm has bold reaction in only one area	2135	0,09	0,28	0,00	1,00
Firm has bold reaction in several areas	2135	0,35	0,48	0,00	1,00
Level of transformation in Distribution Channels	1865	3,08	1,10	1,00	5,00
Level of transformation in Core Operations	1941	3,04	1,06	1,00	5,00
Level of transformation in Supply Chain	1700	2,91	1,05	1,00	5,00
Level of integration of digital into corporate strategy	2135	4,18	1,74	0,00	6,00
Digital strategy is fully integrated into corporate strategy	2135	0,25	0,43	0,00	1,00
Instrumental variables					
Risk aversion	2135	0,24	0,43	0,00	1,00
Slow decision making	2135	0,19	0,39	0,00	1,00
Digital capabilities	2135	5,79	12,46	1,00	88,00
CEO Support to digital initiative	2135	2,89	1,14	0,00	4,00
Firm controls					
Firm is public	2135	0,27	0,45	0,00	1,00
Firm is large (Rev>1b$)	2135	0,28	0,45	0,00	1,00
Firm's main focus is B2C	2135	0,23	0,42	0,00	1,00
Firm portfolio is mono-product or mono-service	2135	0,18	0,38	0,00	1,00
Firm portfolio includes products	2135	0,59	0,49	0,00	1,00

Table 2. Comparative statics of bold players v. others

Definition	Bold at scale Obs	Mean	SD	Other players Obs	Mean	SD	Difference Raw	%	Sig
Which of the following changes to your corporate business portfolio, if any, has your organization made in response to digital disruptions over the past three years									
We have divested more businesses than we otherwise would have	289	**0,04**	0,21	1846	**0,05**	0,22	**-0,01**	-13%	
We have acquired more businesses than we otherwise would have	289	**0,19**	0,39	1846	**0,09**	0,28	**0,10**	110%	***
We have reviewed our overall corporate portfolio more frequently for opportunities and challenges caused by digital disruptions	289	**0,42**	0,49	1846	**0,31**	0,46	**0,11**	34%	***
We have shifted more resources across businesses in our portfolio to address disruptions	289	**0,52**	0,50	1846	**0,32**	0,47	**0,20**	64%	***
We have increased the overall level of investment into our business portfolio	289	**0,47**	0,50	1846	**0,25**	0,43	**0,22**	90%	***
We have made significant changes to the risk profile and time horizon of our business portfolio (e.g., making smaller bets, pursuing initiatives with more uncertain outcomes, creating more long-term initiatives) than we otherwise would have	289	**0,32**	0,47	1846	**0,16**	0,37	**0,15**	93%	***
Which of the following changes to the strategy of individual business units, if any, has your organization made in response to digital disruptions over the past three years?									
We have devoted more resources to understanding our customers' behaviors and needs	289	**0,50**	0,50	1846	**0,40**	0,49	**0,10**	25%	**
We have adapted our products, services, and touchpoints to better address our customers' needs and preferences	289	**0,66**	0,47	1846	**0,48**	0,50	**0,19**	39%	***
We have included digital metrics in our performance management system	289	**0,39**	0,49	1846	**0,26**	0,44	**0,13**	52%	***
We have created new relationships with external business partners	289	**0,53**	0,50	1846	**0,40**	0,49	**0,13**	32%	***
We have developed new models of sharing profits and value with external business partners	289	**0,30**	0,46	1846	**0,13**	0,33	**0,17**	135%	***
We have increased the speed with which our businesses and functions operate	289	**0,49**	0,50	1846	**0,31**	0,46	**0,18**	57%	***
We have proactively adapted our business model, even at the risk of cannibalizing existing revenues	289	**0,43**	0,50	1846	**0,21**	0,41	**0,22**	103%	***
We have reallocated our best people and resources toward digital initiatives	289	**0,46**	0,50	1846	**0,23**	0,42	**0,23**	101%	***
What are the most important objectives of your digital strategy?									
Better serving the needs of current customers (e.g., unbundling or rebundling existing products or services, providing more opportunities for customization)	289	**1,20**	1,18	1846	**1,31**	1,20	**-0,11**	-8%	
Introducing new products or services with digital features to meet new demand and/or the needs of new customers	289	**1,53**	1,17	1846	**1,11**	1,20	**0,42**	38%	***
Tapping a previously inaccessible supply of given products or services in the market (e.g., ride sharing or room sharing)	289	**0,23**	0,61	1846	**0,22**	0,63	**0,01**	6%	
Making it easier for customers to access the available supply of products or services through digital channels (e.g., through new marketplaces)	289	**1,13**	1,17	1846	**1,22**	1,21	**-0,09**	-8%	
Scaling down the company's cost structure by automating, digitizing, or virtualizing processes	289	**0,70**	0,99	1846	**0,89**	1,10	**-0,19**	-22%	***
Redefining the industry's value chain so customers and suppliers can interact more directly and benefit from network effects (e.g., a platform offering free access to information, crowdsourcing, disintermediating suppliers)	289	**0,96**	1,24	1846	**0,60**	1,02	**0,35**	58%	***
For your organization, how does each of the following digital activities rank as a strategic priority?									
Big data and advanced analytics	289	**4,05**	1,92	1846	**3,50**	2,19	**0,55**	16%	***
Creation of new and/or growing existing digital channels	289	**3,60**	1,86	1846	**3,42**	2,07	**0,18**	5%	
Digital engagement of customers (including digital customer life-cycle management)	289	**4,61**	1,87	1846	**4,37**	2,19	**0,24**	6%	*
Digital engagement of employees, suppliers, or business partners	289	**3,12**	1,84	1846	**3,43**	2,01	**-0,31**	-9%	**
Automation and/or improvement of business processes	289	**3,80**	1,96	1846	**4,17**	2,28	**-0,37**	-9%	***
Digital innovation of products and services, business model, or operating model	289	**5,22**	1,78	1846	**4,32**	2,18	**0,90**	21%	***
Building and/or acquisition of new digital businesses	289	**3,31**	2,14	1846	**2,28**	1,88	**1,04**	46%	***
Which of the following categories best describes your latest digital initiative for which the outcome is largely known?									
Launch of a new digital product or service	289	**0,48**	0,50	1846	**0,26**	0,44	**0,22**	84%	***
Better service for existing customers through digital channels	289	**0,23**	0,42	1846	**0,36**	0,48	**-0,12**	-35%	***
Getting easier or cheaper access to supply	289	**0,02**	0,14	1846	**0,04**	0,20	**-0,02**	-50%	*
Digitization or automation of our own operations	289	**0,18**	0,38	1846	**0,19**	0,39	**-0,01**	-8%	
Redefining how we work with other players in our supply chain	289	**0,06**	0,23	1846	**0,07**	0,25	**-0,01**	-15%	
How does your organization's digital strategy relate to the overall corporate strategy?									
Digital is fully integrated into corporate strategy	289	**0,51**	0,50	1846	**0,21**	0,41	**0,30**	142%	***

Table 3. Impact of digital turbulence and reaction on firm performance

	Separate measures of transformation and investment	Reaction clusters	Separate measures (1st quartile regression)	Separate measures (4th quartile regression)	Reaction clusters (1st quartile regression)	Reaction clusters (4th quartile regression)
Degree of digital turbulence in industry	-0.1081	-0.4699***	-0.4481**	0.1345	-0.7342***	-0.2191
(excl. focal firm)	(0.1477)	(0.1573)	(0.1777)	(0.1485)	(0.1819)	(0.1512)
Difference in Digital Investment wrt	0.2101***		0.2260***	0.1628***		
Industry	(0.0553)		(0.0481)	(0.0554)		
Difference in level of digital	0.3557***		0.3059***	0.4323***		
transformation wrt industry	(0.0547)		(0.0538)	(0.0572)		
Reaction is medium		0.4732***			0.5297***	0.3900***
		(0.1368)			(0.1253)	(0.1462)
Reaction is strong in only one dimension		0.7418***			0.4932***	0.8857***
		(0.1420)			(0.1691)	(0.1583)
Reaction is bold at scale		1.3616***			1.3150***	1.2346***
		(0.1789)			(0.1736)	(0.2004)
Firm is public	-0.2473**	-0.2345*	-0.2826***	-0.2716*	-0.2518*	-0.2724**
	(0.1197)	(0.1210)	(0.1069)	(0.1396)	(0.1341)	(0.1326)
Firm is large (Rev>1b$)	-0.1711	-0.1946*	0.0937	-0.6144***	0.0128	-0.6872***
	(0.1170)	(0.1177)	(0.1209)	(0.1447)	(0.1270)	(0.1340)
Firm's main focus is B2C	0.0622	0.0685	-0.0582	-0.0326	-0.0514	0.0628
	(0.1210)	(0.1218)	(0.0981)	(0.1291)	(0.1140)	(0.1216)
Firm portfolio is mono-product or	0.4555***	0.4577***	0.2359*	0.4653**	0.2845*	0.4268**
mono-service	(0.1413)	(0.1432)	(0.1371)	(0.1887)	(0.1611)	(0.1659)
Firm portfolio includes products	-0.1429	-0.1164	-0.1323	-0.1046	-0.0976	-0.0331
	(0.1087)	(0.1096)	(0.1238)	(0.1142)	(0.1153)	(0.1101)
Constant	0.0640	0.6052	0.3201	0.7155	0.7498	1.3093**
	(0.5104)	(0.5270)	(0.6201)	(0.5297)	(0.6276)	(0.5290)
R^2	0.09	0.07				
Industry F.E.	N	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y	Y
N	1,719	1,719	1,719	1,719	1,719	1,719

Table 4. Instrumental variables regressions (first stage)

	Risk aversion only (OLS)	Slow decision making only (OLS)	Digital capabilities only (OLS)	CEO support only (OLS)	All instruments (OLS)	All instruments (LIML)
Risk aversion	-0.2708***				-0.1733***	-0.1733***
	(0.0550)				(0.0510)	(0.0510)
Slow decision making		-0.2629***			-0.1973***	-0.1973***
		(0.0567)			(0.0512)	(0.0512)
Digital capabilities			0.0333***		0.0287***	0.0287***
			(0.0119)		(0.0093)	(0.0093)
CEO Support to digital initiative				0.3202***	0.2999***	0.2999***
				(0.0215)	(0.0215)	(0.0215)
Degree of digital turbulence in industry (excl. focal firm)	0.7119***	0.7053***	0.7080***	0.5601***	0.5245***	0.5245***
	(0.0651)	(0.0661)	(0.0646)	(0.0636)	(0.0620)	(0.0620)
Firm is public	-0.0377	-0.0541	-0.0250	-0.0281	0.0007	0.0007
	(0.0619)	(0.0619)	(0.0611)	(0.0592)	(0.0578)	(0.0578)
Firm is large (Rev>1b$)	0.0133	0.0043	-0.0131	0.0212	0.0510	0.0510
	(0.0629)	(0.0629)	(0.0622)	(0.0597)	(0.0587)	(0.0587)
Firm's main focus is B2C	0.0822	0.0738	0.0660	0.0552	0.0515	0.0515
	(0.0567)	(0.0568)	(0.0567)	(0.0532)	(0.0525)	(0.0525)
Firm portfolio is mono-product or mono-service	-0.1235*	-0.1175*	-0.1141*	-0.1103*	-0.1048*	-0.1048*
	(0.0674)	(0.0667)	(0.0659)	(0.0633)	(0.0624)	(0.0624)
Firm portfolio includes products	0.0849*	0.0899*	0.0942*	0.0804*	0.0962**	0.0962**
	(0.0495)	(0.0495)	(0.0488)	(0.0468)	(0.0456)	(0.0456)
Constant	-0.7064***	-0.7109***	-0.8983***	-1.2366***	-1.1223***	-1.1223***
	(0.2246)	(0.2273)	(0.2201)	(0.2109)	(0.2073)	(0.2073)
R^2	0.09	0.08	0.10	0.18	0.22	0.22
Industry F.E.	N	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y	Y
N	1,719	1,719	1,719	1,719	1,719	1,719

Table 5. Instrumental variables regressions (second stage)

	Baseline (non-IV)	Risk aversion only (OLS)	Slow decision making only (OLS)	Digital capabilities only (OLS)	CEO support only (OLS)	All instruments (OLS)	All instruments (LIML)	All instruments (SEM-ML)
Degree of digital turbulence in	-0.4667***	-0.9806***	-0.9303**	-1.1643***	-0.8050***	-0.8867***	-0.8904***	-0.4667***
industry (excl. focal firm)	(0.1570)	(0.3593)	(0.3958)	(0.2872)	(0.1887)	(0.1853)	(0.1858)	(0.1565)
Reaction category (0=Weak -	0.4188***	1.1240***	1.0550**	1.3761***	0.8830***	0.9951***	1.0001***	0.4188***
3=Bold-at-scale)	(0.0538)	(0.4296)	(0.4945)	(0.3331)	(0.1506)	(0.1391)	(0.1401)	(0.0536)
Firm is public	-0.2361*	-0.1996	-0.2032	-0.1866	-0.2121*	-0.2063*	-0.2060*	-0.2361*
	(0.1213)	(0.1279)	(0.1289)	(0.1333)	(0.1229)	(0.1245)	(0.1245)	(0.1209)
Firm is large (Rev>1b$)	-0.1912	-0.1813	-0.1823	-0.1778	-0.1847	-0.1831	-0.1831	-0.1912
	(0.1181)	(0.1254)	(0.1238)	(0.1317)	(0.1211)	(0.1228)	(0.1229)	(0.1176)
Firm's main focus is B2C	0.0703	0.0171	0.0224	-0.0019	0.0353	0.0269	0.0265	0.0703
	(0.1218)	(0.1347)	(0.1342)	(0.1383)	(0.1267)	(0.1284)	(0.1285)	(0.1214)
Firm portfolio is mono-product or	0.4590***	0.5441***	0.5358***	0.5745***	0.5150***	0.5285***	0.5291***	0.4590***
mono-service	(0.1430)	(0.1532)	(0.1563)	(0.1561)	(0.1436)	(0.1448)	(0.1448)	(0.1425)
Firm portfolio includes products	-0.1137	-0.1724	-0.1666	-0.1933	-0.1523	-0.1617	-0.1621	-0.1137
	(0.1098)	(0.1182)	(0.1225)	(0.1226)	(0.1128)	(0.1139)	(0.1139)	(0.1094)
Constant	0.5893	1.1679*	1.1113	1.3747**	0.9702*	1.0621*	1.0662**	0.5893
	(0.5214)	(0.6649)	(0.6791)	(0.6080)	(0.5402)	(0.5429)	(0.5434)	(0.5195)
Industry F.E.	N	N	N	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y	Y	Y	Y
N	1,719	1,719	1,719	1,719	1,719	1,719	1,719	1,719

Table 6. Mediating effect of digital alignment

	Level of integration	Full integration dummy	Full integration dummy interaction	Full integration dummy + interaction
Degree of digital turbulence in industry (excl. focal firm)	-0.5103***	-0.5385***	-0.5602***	-0.5469***
	(0.1576)	(0.1585)	(0.1589)	(0.1578)
Reaction is medium	0.4176***	0.4480***	0.4703***	0.4082***
	(0.1383)	(0.1375)	(0.1399)	(0.1423)
Reaction is strong in only one dimension	0.6487***	0.6699***	0.6102***	0.5471***
	(0.1453)	(0.1449)	(0.1527)	(0.1547)
Reaction is bold at scale	1.2510***	1.2358***	0.8717***	0.8088***
	(0.1855)	(0.1857)	(0.2207)	(0.2218)
Level of integration of digital into corporate strategy	0.0896***			
	(0.0334)			
Digital strategy is fully integrated into corporate strategy		0.3565***		-0.7097*
		(0.1351)		(0.3860)
Medium reaction X Digital is fully integrated in corp. strategy			0.0293	0.7330
			(0.2615)	(0.4659)
Half-strong reaction X Digital is fully integrated in corp. strategy			0.4541**	1.1592***
			(0.2052)	(0.4350)
Bold at scale reaction X Digital is fully integrated in corp. strategy			1.0441***	1.7485***
			(0.2763)	(0.4725)
Firm is public	-0.2312*	-0.2409**	-0.2367**	-0.2344*
	(0.1201)	(0.1205)	(0.1205)	(0.1209)
Firm is large (Rev>1b$)	-0.1764	-0.1613	-0.1707	-0.1883
	(0.1173)	(0.1183)	(0.1177)	(0.1184)
Firm's main focus is B2C	0.0572	0.0735	0.0753	0.0772
	(0.1218)	(0.1217)	(0.1208)	(0.1202)
Firm portfolio is mono-product or mono-service	0.4289***	0.4154***	0.4104***	0.4257***
	(0.1436)	(0.1441)	(0.1425)	(0.1424)
Firm portfolio includes products	-0.1122	-0.1157	-0.1281	-0.1286
	(0.1093)	(0.1094)	(0.1093)	(0.1093)
Constant	0.4070	0.7783	0.8701	0.8951*
	(0.5304)	(0.5301)	(0.5327)	(0.5331)
R^2	0.08	0.08	0.08	0.08
Industry F.E.	N	N	N	N
Region F.E.	Y	Y	Y	Y
N	1,719	1,719	1,719	1,719

Table 7. Exploring different digital areas of reaction

	Number of digital areas where firm reacts	Number of digital areas (dummies)	Distribution channels	Core operations	Supply chain	All digital areas
Degree of digital turbulence in industry (excl. focal firm)	-0.5197***	-0.5286***	-0.1328	-0.1198	-0.1905	-0.1988
	(0.1578)	(0.1578)	(0.1518)	(0.1466)	(0.1589)	(0.1710)
Reaction is medium	0.4574***	0.4557***				
	(0.1369)	(0.1379)				
Reaction is strong in only one dimension	0.5344***	0.5413***				
	(0.1664)	(0.1763)				
Reaction is bold at scale	1.0590***	1.0747***				
	(0.2272)	(0.2288)				
Nb of areas in which reaction is bold	0.1047**					
	(0.0486)					
Firm has bold reaction in one area		0.0158				
		(0.1965)				
Firm has bold reaction in several areas		0.3510**				
		(0.1675)				
Difference in Digital Investment wrt Industry			0.1819***	0.2294***	0.2587***	0.2188***
			(0.0573)	(0.0566)	(0.0620)	(0.0654)
Difference in level of transformation of DC wrt industry			0.3530***			0.3105***
			(0.0572)			(0.1008)
Difference in level of transformation of CO wrt industry				0.3270***		0.0833
				(0.0604)		(0.1119)
Difference in level of transformation of SC wrt industry					0.2547***	-0.0218
					(0.0650)	(0.0925)
Firm is public	-0.2367*	-0.2387**	-0.2786**	-0.1548	-0.2253*	-0.2101
	(0.1209)	(0.1208)	(0.1254)	(0.1223)	(0.1319)	(0.1380)
Firm is large (Rev>1b$)	-0.1932	-0.1991*	-0.2244*	-0.2578**	-0.1997	-0.1444
	(0.1177)	(0.1176)	(0.1213)	(0.1212)	(0.1291)	(0.1333)
Firm's main focus is B2C	0.0626	0.0619	0.0171	0.0276	0.1346	0.0651
	(0.1212)	(0.1212)	(0.1200)	(0.1202)	(0.1269)	(0.1315)
Firm portfolio is mono-product or mono-service	0.4623***	0.4538***	0.3178**	0.3294**	0.2809*	0.2541
	(0.1433)	(0.1435)	(0.1431)	(0.1419)	(0.1527)	(0.1646)
Firm portfolio includes products	-0.1150	-0.1138	-0.1315	-0.1674	-0.0680	-0.1218
	(0.1094)	(0.1095)	(0.1107)	(0.1101)	(0.1206)	(0.1250)
Constant	0.7329	0.7589	0.1729	0.2158	0.3133	0.2888
	(0.5273)	(0.5268)	(0.5238)	(0.5051)	(0.5475)	(0.5914)
R^2	0.07	0.07	0.08	0.08	0.07	0.08
N	1,719	1,719	1,671	1,741	1,533	1,370

Table 8. Effect of digital on firm performance by industry aggregate

	1	2	3	4	5
Degree of digital turbulence in industry (excl. focal firm)	-0.5303	-2.0993*	-0.3290	0.7332	-0.7251
	(0.6921)	(1.1651)	(0.4300)	(0.9213)	(0.5971)
Reaction is medium	0.1299	0.9215*	0.1761	0.3250	0.8285***
	(0.3082)	(0.5156)	(0.2602)	(0.3211)	(0.2574)
Reaction is strong in only one dimension	0.3156	1.6305***	0.6962**	0.1971	0.9195***
	(0.3099)	(0.4779)	(0.2921)	(0.3376)	(0.2669)
Reaction is bold at scale	1.1315***	2.3494***	0.3975	0.7093	1.5511***
	(0.3436)	(0.5042)	(0.5122)	(0.4485)	(0.3615)
Firm is public	-0.2838	-0.9562***	-0.4744*	0.4629	0.1500
	(0.2742)	(0.3431)	(0.2461)	(0.3357)	(0.2541)
Firm is large (Rev>1b$)	-0.4630*	-0.1925	-0.1542	0.2640	-0.3967
	(0.2667)	(0.3305)	(0.2556)	(0.2706)	(0.2788)
Firm's main focus is B2C	-0.0701	-0.5097	0.2322	0.4204	0.3221
	(0.2452)	(0.5087)	(0.2197)	(0.2691)	(0.2464)
Firm portfolio is mono-product or mono-service	0.0424	0.4570	-0.3189	1.4483***	0.4700*
	(0.2999)	(0.3924)	(0.3354)	(0.2803)	(0.2646)
Firm portfolio includes products	-0.2602	-0.2957	-0.2038	0.5090*	-0.5093**
	(0.2633)	(0.2795)	(0.3292)	(0.2659)	(0.2166)
Constant	1.2418	6.3755	0.8244	-3.4026	1.1537
	(2.1034)	(4.4902)	(1.2758)	(2.9441)	(1.9143)
R^2	0.09	0.15	0.13	0.13	0.10
Industry F.E.	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y
N	286	331	339	271	492

1	Financial Services
2	High Tech & Telecom
3	Manufacturing
4	Public, Social, Healthcare and Other Services
5	Services: Professional, Media, Transport & Retail

Table 9. EBIT growth as alternative dependent variable

	Separate measures of transformation and investment	Reaction clusters	IV (stage 2, all instruments)	Level of integration	Full integration dummy	Full integration dummy interaction
Degree of digital turbulence in industry (excl. focal firm)	-0.0798	-0.3063*	-0.8867***	-0.3451**	-0.3557**	-0.3601**
	(0.1521)	(0.1600)	(0.1853)	(0.1606)	(0.1625)	(0.1624)
Difference in Digital Investment wrt Industry	0.2560***					
	(0.0593)					
Difference in level of digital transformation wrt industry	0.1252**					
	(0.0587)					
Reaction is medium		0.3677**		0.3183**	0.3495**	0.3188**
		(0.1437)		(0.1453)	(0.1441)	(0.1516)
Reaction is strong in only one dimension		0.4021***		0.3164**	0.3502**	0.2769*
		(0.1512)		(0.1549)	(0.1532)	(0.1656)
Reaction is bold at scale		0.9525***		0.8480***	0.8602***	0.6096**
		(0.1929)		(0.1986)	(0.1990)	(0.2421)
Reaction category (0=Weak - 3=Bold-at-scale)			0.9951***			
			(0.1391)			
Level of integration of digital into corporate strategy				0.0891**		
				(0.0361)		
Digital strategy is fully integrated into corporate strategy					0.2674*	-0.3288
					(0.1421)	(0.3829)
Medium reaction X Digital is fully integrated in corp. strategy						0.4348
						(0.4609)
Half-strong reaction X Digital is fully integrated in corp. strategy						0.6461
						(0.4422)
Bold at scale reaction X Digital is fully integrated in corp. strategy						0.9887**
						(0.4853)
Firm is public	-0.0019	-0.0142	-0.2063*	-0.0072	-0.0184	-0.0178
	(0.1307)	(0.1318)	(0.1245)	(0.1314)	(0.1315)	(0.1314)
Firm is large (Rev>1b$)	-0.0601	-0.0770	-0.1831	-0.0599	-0.0520	-0.0629
	(0.1273)	(0.1278)	(0.1228)	(0.1269)	(0.1276)	(0.1274)
Firm's main focus is B2C	0.0394	0.0372	0.0269	0.0286	0.0424	0.0427
	(0.1270)	(0.1279)	(0.1284)	(0.1280)	(0.1278)	(0.1274)
Firm portfolio is mono-product or mono-service	0.0516	0.0642	0.5285***	0.0399	0.0315	0.0351
	(0.1560)	(0.1573)	(0.1448)	(0.1574)	(0.1589)	(0.1585)
Firm portfolio includes products	-0.2343**	-0.2119*	-0.1617	-0.2064*	-0.2100*	-0.2217*
	(0.1171)	(0.1182)	(0.1139)	(0.1179)	(0.1180)	(0.1182)
Constant	0.0779	0.3885	1.0621*	0.1749	0.5046	0.5748
	(0.5267)	(0.5398)	(0.5429)	(0.5448)	(0.5459)	(0.5515)
R^2	0.04	0.03	0.00	0.03	0.03	0.03
Industry F.E.	N	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y	Y
N	1,584	1,584	1,719	1,584	1,584	1,584

Table A1. Impact of digital turbulence on firm performance

	Baseline	Reaction is Weak or inexistent	Reaction is Medium	Reaction is Strong in only one dimension	Reaction is bold at scale	Quantile Regression (1st quartile)	Quantile Regression (Median)	Quantile Regression (4th quartile)
Degree of digital turbulence in industry (excl. focal firm)	-0.0960	-1.1390***	-0.7848***	-0.2229	0.0696	-0.5333***	-0.0147	0.2976**
	(0.1431)	(0.4089)	(0.2935)	(0.2574)	(0.3986)	(0.1947)	(0.1320)	(0.1247)
Firm is public	-0.2193*	-0.4903**	-0.1812	-0.2452	-0.0115	-0.2501	-0.2867***	-0.3257***
	(0.1212)	(0.2421)	(0.2059)	(0.2287)	(0.2959)	(0.1668)	(0.1016)	(0.1144)
Firm is large (Rev>1b$)	-0.3207***	0.0924	-0.3658*	-0.2287	-0.3554	0.0003	-0.4698***	-0.6750***
	(0.1182)	(0.2362)	(0.1984)	(0.2264)	(0.3127)	(0.1569)	(0.1002)	(0.1178)
Firm's main focus is B2C	0.0753	0.5027**	0.3280*	-0.2120	-0.3780	0.2199	-0.0447	-0.0244
	(0.1168)	(0.2301)	(0.1921)	(0.2422)	(0.3397)	(0.1353)	(0.0894)	(0.1042)
Firm portfolio is mono-product or mono-service	0.2125	0.2546	0.0526	0.6575**	1.1821***	-0.0003	0.0413	0.2886*
	(0.1344)	(0.2701)	(0.2714)	(0.2807)	(0.3287)	(0.1657)	(0.1198)	(0.1616)
Firm portfolio includes products	-0.1050	0.0586	-0.4944**	0.0741	-0.4756	-0.0697	-0.0446	-0.0097
	(0.1062)	(0.2426)	(0.1986)	(0.1966)	(0.3005)	(0.1334)	(0.0931)	(0.1018)
Constant	0.1900	2.5617*	2.3114**	0.5635	0.2626	0.6471	0.2669	0.4355
	(0.4913)	(1.3365)	(0.9800)	(0.8941)	(1.4385)	(0.6629)	(0.4355)	(0.4388)
R^2	0.03	0.08	0.06	0.04	0.09			
Industry F.E.	N	N	N	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y	Y	Y	Y
N	1,952	393	492	573	261	1,952	1,952	1,952

Table A2. Impact of digital turbulence on firm digital reaction

	Digital investments	Strategic transformation	Reaction is weak (logit)	Reaction is medium (logit)	Reaction is strong in only one dimension (logit)	Reaction is bold at scale (logit)
Degree of digital turbulence in industry (excl. focal firm)	0.5716***	0.9120***	-1.4904***	-0.4883***	0.5782***	1.3669***
	(0.0677)	(0.0687)	(0.1866)	(0.1522)	(0.1406)	(0.1782)
Firm is public	-0.0368	0.0451	-0.0241	0.0969	-0.0318	-0.0929
	(0.0618)	(0.0615)	(0.1513)	(0.1365)	(0.1348)	(0.1832)
Firm is large (Rev>1b$)	-0.0669	-0.0329	0.0331	-0.0147	-0.0336	0.0314
	(0.0637)	(0.0604)	(0.1520)	(0.1379)	(0.1351)	(0.1822)
Firm's main focus is B2C	0.0382	0.0592	-0.1594	0.0863	-0.0107	0.1557
	(0.0581)	(0.0577)	(0.1360)	(0.1222)	(0.1200)	(0.1630)
Firm portfolio is mono-product or mono-service	-0.0122	-0.0879	0.2887*	-0.0306	-0.0953	-0.1816
	(0.0631)	(0.0716)	(0.1522)	(0.1463)	(0.1386)	(0.1921)
Firm portfolio includes products	0.1070**	0.0903*	-0.0441	-0.1548	-0.0644	0.3199**
	(0.0497)	(0.0514)	(0.1204)	(0.1094)	(0.1036)	(0.1427)
Constant	0.8028***	-0.6142***	3.3539***	0.4045	-2.2631***	-6.1094***
	(0.2304)	(0.2377)	(0.6113)	(0.5181)	(0.4821)	(0.6282)
R^2	0.04	0.10				
Industry F.E.	N	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y	Y
N	2,048	1,929	1,860	1,860	1,860	1,860

Table A3. Impact of digital reaction on firm performance

	Direct effect of digital only (DV=nominal level of performance)	Reaction clusters (DV=nominal level of performance)	Direct effect of digital (intra-industry differences)	Digital reaction clusters (intra-industry-differences)	Including turbulence (intra-industry-differences)	Reaction clusters with turbulence (intra-industry-differences)	Residual digital reactions (intra-industry-differences)	Residual digital reaction clusters (intra-industry-differences)	Low turbulence only (intra-industry-differences)	High turbulence only (intra-industry-differences)	Residual digital reactions (1st quartile regression)	Residual digital reactions (4th quartile regression)	Residual digital reaction clusters (1st quartile regression)	Residual digital reaction clusters (4th quartile regression)
Degree of digital turbulence in industry (excl. focal firm)					-0.1081	-0.4699***	-0.1437	-0.1226			-0.4537**	0.0970	-0.3894**	0.1219
					(0.1477)	(0.1573)	(0.1477)	(0.1493)			(0.1819)	(0.1459)	(0.1769)	(0.1430)
Digital Investments	0.2097***													
	(0.0557)													
Firm's level of strategic transformation	0.3615***													
	(0.0553)													
Reaction is medium		0.4799***		0.4368***		0.4732***								
		(0.1404)		(0.1373)		(0.1368)								
Reaction is strong in only one dimension		0.7562***		0.6655***		0.7418***								
		(0.1440)		(0.1393)		(0.1420)								
Reaction is bold at scale		1.3802***		1.2350***		1.3616***								
		(0.1808)		(0.1721)		(0.1789)								
Difference in Digital Investment wrt Industry			0.2101***		0.2101***				-0.0414	0.4244***				
			(0.0553)		(0.0553)				(0.1081)	(0.1145)				
Difference in level of digital transformation wrt industry			0.3572***		0.3557***				0.3727***	0.4224***				
			(0.0547)		(0.0547)				(0.1110)	(0.1136)				
Residual of digital investment after regression on turbulence							0.2095***				0.2273***	0.1430***		
							(0.0552)				(0.0522)	(0.0543)		
Residual of strategic transformation after regression on turbulence							0.3502***				0.2867***	0.4339***		
							(0.0541)				(0.0560)	(0.0563)		
Reaction is medium (residuals)								0.4528***					0.5897***	0.2875**
								(0.1264)					(0.1309)	(0.1228)
Reaction is strong in only one dimension (residuals)								0.7300***					0.5137***	0.9218***
								(0.1347)					(0.1987)	(0.1346)
Reaction is bold at scale (residuals)								1.4635***					1.4142***	1.3574***
								(0.1769)					(0.1820)	(0.2160)
Firm is public	-0.2714**	-0.2539**	-0.2452**	-0.2280*	-0.2473**	-0.2345*	-0.2406**	-0.2436**	-0.3561*	-0.4993*	-0.2430*	-0.2413*	-0.3436**	-0.2880**
	(0.1220)	(0.1235)	(0.1199)	(0.1222)	(0.1197)	(0.1210)	(0.1196)	(0.1210)	(0.2063)	(0.2552)	(0.1296)	(0.1354)	(0.1392)	(0.1253)
Firm is large (Rev>1b$)	-0.2051*	-0.2288*	-0.1670	-0.1787	-0.1711	-0.1946*	-0.1955*	-0.2356**	-0.0435	-0.2230	0.0818	-0.6450***	-0.0386	-0.5884***
	(0.1222)	(0.1231)	(0.1172)	(0.1189)	(0.1170)	(0.1177)	(0.1169)	(0.1179)	(0.2319)	(0.2539)	(0.1321)	(0.1403)	(0.1228)	(0.1308)
Firm's main focus is B2C	0.0297	0.0445	0.0751	0.1245	0.0622	0.0685	0.0905	0.1228	0.1552	-0.3212	-0.0512	-0.0249	0.1408	0.0871
	(0.1312)	(0.1322)	(0.1181)	(0.1195)	(0.1210)	(0.1218)	(0.1210)	(0.1219)	(0.2011)	(0.3708)	(0.1061)	(0.1233)	(0.1198)	(0.1157)
Firm portfolio is mono-product or mono-service	0.4566***	0.4582***	0.4545***	0.4482***	0.4555***	0.4577***	0.4214***	0.3756***	0.1051	0.1833	0.2266	0.4650**	0.1739	0.5219***
	(0.1439)	(0.1460)	(0.1413)	(0.1441)	(0.1413)	(0.1432)	(0.1412)	(0.1425)	(0.2827)	(0.3269)	(0.1516)	(0.1854)	(0.1668)	(0.1137)
Firm portfolio includes products	-0.1992*	-0.1714	-0.1391	-0.0963	-0.1429	-0.1164	-0.0880	-0.0726	-0.1755	-0.5594**	-0.0796	-0.0303	-0.0166	0.0790
	(0.1202)	(0.1216)	(0.1082)	(0.1092)	(0.1087)	(0.1096)	(0.1086)	(0.1093)	(0.2879)	(0.2298)	(0.1299)	(0.1133)	(0.1297)	(0.1020)
Constant	6.1362***	6.8563***	-0.2836	-0.8458***	0.0640	0.6052	0.1927	-0.3414	-0.1508	0.2151	0.3244	0.8570	-0.3661	0.2884
	(0.3523)	(0.3473)	(0.1746)	(0.1987)	(0.5104)	(0.5270)	(0.5101)	(0.5230)	(0.4506)	(0.4287)	(0.6304)	(0.5249)	(0.6222)	(0.4996)
R^2	0.12	0.10	0.09	0.07	0.09	0.07	0.09	0.08	0.12	0.14				
Industry F.E.	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	1,711	1,711	1,719	1,719	1,719	1,719	1,719	1,719	401	446	1,719	1,719	1,719	1,719

Table A4. Exploring mediating effect of digital alignment

	Level of integration	Full integration dummy	Full integration dummy interaction	Full integration dummy + interaction
Degree of digital turbulence in industry (excl. focal firm)	-0.1943	-0.2203	-0.2366	-0.2209
	(0.1518)	(0.1535)	(0.1535)	(0.1531)
Reaction is medium (residuals)	0.4140***	0.4290***	0.4465***	0.4096***
	(0.1273)	(0.1273)	(0.1343)	(0.1380)
Reaction is strong in only one dimension (residuals)	0.6577***	0.6590***	0.4640***	0.4270***
	(0.1373)	(0.1378)	(0.1533)	(0.1563)
Reaction is bold at scale (residuals)	1.3736***	1.3567***	0.9978***	0.9613***
	(0.1813)	(0.1812)	(0.2212)	(0.2230)
Level of integration of digital into corporate strategy	0.0892***			
	(0.0333)			
Digital strategy is fully integrated into corporate strategy		0.3405**		-0.2578
		(0.1333)		(0.2660)
Medium reaction X Digital is fully integrated in corp. strategy			-0.0558	0.1967
			(0.2373)	(0.3557)
Half-strong reaction X Digital is fully integrated in corp. strategy			0.7516***	1.0035***
			(0.2210)	(0.3428)
Bold at scale reaction X Digital is fully integrated in corp. strategy			1.0075***	1.2589***
			(0.3117)	(0.4062)
Firm is public	-0.2392**	-0.2493**	-0.2493**	-0.2461**
	(0.1201)	(0.1205)	(0.1205)	(0.1209)
Firm is large (Rev>1b$)	-0.2146*	-0.2007*	-0.1909	-0.1995*
	(0.1176)	(0.1186)	(0.1178)	(0.1183)
Firm's main focus is B2C	0.1073	0.1236	0.1244	0.1246
	(0.1219)	(0.1217)	(0.1208)	(0.1207)
Firm portfolio is mono-product or mono-service	0.3550**	0.3422**	0.3187**	0.3294**
	(0.1426)	(0.1430)	(0.1414)	(0.1415)
Firm portfolio includes products	-0.0707	-0.0763	-0.0897	-0.0913
	(0.1090)	(0.1092)	(0.1092)	(0.1092)
Constant	-0.4667	-0.0887	0.0160	0.0072
	(0.5217)	(0.5338)	(0.5377)	(0.5368)
R^2	0.08	0.08	0.09	0.09
Industry F.E.	N	N	N	N
Region F.E.	Y	Y	Y	Y
N	1,719	1,719	1,719	1,719

Table A5. Effect of digital on EBIT by industry aggregate

	1	2	3	4	5
Degree of digital turbulence in industry (excl. focal firm)	-0.2238	-0.8022	-0.4701	0.6735	-0.3645
	(0.7712)	(1.3707)	(0.5364)	(0.9877)	(0.6189)
Reaction is medium	0.1571	0.8763*	0.1652	0.5307*	0.5093*
	(0.3554)	(0.5024)	(0.2797)	(0.3212)	(0.2816)
Reaction is strong in only one dimension	0.2581	1.2532***	0.3452	-0.0772	0.5094*
	(0.3687)	(0.4741)	(0.3184)	(0.3449)	(0.2879)
Reaction is bold at scale	0.6786	1.8384***	0.8116	1.0274**	0.6748*
	(0.4420)	(0.4994)	(0.5642)	(0.4370)	(0.4061)
Firm is public	0.0908	-0.3449	-0.3080	0.2475	0.2755
	(0.2922)	(0.3538)	(0.2750)	(0.3621)	(0.2922)
Firm is large (Rev>1b$)	-0.4342	-0.0146	0.1401	0.3631	-0.2714
	(0.2718)	(0.3436)	(0.2904)	(0.3132)	(0.2999)
Firm's main focus is B2C	-0.3409	-0.3561	0.0712	0.7951***	0.1961
	(0.2996)	(0.5452)	(0.2459)	(0.2832)	(0.2549)
Firm portfolio is mono-product or mono-service	-0.6793	-0.6647	0.4263	0.4675	0.4080
	(0.4255)	(0.4108)	(0.3452)	(0.3405)	(0.2784)
Firm portfolio includes products	-0.4323	-0.2705	0.0048	-0.0676	-0.4849**
	(0.3244)	(0.2960)	(0.3441)	(0.2766)	(0.2316)
Constant	0.4552	1.9001	0.8350	-3.0239	0.6154
	(2.3193)	(5.2788)	(1.5852)	(3.1286)	(1.9884)
R^2	0.07	0.07	0.07	0.10	0.05
Industry F.E.	N	N	N	N	N
Region F.E.	Y	Y	Y	Y	Y
N	261	304	318	239	462

1	Financial Services
2	High Tech & Telecom
3	Manufacturing
4	Public, Social, Healthcare and Other Services
5	Services: Professional, Media, Transport & Retail

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