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**Working Paper**

## Going global, going digital: Firm internationalisation and digital resource use

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Diskussionspapier des  
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1/2025

**Going Global, Going Digital**

Firm Internationalisation and Digital Resource Use

Pascal Mayer

Discussion Paper of the  
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**Going Global, Going Digital  
Firm Internationalisation and Digital Resource Use**

*Pascal Mayer*

**Abstract**

This research paper explores the relationship between firm internationalisation and digital resource use. On the one hand, the modularity of digital resources and their applicability in different international contexts provide significant benefits to multinational companies. On the other hand, the complexity of managing digital resources across different institutional systems escalates with rising levels of internationalisation. Because of these competing forces, I argue that the relationship is inversely U-shaped. Additionally, I investigate the moderating effect of firms' financial constraints and conjecture a steepening effect of the inverted U-shape. In my empirical identification strategy, I employ a text-based measure of internationalisation, based on companies' 10-K annual reports, and combine this measure with data on internet and e-commerce technology used by Standard & Poor's 1,500 firms. The results provide empirical support of an inverse U-shaped relationship and the moderating role of financial constraints. Various robustness tests corroborate the findings. This study contributes to the literature streams of firm internationalisation and information systems research by highlighting the trade-offs faced by MNEs when they "go digital".

JEL Codes: F20, F23, M16, O33

Keywords: Digital Resources, Digital Strategic Initiatives, Financial Constraints, Firm Internationalisation, Multinationals

# **Globalisierung und Digitalisierung**

## **Internationalisierung von Unternehmen und Nutzung digitaler Ressourcen**

### **Zusammenfassung**

Diese Studie untersucht den Zusammenhang zwischen der Internationalisierung von Unternehmen und der Nutzung digitaler Ressourcen. Einerseits bieten die Modularität digitaler Ressourcen und ihre Anwendbarkeit in verschiedenen internationalen Kontexten erhebliche Vorteile für internationale Unternehmen. Andererseits nimmt die Komplexität der Verwaltung digitaler Ressourcen über verschiedene institutionelle Systeme hinweg mit zunehmenden Internationalisierungsgrad zu. Aufgrund dieser konkurrierenden Kräfte argumentiere ich, dass sich die Beziehung durch ein umgekehrtes U beschreiben lässt. Darüber hinaus untersuche ich die moderierende Wirkung von finanziellen Beschränkungen und vermute eine Streckung des Zusammenhangs. In der empirischen Identifikationsstrategie verwende ich ein textbasiertes Maß zur Messung der Internationalisierung von Unternehmen, das auf 10-K-Jahresberichten US-amerikanischer Unternehmen des S&P 1.500 Index basiert, und kombiniere dieses mit Daten zu Internet- und E-Commerce-Technologien sowie Buchhaltungs- und Finanzkennzahlen. Die Ergebnisse unterstützen die Hypothesen einer umgekehrt U-förmigen Beziehung sowie der Moderation durch finanzielle Beschränkungen. Mehrere Robustheitstests untermauern die Ergebnisse. Diese Studie leistet einen Beitrag zur Literatur im Bereich der Unternehmensinternationalisierung und Informationssysteme, indem sie Zielkonflikte aufzeigt, denen sich multinationale Unternehmen gegenübersehen, wenn sie digitalisieren.

Im Internet unter:

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# Going Global, Going Digital

## Firm Internationalisation and Digital Resource Use

### 1. Introduction

The ongoing digitalisation and rapid improvement of digital technologies fundamentally impact economic activity. This includes consumption patterns (Agarwal et al. 2024), evidenced by the adoption of digital payment systems or new purchase opportunities made available through smart speakers (Son et al. 2023). Firms are significantly affected by the shifts caused by digital technologies as they substantially reduce “the cost of storage, computation, and transmission of data” (Goldfarb & Tucker 2019, p. 3). Research has highlighted the necessity for firms to adapt their strategies to remain competitive and survive in light of the fast-changing environment (Menz et al. 2021, Miller & Wang 2024) and the special role information technology (IT) play in those strategies (Bharadwaj et al. 2013). The recent academic debate has put a spotlight on *digital resources* because of their attributes and special capacity “to create and appropriate economic value” (Piccoli et al. 2022, p. 2289).

Despite this growing body of literature, there are still gaps in our understanding of how digital resources are related to specific aspects of firm strategy. As firms increasingly operate in a global environment, multinational corporations (MNCs) face particular circumstances and challenges regarding the digital realm, about which little is known, as evidenced by calls for research into the consequences of digital technology MNCs use in their operations (Chabowski & Samiee 2020).

Responding to this call to investigate MNCs behaviour regarding digital technology, I set out to examine the relationship between firm internationalisation and the use of digital resources. Based on the insights from research in management, international business and information systems, I conjecture that the relationship between firm internationalisation and digital resource use can be described by the functional form of an inverted U. I suggest this specific form because of two latent relationships. First, with increasing levels of internationalisation, MNCs enjoy various benefits in implementing digital resources as the digital resources help to manage the complexity associated with further internationalisation. This is rooted in the modularity attribute of digital resources (Piccoli et al. 2022). In addition, digital resources bring particular benefits, such as positive economies of scale in global service provision (Autio et al. 2021). This latent relationship is subject to diminishing returns, as each additional digital resource used brings a smaller benefit to the firm. The second latent

relationship counteracts the advantages of the first latent relationship and causes disadvantages. With increasing firm internationalisation, institutional distance (Kostova et al. 2020, Xu & Shenkar 2002) increases. Given the presence of multinational corporations in, and their export activities to multiple countries, the use of digital resources brings escalating challenges due to differing national technology regulations (Kallinikos 2010).

Financial constraints have been shown to affect firms' behaviour and their investment options (Almeida et al. 2004, Fazzari et al. 1988, Whited 1992). This is arguably an important contingency of the relationship at focus, as the implementation of digital resources constitute an investment. I argue that firms' financial constraints moderate the inverted U-shaped relationship between firm internationalisation and digital resource use, because financial constraints affect both latent relationships. On the one hand, firms' that face larger financial constraints are in higher need to address the complexity associated with internationalisation and thus invest more in digital infrastructure than their less constraint peers do. On the other hand, stronger financial constraints restrict firms to adapt their digital infrastructure to various local digital institutional systems. Together, those effects suggest a steepening moderating effect of financial constraints.

In order to test the hypotheses and clarify the relationship between firm internationalisation and digital resource use, I bring together various types of data. A text-based measure, based on companies 10-K annual reports, quantifies firms' level of internationalisation (Mayer & Schäper 2023). Combined with information of firms' use of digital technologies and enriched by firms' financial and accounting data, the final sample contains more than 7,300 firm-year-observations of more than 1,300 firms. The main regression results, as well as additional robustness checks, support my theorising and buttress the notion of an inverted-U relationship.

By clarifying the relationship between firm internationalisation and digital resource use, this study contributes to information systems (Baiyere et al. 2023, Piccoli et al. 2022) and international business research. I show that MNCs face particularly complex realities and challenges in the digital age (Verbeke & Hutzschenreuter 2021), which necessitates a thorough understanding of the trade-offs associated with implementing digital resources in global strategy formation. The findings of this study, therefore, also have implications for management. Managerial decisionmakers should be aware of the complex implications of strategically planning to use more digital resources.

## 2. Theoretical Background

With the rise of digital technologies, consumers shift more and more consumption into the digital space (Agarwal et al. 2024, Son et al. 2023). Research has shown, for example, that consumer spending increased after the introduction of digital payment systems in India (Agarwal et al. 2024). There is also evidence of a significant impact of email advertisement on retail sales (Zhou et al. 2024).

This market-driven trend is caused and accompanied by technology reducing “the cost of storage, computation, and transmission of data” (Goldfarb & Tucker 2019, p. 3). Adner, Puranam, and Zhu (2019) identified three basic developments that represent the root cause of digital transformation and, thus, firms’ need of strategic change: representation, connectivity, and aggregation. With representation the authors refer to the idea that information is captured and represented by previously unattainable data or differently coded. Connectivity captures the fact that links between people and organisations are intensified and multiplied, and aggregation relates to the new possibilities of inference due to new and distinct combinations of various data (Adner et al. 2019). Those fundamental changes due to digitalisation necessitate firms to adapt and realign their strategy to survive and thrive in today’s competitive global environment (Miller & Wang 2024). Firms that do not adapt to the fast-changing competitive global environment due to technological change may be crowded out of the market quickly in a Schumpeterian kind of creative destruction (Christensen 1997, Schumpeter 1942). In fact, the need for information technology to play a central role in business strategy, rather than just a functional role, was called for more than ten years ago (Bharadwaj et al. 2013), and its relevance has only increased. Various studies have demonstrated the relevance of digitalisation for firm strategy. For instance, Steelman, Havakhor, Sabherwal, and Sabherwal (2019) established a positive link between IT initiatives and firm performance. Miller and Wang (2024) have highlighted the need to consider the different attributes of digital products compared to physical products, implying that firms need to adjust their focus to maintain their market position. Benzell, Hersh, and van Alstyne (2024) showed that firms can achieve substantial growth rates and outperform their peers when they voluntarily disclose data through application programming interfaces (APIs). Firms can also obtain a competitive advantage by selling their products directly to customers, using digitalisation and cutting out the downstream middleman (Schauerte et al. 2024).

Because digitalisation affects firms and their strategy on such a fundamental level, academic research has seen a substantial increase in constructs specifically addressing the digital dimen-

sion of firms (Baiyere et al. 2023). In response to research calls that emphasise the need to bring clarity to concepts and terminology in the digital realm, recent research has proposed the constructs of *digital strategic initiatives* and *digital resources* (Piccoli et al., 2022). This research project specifically builds on the work of Piccoli, Rodriguez, and Grover (2022) and conceptualises “digital strategic initiatives as identifiable competitive moves that depend on the use of digital resources to create and appropriate economic value” (p. 2290). Furthermore, I follow the authors and conceptualise digital resources as a “specific class of digital objects that (1) are modular, (2) encapsulate objects of value, namely assets and/or capabilities, and (3) are accessible by way of a programmatic interface” (Piccoli et al. 2022, p. 2293). The first attribute of modularity captures the fact that digital objects can be assembled in multifaceted ways with other digital objects and that digital objects itself can be a combination of various digital objects. From this perspective, modularity implies that digital resources can manifest themselves in many potential configurations and reconfigurations, allowing for flexibility (Schilling 2000). The value characteristic refers to the idea that implementing a digital resource must contribute to the value-creating processes of the firm. The accessibility of digital objects with a programmatic interface is a specific distinction from access by using “a manual or physical interface” (Piccoli et al. 2022, p. 2294) A digital resource is accessed with a bitstring, i.e., an array of zeros and ones (Piccoli et al. 2022).

Digital resources are thus necessary components of any digital strategy, and firms need to manage those within the company. However, managing digital resources and aligning firm strategy is difficult for organisations. Previous research has identified various challenges firms encounter in their digitalisation strategy. Based on findings from multiple firms using a case-study methodology, Björkdahl (2020) diagnosed a tendency for firms to focus their digitalisation efforts towards efficiency instead of growth, rooted in firms’ struggles in “identifying profitable configurations of competencies, assets, and data generated from digital technologies, orchestrating them, and exploiting them in an agile organization” (p. 17). Other studies have revealed practical challenges for firms. The wide variety of devices consumers may use to access digital products is proving challenging for firms’ bundling strategies, for example (Bhargava 2023). Other investigations suggest that the uncertainty associated with digital transformation is causing firms to lose out to competitors (Gomes et al. 2024, Nambisan 2017).

The need to devise digital strategies to stay competitive and its associated challenges are not confined to firms that operate in a domestic environment alone. Multinational corporations



(MNCs), operating in multiple countries (Ghoshal & Bartlett 1990), are also grappling with devising digital strategies. MNCs have substantial opportunities to be gained by implementing digital strategies and resources, but they also face an additional layer of complexity due to their international footprint. Research has discussed firms that are international from the outset, the so-called “born globals”, and identified the particular role key technologies play in their function to decrease transaction costs (Birkinshaw 2022, Knight 2010). However, the relevance of digitalisation is not limited to those born global firms. Traditional MNCs also face the market pressure and the challenges associated with digitalisation in numerous ways.

The great challenges that MNCs face in the global marketplace due to digitalisation is also reflected in a variety of reports that address the challenges associated with digitalisation for firms, countries and employees alike. For instance, the Lausanne Institute for Management Development Report on World Digital Competitiveness (IMD 2025) highlights the key role of digital competitiveness for countries to achieve economic growth and the danger for countries of being left behind. The report illustrates the wide disparities between countries’ digital competitiveness by ranking them and thus demonstrates the challenges for MNCs to navigate this complex digital environment successfully. Other reports, such as the German ifo Institute’s annual report (ifo Institute 2024) or OECD working papers (Berger & Frey 2016), emphasise the transformative role of digitalisation. The ifo Institute (2024) highlights the impact and challenges of digitalisation for many industries, not only, but especially the German car industry, which is affected by digitalisation. Berger and Frey (2016) underline the potential effects of digital technology on productivity and labour markets. In general, the density of academic articles, reports and general media coverage on the transformative role of digitalisation, in which firms are the main actors, is exemplary of the need for firms to develop digital strategies and use digital resources.

### **3. Hypotheses Development**

Two latent and competing forces are key to my argument concerning the relationship between firm internationalisation and the use of digital resources. The first latent relationship represents the link between digital resources and the variety of benefits they bring to the multinational firm. The various positive effects that digital resources can bring to the multinational corporation arise from the attribute of modularity (Piccoli et al. 2022). The key aspect of modularity is the ability to separate and recombine the components of a system (Schilling 2000). For this reason, digital resources are highly beneficial to multinational

corporations, whose reality is often described as complex, because of “the multiplicity of entities, multiplexity of interactions, and dynamism of the global economic system” (Eden & Nielsen 2020, p. 1609), the relationships to its’ subsidiaries (Andrews et al. 2023) or the “embeddedness of MNE and host government in a complex global network of nations” (Cannizzaro 2020, p. 829). Because digital resources are modular, they can be separated and arranged in various ways such that they address the specific complexity MNCs face and adjusted to the idiosyncrasies of different countries, markets, cultures, business infrastructures and contexts. This is illustrated, for example, by Tatarinov, Ambos, and Tschang (2023), who use a case study methodology to analyse four United Nations projects, in which the modularity aspect of digital solutions allow scaling across different contexts. They contend that “digital solutions allow simultaneous replication (through their modularity) and adaptation (through their generativity and affordances). Because these properties are always interconnected, they enable the digital solution to scale across borders faster and more seamlessly than traditional technology products” (Tatarinov et al. 2023, p. 650).

Viewed from this perspective, digital resources can help firms to scale up their service in a global environment (Autio et al. 2021), provide services in foreign markets without a physical presence there by using added manufacturing and augmented reality, and simplify communication (Laplume et al. 2016). Digital resources may also help firms tread new paths when entering new countries and enable them to create a “virtual presence” (Brouthers et al. 2022). Brouthers, Chen, Li, and Shaheer (2022) suggest that digitalisation can support firms in identifying and insourcing capabilities or knowledge flows. They also point out that digitalisation facilitates novel capital flows and, thus, new ways of raising capital. Research also shows that the adoption of digital technologies is enabling organisations to source their work from anywhere through remote working and employees to work from anywhere (Choudhury et al. 2021). However, even though digital resources are beneficial for the firm, I conjecture that this beneficial impact is subject to diminishing returns. Whereas the first digital resources implemented bring substantial benefits to the MNC, the marginal effect decreases such that each additional digital resource added brings a smaller marginal benefit to the firm.

The second latent relationship counteracts the first relationship. With increasing levels of firm internationalisation, the MNC needs to navigate more and various institutional systems regarding the digital space. Adjusting and recombining the digital resources becomes increasingly difficult for firms as the legislation and regulation between different institutional landscapes differs (Kallinikos 2010, Stallkamp 2021). The challenges such regulation brings

to firms is for instance exemplified in the EU's Digital Service Act (The Economist 2024a) or the role of the EU in regulating technology such as artificial intelligence (The Economist 2023). Similarly, the so-called "tech war" between the United States and China (Ryan & Burman 2024), a corollary of geopolitical tensions, illustrates the difficulties MNCs face when implementing digital resources across borders. The hotly debated topic of foreign platform regulation is emblematic of this (Sitaraman 2022). In the context of global powers competing, rivalling for influence, technology emerges as the means and battleground in the geopolitical landscape (The Economist 2022, 2024b), in effect impeding MNCs in their strategy to deploy digital resources.

In addition, with higher levels of firm internationalisation, firms may struggle to implement digital resources and coherently integrate them into their strategy because they lack the knowledge and capabilities to manage the resources that can only be built up slowly over time (Jean et al. 2020, Saban & Rau 2005). The implementation of too many digital resources may also change the processes of the firm's value creation so drastically, such as distribution and sales (Meyer et al. 2023), for example through novel technologies such as artificial intelligence or 3D printing (Choi et al. 2022), that digitalisation may sever the link between the firm-specific advantages that an MNC owns (Verbeke & Hutzschenreuter 2021).

Combining those two underlying latent relationships results in a curvilinear relationship (Haans et al. 2016) between firm internationalisation and digital resource use. Firms face this trade-off between advantages and disadvantages of implementing digital resources. In the first relationship, firm internationalisation is positively related to benefits due to the use of digital resources but characterised by diminishing returns. In essence, this is because MNCs can exploit the modularity attribute of digital resources and reconfigure them to various contexts. In the second relationship, firm internationalisation brings disadvantages due to different institutional systems regarding digital regulation. Crucially, this study assumes that firms consider these trade-offs and choose the optimal level of digital resources that maximises net benefits. Therefore, the latent relationship between firm internationalisation and benefits of digital resource use, and the latent relationship between firm internationalisation and disadvantages of digital resource use, results in an overall relationship of a functional form of an inverted U. With such a functional form, the optimal level of digital resource usage can be found at intermediate levels of firm internationalisation. Formally, the hypothesis is stated as follows:

*Hypothesis 1: The relationship between firm internationalisation and firm digital resource use takes the functional form of an inverted U.*

A crucial condition that facilitates or restricts the firms' possible set of actions is the extent of financial constraints it faces. The concept of financial constraints is prominent in the finance literature and essentially describes the idea that firms' do not have equal access to capital markets, i.e. internal financing enjoys a cost-advantage over external financing (Fazzari et al. 1988). This notion constitutes a departure from an unconstrained, perfect information perspective based on Modigliani and Miller (1958), in which firms represent homogeneous actors whose financial structure is irrelevant for their respective capital costs. From a financial constraint perspective, since firms differ along various characteristics, firms face different degrees of financing constraints, affecting their set of possible investments (Fazzari et al. 1988). Various studies have attempted to quantify firms' financial constraints and investigate the effect on various outcomes with different techniques and data. For instance, Whited (1992) used data from US firms and structural equation modelling to explain differences in real investment expenditures with firms' debt structure, whereas Love (2003) exploited financial development differences across countries and showed that firms face larger financial constraints in less developed financial markets. Almeida, Campello, and Weisbach (2004) showed that firms with higher financial constraints exhibit a higher cash flow sensitivity of cash, i.e. they save a larger proportion of cash from their cash flow than their less constrained peers. Lamont, Polk, and Saá-Requejo (2001) provided evidence that the stock market treats constrained firms similarly, suggesting that those firms are exposed to the same market shocks. Another study finds that constrained firms have a better ratio of value-to-investment than unconstrained firms, suggesting that constrained firms funnel cash to more attractive projects (Denis & Sibilkov 2010).

Since (aggregate) investment is also crucial for macroeconomic developments, understanding the concept of financial constraint is also highly relevant to the economic research community (Bahaj et al. 2022, Drechsel & Kim 2024, Jeanne & Korinek 2019). Whereas financial constraints traditionally have been measured by indices based "on macro firm characteristics such as age and size" (Bodnaruk et al. 2015, p. 623), more recent studies used different approaches, in which the language within firms' 10-K annual reports have been analysed. In essence, these text-based measures quantify financial constraints by analysing how many constraining words are used in the relevant passages of the report. Studies that developed and applied these mea-

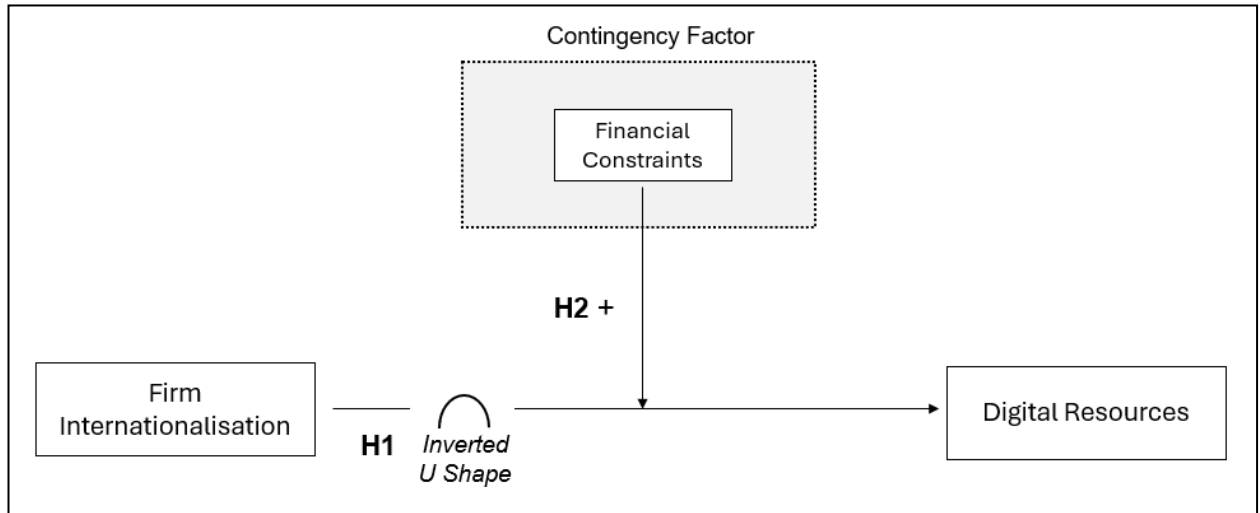
asures are, for instance, Bodnaruk, Loughran, and McDonald (2015), Hoberg and Maksimovic (2015), and Loughran and McDonald (2011).

Financial constraints are also relevant in this investigation on the relationship between firm internationalisation and digital resource use and likely moderate the relationship since implementing digital resources requires investment. Firms that face less constraints can invest more lavishly than their constrained peers because they enjoy a cost-advantage with respect to capital (Fazzari et al. 1988). I conjecture that financial constraints affect both latent relationships that are underlying my first hypothesis. First, financially constrained firms have a shortage of cash to fund the projects they are hoping to realise. This scarcity of cash leads the affected firms to prioritise investments in digital resources as their modularity attribute allows the constrained firm to reduce the complexity constraining them, effectively identifying high value-to-investment ratios (Denis & Sibilkov 2010). Second, financial constraints also amplify the disadvantageous effect of higher levels of firm internationalisation on digital resources. This is because financial constraints constrain the firm to a greater extent than their unconstrained peers regarding their ability to navigate the different institutional systems with their digital strategy and shoulder the costly adaption of digital resources to specific compliance regulations of different countries. In addition, lobbying practices for favourable foreign regulation towards technology is costly, putting constrained firms at a disadvantage compared with unconstrained firms. This is illustrated, for instance in big tech companies' efforts in influencing the EU's "General Data Protection Regulation" (Gorwa et al. 2024, p. 2).

Financial constraints thus play a dual role: On the one hand they lead firms to prioritise crucial investments in digital resources, allowing the firm to scale up and relieve constraints, on the other hand they prevent the firm from adapting its digital resources to adverse digital and institutional regulations. Formally, I state the second hypothesis as follows:

*Hypothesis 2: Financial constraints positively moderate the relationship between firm internationalisation and digital resource use such that the functional form of an inverted U is stretched for higher levels of financial constraints.*

The conceptual research model, depicting our hypotheses, is shown in Figure 1.



**Figure 1: Conceptual Model**

## 4. Empirical Methodology

This section presents the empirical approach to test the hypotheses. The first subsection describes the text-based measure, a quantifiable metric of firms' level of internationalisation. The following subsections specify the development of the final sample for the analysis and delineate the variables and the employed regression models.

### 4.1. Text-Based Measure for Internationalisation

The text-based measure quantifying the level of firm internationalisation is founded on the methodology of Schäper, Jung, Foege, Bogers, Fainshmidt, and Nüesch (2023) and applied to the context of internationalisation by Mayer and Schäper (2023). The method is based on a dictionary of keywords and topics that capture, in this context, various dimensions of firm internationalisation. In a second step, an algorithm utilises the dictionary, combs through a body of text and quantifies the prevalence of the keywords previously specified. I obtained the dictionary by using an unsupervised learning algorithm that identifies common themes in the 1,000 most-cited papers on internationalisation, confining the search to the main journals in this research area, following the restrictions of Kim and Aguilera (2016). Table A1 in the appendix informs the reader with example themes and the associated keywords of the dictionary. This dictionary is then applied to companies' 10-K annual reports, which were retrieved from the United States Securities and Exchange Commission (SEC) database. The final score indicates the relative frequency of the dictionary keywords in relation to the total

number of words of each report. Since companies have to issue those reports every year, the resulting metric is available on the level of firm-year.

## 4.2. Sample Construction

Information from three separate databases make up the final sample, with which the relationship between firm internationalisation and digital resource use is examined. For the dependent variable, I used longitudinal data on firms' web technologies compiled by Builtwith, an Australian firm specialising in market analysis and providing business analysis tools. To this data, I merged the firm's financial and accounting data, retrieved from the CRSP/Compustat merged database, allowing to introduce controls for fundamental firm characteristics and performance metrics (Kim & Bettis 2014). Finally, I added the text-based metric that captures the level of internationalisation per firm-year. The final sample contains more than 7,000 observations from more than 1,300 firms from 2011 to 2019.

## 4.3. Variables

**Dependent Variable:** I measured *Digital Resources* by the number of active digital technologies a firm utilises each year. The dataset from Builtwith contains information on the internet and e-commerce technology used by Standard & Poor's 1,500 firms per year. Such technology can be implemented in the form of shop software used by online vendors or marketing software that facilitates an artificial intelligence controlled, targeted customer approach via e-mail or SMS. Based on that information, I calculated the number of active technologies per firm-year. Finally, I transformed the count variable by the natural logarithm. Even though internet and e-commerce technology only represent a subset of all the varieties of digital resources, I believe that the measure represents a good proxy for digital resources in general.

**Independent Variable:** I measured *Firm Internationalisation* with the metric described in the previous section reflecting the number of internationalisation keywords as a percentage of the total number of words in firms' 10-K annual reports. A higher value of our score reflects a higher level of firm internationalisation in a given year.

**Moderating Variable:** In order to measure *Financial Constraints*, I reverted to the measure developed by Hoberg and Maksimovic (2015). The metric the authors developed is "based on analysis of the Management's Discussion and Analysis (MD&A) section" (Hoberg & Maksimovic 2015, p. 1313), in which managers discuss the firms' liquidity issues. In essence, the metric captures liquidity constraints by computationally comparing the vocabulary of relevant

passages in firms' 10-K reports with the vocabulary of a training dataset of firms which are known to have liquidity problems. The final score is continuous and higher values of the score indicate that the respective firm shares more similarities with firms with liquidity problems, i.e. the firm faces tighter financial constraints.

**Control Variables:** Following established practice (Deb et al. 2017, Kim & Bettis 2014), I included various control variables to account for confounding effects of firm characteristics and firm performance. To control for the effects of firm size, I included the book value of firms' total assets as well as the number of sales, both of which were transformed by the natural logarithm to reduce the effect of outliers. I also added firms' research intensity (Hall 1992) as this could be an important factor influencing the adoption of new technology. I also controlled for sales growth as a proxy for firm growth, firms' scaled capital expenditures, leverage ratio and return on sales (Kim & Bettis 2014).

#### 4.4. Statistical Model

The final longitudinal dataset contains information about firms over several years. Thus, I can use panel data econometric techniques to explain the variation in the dependent variable (Wooldridge 2008). For the main models, both the main effect and the moderating effect, I use generalised estimation equation (GEE) regression modelling with an assumed Gaussian distribution of the dependent variable. I lag all independent variables by one year to accommodate the time required for their effects on the dependent variable to manifest. In addition, I use cluster-adjusted standard errors on the firm-level to account for heteroskedasticity. Since I am testing for an inverted U-shape relationship, I have to include the squared term of the independent variable in the regression model (Haans et al. 2016). Testing the moderating effect of *Financial Constraints* requires the interaction of the moderator variable with both the linear and the squared term of the main independent variable, *Firm Internationalisation*, and the inclusion of the linear effect of the moderator variable.

### 5. Results

#### 5.1. Descriptive Statistics

Descriptive statistics of the sample are presented in Table 1. The correlation table is shown in Table A2 in the appendix. For the first model, the regression considers 7,257 observations from 1,364 firms. Unfortunately, data for the moderating variable is only available up to 2015. As I lag my independent variables by one year, this allows me to run a regression up to



2016 for the dependent variable with a sample size of 2,556 observations for the second regression model.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Digital Resources	7,257	3.787	0.971	0	6.165
Firm Internationalisation	7,257	0.302	0.208	0.057	1.661
Firm Internationalisation <sup>2</sup>	7,257	0.135	0.280	0.003	2.758
Financial Constraints	2,556	-0.023	0.078	-0.242	0.246
Total Assets	7,257	8.261	1.740	1.950	14.78
Firm Size	7,257	7.668	1.604	1.796	13.07
Capital Intensity	7,257	0.039	0.048	0	.519
Firm Growth	7,257	0.079	0.213	-1.684	7.324
Leverage Ratio	7,257	0.755	0.194	0.014	1
Return on Sales	7,257	0.091	0.147	-1.089	0.535
R&D Ratio	7,257	0.034	0.077	0	0.965

**Table 1: Descriptive Statistics**

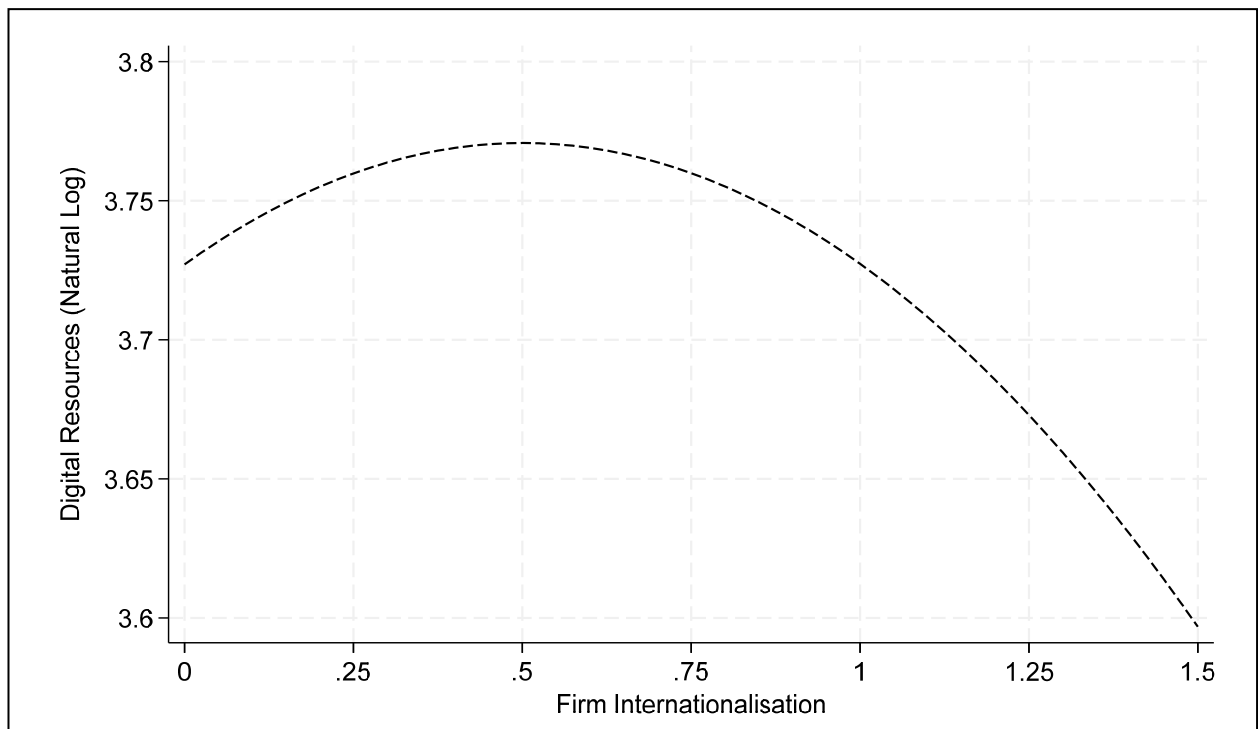
## 5.2. Regression Results

Table 2 shows the regression results of the main model specification. In the first regression model which tests the main relationship, the estimated coefficient of the main independent variable *Firm Internationalisation* is positive and marginally significant ( $\beta = 0.174$ ,  $p = 0.059$ ), close to the usually accepted threshold of 5 %. Importantly, the coefficient of the squared term of the independent variable is negative and significant at the 5 % level ( $\beta = -0.174$ ,  $p = 0.012$ ). Those results suggest the presence of a functional form of an inverted-U between *Firm Internationalisation* and *Digital Resources*. Confidence in this result is reinforced by an additional post-estimation test, which follows the suggestions of established research (Haans et al. 2016). The test indicates with a t-value of 1.82 and a p-value of 0.035 that the slope of the function is positive for lower levels of the independent variable, reaches a maximum, and then becomes negative for higher levels of the respective variable. Based on the estimated coefficients of the regression results, the plotted estimated values of the dependent variable presented in Figure 2 have the typical shape of an inverse parabola, which further strengthens the confidence in the results.

Model	(1)	(2)
Dependent Variable	Digital Resources (Natural Log)	Digital Resources (Natural Log)
Firm Internationalisation	0.174* (0.092)	0.430*** (0.149)
Firm Internationalisation <sup>2</sup>	-0.174** (0.069)	-0.315*** (0.098)
Financial Constraints		-0.820** (0.398)
Firm Internationalisation × Financial Constraints		3.696*** (1.425)
Firm Internationalisation <sup>2</sup> × Financial Constraints		-2.046** (0.952)
Total Assets	-0.050*** (0.017)	-0.031 (0.036)
Firm Size	0.119*** (0.019)	0.107*** (0.038)
Capital Intensity	-0.362 (0.308)	-0.279 (0.357)
Firm Growth	0.015 (0.024)	-0.066** (0.034)
Leverage Ratio	0.033 (0.071)	0.163 (0.114)
Return on Sales	-0.001 (0.043)	0.008 (0.082)
R&D Ratio	0.658*** (0.173)	0.944*** (0.246)
Constant	2.166*** (0.119)	1.942*** (0.188)
Observations	7,257	2,556
Number of Firms	1,364	815
Year Dummies	Yes	Yes
R <sup>2</sup>	-	-
Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1		

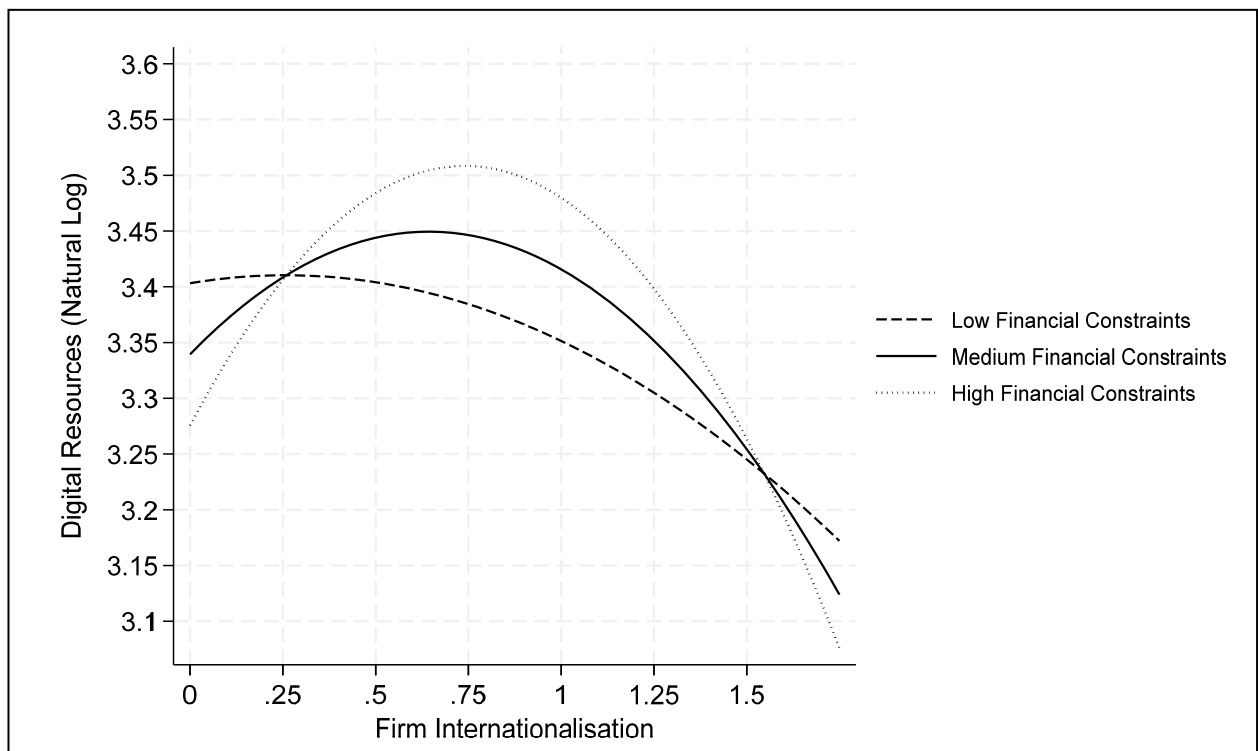
**Table 2: Main Regression Results**

The second regression model tests for a potential moderating effect of *Financial Constraints* on the main relationship between *Firm Internationalisation* and *Digital Resources*. The coefficients of *Firm Internationalisation* ( $\beta = 0.430$ ,  $p = 0.004$ ) and *Firm Internationalisation*<sup>2</sup> ( $\beta = -0.315$ ,  $p = 0.001$ ) retain their direction and are both highly significant. In addition, the interaction effect of the moderator variable *Financial Constraints* with *Firm Internationalisation* ( $\beta = 3.660$ ,  $p = 0.009$ ) as well as with *Firm Internationalisation*<sup>2</sup> ( $\beta = -2.046$ ,  $p = 0.032$ ) show the hypothesised signs and are both significant.



**Figure 2: Estimated Values of Regression Model 1**

Figure 3 shows the plotted estimated values of *Digital Resources* as a function of *Firm Internationalisation* for three different values of the moderator variable, the mean value and one standard above and below the mean, respectively.



**Figure 3: Estimated Values of Regression Model 2**

Again, the graph suggests the form of an inverted U-shape relationship, although this relationship is very much attenuated for low levels of financial constraints and more pronounced for high levels of *Financial Constraints*. This suggests that the trade-off and inverse U-shape is especially prevalent among financially constrained firms.

### 5.3. Robustness Checks

In addition to the main model, I run several other regression models to validate the robustness of the estimations. All regression results of the robustness tests are shown in Table A3 in the appendix. In all models I retain robust standard errors. In the third and fourth regression model I use a random effects panel regression model instead of the GEE regression model and test whether the main effect as well as the moderating effect are robust to this model change. The random effects regression does not alter the results, and all the relevant coefficients show the expected sign and retain their significance. In the fifth regression model I employ a GEE model specification again but revert to non-logarithmised count data of the dependent variable. Consequently, I assumed a Poisson distribution of the GEE model, characteristic for count data. The coefficients of both the linear and squared term of *Firm Internationalisation* retain their direction. Whereas the squared term keeps being significant on the 5 % level ( $\beta = -0.121$ ,  $p = 0.021$ ), the coefficient of *Firm Internationalisation* is just above the marginally significant threshold of 10 % ( $\beta = 0.127$ ,  $p = 0.106$ ).

In the sixth and seventh regression model I use model specifications that both assume a negative binomial distribution of the dependent variable, which is also typical for count data. In the sixth model I run a GEE regression with the assumed distribution, in the seventh model I use a population-averaged negative binomial panel regression with bootstrapped standard errors. Both regression results yield the same estimated coefficients for *Firm Internationalisation* ( $\beta = 0.177$ ) and *Firm Internationalisation*<sup>2</sup> ( $\beta = -0.151$ ), but the sixth model has slightly lower standard errors, leading to lower p-values. In both cases, however the coefficients are significant on the 5 % level and for the squared term even on the 1% level.

In the eighth and ninth regression model, I divide the dependent variable in four quantiles and run an ordered probit and an ordered logit regression model. Both models show significant coefficients with the expected signs (Probit: *Firm Internationalisation*  $\beta = 0.745$ ,  $p = 0.018$ ; *Firm Internationalisation*<sup>2</sup>  $\beta = -0.632$ ,  $p = 0.005$ ; Logit: *Firm Internationalisation*  $\beta = 1.385$ ,  $p = 0.015$ ; *Firm Internationalisation*<sup>2</sup>  $\beta = -1.136$ ,  $p = 0.006$ ). The results are unchanged irrespective of using quantiles of the dependent variable log transformed or as count data.

In the final robustness tests, in the tenth and eleventh regression model, I revert to the main regression model again. However, instead of using lagged independent variables, I now use lead variables and expect non-significant results, as we reverse the time relationship between dependent and independent variables. As expected, the coefficients of the main effect as well as the moderating effect turn highly insignificant.

## 6. Discussion

This study hypothesised and tested for an inverse U-shaped relationship between firm internationalisation and digital resource use. In addition, I conjectured a moderating effect of financial constraints. Empirically, I applied a text-based measure of firm internationalisation at the firm-year level and combined it with information on firms' use of digital resources as well as financial data. The results of the main regression model as well as several robustness tests support the hypothesising of an inverse U-shaped relationship between *Firm Internationalisation* and *Digital Resources* as well as a moderating effect of *Financial Constraints*.

This research contributes to two largely disparate literature streams. By showing that firms pursuing an international strategy face particular challenges but can also reap significant benefits from adopting digital resources, this study contributes to the research on *digital strategic initiatives* and *digital resources* (Piccoli et al. 2022) and the academic conversation on digital-themed research (Baiyere et al. 2023). The real-world trade-offs illustrated here also speak to the academic community researching the behaviour of multinational corporations in the digital age (Meyer et al. 2023, Verbeke & Hutzschenreuter 2021) and build specifically on the idea of modularity (Schilling 2000, Tatarinov et al. 2023) and its relevance for multinational firms. The findings suggest that more international firms utilise more digital resources arguably due to the various benefits that the modularity attribute of digital resources bring for reducing complexities the MNCs faces (Andrews et al. 2023, Cannizzaro 2020, Eden & Nielsen 2020), but that after a certain point the use declines due to challenges such as different legislation regarding digital resources (Kallinikos 2010). Additionally, this study points to the relevance of financial constraints (Bodnaruk et al. 2015, Fazzari et al. 1988, Hoberg & Maksimovic 2015) for implementing digital resources as part of firms' digital strategy.

Managers can benefit from these insights by being aware of these distinct benefits and costs and by identifying the optimal level of digital resource use, particularly given their organisation's global footprint. Moreover, managerial decisionmakers need to be aware that especially

in financially constrained contexts investments in digital strategy by incorporating digital resources may yield substantial payoffs due to arguably beneficial value-to-investment ratios (Denis & Sibilkov 2010). Due to the modularity attribute of digital resources, investments in them enable them to be used in various contexts and can thus reduce complexity to a large degree.

Despite the valuable insights revealed in this study, limitations need to be acknowledged. First, the text-based measure of internationalisation relies on the dictionary, developed and based on the 1,000 most cited papers on this topic. I cannot rule out that different conceptualisations and measurements of firm internationalisation may reveal other insights. Second, data availability of both the dependent and independent variables restricts the analysis to US publicly listed firms. An analysis of MNCs from emerging markets or developing countries might show disparate dynamics. In addition, I used web technologies as a proxy for digital resources. Even though I believe that this is a reasonable assumption, I cannot dismiss the possibility that this metric is imprecise for capturing the concept of digital resources as a whole.

This study and the findings of a U-shaped relationship between firm internationalisation and digital resource use suggest several avenues for further research. Further research into different types of digital resources and their impact on the firm is warranted. Potentially, digital resources differ regarding the difficulty of implementation and their contribution to a competitive digital strategy. Digital resources may be further categorised into different types that allows researchers to disentangle their differential effect. There is also a need for additional investigations into the modularity aspect of digital resources. What are the distinctive attributes that define a resource with a high degree of modularity that allow for many potential configurations (Schilling 2000)? A deeper exploration into the organisational dynamics would help us to further understand the intricate dynamics associated with digital resource use. For instance, understanding the role of employees in the use of digital resources in MNCs warrant further investigation. At present, it is unclear under which conditions employees are a driving force in promoting the use of digital resources and how this relates to employee wellbeing (Engelen et al. 2022). Furthermore, future research should pay particular attention to performance implications (Beynon et al. 2021) as well as risks faced by MNCs when implementing digital resources, in terms of the types of risks involved and how MNCs can address these risks (Luo 2022).

In conclusion, this study provides evidence of the presence of an inverse U-shape relationship between firm internationalisation and digital resource use. In so doing, it contributes to the academic debate in information systems and international business research and provides a steppingstone for future researchers to build on.

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## Appendix

Topic	Example Keywords	Topic	Example Keywords
<b>Export, International Sales and Trade</b>	Foreign Sales International Sales International Pricing International Earnings Export Export Performance International Export International Import International Trade Foreign Trade Overseas Trade Global Trade	<b>Inter-nationalisation and Diversification</b>	Geographic Diversification Expansion International Expansion International Operations International Activities Internationalisation Knowledge Development Market Knowledge
		<b>FDI, Cross Border Acquisitions and Entry</b>	International Acquisition International Merger International Investment Cross Border Acquisition Cross Border Merger Foreign Direct Investment FDI Market Entry Overseas Market
<b>Emerging &amp; Developing Economies</b>	Emerging Economy Emerging Market Emerging Country Developing Economy Developing Market	<b>MNCs and Born Global</b>	Multinational Corporation Multinational Enterprise Multinational Firm Multinational Business Global Firm Transnational Corporation Transnational Enterprise International Firm Born Global
<b>Top Management Team &amp; Decision Making</b>	International Directors International Top Team International Team Internationalisation Global Officer TMT International International Alliance TMT National Diversity TMT Cultural Diversity		
<b>Joint Ventures, Wholly Owned Subsidiaries, Knowledge Transfer</b>	International Partnership International Joint Venture International Alliance Subsidiary Regional Headquarter Foreign Subsidiaries	<b>Transaction Costs, Supply Chain and Outsourcing</b>	Outsourcing Offshoring Offshore Outsourcing Transaction Cost Supply Chain
<b>Property Rights and Institutions</b>	Institution Institutional International Law International Regulation Cross Border Across Border Legal Protection Intellectual Property	<b>Distance Concepts</b>	Psychic Distance Cultural Distance Administrative Distance Economic Distance Geographic Distance

**Table A1: Internationalisation Dictionary**

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Digital Resources	1.000										
(2) Firm Internationalisation	-0.027**	1.000									
(3) Firm Internationalisation <sup>2</sup>	-0.032***	0.912***	1.000								
(4) Financial Constraints	0.007	0.069***	0.046**	1.000							
(5) Total Assets	0.131***	-0.074***	-0.074***	0.025	1.000						
(6) Firm Size	0.172***	-0.069***	-0.084***	-0.004	0.792***	1.000					
(7) Capital Intensity	-0.051***	-0.039***	-0.019*	0.033*	-0.069***	0.085***	1.000				
(8) Firm Growth	-0.019*	0.006	-0.003	0.035*	-0.124***	-0.138***	0.019	1.000			
(9) Leverage Ratio	-0.059***	0.032***	0.034***	-0.085***	-0.238***	-0.161***	-0.006	0.004	1.000		
(10) Return on Sales	-0.006	-0.029**	-0.006	-0.080***	0.204***	0.004	-0.163***	0.049***	-0.002	1.000	
(11) R&D Ratio	0.096***	0.026**	-0.011	0.081***	-0.231***	-0.218***	-0.084***	0.155***	0.153***	-0.167***	1.000

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

**Table A2: Correlation Table**

Model	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Dependent Variable	Digital Resources (Natural Log)	Digital Resources (Natural Log)	Digital Resources (Count)	Digital Resources (Count)	Digital Resources (Count)	Digital Resources (Quantiles)	Digital Resources (Count)	Digital Resources (Natural Log)	Digital Resources (Natural Log)
Firm Internationalisation	0.169* (0.093)	0.443*** (0.148)	0.127 (0.079)	0.177** (0.072)	0.177** (0.080)	0.745** (0.315)	1.385** (0.568)	0.069 (0.097)	-0.090 (0.197)
Firm Internationalisation <sup>2</sup>	-0.169** (0.069)	-0.324*** (0.097)	-0.121** (0.053)	-0.151*** (0.050)	-0.151*** (0.057)	-0.632*** (0.226)	-1.136*** (0.411)	-0.095 (0.067)	0.027 (0.137)
Financial Constraints		-0.883** (0.398)							0.196 (0.561)
Firm Internationalization × Financial Constraints		3.879*** (1.432)							-0.456 (2.227)
Firm Internationalization <sup>2</sup> × Financial Constraints		-2.164** (0.961)							-0.041 (1.383)
Total Assets	-0.047** (0.018)	-0.026 (0.036)	-0.027 (0.017)	-0.034** (0.014)	-0.034** (0.016)	-0.159*** (0.054)	-0.298*** (0.098)	-0.067*** (0.017)	-0.042 (0.040)
Firm Size	0.111*** (0.021)	0.098** (0.039)	0.202*** (0.018)	0.112*** (0.015)	0.112*** (0.019)	0.399*** (0.059)	0.733*** (0.108)	0.123*** (0.019)	0.099** (0.041)
Capital Intensity	-0.267 (0.295)	-0.202 (0.344)	-0.715*** (0.258)	0.045 (0.192)	0.045 (0.179)	-0.890 (1.036)	-1.854 (1.940)	0.121 (0.295)	-0.267 (0.412)
Firm Growth	0.019 (0.025)	-0.065* (0.034)	-0.024 (0.022)	0.004 (0.017)	0.004 (0.022)	-0.061 (0.086)	-0.103 (0.153)	-0.100** (0.041)	-0.065 (0.064)
Leverage Ratio	0.011 (0.073)	0.144 (0.111)	0.066 (0.071)	0.014 (0.062)	0.014 (0.057)	0.164 (0.253)	0.338 (0.458)	0.001 (0.073)	-0.076 (0.141)
Return on Sales	-0.007 (0.043)	0.017 (0.082)	0.023 (0.042)	-0.011 (0.035)	-0.011 (0.043)	0.121 (0.179)	0.292 (0.325)	0.018 (0.056)	0.136 (0.106)
R&D Ratio	0.545*** (0.176)	0.906*** (0.239)	1.073*** (0.203)	0.658*** (0.141)	0.658*** (0.184)	2.566*** (0.687)	4.603*** (1.267)	0.688*** (0.204)	0.923** (0.361)
Constant	2.219*** (0.123)	1.981*** (0.187)	1.480*** (0.135)	2.292*** (0.108)	2.292*** (0.112)	- (0.112)	- (0.112)	1.019*** (0.125)	1.111*** (0.212)
Observations	7,257	2,556	7,332	7,332	7,332	7,332	7,332	8,537	2,748
Number of Firms	1,364	815	1,373	1,373	1,373	1,373	1,373	1,409	822
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.40	0.25	-	-	-	-	-	-	-

Robust standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Table A3: Robustness Checks**

## Diskussionspapiere des Instituts für Organisationsökonomik

Seit Institutsgründung im Oktober 2010 erscheint monatlich ein Diskussionspapier. Im Folgenden werden die letzten zwölf aufgeführt. Eine vollständige Liste mit Downloadmöglichkeit findet sich unter <http://www.wiwi.uni-muenster.de/io/de/forschen/diskussionspapiere>.

- DP-IO 1/2025**    Going Global, Going Digital  
Firm Internationalisation and Digital Resource Use  
*Pascal Mayer*  
Januar 2025
- DP-IO 12/2024**    Auswirkungen von weniger Studierenden  
*Alexander Dilger*  
Dezember 2024
- DP-IO 11/2024**    Home Market Competitive Pressure and the Tendency to Internationalise  
An Inverse U-shape  
*Pascal Mayer/Thomas Schäper*  
November 2024
- DP-IO 10/2024**    14. Jahresbericht des Instituts für Organisationsökonomik  
*Alexander Dilger*  
Oktober 2024
- DP-IO 9/2024**    Ökonomische Bildung in der Sozialen Marktwirtschaft  
Korreferat zu Nils Goldschmidt und Marco Rehm  
*Alexander Dilger*  
September 2024
- DP-IO 8/2024**    The Impact of Host Country Institutional Factors on International Investments  
*Miriam Nebenführ*  
August 2024
- DP-IO 7/2024**    Flexibles Arbeiten im Hochschulmanagement  
*Caroline Werner*  
Juli 2024
- DP-IO 6/2024**    Coach Characteristics and Their Impact on Substitution Decisions  
*Lars Vischer*  
Juni 2024
- DP-IO 5/2024**    Development of Loan Players in Professional Football  
*Niklas Günter/Lars Vischer*  
Mai 2024
- DP-IO 4/2024**    Effects of the Video Assistant Referee on Games in the Bundesliga  
*Tom Böttger/Lars Vischer*  
April 2024
- DP-IO 3/2024**    The Influence of Role Models on Women's Entrepreneurial Intention and Behaviour  
*Lilo Seyberth/Anja Overwien*  
März 2024
- DP-IO 2/2024**    Klausuren des Instituts für Organisationsökonomik  
*Alexander Dilger*  
Februar 2024



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