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Abstract

We examine the effect of business model digitalization on competition and how corporate tax savings through digitalization may augment this relationship. Global policymakers express concern that digitalization-related tax savings unfairly benefit the competitive standing of rival firms over their competitors. Using textual analysis techniques to identify firms' business models, we show that rivals' adoption of a digital business model leads to negative economic effects on the performance of their non-digitalizing competitors. We estimate that a one standard deviation increase in the share of digitalized rivals in a market reduces a competitor's market share by 4.6%. Suggesting significant tax savings from digitalizing, we also find that digitalizing rivals substantially reduce their effective tax rates, mostly by increased use of tax havens. However, when we test whether the detected competitive externalities vary depending on the share of digitalizing rivals with versus without substantial digitalization-related tax savings, we find the economic magnitudes of their effects are quantitatively similar. Therefore, contrary to policymakers' concerns of digitalization-related tax savings unfairly shaping competition, our findings suggest that tax savings from digitalization is not a key driver of altering competition between digitalized and non-digitalized firms.

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1. INTRODUCTION

Digitalization of a business model is a process where firms adopt digital technologies in their core product or service offering. Digitalization is a major driving force behind economic growth and a significant source of competitive advantage (Bloom et al., 2012; Holmström et al., 2019). It has not only led to the emergence of large technology firms, but also induced non-tech firms to adopt digital business models on a large scale (Fitzgerald et al., 2014; Svahn et al., 2017). At the same time, within the realm of taxation, policymakers fear that business model digitalization allows firms to substantially reduce their global tax burdens. The concern is not only the loss of tax revenues when firms shift income to low-tax jurisdictions, but that firms can also exploit large digitalization-related cash tax savings to compete more aggressively (OECD, 2015, 2014). As a result, the links between business model digitalization, competition, and tax savings have been the focus of recent policy initiatives. We examine these issues by focusing on the extent to which (1) business model digitalization shapes competition generally; and (2) digitalization-related *tax savings* disproportionately benefit digitalizing firms at the expense of their non-digitalizing competitors.

The Organisation of Economic Co-operation and Development's (OECD) Base Erosion and Profit Shifting (BEPS) report explicitly views digitalization as an enabling factor for increased corporate tax avoidance (OECD, 2015). The report highlights that although digitalization affects the economy at large, policy initiatives should not address in isolation (i.e., "ringfence") only certain sectors or technologies when considering the tax effects of digitalization. In line with this expansive view of digitalization, Pillar One under the OECD/G20 Inclusive Framework on BEPS seeks to account for the tax challenges from broadly defined "intangible driven" business models. Yet, despite policymakers' fears, little evidence has been documented empirically about how business model digitalization beyond those of giant tech firms affects competitive market outcomes and the extent to which digitalizing firms use tax savings to secure competitive advantages.

Importantly, there is limited understanding of the relative importance of tax savings in how digitalization shapes competition. We close this gap by using a novel empirical measure of identifying business model digitalization—especially those of *non*-tech firms—to better understand its interaction with tax savings in affecting competition.

Digitalization of a business model can include investments in a wide array of technologies, such as cloud computing, analytics, and machine learning. The adoption of these technologies can, for example, aid medical equipment providers and car manufacturers in product development, or help retailers adopt data analytics-based digital sales and marketing technologies to reach new markets. Focusing on the digitalization of *overall business models*, rather than the adoption of individual technologies that digitize discrete tasks, is important in the context of taxation because policy initiatives are intended to target these digital business *models* (e.g., digital sales channels or reliance on intangibles) rather than technologies.

Beyond the above-mentioned Pillar One proposal, many countries have already implemented or announced local initiatives, like the digital services tax, with the aim of creating a "level playing field" for digital and non-digital firms.[1] These taxes would initially be aimed at a small number of very large multinational corporations (MNCs), but are likely to affect more firms as they also adopt digitalized business models. Given the potential adverse consequences of such taxes (see Russo, 2019; Vella, 2019), it is important to understand how and the extent to which digital business models themselves allow firms to reduce tax payments and potentially use these tax savings to compete more aggressively against their non-digitalized competitors.

[1] The Tax Foundation reports that as of 2022, Austria, France, Hungary, Italy, Poland, Portugal, Spain, Turkey, and UK implemented a digital services tax (although some announced to repeal it upon the introduction of Pillar One). Belgium, Denmark, Czech Republic, Slovakia, Latvia, Norway, and Slovenia have proposed to implement such a tax. The tax rates range from 1.5% in Poland to 7.5% in Turkey and Hungary, and applies on gross revenues from a wide variety of online activities, including advertising and transmission of data collected on users. Eventually, these rules may be replaced by a multilateral approach to taxing digital business models under Pillar One of the OECD Inclusive Framework. See https://taxfoundation.org/data/all/eu/digital-tax-europe-2022/

One reason why there is little empirical evidence on business model digitalization is that digitalization is difficult to measure, as it is not directly observable in financial numbers (Tambe, Hitt, Rock, & Brynjolfsson, 2020). One approach is to compare firms in industry sectors with different *perceived* levels of digitalization. However, digitalization is present in all sectors and varies within sector and across firms. Thus, digitalization is not well-reflected in industry classifications (e.g., SIC or NAICS codes), which remain static over time. Moreover, from an econometric perspective, exploiting only cross-sectional variation across industries cannot clearly separate industry characteristics (Heitzman and Ogneva, 2019) from a *firm's* business model digitalization.

We overcome these challenges by developing a new measure of digitalization derived from the textual analysis of a firm's business model description in its annual 10-K filing. We focus on the 10-K because it is the most important form of corporate disclosure (Hope, 2003; Previts et al., 1994) in which firms are required to accurately describe their core business model (Song, 2021). We extract the business descriptions of all 10-K's available for U.S. public firms from the website of the U.S. Securities and Exchange Commission (SEC). We then apply a "bag-of-words" technique in which a collection of terms (i.e., a dictionary) is used to capture a specific attribute of a document (Loughran and Mcdonald, 2016). To identify digital business models, we apply the "digital word" list from Chen and Srinivasan (2023) (see Appendices A and B). We compute the frequency of each "digital word" used in the firm's business description. We assign the first year in which the business description contains a "digital word" as the year in which the digitalization of the business model is initiated. This approach provides us with a measure of business model digitalization that varies across firms, within industries, and within firms across time.[2]

We follow Donohoe et al. (2022) and measure competition by observing spillover effects

[2] See Appendix A for examples of business *model* digitalization in our sample, and examples of firms that use digital technology for *process* changes but do not change their business model to a digitalized one.

among firms within the same product market space. For this purpose, we define *rival firms* as those firms that adopt a digital business model during the sample period, and *competitor firms* as all other firms that do not adopt a digital business model during the sample period. We focus on the competitive pressure on *competitor* firms by computing the share of digitalized rivals (DRs) within their product market space. Importantly, the variation of interest arises from the strategic decisions of *rivals*, which are plausibly exogenous to the non-digitalizing *competitor* firms. In addition, the share of DRs is competitor firm-specific and varies over time as it reflects changes to the extent of competition from DRs. We follow Hoberg and Phillips (2016) and define a competitor's product market space based on the similarity to other firms of its 10-K product description, or Text-based Network Industry Classifications (TNIC). We regress three key performance measures of non-digitalizing competitor firms—market share, cost of goods sold, and gross margin—on the asset-weighted share of DRs within that competitor's product market space. We control for a comprehensive set of competitor and rival firm characteristics, as well as for firm and industry-year fixed effects. We find that business model digitalization generates negative and economically significant competitive externalities for non-digitalized competitors: a one standard deviation increase in the share of digitalized rivals reduces a non-digitalized competitor's market share by about 4.6%.

Having established the baseline that non-digitalized competitors are negatively affected by the extent of digitalized rivals within their product market, we examine whether these competitive effects vary depending on whether DRs use their business model to generate *tax savings* specifically. We begin by estimating the effect of digital business model adoption on the three-year average Cash ETR of DRs. We find an average reduction in their Cash ETR of 2 percentage points. We find the reduction to be concentrated in MNC DRs, rather than domestic DRs.[3] Therefore, MNC

[3] We only keep multinational DRs that are already MNCs prior to digitalization to rule out that our effects are driven by internationalization. Our results are robust to including these firms.

DRs appear to generate significant tax savings from digitalizing their business models.

Next, we study the mechanism by which rivals generate tax savings when digitalizing their business models. While tax savings may arise somewhat mechanically (e.g., because of the uptake of R&D tax credits or other targeted investment incentives for new technologies), firms may also engage in more tax planning behavior related to investments in digital assets (Tambe, Hitt, Rock, & Brynjolfsson, 2020). For example, firms may establish subsidiaries in low-tax jurisdictions into which mobile profits resulting from digital intangibles can be shifted. Consistent with this mechanism, we find that after business model digitalization, Cash ETR savings from digitalization concentrate in MNC rival firms with tax haven affiliates, while those MNCs without haven affiliates do not generate incremental Cash ETR savings. Furthermore, some MNC rivals establish new affiliates in tax haven locations after digitalization.

Finally, we estimate whether the negative performance of non-digitalizing competitors varies based on whether their rivals' digitalization generates significant tax savings, where significant tax savings is defined as a reduction in DRs' Cash ETR of at least 2 percentage points in the post-digitalization period. We therefore decompose our main variable of interest into (1) the share of DRs with significant tax savings and (2) the share of DRs without significant tax savings. We regress our three competitor firm performance measures on both of these shares.

Our findings reveal only weak negative competitive effects on non-digitalized competitors when they face *tax-saving* DRs. In particular, we find that increases in the share of tax-saving DRs does *not* significantly reduce market share or increase cost of goods sold for non-digitalized competitors, while the negative effects on competitors' market share and cost of goods sold do manifest as the share of *non*-tax saving DRs increases. We only find that tax-saving DRs reduce the gross margin of their non-digitalized competitors, but we also find this result with *non*-tax saving DRs.

Given that we observe no significant effects of tax-saving DRs on competitors' input costs

(cost of goods sold) or output prices (market share), one possible explanation for the different result on gross margin is that tax-saving DRs engage in aggressive output price competition to a larger extent than non-tax saving DRs. That is, non-digitalized competitor firms seem likelier to face a price war-type of competition when their DRs generate significant tax savings compared to when their DRs do not generate significant tax savings. While the qualitative nature of competition seems to differ depending on the rivals' tax savings, we find that quantitatively the externalities on competitors from rivals that digitalize with tax savings are comparable to those of rivals that digitalize without tax savings. Thus, we conclude that *tax savings* from digitalization do not play a decisive role in competition. Overall, contrary to global policymakers' stated concerns, our evidence suggests that digitalization generates competitive pressure on non-digitalizing firms *independent* of whether rivals generate significant tax savings from digitalization.

Our study makes three contributions. First, we inform the global academic and policy debate on the design of tax systems in digitalizing economies (OECD, 2014; Olbert and Spengel, 2017; Vella, 2019). Specifically, this study increases our understanding—beyond large MNC tech firms—of the extent to which business model digitalization occurs, whether adopting such a model reduces a firm's tax burden, and how firms might exploit any accompanying tax savings in the competitive environment. Our results are timely because in July 2023, many countries agreed to move towards changing existing corporate tax systems that are designed more for "brick-and-mortar" economies rather than intangible-driven businesses. An important motivation behind these reforms is the assumption that digitalization-driven aggressive tax planning leads to competitive distortions. Our empirical evidence shows that although digitalization is accompanied by tax savings, there are only modest effects of digitalization-driven tax savings on competition. Therefore, our findings call for caution by policymakers when motivating a re-design of global tax systems to mitigate perceived competitive advantages due to business model digitalization.

Second, we extend the literature by developing a novel measure that specifically identifies digitalized business *models*. Existing studies on the effect of digitalization on tax savings focus on the digitalization of individual *processes* internal to the firm. They show that firms' decision-making capabilities with respect to internal tax functions improve as a result of increased investments in software or IT (Hamilton and Stekelberg, 2016; Klein et al., 2020), allowing firms to avoid more taxes without incurring greater risk from potentially aggressive tax planning behavior (Hamilton and Stekelberg, 2016). We complement this literature by using a measure that more broadly captures digitalized business models—that is, the adoption of a variety of digital technologies in a firm's core products or services, which requires not only investments in software or IT, but also human resource development, R&D, or M&A. Our broader measure of digitalization allows us to examine the effects of the full spectrum of digitalization strategies and modes (e.g., digitalization of products and services by use of cloud computing or increased reliance on artificial intelligence). With our new measure of firms' business models, we also extend prior research that examines how business strategy can affect firms' approach to corporate tax outcomes (Higgins et al., 2015).

Third, we build on nascent research examining the intersection of taxes and competition. Donohoe et al. (2022) show that heterogeneity in the tax savings of rival firms negatively affects competitors through reduced performance and market share. Our paper builds on Donohoe et al. (2022) by examining the extent to which tax savings connected to broad changes in a firm's business model affects competition. Gallemore et al. (2023) provide evidence of a positive association between tax planning and competition, but no strong evidence that tax planning increases market concentration. In contrast, Martin et al. (2023) shows that tax planning increases sales for market leaders. We extend this literature by examining the outcomes of competitors if rivals adopt a digital business model and enjoy tax savings from this change. We show that firms can generate competitive externalities from digitalization independent of tax savings.

2. BACKGROUND AND HYPOTHESIS DEVELOPMENT

2.1. Background

2.1.1. Digitalization and Competition

Digitalization of a business model is a process in which firms adopt digital technologies in their core product or service offering. Prior literature shows that digitalization is a major driving force behind economic growth (Bloom et al., 2012; Holmström et al., 2019), and that large tech firms reap significant abnormal profits from digital activities (Rajgopal et al., 2023). Specifically, Rajgopal et al. (2023) find evidence that abnormal digitalization-related profits are driven by both a firm's market power and its productivity.

Beyond large tech firms, Hitt et al. (2002) find a positive relationship between the adoption of enterprise resource planning software and key performance indicators. Chen and Srinivasan (2023) show that non-tech firms that adopt digitalized business models have higher market valuations. Grover et al. (2018) find that adoption of big data analytics can enhance firm productivity, whereby the positive impact depends on firms' ability to integrate the technology into existing processes and the availability of tech-trained human capital (Janssen et al., 2017; Müller et al., 2018). These results underscore the importance of examining firms' digitalization in terms of broad business model changes.

However, the perspective that prior literature takes is on the effects of digitalization on the adopting firm itself. This leaves open the question of how digitalization affects *competitor* firms. Our study takes a broader view to examine externalities of digitalizing rivals on their non-digitalizing competitors.

2.1.2. Digitalization and Taxes

While it is widely accepted that the adoption of digital technologies contributes positively to economic growth, large technology firms are at the center of policy discussions due to anecdotal

evidence on their aggressive tax planning strategies. For example, the current reliance on physical presence to establish nexus (i.e., an obligation to pay tax) in a particular country presents a substantial hurdle for taxing the cross-border transactions of "intangible driven" businesses. Policymakers fear that inadequate tax rules lead companies to exploit digitalization-related tax savings to compete more aggressively against their competitors.

In response, the European Commission introduced a "digital tax package" on March 21, 2018.[4] This package includes two proposals: (1) an EU-wide tax targeting the revenues from specific digital services; and (2) a new concept for nexus in the case of firms with a significant digital presence. Digital services taxes now exist in several EU countries, as well as beyond the EU, including India. Although in the U.S. there is no federal digital services tax, several states have expressed interest in introducing such a tax. On February 12, 2021, Maryland became the first U.S. state to launch a digital services tax.

Governments mostly introduced such measures to address "in an interim way the problem that the current corporate tax rules are inadequate for the digital economy."[5] The underlying idea is to repeal the patchwork of such unilateral tax measures once the OECD's coordinated Pillar One approach is launched. Specifically, Pillar One addresses the tax challenges from the digital economy by granting "market jurisdictions" a new taxing right on a portion of the residual profits of the world's largest and most profitable MNCs. Relying on a new formula, Pillar One will reallocate a portion of the consolidated profit of MNCs with profitability above 10% and global turnover above €20 billion to markets where sales occur.

[4] European Commission 2018, "Communication from the Commission to the European Parliament and the Council: Time to Establish a Modern, Fair and Efficient Taxation Standard for the Digital Economy— COM (2018) 146 Final." Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0146

[5] European Commission, 2018 "Proposal for a Council Directive on the Common System of a Digital Services Tax on Revenues Resulting from the Provision of Certain Digital Services." Available at eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018PC0148, page 2.

Despite the intensive public debate and the active policy landscape, there is limited empirical evidence on how digitalization of business models impacts competitive market outcomes and the extent to which these firms leverage any tax savings for competitive advantage. Our study bridges the gap in the literature to better understand the interaction of digitalization and tax savings in shaping competition.

2.1.3. Taxes and Competition

Donohoe et al. (2022) connect the literature on taxes with competition. Using the setting of the U.S. repatriation tax holiday in 2004 where U.S. MNCs—but not their domestic counterparts—temporarily enjoyed a substantial decrease in corporate income taxes, their study shows that tax savings that disproportionately benefited MNCs over domestic firms caused significant negative externalities on domestic firms. Specifically, as the share of repatriating MNC rivals that non-repatriating domestic firms competed against increased, domestic firms' operating performance and market share decreased after the tax holiday. These results suggest that repatriating firms used their tax savings to the detriment of their competitors (Bolton and Scharfstein 1990).

Although Donohoe et al. (2022) use an exogenous decrease in taxes to examine firm effects on competition, recent studies examine the effects of firms' tax planning decisions on competition. Martin et al. (2023) find positive effects of tax avoidance for future sales growth concentrated in large firms. The authors suggest that tax planning could explain increased market power and industry concentration in the last decades. However, Gallemore et al. (2023) also examine the extent to which market leaders' tax planning is used as a competitive advantage to increase industry concentration. They show that tax planning is not associated with industry concentration, and that tax planning by industry leaders is no greater than tax planning by their smaller counterparts. They conclude that the trends in industry concentration are *not* driven by tax savings. The opposing inferences in Martin et al. (2023) and Gallemore et al. (2023) speak to policymakers' concerns that

tax savings may facilitate concentration that disproportionately benefits market leaders, but that more research is needed. We add to the literature by examining the extent to which business model digitalization generates tax savings, which in turn may affect the market outcomes of firms competing against digitalizing rivals.

2.2. Hypothesis Development

The adoption by a firm of a digital business model can yield several competitive effects. First, a digital business model can create incremental value to customers, for example through quicker and more targeted provision of goods and services, relative to non-digitalizing firms (Hanelt et al., 2021; Pagani, 2013). This operating improvement may increase demand and market share for digitalizing firms' products and services at the cost of their non-digitalizing competitors. Second, digital business models may improve efficiency, for example using customer data for market segmentation, thus increasing returns to capital and labor investment consistent with findings in prior literature. Digitalized firms could also be incentivized to attract high-skilled workers away from their non-digitalized competitors by offering higher salaries or more attractive work environments (de Bettignies and Chemla, 2008; He, 2018). In turn, input prices would rise for non-digitalized competitors. Taken together, these effects are likely to deteriorate the performance of competitors, either by reducing their demand or by increasing their cost of production. Given the potential improvements in operating efficiency due to the adoption of a digitalized business model relative to non-digitalizing competitors, we formulate our first hypothesis as follows:

H1: As the share of rival firms adopting a digitalized business model in a product market increases, the economic performance of competitor firms not adopting a digitalized business model decreases.

There are at least two reasons why we may not observe adverse effects on the competitors of digitalizing rival firms. First, improved value creation in digitalized firms may create additional

demand for a certain class of goods and services, rather than drawing it away from competitors (i.e., digitalization "increases the pie" of the market rather than takes business away from competitors). If this effect dominates, non-digitalizing competitors may not experience a significant reduction in performance. Second, some digitalizing firms may not implement their new business model effectively and thus fail to realize the associated benefits, especially in the short-term (Brynjolfsson et al., 2019). In this case, rivals' business model digitalization is unlikely to affect their competitors' performance. Whether or not business model digitalization has an economically significant competitive effect is thus an empirical question.

While a digital business model has the potential to increase firm value, it also creates intangible assets, for example matching algorithms for consumer preferences and identifying patterns in consumer behavior. This intangibility can provide greater discretion in the allocation of income across jurisdictions independent of physical presence. Prior research shows that firms are likely to exploit such flexibility to allocate profits to low-tax rate jurisdictions or to loss-making subsidiaries to reduce their tax burden (e.g., De Simone et al., 2017; De Simone and Sansing, 2018; Griffith et al., 2014; Grubert, 2003; Hopland et al., 2018). Indeed, the case of firms with digital business models engaging in aggressive tax planning has featured prominently in the public debate and in recent policy initiatives (e.g., Pillar One under the OECD/G20 Inclusive Framework on BEPS).

Since such tax planning is likely to increase digitalized firms' after-tax profits, it may lead to incremental competitive effects. For example, digitalized firms with higher tax savings can accumulate cash resources more quickly, allowing them to compete more aggressively against non-digitalized firms by reducing product prices and/or increasing market share (Fresard, 2010; Donohoe et al. 2022). Such effects could further reduce competing firms' performance. Nevertheless, firms might use cash tax savings for other purposes than competition, for example shareholder distributions (Blouin & Krull, 2009). Furthermore, prior evidence shows that associated

uncertainties from tax planning can induce firms to hold *more* cash, reducing opportunities for using tax savings to pursue competitive strategies (Saavedra, et al. 2017; Guenther et al., 2020). At the same time, improved information flows due to digitalization may enable tax planning without incurring higher tax risk (Hamilton and Stekelberg, 2016).

We formulate our second hypothesis as follows:

H2: Any decrease in economic performance of competitor firms without business model digitalization after rival firms' adoption of digital business models is stronger if the business model digitalization also leads to tax savings.

Importantly, testing H2 will shed additional light on the competitive effects of business model digitalization, specifically focusing on whether *tax savings* from digitalization provides firms with an incremental competitive edge, consistent with global policymakers' concerns.

3. METHODOLOGY

3.1. Measuring the Digitalization of Business Models

We identify whether a firm has a digital business model by examining its business description in its 10-K filing. We focus on 10-K's because they are widely considered one of the most important sources of disclosure (Hope, 2003; Previts et al., 1994). We identify the business model from the "Item 1 Business" and "Item 1A Risk Factors" sections of the 10-K.[6] Examining the "Item 1" section has three key advantages. First, firms are required to accurately describe their business model, products, and services in this part of the 10-K (Hoberg and Phillips, 2016; Song, 2021). Indeed we find that many firms discuss the role of digitalization in this section. Second, the business description can be reliably extracted from this section (Peterson et al., 2015). Third, business model

[6] Following prior literature (e.g., Hoberg and Phillips, 2016), we consider information in both of these sections of the 10-K. One concern is that the "Item 1A Risk Factors" section covers the business models of competitors and thus contains terms that are *not* related to the disclosing rival firm's business model. To mitigate this concern, we manually inspect a random sample of 10-K's, where digital term(s) only appear in the Item 1A Risk Factors section. We report these examples in Appendix B. None of the inspected cases discusses the adoption of digital products by competitors.

descriptions are sticky (Dyer et al., 2017), such that *changes* in the descriptions reflect major updates to the business model. Importantly, our measure explicitly captures changes in the business *model* rather than in discrete technologies. This approach differentiates our study from others that focus on digitization of processes (e.g., Hamilton and Stekelberg, 2016).

To provide an example, we classify a firm in our sample as digitalized when we observe that it adopts cloud computing technologies to develop a previously non-digital product offering, moving the firm towards a business model that includes a significant digital service component. However, if a business introduces cloud computing solutions for an internal task or process only, we do *not* classify this as digitalization of the business model. See Appendix A for examples.

To identify the digitalization of a firm's business model, we adopt a dictionary approach. This is a bag-of-words technique in which a collection of terms (i.e., a dictionary) is developed and used to capture a specific attribute of a document. According to Loughran and McDonald (2016), the dictionary approach has several desirable features. First, once the term list is established, it can be objectively applied by researchers and used in the replication of empirical results. Second, it can be applied to large samples, as the only required outcome is the frequency count of each selected term. In our setting, we use the dictionary developed by Chen and Srinivasan (2023) who identify "digital words" from dedicated articles and specialized glossaries provided by consulting firms focusing on digital transformation.[7] The list of digital words covers seven topics: analytics, automation, artificial intelligence, big data, cloud(-computing), digitization, and machine learning. We validate the suitability of this word list to our setting by confirming it uses similar words to those in (1) the OECD report on Action 1 "Addressing the Tax Challenges of the Digital Economy" in the BEPS Project (OECD, 2014); (2) the digitalization index developed by MIT in cooperation

[7] Chen and Srinivasan (2023) apply their dictionary to firms' business description sections and validate that their dictionary captures firms with a higher probability of filing digital-related patents and a higher proportion of IT workers when compared to industry peers.

with Capgemini Consulting (McAffee et al., 2011); and (3) annual reports of companies that are generally considered to provide digital services or products.

We count the frequency of each digital term extracted from the two above-mentioned sections of the firm's 10-K. The average digitalized firm in our sample uses about five digital terms in its business description section. We classify a firm as digitalized if its business description contains at least one term from the dictionary. We then isolate the *change* in business model based on the first year a firm uses a digitalized word from the dictionary. Once a firm is classified as digitalized in one year, we classify it as digitalized for the remainder of the sample period.

Figure 1 displays the evolution of the share of firms with digitalized business models in our initial sample of firms (also see Table 1).[8] We find that the share of firms with digitalized business models substantially increases from 19% to 44% during the sample period.

Figure 2 presents the same evolution, but by industry sector. We observe that digitalization is not simply concentrated in high-tech sectors. Digitalization occurs at a more moderate rate in the chemicals and healthcare sectors (subfigures (a) and (b)) and a greater rate in the manufacturing and wholesale sectors (subfigures (c) and (d)). Importantly, the subfigures underscore the importance of using a measure of digitalization that is *not* based on industry classification. For greater contrast, subfigure (e) displays the evolution of the share of digital business models in firms operating in the information technology (IT) sector. On average, there is little change over time as expected, with most IT firms having already adopted digital technologies. However, this pattern masks substantial within-sector variation. Subfigure (f) presents the evolution of digitalization of the IT sector, but after excluding high-tech firms, revealing greater variation over time. Overall, the trends shown in Figures 1 and 2 demonstrate the rising importance of digital business models and motivate our use of corporate disclosure rather than static industry classification to identify

[8] We include technology firms for comparative purposes and completeness.

changing business models across various industries, and within firms over time.

3.2. Empirical Strategy

We broadly mirror the approach in Donohoe et al. (2022) and identify the competitive effects of digital business model adoption by regressing various performance measures of non-digitalizing *competitor* firms on the share of *rival* firms in their product market space that have adopted digitalized business models. Thus, to test H1, we estimate the following OLS regression model:

$$Performance_{it} = \beta Digital\_Rival\_Share_{it} + \gamma X_{it-1} + \eta Z_{it-1} + \phi_i + \phi_{jt} + \epsilon_{it} \qquad (1)$$

Our main variable of interest is $Digital\_Rival\_Share$, which captures the share of rivals in competitor firm *i*'s product market that have adopted a digital business model in year *t*. To define product markets, we use the Text-based Network Industry Classification (TNIC) by Hoberg and Philipps (2016) who define product markets based on the similarity of firms' business and product market description in their 10-K filings (i.e., from Item 1). This measure is firm-specific, so each competitor firm has a unique set of rivals that constitute its product market based on how similar its product description is to other firms. As in Donohoe et al. (2022), we fix the composition of a product market at the beginning of our sample period to avoid endogenous changes over time. We include firm-fixed effects (ϕ_i) that capture time-invariant differences in performance across firms. Hence, *Digital_Rival_Share,* captures changes in the degree of digitalization within precisely defined competitor firm product markets. Moreover, we include industry × year fixed effects to capture industry-specific time trends. As a result, β captures the effect of changes in the degree of digitalization of direct product market rivals on the performance of non-digitalizing competitor firm *i*, identified from within-firm variation over time. Importantly, this variation arises from strategic decisions of *rivals*, which are plausibly exogenous to non-digitalizing competitor firms.

$Performance$ is one of three financial outcome measures: market share within the TNIC product market (in terms of sales), cost of goods sold (COGS), and gross margin. Each measure

identifies a different aspect of performance and competitive effects. Market share captures how digitalizing rivals affect their non-digitalized competitors' demand, for example through output prices on goods and services. COGS captures how digitalizing rivals affect competitors' input prices. Gross margin captures how digitalizing rivals affect competitors' profit margins, that is, the net of output and input prices. If increasing adoption of digital business models by rival firms negatively affects their non-digitalized competitors, as hypothesized in H1, we expect the β coefficient on *Digital_Rival_Share* to be significantly negative (positive) when using market share or gross margin (cost of goods sold).

We control for time-varying characteristics of the competitor firm i (X_{it-1}) and its rivals (Z_{it-1}). At the non-digitalizing competitor firm level, we include the natural logarithm of total assets to measure size (*SIZE*), cash holdings (*CASH*), market-to-book ratio (*MTB*), leverage (*LEVERAGE*), net operating losses (*NOL*), and Cash ETR (*ETR*). At the digitalizing rival firm level, we control for cash holdings (*CASH_Rivals*), sales volatility (*SALESVOL_Rivals*) and Cash ETR (*ETR_Rivals*). Finally, we control for time-varying characteristics of competitor firm *i*'s product market, which include market concentration (*HHI*) and the share of rivals that are always digital (*Share of Always Digi Rivals*). To allow for delayed effects on competitor firm performance, we lag these control variables by one year. All variables are winsorized at the top and bottom 1%.

Next, to test H2, we decompose $Digital\_Rival\_Share$ into the share of rivals (1) with significant tax savings ($Digital\_Rival\_TaxSav\_Share$) and (2) without significant tax savings ($Digital\_Rival\_NoTaxSav\_Share$). If the adoption of digital business models is accompanied by significant tax savings via decreases in the Cash ETR, then consistent with H2 we expect the coefficient on $Digital\_Rival\_TaxSav\_Share$ to be negative (positive) when using market share or gross margin (cost of goods sold) as the dependent variable. Although we are agnostic as to which effect should be greater (i.e., digitalization without tax savings vs. digitalization with tax savings),

we test the difference in coefficients between *Digital_Rival_NoTaxSav_Share* and *Digital_Rival_TaxSav_Share* to identify the extent to which *tax savings* from digitalization serves as a distinct channel from general digitalization that affects competitors' performance.

We define tax savings as significant if the average Cash ETR of digitalizing rival firms drops by 2 percentage points or more in the post-digitalization period (i.e., average of the three years after digitalization) over the pre-digitalization period (i.e., average of the three years before digitalization). For example, if a firm digitalizes in 2013, then the tax savings from digitalization in 2015 is calculated by taking the difference over the 3-year Cash ETR during 2013–2015 (post-digitalization Cash ETR) minus the 3-year Cash ETR in years 2010-2012 (pre-digitalization Cash ETR). We conservatively assume that the rival's tax savings related to digitalization should not immediately affect competitors. For this reason, we set tax savings in the first two years after digitalization to zero. We select a threshold of 2 percentage points because this is the average post-digitalization decrease in Cash ETR in our sample of digitalizing rivals. In a robustness test, we use other thresholds to split digitalizing rivals, for example considering tax savings as significant if there is at least a 5-percentage point change in Cash ETR, or taking the difference in the 2-year average Cash ETR instead of 3-year average Cash ETR to narrow the window during which tax savings are realized.

3.3. Sample Construction and Descriptive Statistics

Our initial sample selection is based on observations from Compustat over the years 2007 to 2017.[9] We start with 13,668 unique firms (94,737 firm-year observations) for which we retrieve annual 10-K filings in HTML format from EDGAR, the SEC's public filing platform. We match 10-K's to financial information in Compustat using the CIK firm identifier and the financial year noted in the 10-K. Following prior literature, we exclude financial firms (i.e., SIC codes 6000-6999

[9] Given the major changes to the corporate tax system introduced under the Tax Cuts and Jobs Act of 2017, we exclude the years after 2017 from our sample.

and 4900-4999) and loss firms (i.e., firms with negative pre-tax income net of special items; see De Simone et al., 2020; Drake et al., 2020; Dyreng et al., 2010, 2017). In our competition analysis, we keep only never-digitalizing competitors. We also drop observations with missing variables, as well as firms suspected to have undergone a merger and/or reorganization (i.e., product-market adjusted sales growth >100%; see Donohoe et al., 2022). Our final sample for the competition tests consists of 4,080 never-digitalizing competitor firm-year observations.

Table 2 Panel A presents descriptive statistics for the competition analysis. The average firm in our sample of never-digitalizing competitors has a gross margin of 37%, a market share of 15% within its product market group, and cost of goods sold of 75% of lagged total assets. On average, the share of digitalizing rivals in a competitor's market is 13%. This share can be divided into 9% of digitalizing rivals *without* significant tax savings and 4% of rivals *with* significant tax savings. The asset-weighted average Cash ETR of rival firms (i.e., rivals that digitalized or were always digitalized) is 25%, which is very similar to that of competitor firms (24%) and consistent with other studies (e.g., De Simone et al., 2020; Drake et al., 2019).[10]

Table 2 Panel B reports descriptive statistics for the tax avoidance analysis sample. Here we gauge the extent to which firms reduce their Cash ETRs after adopting digitalization business models (for sample selection steps, see Table 1). We find that 35% of our sample firm-years are digitalized. The mean Cash ETR lies at 25%, as in Panel A. Also, 83% of the sample firm-years are MNC firm-years and 67% of the sample firm-years report using a tax haven subsidiary.

[10] Note that competitor firm A can be a (non-digitalizing) rival of another competitor B (i.e., competitor A can be included in competitor B's *Digital_Rival_Share* measure), and that different competitors can share the same rival firm (i.e., competitors A and B can face digitalizing rival firm C). Decomposing the mean Cash ETR by digitalization type instead of by rivals versus competitors, we find that tech firms (considered always digital) have a Cash ETR of on average 23% and non-digitalized firms have an average Cash ETR of 27%, which reduces to 26% after they digitalize. We systematically test the effect of digitalization on Cash ETRs in regression analyses below.

4. RESULTS

4.1. Effect of Rivals' Digitalization on Competitors' Performance

Table **3** presents results of the competition analysis testing H1, focusing on competitors' market share, COGS, and gross margin. Column (1) presents a parsimonious model only including firm fixed effects, industry-by-year fixed effects, and our main variable of interest, *Digital_Rival_Share*, in explaining competitors' market share (*MKT Share*). We find a significantly negative coefficient on *Digital_Rival_Share* ($p<0.10$), suggesting that an increasing share of digitalized rivals (DRs) within a competitor's product market decreases the market share of the non-digitalizing competitor. Our baseline estimate implies that if the share of DRs increases by one standard deviation (i.e., if one in four rival firms in the same product market digitalizes), the competitor's market share decreases by 0.7 percentage points over the next three years.[11] Compared to the sample mean of 15% market share, our estimate implies an economically significant decline in average competitor market share of 4.7%. Thus, DRs appear to capture a substantial share of the demand within their product market from competing firms that do not digitalize over the following three years.

Results in Table 3 column (2) show that COGS increases when the share of DRs increases, albeit not significantly. Finally, column (3) reports a significantly negative coefficient on *Digital_Rival_Share* when estimating the effect of rivals' digitalization on competitors' gross margins ($p<0.01$). We estimate that a one standard deviation increase in the share of DRs decreases competitors' gross margins by about 0.425 percentage points over the next three years. Compared to the sample mean of 37%, this constitutes a moderate decline in gross margins of about 1.1%.

In columns (4)–(6) of Table 3, our results remain robust to including the full set of control variables. Therefore, the main results are not driven by confounding factors, such as differences between digitalized and non-digitalized firms in financial condition, size, or market concentration.

We note that if COGS largely reflects variable costs and thus varies with total units sold, then

[11] We multiply the coefficient (-0.028) by the standard deviation *Digital_Rival_Share* (0.25), which yields 0.007.

the gross margin reflects the relative difference in the price of inputs and outputs.[12] Thus, the highly significant decrease in gross margin together with the insignificant effect on COGS (input prices and quantities) implies that the observed competitive effects likely result from aggressive output price reductions that drive down margins (i.e., downward pressure on competitors' prices). Similarly, the significantly negative effect on the market share of competitors could be driven by digitalized firms providing superior products and boosting sales more, relative to its competitors. Because we do not have granular data on prices and quantity, we caution that we cannot precisely attribute our results to either effect, as likely both can occur. Nevertheless, we find support for H1 that business model digitalization has negative competitive effects on non-digitalizing competitors.

4.2. Tax Savings from Digital Business Model Adoption

Having established a general negative effect on non-digitalizing competitors from rivals that digitalize their business models, next we investigate the extent and role of *tax savings* from adopting digital business models in generating additional competitive effects. We begin by presenting evidence that digital business model adoption leads to a decline in a rival firm's tax burden.

Table 4 presents results from regressing the 3-year average Cash ETR on an indicator variable equal to one in the year a firm adopts a digital business model and all following years (*DIGITAL*); 0 otherwise. We use the full sample of profitable firms, including non-digitalizing competitors and their DRs (see Table 1). We present results with and without controls. Following prior literature (Chen et al., 2010; e.g., Rego, 2003), we control for return on assets (*ROA*), intangible intensity (*INTANGIBLE*), PPE intensity (*PPE*), size (*SIZE*), market-to-book ratio (*MTB*), sales growth (*SALES_GROWTH*), leverage (*LEVERAGE*), and earnings volatility (*EARN_VOL*), which

[12] To illustrate this concept formally, denote the units sold by x, input price by q, and the output price by p. Then $Gross\ margin\ = \frac{SALES-COGS}{SALES} = \frac{px-qx}{px} = \frac{p-q}{p}$.

are all winsorized at the 1st and 99th percentiles.[13] We control for multinational firms (*MNC*), but we also split our sample in columns (3)–(6) into domestic firms and MNCs given that we expect that digitalization may especially allow MNCs to save taxes via increased opportunities of intangible-based profit shifting.[14] We highlight that the focal firm in these tests is the rival firm, not the competitor firm, as we seek to estimate the extent to which business model digitalization generates tax savings. Later we further test if digitalizing rivals' *tax savings* augment the negative performance effect on competitors.

In column (1) of Table 4, we present baseline results using a parsimonious model with only firm fixed effects, industry-by-year fixed effects, and the *DIGITAL* indicator to explain rivals' Cash ETR. Our results suggest that a firm adopting a digital business model reduces its Cash ETR by 1.7 percentage points. If we split the sample into domestic and MNC firms, we find no significant change for domestic firms post-digitalization relative to the control group (columns 3 and 4), while MNCs significantly reduce their Cash ETR by 1.8 to 2.0 percentage points (columns 5 and 6) post-digitalization.[15] The results are robust to including a large set of control variables to account for confounding factors that could be correlated with both ETRs and digital business model adoption.

We also estimate a generalized difference-in-differences model in which we regress the 3-year average Cash ETR on separate treatment dummies indicating the years in the 10-year window around digital business model adoption (*t=0*). We plot the regression coefficients in Figure 3. In confirming the parallel trends assumption, we do not observe a significantly different Cash ETR

[13] In unreported analysis, we also control for the total length of the 10-K (*LENGTH*) and results are unchanged. 10-K's with different lengths could point to different types of firms, but also make it more likely that the 10-K includes digital terms.

[14] We drop MNCs from this analysis that only become MNCs during our sample period to rule out that Cash ETR captures effects due to concurrent internationalization. This screen results in the loss of 103 firms and 871 observations. Our analysis is robust to re-including these MNCs.

[15] In untabulated results, we also find an economically similar decrease when considering GAAP ETR instead of Cash ETR of 1.5 percentage points (for all firms pooled), significant at the 10%-level in a regression including the full set of control variables and fixed effects. GAAP ETR is defined as total tax expense (TXT) scaled by pre-tax income (PI), winsorized at 1 and 0 and set to missing for negative pre-tax income.

for digitalizing rivals relative to their non-digitalizing competitors prior to rivals' digital business model adoption. In the years following rivals' business model adoption, we find that their Cash ETR decreases significantly compared to non-digitalizing competitors, suggesting that business model digitalization generates substantial tax savings. The effect is most pronounced in year 4 after adoption, indicating that it takes some time for digitalizing rivals to realize incremental tax savings.

An important question is whether DRs merely benefit from a mechanical reduction in the tax burden due to benign tax incentives (e.g., due to a higher uptake in the R&D tax credit), or whether these firms actively exploit tax planning opportunities that become available under such business models. There are at least two tax planning opportunities that are likely linked to business model digitalization: (1) the ability to allocate sales to low-tax jurisdictions and away from customers' physical locations (i.e., market countries), and/or (2) the ability to assign profits to intangible assets located in low-tax jurisdictions (OECD, 2014, pp. 85–86). Both tax planning strategies involve an affiliate in a low-tax jurisdiction.

To examine these explanations, we test whether the tax savings documented in Table 4 are concentrated in firms with tax haven subsidiaries. Table 5 reports the results. We find that rivals appear to use tax haven jurisdictions to generate the tax savings related to digitalization. Specifically, in columns (1)–(4), we split the MNC sub-sample into firms with and without a tax haven subsidiary. This split shows that the reduction in Cash ETRs is driven by MNCs with a tax haven subsidiary (columns 1 and 2). In contrast, for MNCs without a tax haven subsidiary, we do not observe an effect of digitalization on the Cash ETR. Among MNCs with a tax haven subsidiary, those that digitalize reduce their Cash ETR by 2.1 (2.3) percentage points relative to non-digitalizing MNCs with a haven subsidiary in regressions without (with) control variables. These findings provide empirical support to the notion that firms exploit tax planning opportunities from digital business models by using tax haven subsidiaries.

If DRs actively exploit tax planning opportunities arising from a digitalized business model, we expect them to be more likely to have subsidiaries in low-tax jurisdictions once a digital business model is implemented. In columns (5) and (6), we estimate linear probability models using an indicator dependent variable equal to one if a firm reports a significant foreign subsidiary in a low-tax jurisdiction in Exhibit 21 (Dyreng et al., 2020); 0 otherwise. We regress this variable on *DIGITAL*, our indicator that identifies a firm that adopted a digitalized business model. The coefficient for *DIGITAL* is significantly positive and implies that a firm is about 5.5% to 6.5% more likely to have a subsidiary in a tax haven location after the adoption of a digital business model.

Overall, we find evidence that business model digitalization is accompanied by future tax savings. Next, we examine whether tax savings from digitalization augment the baseline relationship between rivals' digitalization and competitors' performance.

4.3. Effect of Tax Savings from Digital Business Model Adoption on Competitors' Performance

In testing H2, we investigate whether tax savings following rivals' business model digitalization has a differential effect on the negative performance of non-digitalizing competitors. To do so, we decompose our main measure of the share of digitalized rivals in a competitor's market (*Digital_Rival_Share*) into (1) rivals whose adoption of a digital business model led to a significant decrease in Cash ETR (i.e., at least 2 percentage point decrease in Cash ETR starting in year 3 after digitalization)[16] (*Digital_Rival_TaxSav_Share*); and (2) rivals whose adoption of a digital business model did not lead to such a large reduction in the Cash ETR (*Digital_Rival_TaxSav_Share*).

Table 6 reports results on the competitive effects of the decomposed measures on our three performance outcomes of competitor firms—market share, cost of goods sold, and gross margin.

[16] We only measure the Cash ETR reduction after two years of digitalization because we see in the tax avoidance analysis in Figure 3 that the Cash ETR is only significantly reduced after a 3-year post period. Otherwise, we could underestimate the share of rivals that digitalize with substantial tax savings. We vary this assumption in robustness analysis below.

We report results with only fixed effects in columns (1)–(3) and include all controls in columns (4)–(6). We find that digitalizing rivals *without* significant tax savings generate significantly negative effects on non-digitalizing competitor firms (*Digital_Rival_NoTaxSav_Share*; all $p<0.10$). However, we find little evidence that digitalizing rivals *with* significant tax savings generate negative competitive effects on competitor firms with respect to market share and cost of goods sold (see *Digital_Rival_TaxSav_Share* in columns 1, 2, 4, and 5).

Interestingly, both tax-saving and non-tax-saving DRs reduce their competitors' gross margins, evident in columns (3) and (6). In fact, the negative coefficient is about twice as large for increases in the share of tax-saving DRs compared to increases in the share of non-tax savings rivals (i.e., -0.028 vs. -0.014 coefficients in column 3). This difference is significant at $p<0.075$. The economic magnitudes in both cases are, however, moderate. If one in four rivals digitalize with (without) tax savings, the competitors' gross margins at the mean (which is 37 percent) reduces by 1 percent (2 percent), or 0.35 (0.7) percentage points. The results hold after including the full set of controls in columns (4)–(6), although the difference in magnitudes of digitalized rivals with vs. without tax savings on gross margin becomes marginally insignificant at $p<0.13$.

A possible explanation for the pattern of results in Table 6 is that DRs with tax savings use their additional financial capacity to mainly compete by aggressively reducing output prices. Since sales are the product of output prices and units sold, we observe that tax saving rivals' market share does not increase as strongly as for non-tax saving rivals. Hence, while tax-saving rivals attract some demand from competing firms and thus increase the number of units sold, they do so at a lower output price, which dampens their sales increases, at least in the short run, relative to those of non-tax-saving digitalized rivals that may mainly provide superior products. This interpretation would also be consistent with the finding that competitors' COGS only increase in response to increases in the share of non-tax-saving DRs. Hence, a larger share of tax-saving DRs does not

significantly affect input competition within competitors' product market space. Overall, we do not find strong support for H2 that *tax savings* from digitalization have incrementally negative competitive effects on non-digitalizing rivals, beyond that of digitalization generally.

4.4. Robustness Tests

One concern with our analysis is that business model digitalization could coincide with an increase in multinational activities of a firm, and so our digitalization variable captures the internationalization of operating activities rather than a change in the business model. We note that MNCs already make up a large part of our sample (about 80%). As an additional robustness check, we repeat our baseline analysis after using only MNCs as rivals and competitors. We report results in Table 7 Panel A. We find that results using only MNCs are qualitatively similar to those using the full sample, thus the competitive effects we observe are not driven by internationalization.

In Panel B of Table 7 we restrict our analysis to domestic rivals and competitors. We find that digitalization generates competitive externalities also in this purely domestic setting. From Table 4, we see that domestic firms do not generate significant *tax savings* from digitalization. However, this result underscores that digitalization *independent* of tax savings generates competitive externalities on non-digitalizing competitors. Another concern we rule out with this test of purely domestic rivals and competitors is that our results are driven by a spurious correlation between MNCs being more efficient over time compared to domestic firms and thus generating more negative competitive externalities, while MNCs are also more likely to digitalize.

A further concern is that our definition of "significant tax savings" for DRs is arbitrary. To mitigate this concern, we re-estimate our baseline tests after redefining tax-saving DRs as those with a reduction in Cash ETR of 5 (instead of 2) percentage points or more. The results are presented in columns (1)–(3) in Table 8. Results are very similar to those reported in Table 6.

Moreover, by measuring the tax savings of DRs using a rolling window of Cash ETR in the

3 years after digitalization, we set tax savings to zero in the first and second years of digitalization. We do this because our Cash ETR analysis shows that tax savings on average materialize only about 3 years after the business model digitalization (see Figure 3), and measuring over multiple years allows us to capture long-run effects, as one might expect after changing a business model. However, tax savings may manifest more quickly for some DRs. To examine whether our results are driven by this measurement choice, we re-estimate our baseline model using a 2-year window to measure the average post-digitalization Cash ETR. Results are presented in columns (4)–(6) of Table 8. Again, we find results similar to those on tax saving DRs in Table 6.

5. CONCLUSION

This study investigates (1) the effect of business model digitalization on competition, (2) the extent to which tax savings from digitalization shape the nature of competition by generating negative externalities on non-digitalizing competitor firms. These links between digitalization, taxes, and competition represent a largely unexplored area despite their high relevance to global policymakers (e.g., OECD). Our novel text-based measure of business model digitalization from 10-K filings (Chen and Srinivasan, 2023; Hoberg and Phillips, 2016) allows us to employ within-industry, within-firm, and time-series tests to identify the effects of business model digitalization on non-digitalizing competitors.

By examining changes in the share of digitalizing rivals within non-digitalizing competitor firms' product market spaces, we study the effect of digitalization on the performance of these non-digitalizing competitor firms. We find that rivals' adoption of a digital business model leads to important negative competitive externalities: a one standard deviation increase in digitalizing rivals reduces a competitor firm's market share by about 4.6% and gross margin by 1% at the mean.

In the second part of our analysis, we study the extent to which digitalization leads to tax savings. We find an average reduction of Cash ETR of about 2 percentage points concentrated in

MNC rival firms that adopt a digital business model. We show that digitalizing firms achieve the reduction in effective tax rates if they have a subsidiary in a low-tax rate jurisdiction and that they expand their presence to low-tax jurisdictions.

In the final part of our analysis, we examine the extent to which *tax savings* from digitalization might impact competition. While we find that an increase in the share of non-tax saving digitalizing rivals leads to a significant reduction in competitors' market share and increase in cost of goods sold, no such effect is detected for an increase in the share of tax saving digitalized firms. Results regarding gross margins provide only marginal evidence that tax saving digitalizing rivals exert pressure on competitors. With a view to the *economic* magnitude of the estimated effect, the competition effects from digitalizing rivals with tax savings are not substantially larger than those from rivals without such tax savings. Thus, we conclude that digitalization-related tax savings do not drive a significant competitive advantage for digitalizing rivals.

Overall, our study contributes to the literature on business models, taxes, and competition (Higgins et al. 2015; Donohoe et al. 2022; Gallemore et al. 2023; Martin et al. 2023), and presents tempered evidence to global policymakers on the role of tax savings in generating unfair advantages over competitors in a digitalizing economy (OECD 2014, 2015).

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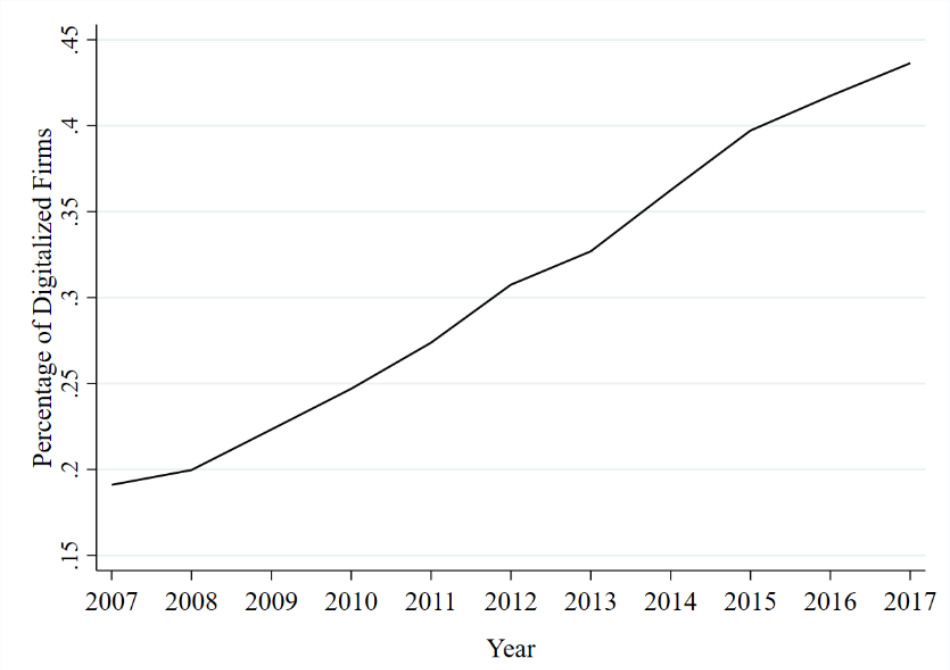
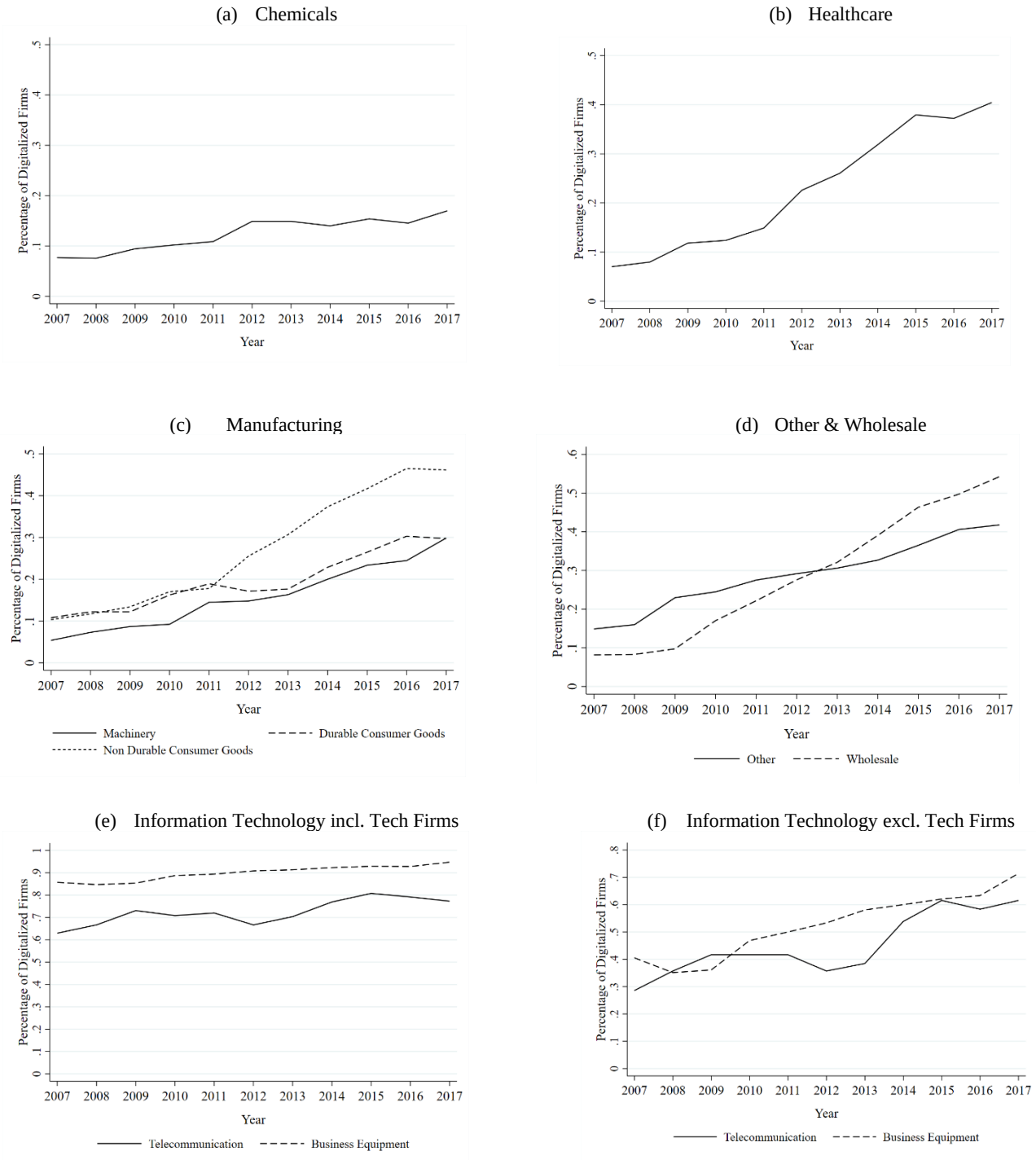
Figure 1: The evolution of business model digitalization in U.S. firms



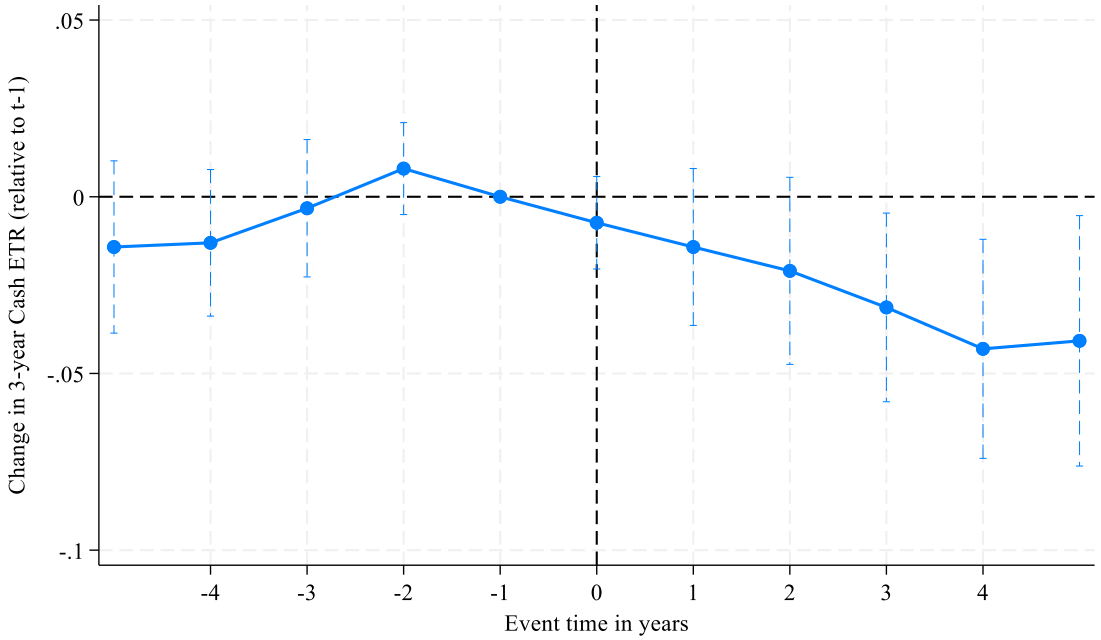
The figure shows the evolution over time of the proportion of firms disclosing digital words when describing their business models in the Business Section of their 10-K filing.

Figure 2: Digitalization by Industry Sector



The figures show the evolution over time of the proportion of firms disclosing digital words when describing their business models in the Business Section of the 10-K filings for specific Fama & French industries.

Figure 3: The Effect of Digitalization on Effective Tax Rates in a Generalized Difference-in-Differences Design



The figure plots the regression coefficients (blue circles), β_k, and 95% confidence intervals (the dotted blue vertical lines) based on cluster robust standard errors (firm-level) from the following specification: $CashETR_{it} = \sum_{k=-5}^{5} \beta_k * D_t^k + \varphi i + \varphi t + \beta X_{it} + \epsilon_{it}$. $CashETR_{it}$ is defined as the sum of cash taxes paid over three years (t, t–1, t–2) scaled by the sum of pre-tax income adjusted for special items over the same period. $\beta_k * D_t^k$ is a series of year dummies that equal one in each of the k years before and after the digitalization shock measured by term count in the business section of firms' 10-K's. We bin event dummies at beginning- and end-points of the event window, at k= +/- 5. We show coefficients 4 years before and after the business model digitalization, as well as the coefficients corresponding to the binned-up time frames. βX_{it} is the full set of firm-level controls as used in our tax avoidance analysis; return on assets (*ROA*), intangible intensity (*INTANGIBLE*), PPE intensity (*PPE*), size (*SIZE*), market to book ratio (*MTB*), leverage (*LEVERAGE*), sales growth (*SALES_GROWTH*), earnings volatility (*EARN_VOL*), the total length of the 10-K file (*LENGTH*) and multinational companies (*MNC*). Detailed variable definitions can be found in appendix A. φi are the firm fixed effects and φt are time fixed effects. We use t–1 as the base year in this fixed-effects estimation.

Table 1: Sample Selection

	No. of observations	
	Firm-year	Unique firms
All Compustat No. of observations from 2007 to 2017	94,737	13,668
Less: Missing 10-K filings from SEC EDGAR	(36,704)	
Less: Financial industries (SIC: 6000-6999)	(12,976)	
Less: Obs. with negative pre-tax income	(32,329)	
Intermediate Sample	12,728	1,730
Competition Analysis:		
Intermediate Sample (*see above*)	12,728	
Less: Obs. with missing rival control variables	(703)	
Less: Obs. with missing TNIC product market data	(3,148)	
Less: Obs. likely to have undergone an M&A or reorganization	(561)	
Less: All digitalizing or always digital obs. (never digitalizing obs. remain)	(4,041)	
Less: Obs. with missing control and outcome variables & singleton obs.	(195)	
Final Sample for competition analysis (incl. only never digitalizing firms)	4,080	531
Tax Savings Analysis:		
Intermediate Sample (*see above*)	12,728	
Less: Obs. with missing control and main outcome variables & singleton obs.	(4,328)	
Final Sample for tax avoidance analysis (all rivals)	8,400	1,105

Table 2: Descriptive Statistics

Panel A: Competition Analysis

	N	Mean	SD	25th Perc.	Median	75th Perc.
MKT Share	4,080	0.15	0.2	0.02	0.05	0.2
COGS	4,080	0.75	0.73	0.27	0.57	0.96
Gross Margin	4,080	0.37	0.18	0.24	0.34	0.46
Digital_Rival_Share	4,080	0.13	0.25	0	0	0.11
Digital_Rival_TaxSav_Share	4,080	0.04	0.13	0	0	0
Digital_Rival_NoTaxSav_Share	4,080	0.09	0.21	0	0	0.04
SIZE	4,080	7.73	1.72	6.56	7.71	8.89
CASH	4,080	0.09	0.11	0.02	0.05	0.13
MTB	4,080	2.97	6.88	1.57	2.27	3.5
LEVERAGE	4,080	0.27	0.18	0.14	0.27	0.37
NOL	4,080	0.77	0.42	1	1	1
ETR	4,080	0.24	0.14	0.15	0.24	0.32
CASH_Rivals	4,080	684.57	1195.34	134.23	320.02	645.23
SALESVOL_Rivals	4,080	0.02	0.02	0.01	0.01	0.03
ETR_Rivals	4,080	0.25	0.15	0.16	0.24	0.3
AlwaysDigital_Rival_Share	4,080	0.02	0.11	0	0	0
HHI	4,080	0.43	0.34	0.14	0.35	0.68

Panel A presents summary sample statistics related to relevant variables used in the analysis. The sample consists of 4,080 competitor firm-year observations representing 531 unique firms. The data spans the 2007- 2017 financial year period. All variables are defined in Appendix C. Cash ETR is winsorized at 0 and 1. All other variables are winsorized at the 1st and 99th percentiles.

Panel B: Tax Savings Analysis

	N	Mean	SD	25th Perc.	Median	75th Perc.
DIGITAL	8,400	0.35	0.48	0.00	0.00	1.00
Cash ETR	8,400	0.25	0.14	0.17	0.26	0.33
Subsidiary in Tax Havens	8,400	0.67	0.47	0.00	1.00	1.00
ROA	8,400	0.10	0.09	0.05	0.09	0.14
INTANGIBLE	8,400	0.26	0.21	0.08	0.21	0.40
PPE	8,400	0.26	0.22	0.09	0.18	0.35
SIZE	8,400	7.85	1.66	6.69	7.75	8.91
MTB	8,400	3.28	7.43	1.60	2.46	3.94
SALES_GROWTH	8,400	0.30	0.71	0.02	0.18	0.40
LEVERAGE	8,400	0.25	0.22	0.10	0.24	0.36
EARN_VOL	8,400	-3.59	0.90	-4.17	-3.60	-3.03
MNC	8,400	0.82	0.38	1.00	1.00	1.00

Panel B presents summary sample statistics related to relevant variables used in the tax avoidance analysis. The sample consists of 8,400 film-year observations. The data spans the 2007- 2017 fiscal year periods. All variables are defined in Appendix C. Cash ETR is winsorized at 0 and 1. All other continuous variables are winsorized at the 1st and 99th percentiles.

Table 3: Effect of Rival Firms' Business Model Digitalization on Competitors' Performance

	(1)	(2)	(3)	(4)	(5)	(6)
Sample			***Full Sample***			
Dep. Variable	MKT Share	COGS	Gross Margin	MKT Share	COGS	Gross Margin
Digital_Rival_Share	-0.028*	0.045	-0.017***	-0.028*	0.045	-0.017***
	(0.017)	(0.031)	(0.006)	(0.015)	(0.030)	(0.006)
SIZE				0.018	0.386	-0.005
				(0.046)	(0.330)	(0.022)
CASH				0.045***	-0.298***	-0.001
				(0.007)	(0.044)	(0.006)
MTB				-0.050**	-0.396***	0.059***
				(0.021)	(0.093)	(0.019)
LEVERAGE				-0.000	0.000	0.000
				(0.000)	(0.001)	(0.000)
NOL				-0.051***	-0.264***	0.007
				(0.015)	(0.090)	(0.015)
ETR				0.013**	0.068**	-0.010**
				(0.005)	(0.029)	(0.004)
CASH_Rivals				0.095**	-0.051	-0.004
				(0.041)	(0.055)	(0.010)
SALESVOL_Rivals				-0.000***	0.000	-0.000
				(0.000)	(0.000)	(0.000)
ETR_Rivals				0.147	0.124	-0.074
				(0.146)	(0.566)	(0.069)
AlwaysDigital_Rival_Share				0.022	-0.008	-0.011
				(0.014)	(0.056)	(0.013)
HHI				-0.012	0.053	-0.006
				(0.028)	(0.078)	(0.014)
No. of observations	4,080	4,080	4,080	4,080	4,080	4,080
Firm FE	Y	Y	Y	Y	Y	Y
Industry × year FE	Y	Y	Y	Y	Y	Y
Clustering	Firm	Firm	Firm	Firm	Firm	Firm
Adj. R^2	0.934	0.936	0.968	0.939	0.946	0.969

In columns (1) and (4) the dependent variable is the market share (MKT Share) for competitor *i* in year *t*, as measured by the firm's sales divided by total sales in the TNIC-defined product market space. In columns (2) and (5) the dependent variable is the cost of goods sold (COGS) scaled by lagged total assets for competitor *i* in year *t*. In columns (3) and (6) the dependent variable is Gross Margin defined as sales minus cost of goods sold divided by sales. In each column the dependent variables are regressed on *Digital_Rival_Share*, defined as the asset weighted share of digitalized rivals of competitor *i* in year *t*. The share is calculated excluding rivals that are always digitalized within our sample period, i.e., it comprises rivals that become digitalized during the sample period. In columns (4)-(6) control variables are added to the regression (lagged). Detailed variable definitions are provided in Appendix C. All specifications include firm and industry-by-year fixed effects. Standard errors (adjusted for clustering at firm level) are reported in parentheses, stars indicate significance levels: ***, $p < 0.01$, **, $p < 0.05$, *, $p < 0.10$.

Table 4: Effect of Digitalization on Cash Tax Savings

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	***Full Sample***		***Domestic Firms***		***MNC Firms***	
Dep. Variable	Cash ETR					
DIGITAL	-0.017**	-0.019**	0.010	0.010	-0.018*	-0.020**
	(0.008)	(0.008)	(0.025)	(0.030)	(0.010)	(0.010)
ROA		-0.095***		-0.009		-0.114***
		(0.027)		(0.087)		(0.034)
INTANGIBLE		-0.030		-0.233		-0.005
		(0.027)		(0.143)		(0.029)
PPE		-0.059		-0.188*		-0.034
		(0.051)		(0.104)		(0.066)
SIZE		0.004		0.008		0.003
		(0.010)		(0.035)		(0.011)
MTB		0.000		0.001**		0.000
		(0.000)		(0.001)		(0.000)
SALES_GROWTH		-0.010***		-0.002		-0.012***
		(0.004)		(0.009)		(0.004)
LEVERAGE		0.002		-0.045		-0.002
		(0.022)		(0.082)		(0.026)
EARN_VOL		0.003		0.012		0.002
		(0.003)		(0.012)		(0.003)
MNC		0.008				
		(0.008)				
No. of observations	8,400	8,400	949	949	6,401	6,401
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry × year FE	Yes	Yes	Yes	Yes	Yes	Yes
Clustering	Firm	Firm	Firm	Firm	Firm	Firm
Adj. R^2	0.674	0.678	0.779	0.785	0.643	0.647

In column (1) and (2), the dependent variable is Cash ETR, defined as the sum of cash taxes paid over three years (*t*, *t−1, t−2*) scaled by the sum of pre-tax income adjusted for special items over the same period. In each column the dependent variables are regressed on *DIGITAL*, an indicator variable equal to 1 if a firm has a digitalized business model in year *t*; 0 otherwise. Column (2) includes control variables. In Domestic firms we include all firms that never internationalize in our sample period (no MNC observations). In MNC firms we include all firms that are MNCs in our sample period excl. those MNC firms that become MNCs during the sample period. Detailed variable definitions are provided in Appendix C. All specifications include firm and year fixed effects. Standard errors (adjusted for clustering at firm level) are reported in parentheses, stars indicate significance levels: ***p <0.01, **p <0.05, *p <0.10.

Table 5: Effect of Digitalization on Cash Tax Savings by Haven Presence in MNCs

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	***MNCs with haven subsidiary***		***MNCs without haven subsidiary***		***Full Sample***	
Dep. Variable	Cash ETR	Cash ETR	Cash ETR	Cash ETR	Subsidiary in Haven	
DIGITAL	-0.021*	-0.023**	-0.001	-0.002	0.065***	0.055**
	(0.011)	(0.011)	(0.019)	(0.020)	(0.025)	(0.024)
Controls	***N***	***Y***	***N***	***Y***	***N***	***Y***
No. of observations	5,336	5,336	850	850	8,400	8,400
Firm FE	Y	Y	Y	Y	Y	Y
Industry × year FE	Y	Y	Y	Y	Y	Y
Clustering	Firm	Firm	Firm	Firm	Firm	Firm
Adj. R-squared	0.624	0.631	0.805	0.807	0.823	0.839

In column (1) to (4), the dependent variable is Cash ETR, defined as the sum of cash taxes paid over three years (t, $t-1$, $t-2$) scaled by the sum of pre-tax income adjusted for special items over the same period. In columns (5) and (6), the dependent variable is an indicator variable equal to 1 in year t if the firm lists in Exhibit 21 at least one subsidiary in a tax haven, as defined by Dyreng et al. (2020); 0 otherwise. In each column the Dependent variable is regressed on *DIGITAL*, an indicator variable equal to 1 if a firm has a digitalized business model in year t; 0 otherwise. In columns (1), (3), and (5) control variables are added to the regression (lagged). In column (5) we additionally control for whether a firm lists any subsidiary in Exhibit 21. Detailed variable definitions are provided in Appendix C. All specifications include firm and year fixed effects. Standard errors (adjusted for clustering at firm level) are reported in parentheses, stars indicate significance levels: ***p <0.01, **p <0.05, *p <0.10.

Table 6: Effect of Rival Firms' Business Model Digitalization on Competitors' Performance – The Role of Rivals' Tax Savings

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	***Full sample, no control variables***			***Full sample, incl. control variables***		
Dep. Variable	MKT Share	COGS	Gross Margin	MKT Share	COGS	Gross Margin
Digital_Rival_TaxSav_Share	-0.014	0.011	-0.028***	-0.021	0.009	-0.027***
	(0.020)	(0.046)	(0.010)	(0.019)	(0.043)	(0.010)
Digital_Rival_NoTaxSav_Share	-0.033*	0.054*	-0.014**	-0.029*	0.054*	-0.014**
	(0.017)	(0.032)	(0.006)	(0.015)	(0.031)	(0.006)
SIZE				0.045***	-0.298***	-0.001
				(0.007)	(0.044)	(0.006)
CASH				-0.050**	-0.400***	0.058***
				(0.021)	(0.093)	(0.019)
MTB				-0.000	0.000	0.000
				(0.000)	(0.001)	(0.000)
LEVERAGE				-0.051***	-0.265***	0.007
				(0.015)	(0.090)	(0.015)
NOL				0.013**	0.069**	-0.009**
				(0.005)	(0.029)	(0.004)
ETR				-0.000***	0.000	-0.000
				(0.000)	(0.000)	(0.000)
CASH_Rivals				0.144	0.139	-0.069
				(0.147)	(0.568)	(0.069)
SALESVOL_Rivals				0.023	-0.010	-0.012
				(0.014)	(0.056)	(0.013)
ETR_Rivals				-0.010	0.042	-0.009
				(0.028)	(0.078)	(0.014)
AlwaysDigital_Rival_Share				0.018	0.389	-0.004
				(0.046)	(0.330)	(0.022)
HHI				0.094**	-0.050	-0.004
				(0.041)	(0.054)	(0.010)
No. of observations	4,080	4,080	4,080	4,080	4,080	4,080
Firm FE	Y	Y	Y	Y	Y	Y
Industry × year FE	Y	Y	Y	Y	Y	Y
Clustering	Firm	Firm	Firm	Firm	Firm	Firm
Adj. R^2	0.934	0.936	0.968	0.939	0.946	0.969
Test of Equiv. P-Value	**0.184**	**0.272**	**0.0748**	**0.485**	**0.231**	**0.129**

In columns (1) and (4) the Dependent variable is the market share (MKT Share) for competitor *i* in year *t*, as measured by the firm's sales divided by total sales in the TNIC-defined product market space. In columns (2) and (5) the Dependent variable is the cost of goods sold (COGS) scaled by lagged total assets for competitor *i* in year *t*. In columns (3) and (6) the Dependent variable is Gross Margin defined as sales minus cost of goods sold divided by sales. In each column the Dep. Variables are regressed on Digital_Rival_TaxSav_Share and Digital_Rival_NoTaxSav_Share. Digital_Rival_*(No)*TaxSav_Share is defined as the asset weighted share of digitalized rivals of competitor *i* in year *t with(without)* significant tax savings from digitalization. Tax savings are calculated as the difference in the 3-year average Cash ETR pre-/post-digitalization for each year after digitalization and are considered to be significant if they exceed 2 percentage points. The share is calculated excluding rivals that are always digitalized within our sample period, i.e., it comprises rivals that become digitalized during the sample period. In columns (4)-(6) control variables are added to the regression (lagged). Detailed variable definitions are provided in Appendix C. All specifications include firm and industry-by-year fixed effects. Standard errors (adjusted for clustering at firm level) are reported in parentheses, stars indicate significance levels: ***, $p < 0.01$, **, $p < 0.05$, *, $p < 0.10$.

Table 7: Effect of Rival Firms' Business Model Digitalization on Competitors' Performance – by MNC or Domestic Firm

Panel A – Only MNC Competitors and Rivals

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	***MNC Competitors and Rivals, no control variables***			***MNC Competitors and Rivals, incl. control variables***		
Dep. Variable	MKT Share	COGS	Gross Margin	MKT Share	COGS	Gross Margin
Digital_Rival	-0.018	0.049	-0.017**	-0.018	0.044	-0.017**
	(0.019)	(0.031)	(0.007)	(0.017)	(0.031)	(0.007)
Controls	N	N	N	Y	Y	Y
No. of observations	3,106	3,106	3,106	3,106	3,106	3,106
Firm FE	Y	Y	Y	Y	Y	Y
Industry × year FE	Y	Y	Y	Y	Y	Y
Clustering	Firm	Firm	Firm	Firm	Firm	Firm
R-squared	0.950	0.948	0.976	0.955	0.956	0.976

Panel B – Only Domestic Competitors and Rivals

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	***Domestic Competitors and Rivals, no control variables***			***Domestic Competitors and Rivals, incl control variables***		
Dep. Variable	MKT Share	COGS	Gross Margin	MKT Share	COGS	Gross Margin
Digital_Rival	-0.049	0.203	-0.071***	-0.041	0.271*	-0.070***
	(0.054)	(0.186)	(0.016)	(0.045)	(0.159)	(0.015)
Controls	N	N	N	Y	Y	Y
No. of observations	711	711	711	711	711	711
Firm FE	Y	Y	Y	Y	Y	Y
Industry × year FE	Y	Y	Y	Y	Y	Y
Clustering	Firm	Firm	Firm	Firm	Firm	Firm
Adj. R-squared	0.930	0.964	0.967	0.933	0.970	0.968

The sample in these tests is restricted in panel A to multinational companies (MNC) in competitors and rivals. A firm is defined as MNC on the firm-year level if the absolute value of foreign profits or foreign tax expense is greater than 0, following Dyreng et al. (2017) or reports a foreign subsidiary in Exhibit 21. In panel B the sample is restricted to domestic firms in competitors and rivals. In columns (1) and (4) the Dependent variable is the market share (MKT Share) for competitor *i* in year *t*, as measured by the firm's sales divided by total sales in the TNIC-defined product market space. In columns (2) and (5) the Dependent variable is the cost of goods sold (COGS) scaled by lagged total assets for competitor *i* in year *t*. In columns (3) and (6) the Dependent variable is Gross Margin defined as sales minus cost of goods sold divided by sales. In each column the Dep. Variables are regressed on Digital_Rival_TaxSav_Share and Digital_Rival_NoTaxSav_Share. Digital_Rival_*(No)*TaxSav_Share is defined as the asset weighted share of digitalized rivals of competitor *i* in year *t with(without)* significant tax savings from digitalization. Tax savings are calculated as the difference in the 3-year average Cash ETR pre-/post-digitalization for each year after digitalization and are considered to be significant if they exceed 2 percentage points. The share is calculated excluding rivals that are always digitalized within our sample period, i.e., it comprises rivals that become digitalized during the sample period. In columns (4)-(6) control variables are added to the regression (lagged). Detailed variable definitions are provided in Appendix C. All specifications include firm and industry-by-year fixed effects. Standard errors (adjusted for clustering at firm level) are reported in parentheses, stars indicate significance levels: ***, $p < 0.01$, **, $p < 0.05$, *, $p < 0.10$.

Table 8: Effect of Rival Firms' Business Model Digitalization on Competitor's Performance – Using Various Tax Savings Thresholds

	(1)	(2)	(3)	(4)	(5)	(6)
	larger tax savings (5%-points), incl. control variables			***2-year average tax savings, incl. control variables***		
Dep. Variable	MKT Share	COGS	Gross Margin	MKT Share	COGS	Gross Margin
Digital_Rival_TaxSav_Share	-0.015	0.029	-0.027**	-0.014	0.058	-0.028***
	(0.019)	(0.046)	(0.011)	(0.016)	(0.036)	(0.010)
Digital_Rival_NoTaxSav_Share	-0.030*	0.048	-0.014**	-0.031*	0.051	-0.010*
	(0.016)	(0.031)	(0.006)	(0.016)	(0.036)	(0.005)
No. of observations	4,080	4,080	4,080	4,080	4,080	4,080
Firm FE	Y	Y	Y	Y	Y	Y
Industry × year FE	Y	Y	Y	Y	Y	Y
Clustering	Firm	Firm	Firm	Firm	Firm	Firm
Adj. R^2	0.939	0.946	0.969	0.939	0.946	0.969
Test of Equiv. P-Value	***0.338***	***0.671***	***0.187***	***0.272***	***0.830***	***0.040***

In column (1), tax savings for the explanatory variables Digital_Rival*_(No)*TaxSav_Share are considered significant if they exceed 5 percentage points (instead of 2). In column (2), Digital_Rival*_(No)*TaxSav_Share are determined based on 2-year average Cash ETRs instead of 3-year average Cash ETRs, all else follows the baseline specification. In columns (1) and (4) the Dependent variable is the market share (MKT Share) for competitor *i* in year *t*, as measured by the firm's sales divided by total sales in the TNIC-defined product market space. In columns (2) and (5) the Dependent variable is the cost of goods sold (COGS) scaled by lagged total assets for competitor *i* in year *t*. In columns (3) and (6) the Dependent variable is Gross Margin defined as sales minus cost of goods sold divided by sales. In each column the Dep. Variables are regressed on Digital_Rival_TaxSav_Share and Digital_Rival_NoTaxSav_Share. Digital_Rival*_(No)*TaxSav_Share is defined as the asset weighted share of digitalized rivals of competitor *i* in year *t with(without)* significant tax savings from digitalization. Control variables are added to the regression (lagged). Detailed variable definitions are provided in Appendix C. All specifications include firm and industry-by-year fixed effects. Standard errors (adjusted for clustering at firm level) are reported in parentheses, stars indicate significance levels: ***, $p < 0.01$, **, $p < 0.05$, *, $p < 0.10$.

Appendix A Examples of Companies Adopting a Digital Business Model

This appendix presents two representative examples of rivals' digital business model adoption and two examples of competitors that did not adopt a digital business model, as captured using our dictionary approach based on Chen and Srinivasan (2023). We begin by presenting the examples of two companies that become digital during our sample period using two different representative strategies, specifically vertically by acquiring a supplier company with a digital business model and/or horizontally by expanding its product offering via the development of digital solutions.

First, Korn Ferry International is a U.S. multinational firm active in the management consulting sector. It advises clients on designing optimal organizational structures, roles, and responsibilities. The company started investing in technology since 2013, especially via the acquisition of other companies. For example, the acquisition of PDI enabled Korn Ferry International to introduce a cloud platform.[17]

The adoption of the digital business model by Korn Ferry International is well-reflected in our digitalization variable since it switches from zero to one in 2013. Examples of related sentences in its business section containing words in our dictionary (in bold) include:

- "…the PDI acquisition, we acquired a sophisticated, **cloud-based** technology platform (PALMS) and a robust library of intellectual property. PALMS provides Korn/Ferry with the client-facing technology platform to launch all assessment activities, a centralized database to track and analyze all assessment data and an e-learning platform to launch interactive, simulation-based learning modules. We are currently in the process of integrating PALMS across our entire LTC portfolio."

- "Talent Analytics — Companies are increasingly leveraging **big data** and **analytics** to measure the influence of activities across all aspects of their business, including HR. They expect their service providers to deliver superior metrics and measures and better ways of communicating results. Korn/Ferry's go-to-market approach is increasingly focused on talent analytics — we are injecting research-based intellectual property ("IP") into all areas of our business, cascading innovation and new offerings up to our clients.

[17] For more information, see https://www.prnewswire.com/news-releases/kornferry-completes-acquisition-of-leading-global-leadership-solutions-firm-pdi-ninth-house-185401582.html

Second, ResMed is a medical equipment company providing devices for the treatment of sleep apnea, chronic obstructive pulmonary disease, and other respiratory conditions. In 2015, the company launched cloud-based remote monitoring.[18] For ResMed, we capture their adoption of a digital business model as our digitalization variable switches from zero to one in 2015. Examples of related sentences in its business section containing words in our dictionary (in bold) include:

- "In 2015, we also released the AirViewTM, our **cloud-based** remote monitoring and therapy management system, along with our Air Solutions platform that provides a suite of end-to-end healthcare informatics solutions that address customer business processes from diagnosis to monitoring and patient management and billing. We believe that continued product development and innovation are key factors to our ongoing success."

- "To assist those professionals diagnosing or managing the treatment of patients there are data communications and control products such as EasyCare, ResLink, ResControl, ResControl II, TxControl, ResScan and ResTraxx modules that facilitate the transfer of data and other information to and from the flow generators. (..) With the introduction of our latest generation of flow generators, we are expanding our use of **cloud-based** patient management and engagement platforms such as AirView and myAir enabling remote monitoring, over-the-air trouble shooting and changing of device settings."

Next, we present examples of two companies that are active in the same product market as Korn Ferry International and ResMed, respectively. First, AMN Healthcare offers workforce solutions and staffing services to healthcare facilities within the U.S. According to our dictionary-based approach, we classify the company as never adopting a digital business model. When considering the 10-K filing, they do have digital-related words, but since they never experience a digital transformation of the business model, we correctly classify it as a never digitalizing company. Examples of sentences from the 2013 10-K filing, which would include digital-related words but demonstrate no true digital transformation of the business model include:

- "We are also making investments in innovative **online** recruitment and mobile technologies to further increase the efficiency and effectiveness of our strategies to attract quality clinicians and physicians."

[18] https://investor.resmed.com/investor-relations/events-and-presentations/press-releases/press-release-details/2014/ResMeds-New-AirSense-10-CPAP-and-APAP-Devices-Deliver-Superior-Patient-Comfort-and-Cost-Saving-Efficiency-for-Healthcare-Providers/default.aspx.

- "We continue to be an innovation leader in healthcare workforce solutions by providing **online** services and tools to both our hospital and healthcare facility clients and our healthcare professionals. Through our SingleSource® **technology**, we provide **online** resources for hospital and healthcare facility clients to streamline their communications and process flow to secure and manage staffing services. Another **online** resource, The Service Connection, provides our clinicians the ability to track assignment information and complete key forms electronically."

- "Our ability to deliver services to our clients and to manage our internal systems depends largely upon our access to and the performance of our management information and communications systems, including our client- and clinician-facing self-service **websites**. (..) If our systems do not adequately support our operations, are damaged or disrupted or if we are required to incur significant additional costs to replace, repair, maintain or expand them, it may adversely affect our business operations and our profitability."

Second, Masimo Corp. is a global medical technology company. It develops, produces, and sells patient monitoring technologies. Also in this case, our dictionary-based analysis classifies the company as never adopting a digital business model. Although Masimo has certain digital-related key words in the business section, it never experiences a core change in its business model towards a digital model. Examples of sentences from the 2015 10-K filing, which would include digital-related words, but demonstrate no true digital transformation of the business model, include:

- "For raw materials, we and our contract manufacturers rely on sole source suppliers for some components, including **digital** signal processor chips and analog to digital converter chips."

- "We and our contract manufacturers have taken steps to minimize the impact of a shortage or stoppage of shipments of **digital** signal processor chips or analog to digital converter chips, including maintaining a safety stock of inventory and designing software that may be easily ported to another digital signal processor chip."

- "We are dependent upon the success and market acceptance of our proprietary Masimo SET® **technology**. Currently, our primary product offerings are based on the Masimo SET® **platform**. Continued market acceptance of products incorporating Masimo SET® will depend upon our ability to continue to provide evidence to the medical community that our products are cost-effective and offer significantly improved performance compared to conventional pulse oximeters."

Appendix B Examples of Sentences with Digital Terms from Item 1A Risk Factors

Company	Sentence Examples
Wayfair Inc. (2015)	We believe that our continued revenue growth will depend upon, among other factors, our ability to: • (…); • increase the frequency with which new and repeat customers purchase products on our sites through merchandising, data, **analytics** and technology;
Trupanion Inc. (2017)	The anticipated benefits of our **analytics** platform may not be fully realized. **Our analytics** platform draws upon our proprietary pet data to price our medical plan subscriptions. (…) Furthermore, if any of our competitors developed similar or better data systems, adopted similar or better underwriting criteria and pricing models or received our data, our competitive advantage could decline or be lost.
Lands' End Inc (2017)	The success of our Direct segment depends on customers' use of our digital platform, including our e-commerce websites, and response to direct mail catalogs and **digital marketing**; if our overall marketing strategies, including our maintenance of a robust customer list, is not successful, our business and results of operations could be adversely affected.
Redfin Corp. (2018)	We also use our business data and **proprietary algorithms** to inform our machine learning, such as in the calculation of our Redfin Estimate, which provides an estimate on the market value of individual homes. If customers disagree with us or if our Redfin Estimate fails to accurately reflect market pricing such that we are unable to attract homebuyers or help our customers sell their homes at satisfactory prices, or at all, customers may lose confidence in us.
Hillshire Brands Corp. (2014)	We also use information technology to process financial information and results of operations for internal reporting purposes and to comply with regulatory, legal and tax requirements. In addition, we depend on information technology for **digital marketing** and electronic communications between our facilities, personnel, customers and suppliers.
Nordstrom Inc. (2018)	In addition, these strategies will require further expansion and reliance on **data science** and **analytics** across all our channels. (...) If we do not successfully implement and expand our digital initiatives, or do not seamlessly integrate or maintain them properly, we may fall short of our customer's expectations, impacting our brand, reputation, profitability and growth.
Oxford Industries Inc. (2014)	Certain of our brands, (...), distribute products through brick-and-mortar retail stores and e-commerce websites and communicate with consumers through social media and other methods of **digital marketing**. (...) The continuing shift in the manner in which retail consumers transact business globally and our efforts to respond to these changes and execute our direct-to-consumer retail strategies could adversely affect our financial results and operations (…).
Stanley Black & Decker, Inc. (2018)	Computer hardware and storage equipment that is integral to efficient operations, such as e-mail, telephone and other functionality, is concentrated

	in certain physical locations in the various continents in which the Company operates. Additionally, the Company relies on software applications and enterprise **cloud** storage systems and **cloud** computing services provided by third-party vendors, and our business may be adversely affected by service disruptions or security breaches in such third-party systems.
Tiffany & Co (2015)	Although the Company has developed and implemented systems and processes that are designed to protect personal and Company information and prevent data loss and other security breaches, such measures cannot provide absolute security. Additionally, the Company's increased use and reliance on web-based hosted (i.e., **cloud** computing) applications and systems for the storage, processing and transmission of information, including customer and employee information, could expose the Company, its employees and its customers to a risk of loss or misuse of such information.
TJX Companies Inc /DE/ (2016)	We modify, update, and replace our systems and infrastructure from time to time, including by (…); integrating new service providers and adding enhanced or new functionality, such as for **cloud** computing technologies and for the continued operation and development of our e-commerce businesses; and adding new systems when we acquire new businesses. (…) Although we believe we are diligent in selecting systems, teams and vendors and implementing procedures to enable us to maintain the integrity of our systems when we modify them, there are inherent risks associated with modifying or replacing systems (...).
Nike Inc (2018)	Furthermore, we depend on Information Technology Systems and personal data collection for **digital marketing**, digital commerce, consumer engagement and the marketing and use of our digital products and services. (…) Any interruption in Information Technology Systems may impede our ability to engage in the digital space and result in lost revenues, damage to our reputation, and loss of users.
Alamo Group Inc (2018)	We also depend on our information technology infrastructure for **digital marketing** activities and for electronic communications among our locations, personnel, customers, and suppliers. These information technology systems (…) may be susceptible to damage, disruptions, or shutdowns due to hardware failures, computer viruses, hacker attacks, telecommunication failures, user errors, catastrophic events or other factors.
Tandy Leather Factory Inc (2017)	Additionally, our increased use and reliance on web-based hosted (i.e., **cloud** computing) applications and systems for the storage, processing and transmission of information, including customer and employee information, could expose the Company, our employees and our customers to a risk of loss or misuse of such information.
Sealed Air Corp/DE (2014)	We are dependent on internal and third-party information technology networks and systems, including the Internet, to process, transmit and store electronic information. In particular, we depend on our information technology infrastructure for fulfilling and invoicing customer orders, applying cash receipts, and placing purchase orders with suppliers, making cash disbursements, and conducting **digital marketing** activities, data processing and electronic communications among business locations.

Mondelez International, Inc. (2017)	We use these technologies and third-party service providers to support our global business processes and activities, including (...) executing various **digital marketing** and consumer promotion activities. Working with these technologies and third-party service providers creates risks related to confidentiality, integrity and continuity, and some of these risks may be outside of our control.
Inogen Inc (2016)	Steps we have taken to remediate the material weakness in our internal control over financial reporting of revenue include: implementation of more extensive random and data **analytics** driven quarterly medical documentation audits, supervisor facsimile and call monitoring, and additional independent scrutiny of medical documentation authenticity.
J M Smucker Co (2018)	In addition, certain of our processes rely on third-party **cloud** computing services. If the service providers to which we outsource these functions do not perform effectively, we may not be able to achieve the expected cost savings and may have to incur additional costs to correct errors made by such service providers.
Scholastic Corp (2017)	The Company's future growth depends upon a number of factors, including the ability of the Company to successfully implement its strategies for its respective business units in a timely manner, the introduction and acceptance of new products and services, including the success of its **digital strategy** and its ability to implement and successfully market new programs in its educational publishing business, (...). Difficulties, delays or failures experienced in connection with any of these factors could materially affect the future growth of the Company.
Pinnacle Foods Inc (2017)	We rely on our information technology systems to effectively manage our business data, **digital marketing** activities, communications, supply chain, order entry and fulfillment, and other business processes. The failure of our information technology systems to perform as we anticipate could disrupt our business and could result in transaction errors, processing inefficiencies, and the loss of sales and customers, causing our business and results of operations to suffer.
Shake Shack Inc. (2018)	As our environment continues to evolve in this digital age and reliance upon new technologies, for example **cloud** computing, become more prevalent, it is imperative we secure the private and sensitive information we collect. Failure to do so (...) could not only cause us to fail to comply with these laws and regulations, but also could cause us to face litigation and penalties that could adversely affect our business, financial condition and results of operations.

Appendix C Variable Definitions

SEC Edgar	Definition
Digital_Rival_Share	Asset weighted share of digitalized rivals in year t; the share is calculated excluding rivals that are always digitalized within our sample period.
Digital_Rival_Tax-Sav_Share	Asset weighted share of digitalized rivals in year t **with** significant tax savings materializing after digitalization, excludes rivals that are always digitalized within our sample period. *Tax savings* are the difference between the three-year average Cash ETR (t, t-1, t-2) minus the three-year average Cash ETR calculated in the three years prior to the year of Digitalization. E.g., if a firm digitalizes in 2013 then the tax savings are in 2017 Cash ETR (2017-2015)- Cash ETR (2012-2010). Tax savings are considered *significant* if above 2 percentage points. In the first two years after digitalization tax savings are set to zero.
Digital_Rival_No-TaxSav_Share	Asset weighted share of digitalized rivals in year t **without** significant tax savings materializing after digitalization, excludes rivals that are always digitalized within our sample period. *Tax savings* are the difference between the three-year average Cash ETR (t, t-1, t-2) minus the three-year average Cash ETR calculated in the three years prior to the year of Digitalization. E.g., if a firm digitalizes in 2013 then the tax savings are in 2017 Cash ETR (2017-2015)- Cash ETR (2012-2010). Tax savings are considered *significant* if above 2 percentage points. In the first two years after digitalization tax savings are set to zero.
AlwaysDigital_Rival_Share	The asset weighted share of rivals a competitor firm faces in the product market space that are always digital.
DIGITAL	A firm-year-level binary variable that switches to 1 in the first year in which the count of digital terms in a firm's business section is above zero. From then on it stays switched on until the end of the sample period. If the digital count for a firm in all periods in our sample is above 0 also the proxy of business model digitization is always set to 1. Equally, if the firm we study is in the tech-industry, as defined in Chen and Srinivasan (2023), we set the indicator to 1 in all periods.
LENGTH	The natural log of the total number of words in a the 10-K file.
Compustat	
MKT Share	Market share defined as competitor firm's sales (SALE) divided by total sales in TNIC-defined product market space.
COGS	Cost of goods sold (COGS) divided by lagged total assets (AT).
GROSS MARGIN	Sales (SALE) minus cost of goods sold (COGS)) divided by sales (SALE).
CASH_Rivals	Product-similarity-score weighted average of cash held by competitors' product market rivals following Donohoe et al. 2022.
SALESVOL_Rivals	Using Compustat quarterly data, we construct a competitor-year product market sales volatility measure. Specifically, we calculate for each rival the standard deviation of the quarterly differences in sales and scale the result by average total rivals' assets over the year. To define the rivals' product market sales volatility, we use the median standard deviation of sales divided by average total assets following Donohoe et al. 2022.

ETR_Rivals	Asset weighted average Cash ETR held by competitors' product market rivals.
HHI	The sum of the squared percentage of sales by each rival firm in a given product market space.
CASH ETR	The sum of cash taxes paid (TXPD) over three years (t, t-1, t-2) scaled by the sum of pre-tax income net of special items (PI-SPI) over the same period, winsorized at 0 and 1.
SIZE	The natural logarithm of total assets (AT).
CASH	Cash and short-term investments (CHE) divided by total assets (AT).
LEVERAGE	The ratio of current liabilities (DLC) plus long-term debt (DLTT) all over total assets (AT).
MTB	The ratio of the market value of equity to the book value of equity ((CSHO*PRCC_F)/CEQ).
NOL	1 if tax loss carryforward is greater than 0 (TLCF); 0 otherwise.
ROA	Pre-tax income (PI) over total assets (AT).
INTANGIBLE	Total intangible (INTAN) over total assets (AT).
PPE	Net property plan and equipment (PPENT) over total assets (AT).
SALES_GROWTH	Mean sales growth over the past three financial years ((SALES-L3.SALES)/L3.SALES).
EARN_VOL	The natural log of the standard deviation of the change of split adjusted EPS (EPSPX*ADJEX_F) of the previous 5 years.
MNC	1if the absolute value of foreign profits (PIFO) or foreign tax expense (TXFO) is greater than 0, following Dyreng et al. (2017) or the firm reports in that year a foreign subsidiary in Exhibit 21; 0 otherwise.

Exhibit 21	
Subsidiary in Tax Havens	The total number of subsidiaries located in tax havens as reported in Exhibit 21. The list of tax havens is based on Dyreng et al. (2020).

Appendix D Additional Descriptive Statistics

Panel A Competition Analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) MKT_Share	1.000																
(2) COGS	**0.139**	1.000															
(3) Gross Margin	**-0.071**	**-0.508**	1.000														
(4) Digital_Rival_Share	**-0.061**	**0.048**	**0.102**	1.000													
(5) Digital_Rival_TaxSav_Share	-0.019	-0.008	**0.085**	**0.543**	1.000												
(6) Digital_Rival_NoTax-Sav_Share	**-0.061**	**0.062**	**0.069**	**0.855**	**0.030**	1.000											
(7) AlwaysDigital_Rival_Share	-0.009	0.015	0.004	**-0.030**	-0.017	**-0.025**	1.000										
(8) SIZE	**0.247**	**-0.249**	**-0.069**	-0.020	**0.042**	**-0.050**	**-0.049**	1.000									
(9) CASH	**-0.041**	**0.041**	**0.315**	**0.084**	**0.030**	**0.082**	**0.124**	**-0.298**	1.000								
(10) MTB	**0.028**	0.010	**0.068**	**0.050**	**0.062**	0.021	-0.003	**0.030**	**0.047**	1.000							
(11) LEVERAGE	-0.015	**-0.235**	-0.025	0.009	**0.038**	-0.012	**-0.077**	**0.345**	**-0.401**	**-0.049**	1.000						
(12) NOL	**0.055**	**-0.183**	-0.015	**0.047**	**0.046**	**0.027**	0.023	**0.298**	**-0.160**	-0.021	**0.210**	1.000					
(13) HHI	**0.573**	**0.121**	**0.057**	0.000	-0.010	0.007	**0.056**	**-0.258**	**0.077**	0.016	**-0.140**	**-0.043**	1.000				
(14) CASH_RIVALS	**-0.082**	**-0.060**	**0.218**	**0.120**	**0.101**	**0.081**	**0.028**	**0.186**	**0.124**	**0.057**	**-0.043**	**0.071**	**0.034**	1.000			
(15) SALESVOL_RIVALS	**0.066**	**0.254**	**-0.069**	**0.088**	0.002	**0.104**	**-0.053**	**-0.141**	**0.100**	-0.017	**-0.077**	**-0.063**	**0.136**	**-0.059**	1.000		
(16) ETR	**0.114**	**0.205**	**0.043**	**0.079**	0.009	**0.089**	**0.041**	**-0.112**	**0.205**	0.011	**-0.250**	**-0.176**	**0.153**	**0.114**	**0.155**	1.000	
(17) ETR_RIVALS	**0.054**	**0.227**	**0.083**	**0.067**	**-0.041**	**0.105**	**-0.033**	**-0.069**	**0.143**	0.011	**-0.119**	**-0.119**	**0.086**	**0.204**	**0.246**	**0.287**	1.000

Panel B Tax Savings Analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. DIGITAL	1.000													
2. ETR	**0.024**	1.000												
3. GAAP ETR	0.005	**0.346**	1.000											
4. Subsidiary in Tax Haven	**0.156**	-0.011	**-0.073**	1.000										
5. ROA	0.007	**0.132**	**-0.019**	0.002	1.000									
6. INTANGIBLE	**0.149**	**0.018**	0.010	**0.178**	**-0.161**	1.000								
7. PPE	**-0.283**	**-0.211**	**-0.057**	**-0.310**	**-0.099**	**-0.514**	1.000							
8. SIZE	**0.032**	**-0.075**	0.002	**0.235**	**-0.141**	**0.116**	**0.132**	1.000						
9. MTB	**0.039**	0.013	-0.017	**0.029**	**0.137**	-0.003	**-0.026**	**0.032**	1.000					
10. SALES_GROWTH	0.006	**-0.077**	**-0.072**	**-0.020**	**0.095**	**0.060**	**-0.033**	**-0.087**	**0.021**	1.000				
11. LEVERAGE	**-0.093**	**-0.132**	0.002	-0.011	**-0.137**	**0.164**	**0.198**	**0.241**	**-0.059**	0.000	1.000			
12. EARN_VOL	**0.069**	**0.103**	**0.044**	**0.063**	**0.034**	**0.024**	**-0.239**	**-0.240**	0.000	**0.032**	**-0.045**	1.000		
13. LENGTH	**0.083**	**-0.224**	**-0.075**	**0.077**	**-0.213**	**0.066**	**0.120**	**0.314**	**-0.033**	**0.057**	**0.236**	0.000	1.000	
14. MNC	**0.143**	**0.061**	**-0.025**	**0.652**	**0.019**	**0.232**	**-0.382**	**0.186**	**0.038**	0.008	**-0.029**	**0.088**	**0.023**	1.000

The panels present correlations for the relevant variables in the competition (Panel A) and tax savings (Panel B) analysis. Detailed variable descriptions can be found in Appendix C. Correlations significant at $p < 0.10$ are shown in bold.

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