BALÁZS FEJES – MIKLÓS STOCKER

IMPACT OF ADDITIONAL IT INVESTMENTS ON FIRM-LEVEL COMPETITIVENESS

A KIEGÉSZÍTŐ IT-BEFEKTETÉSEK HATÁSA A VÁLLALATI SZINTŰ VERSENYKÉPESSÉGRE

Competitiveness and digitalization are important topics for businesses, as in the rapidly changing environment, they determine the ability to survive and thrive. This study examines the impact of information technology (IT) investments on firms' competitiveness. The study adopts the dynamic capability approach to examine how IT investments enable firms to adapt to digital transformation and generate value. This study employs causal econometrics methods to test the hypothesis that supplementary IT investments enhance the growth, efficiency, and capital accumulation of firms, which are key indicators of ex-ante competitiveness. The hypotheses are tested on a dataset of 65536 Hungarian firms from 1999 to 2014. Empirical evidence was found to support these hypotheses and confirm the positive relationship between IT investments and firm-level growth, efficiency, and capital accumulation. The findings indicate that a small IT investment does not improve efficiency, while an excessive investment is likely to include irrational investments as well.

Keywords: **competitiveness, digitalization, information technology, resource-based view**

A digitalizáció és a versenyképesség napjainkban kiemelten fontos témák, mivel ezek határozzák meg, hogy mely vállalatok lesznek képesek túlélni és növekedni egy gyorsan változó környezetben. A szerzők tanulmánya az információtechnológiai (IT) beruházások cégek versenyképességére gyakorolt hatását vizsgálja a dinamikus képességek elméletén keresztül, annak érdekében, hogy meg lehessen érteni, hogy az IT-befektetések hogyan teszik lehetővé a cégek számára a digitális átalakuláshoz való alkalmazkodást és az értékteremtést. A tanulmányban kauzális ökonometriai módszertant használva tesztelik azt a hipotézist, hogy a többlet IT-befektetések pozitívan fokozzák a cégek növekedését, hatékonyságát és tőkefelhalmozását, amelyek az előretekintő versenyképesség kulcsfontosságú indikátorai. A hipotéziseket 65536 magyar vállalat 1999 és 2014 közötti adatait tartalmazó adatbázisán vizsgálták. Az empirikus bizonyítékok megerősítették azon hipotéziseiket, hogy a többlet IT-beruházások és a vállalati növekedési képessége, hatékonysága és tőkefelhalmozásának sebessége között pozitív kapcsolat áll fent. Az eredmények azt mutatják, hogy egy kisméretű informatikai beruházás nem javítja érdemben a vállalatok hatékonyságát, miközben a túlzó méretű támogatások irracionális, nem értékteremtő IT-beruházások megvalósulását is eredményezték.

Kulcsszavak: **versenyképesség, digitalizáció, információtechnológia, erőforrás-alapú szemlélet**

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Competitiveness has been a main topic of academic research on businesses for the past six to seven decades. It is widely acknowledged that sustaining a competitive advantage is of utmost importance for organizations (Barney, 1991). Historically, competitiveness has been associated with the growth and expansion of firms

at a global level. The seminal essays authored by Penrose (1959) and Porter (1980) emphasized the significance of resources and competitiveness as crucial factors in the process of internalization and expansion. The Resource-Based View (RBV) theory serves as a fundamental paradigm for understanding the competitiveness and growth of organizations (Wernerfelt, 1984). The dynamic capability approach, a component of the RBV, emphasizes the ability to effectively allocate and exploit resources, as well as the interconnectedness of these capabilities that result in substantial adaptations in the operations of organizations (Danneels, 2012).

During the fourth industrial revolution, we transformed analog processes, objects, and data into digital form (Fichman et al., 2014). This transformation facilitates the emergence of novel processes for generating value (Gobble, 2018; Móricz et al., 2022). Digitalization is most appropriately situated within the framework of dynamic capabilities theory, given that dynamic capabilities theory is concerned with the ability to adapt to a swiftly evolving context. Therefore, most of the research on the topic examines the effects of digitalization on organizational operations via the lens of the RBV (Parida et al., 2019; Rabetino et al., 2018).

This study aims to examine the effects of information technology (IT) investments on company-level competitiveness, specifically in terms of growth, efficiency, and capital accumulation in the 21st century. The primary research question of this study is how supplementary IT investments affect the competitiveness of businesses. Competitiveness, in the context this study refers to, strictly corresponds to ex-ante competitiveness during the examination. The study defines it as a set of Key Performance Indicators (KPIs) that collectively indicate future profitability, thereby reflecting the current level of competitiveness of a firm. This study applied a methodology known as causal econometrics through the employment of fixed-effect long panel models in conjunction with matching methodology. The dataset includes data on 65,536 Hungarian firms from 1999 to 2014.

This study presents empirical evidence that supplementary IT investments have a positive effect on the growth, efficiency, and capital accumulation of firms, which indicates a better competitive state compared to the companies that have not made supplementary investments in their IT infrastructure and digital transformation. These results align with the findings of Bartel et al. (2007), Zeng et al. (2022), Rachinger et al. (2019), Lawrence and Tar (2010), and Lee-Kelley et al. (2003). While also trying to further increase our understanding regarding the role of IT developments and capabilities in firm-level competitiveness through the concept, this study presents the interconnectedness of these capabilities and resources.

The theoretical background of firm-level competitiveness

The concept of competitiveness is complex, and various tiers of the economy (such as the macroeconomic, industry, firm, or product levels) have distinct understandings of competitiveness. Competitiveness can be defined in various ways, even at a company level. Krugman's (1994) perspective on competitiveness, which posits that it can be either dangerous or trivial, enables the identification of two primary methods for characterizing competitiveness. The first technique examines competitiveness by analyzing the balance between costs and shares at the intersection. Conversely, the second method discusses competitiveness by emphasizing the way of value creation. The truth can be found in the middle ground, within the correlation between production, value creation, and expenses (Ketels, 2016). Most approaches indicate that competitiveness is strongly correlated with long-term profitability. Multiple theoretical explanations exist for the origin of the ability in question.

The concept of firm-level competitiveness witnessed substantial expansion in the 1980s. Porter's research (1980) examined the competitiveness of firms by analyzing their financial performance in terms of profitability. Porter argues that the financial performance and profitability of companies depend on two crucial factors: the particular market in which the company operates and the strategic position it has achieved within this market.

According to Peng (2009), three key elements exert an effect on the formulation of a company's strategy and subsequently impact its level of competitiveness. This approach considers a comprehensive range of aspects, encompassing both external and internal dimensions: 1) The external factors include the institutional system, history, transitions, and stability; 2) industry competitiveness, industry, and consumer expectations; and 3) the internal factors consist of the firm's resources and skills. The scholarly literature refers to the analysis of a firm's resources and capabilities as resource-based competitiveness analysis.

The resource-based explanation of the firm-level competitiveness method posits that a company's success and competitive advantage stem from its unique and non-replicable resources. These resources are either inherently difficult to imitate or cannot be imitated at all. The theory initially proposed by Penrose (1959) and further developed by Wernerfelt (1984) centers on examining the interplay between firm resources and the external environment, with a particular emphasis on technical advancements.

The resource-based approach fails to consider the significance of resource capabilities in determining competitiveness. According to Grant (1991), capabilities can be defined as the capacity to carry out a specific task by utilizing a suitable range of resources. This concept pertains to the capacity of a company to generate novel resources using organizational procedures, employing a blend of preexisting competencies and resources to accomplish a specific objective (Amit & Schoemaker, 1993). Four conditions must be met to be classified as a capability. The organization must possess the deliberate ability to execute a certain action: 1) intentionally, 2) repeatably, 3) reliably, and 4) at least satisfactorily (Helfat & Winter, 2011).

Dynamic Capabilities

Danneels (2012) posits that organizations vary both in the resources they possess and in their ability to efficiently distribute and employ these resources, as indicated by the dynamic capability approach. Hence, firms must obtain and deploy novel competencies to efficiently adjust to a dynamic and evolving environment. This approach clarifies a complex network of interdependent relationships, where each capability within a system affects other capabilities and resources, resulting in consequential modifications.

The focus of dynamic capabilities lies in the examination of a „*firm's ability to integrate, build, and reconfigure internal and external resources/competencies to address and shape rapidly changing business environments"* (Teece et al., 1997, p. 516). According to Teece dynamic capabilities are „*higher-level activities that can enable an enterprise to upgrade its ordinary capabilities"* (Teece, 2016, p. 210). In a similar vein, ordinary capabilities can be characterized as those that are deemed essential for the attainment of present objectives and necessitate a management approach that prioritizes efficiency (Teece, 2016).

According to Teece (2014), there exists a relationship between dynamic capabilities, strategy, and competitiveness. Teece posits that while general capabilities and resources are inherent to a corporation, certain ones can also be obtained externally. Barney (1991) defined VRIN/VRIO capabilities and resources as those that are exclusive to the organization, shape, and impact the corporate strategy, as they cannot be obtained or substituted. The business strategy is constructed based on the utilization of these resources, while also being subsequently influenced by them (Peng et al., 1983; Peng, 2002). This, in turn, results in competitive advantage, which ultimately manifests in improved financial performance. According to Teece (2014), these factors eventually contribute to the financial performance of an organization, just as the management's capabilities to integrate them into processes (Teece, 2019).

In the context of a two-tier competitiveness paradigm, it is possible to identify and measure the connection between these capabilities and outcomes. According to Pisano (2017), firms engage in competition at both the capacity level and the product market level. Internal factors such as operational processes, organizational structure, technology, and capacity-level rivalry are rarely visible. Financial KPIs are often linked to competitive advantage in connection with product-market rivalry. The theoretical discussions regarding the interaction between the levels and the empirical findings about the association imply that it is affected by various factors. Likewise, there exists an inherent connection at the level of organizational capabilities, specifically regarding the influence of dynamic capabilities on the allocation and utilization of resources (McKelvie & Davidsson, 2009).

According to theoretical literature, dynamic capacities directly affect competitive advantage (Teece et al., 1997; Bitencourt et al., 2020) or product market competitiveness (Pisano, 2017). In contrast, empirical studies reveal that dynamic capacities and competitive advantage sometimes have an indirect, temporary, or non-existent link (Ambrosini & Bowman, 2009). The direct relationship can be contextualized so that a resource or routine gives a firm competitive edge in one industry, whereas, in another, it may merely sustain competitiveness.

According to Teece (2007), firms perceive, capture, and reconfigure or transform their capabilities. These capabilities were examined in a longitudinal case study of Hummels' B2C digital strategy (Yeow et al., 2018). Eisenhardt and Martin (2000) conducted a study that found a set of activities that differed slightly from one another in their impact. These activities involved utilizing existing resources, creating new ones, obtaining external resources, and converting these into monetary value. The impact mechanism in question was subsequently delineated by Danneels (2011) through the utilization of a longitudinal case study. Lin et al. (2016) found four common components from multiple interpretations, including 1) perceptual capacity, 2) absorptive ability, 3) relational ability, and 4) integrative ability.

In the 4th Industrial Revolution, companies need new skills and resources to sustain or enhance their competitive edge. According to strategic management theories, technological advances significantly impact businesses' competitiveness. The general components of dynamic capabilities can also be found in related functional abilities. Furthermore, alongside the general components of the dynamic capabilities described previously, we can find related functional abilities as well. The study conducted by Ilmudeen et al. (2020) examines the impact of IT-based dynamic capabilities on firm innovativeness and the subsequent influence on business performance. The study analyzes the mechanism that ties sensing to corporate performance and finds a significant positive correlation between IT-based dynamic skills and firms' innovation capabilities. Innovation also boosts business performance. Additionally, a substantial positive relationship exists between firms' innovation capabilities and performance.

Danneels (2015) examines the influence of different types of capabilities on competitiveness and highlights four primary areas of focus: customer competence, technological competence, marketing competence, and R&D competence. The study finds that in stable environments, firms can grow by exploring new markets and adopting new technology. Conversely, in turbulent times, these competencies become essential for ensuring the survival of such firms, which aligns with the findings of Stocker and Várkonyi (Stocker & Várkonyi, 2022), who found customer orientation and customer competencies are essential for the survival and success of international organizations. Wilden and Gudergan (2015) examined the manifestation of the dynamic capability ladder, identified by Teece, in marketing and technology. The researchers also examined how dynamic capabilities and market instability affect these corporate activities and discovered a significant correlation between marketing capabilities and business success in highly competitive contexts, but technological

capabilities were found to enhance performance in stable competitive conditions. This aligns with the findings of Stocker and Pábli (2023) who found a positive correlation between marketing capabilities and export performance, which is considered a reliable indicator of a highly competitive environment.

Measurement of competitiveness

Competitiveness is a complex term hence, there are numerous methods to evaluate a company's competitiveness (Mcfetridge & Rao, 1995). In general, we can distinguish between ex-post and ex-ante forms of competitiveness analysis (Capobianco-Uriarte et al., 2019). Ex-post measurements may determine a company's competitiveness at a given time by measuring the results of competitiveness, such as profitability, but they cannot reveal the underlying factors that contribute to competitiveness. On the contrary, ex-ante indicators reveal the primary source of competitive advantage, by measuring different types of efficiencies, but the impact of competence on profitability remains unexplained (Siggel, 2006).

Mainstream economic and business literature employs ex-post analysis to define competitiveness. Porter (1980) initially measured competitiveness based on profitability. Wernerfelt (1984) argues that a firm's competitiveness can still be measured by its profitability, but the source of this profitability is the organization's inimitable capabilities and its ability to innovate or develop its key competencies and capabilities, which will increase profitability. Other academics attempt to measure competitiveness on a global level, international level. Gorynia (2005) measure competitiveness in export-import performance. Due to the complex nature of competitiveness, numerous scholars have developed complex indexes to synthesize the main components (mostly firm-level resources and capabilities) of stakeholder value creation (Buckley et al., 1988; Chikán, 2006, 2008; Chikán et al., 2022; Lafuente, Szerb et al., 2020; Losonci & Borsos, 2015; Márkus & Rideg, 2021; Szerb, 2015). Chikán (2003) argues that the primary objective of a company is to make profit by satisfying consumer demands. In our perspective, this implies that competitiveness can only be achieved if the organization creates value for all its stakeholders. According to Farida and Setiawan (2022), the excess profit compared to competitors, or to the overall market and market expectations, serves as a more efficient measurement. While profit as a metric may seem logical to measure competitiveness, it is important to acknowledge the several issues associated with relying solely on profit as the primary indicator of competitiveness.

The first reason this study opposes using profit as a measure of competitiveness is its volatile nature. Profit fluctuation has many causes, but one particularly concerning factor must be acknowledged. Companies can influence their short-term profitability by making strategic investments to partially reduce tax liabilities. Furthermore, the evaluation of long-term profitability can only be performed retrospectively, so these results only imply that a company was competitive at a given point in the past.

The second concern about using profit as the primary measure of competitiveness is related to the impact of disruptive technologies in the market. Companies that bring disruptive innovations in their respective markets often face a prolonged period of unprofitability. Despite the introduction of innovative technologies and business models, the expenses of breakthroughs can cause years-long financial losses. On the other hand, disruptive innovations give these companies a competitive edge in the industry. They excel in efficiency and growth, providing the best customer experience in the industry in a short period of time after the innovation is launched. In the meantime, the enterprise value of these companies continues to rise as a direct consequence of their innovation and the long-term profit potential it generates.

KPIs that enable scholars to measure ex-ante competitiveness tend to demonstrate a competitive advantage at the organizational function or product level, rather than at the firm level. These KPIs quantify distinct competitive advantages, such as higher operational efficiency relative to competitors, studied by Lafuente et al. (2020), and directly link them to a specific function of the organization. The proxy KPIs on the outcome side, such as rapid growth or productivity, can signal ex-ante competitiveness (Bartel et al., 2007; Lawrence & Tar, 2010; Lee-Kelley et al., 2003). The problem with ex-ante indicators of competitiveness lies in the existence of uncertainty. The function-specific competitive advantage's impact on a company's financial success and business sustainability is unknown. The indicators may be present, and the product may be superior to competitors, but the precise reaction of the market remains unpredictable.

Upon careful observation, it is evident that both examination approaches include inherent limitations. This study's opinion is that relying just on a single proxy KPI for the outcome might not translate to a definite increase in competitiveness; however, a combination of multiple indicators can be utilized to predict the increased competitiveness of a company. This aligns with Buckley et al. (1988) who emphasize the importance of the sustainability and resilience of our measures and methodologies. From this study's perspective, it is more advantageous to identify the investments and innovations that can result in future competitiveness rather than engaging in a retrospective study of competitiveness. Thus, this study utilizes KPIs that allow for ex-ante examinations of competitiveness rather than employing KPIs for retrospective evaluations.

Digitalization and its impact on competitiveness

The advent of the fourth industrial revolution precipitated the swift advancement of computational tools, resulting in the emergence of information systems that exhibited notable divergence from their predecessors. One of the most significant transformations is the Internet of Things (IoT). Wireless internet networks have rendered device activity and condition data more accessible. This leads to data-driven networks and techniques in production and

service (Atzori et al., 2010; Chen et al., 2014; Xu et al., 2018; Oztemel & Gursev, 2020).

The concept of "digitization" pertains to the conversion of physical or analog processes, objects, and data into digital form (Fichman et al., 2014). This transformation facilitates the emergence of novel processes for generating value (Gobble, 2018). Digital transformation involves integrating new digital technology into an organization's operations and obtaining new digital competencies that effectively leverage digital technology (Matt et al., 2015; Móricz, 2022) while encompassing the reevaluation of a company's operational procedures, aiming to seamlessly include digitized data, objects, or process steps into overall workflows (Drótos & Móricz, 2012). According to Davenport and Westerman (2018), altered processes can change how value is created, often resulting in a significant shift in the value-creation process. Digitization is helping companies to create value, explore new revenue streams, develop innovative products and services, and create new business models (Rachinger et al., 2019).

The proliferation of data generated by modern technological gadgets has given rise to the notion of big data. Three primary attributes characterize big data: 1) it encompasses a substantial volume of data; 2) it encompasses many data sets and data kinds that provide descriptions of various components of the entirety; and 3) big data exhibits a notable velocity, indicating a quick flow of data (Gandomi & Haider, 2015). The acquisition of this dataset requires sophisticated technological tools, encompassing both hardware and software components. The utilization of big data enables companies to develop solutions based on machine learning and artificial intelligence (AI). The utilization of AI improves data analytical capabilities, which eventually results in increased efficiency and productivity. These benefits are especially valuable when business performance is experiencing a decline (Brynjolfsson et al., 2017).

During the fourth industrial revolution, organizations must acquire novel resources and develop additional capabilities to uphold their competitiveness. According to strategic management theories, technological advances in business can significantly impact firms' competitiveness (Porter, 1980; Wernerfelt, 1984). Most related research examines how digitalization affects organizational operations via the lens of the RBV (Parida et al., 2019; Rabetino et al., 2018). Digitalization is most appropriately situated within the framework of dynamic capabilities theory, given that this theory is concerned with the ability to adapt to a swiftly evolving context. Dynamic capabilities theory describes the process and dynamics of this transition. According to Teece (2007), dynamic capacities enable market- and technology-aligned innovation.

Peng (2009) claims that strategy is affected by many factors while also being susceptible to the challenges of digitalization. Digitization is shifting customer needs and changing the competitive landscape. According to Lee-Kelley et al. (2003), organizations that, in the digital world, cater to consumer demands on a higher level are more likely to achieve a higher level of customer loyalty. Simultaneously, the rapid evolution of advertising channels, formerly considered to be sales channels, now have a different function and therefore altered the competitive environment (Reinartz et al., 2019). Digitalization also changes the products and services of enterprises, which subsequently results in renewed value propositions (Lepak et al., 2007). The study conducted by Lee-Kelley et al. (2003) the ability to adapt manufacturing and service processes, enabling the customization of products and services, provides firms with the means to cater to the unique requirements of their clientele. To accomplish this objective, service providers must adopt some attributes of industrial production, such as standardization, modularization, and specialization of service operations (Porter & Heppelmann, 2014; Scholten, 2017). Ultimately, digital transformation and digital markets are forcing business model transformations in industrialized economies (Gozman et al., 2018).

According to Porter (2001), the emergence of the Internet and electronic sales has led corporations to prioritize pricing as a key factor in product differentiation, shifting away from traditional methods. E-commerce has substantially lower transaction costs than in-person trade; hence, it more closely resembles the ideal market structure than the in-person mode of trade. Porter (2001) states that using the Internet alone rarely gives a company a competitive edge, but it allows businesses to build unique strategic positioning and gain a competitive advantage without overhauling their company style. According to Lee-Kelley et al. (2003), the competitive advantage achieved through enhanced efficiency and decreased internal costs is expected to have a limited duration due to the entry of other enterprises into the e-commerce sector.

The Fourth Industrial Revolution has the potential to bring substantial changes in industry competition, alter company-customer and supplier relationships, and introduce disruptive business models through substitute products (Porter & Heppelmann, 2014). According to Teece (2016), dynamic capabilities facilitate identifying, capturing, and organizing market opportunities into operational processes. Rachinger et al. (2019) developed a framework that delineates the sequential stages of digitization, namely sensing, seizing, and reconfiguring, as originally conceptualized by Teece (2007). This framework links these steps with the business model, specifically the value proposition, value delivery, and value capture.

The empirical methodology employed in the literature to measure these effects is divided based on the approach utilized. When it comes to technological skills and developments, the database of empirical studies in the business field primarily relies on cross-sectional data obtained through self-report questionnaires. Dannels (2015), Wilden and Gundergan (2015), Ilmudeen et al. (2020), Song et al. (2005), and Chen et al. (2009) are other notable examples.

The alternative approach is grounded in empirical research employing economic techniques. This approach incorporates a more comprehensive statistical analysis in empirical studies; the analyses place significant emphasis

on financial and other quantifiable data as opposed to relying on self-reported preference rankings. Additionally, it is important to note that they assess performance and outcomes, as well as the accumulation of resources, and tie these findings to business-related modifications and advancements (Bartel et al., 2007; De Stefano et al., 2014; Muraközy & Telegdy, 2020; Rajan & Wulf, 2006).

Since corporations are required to publish financial reports, this method provides more reliable data; however, comprehending the underlying business rationale behind the figures poses a greater challenge. Integrating publicly available financial data and a specialized database with distinct information related to the subject of inquiry enables the analysis of the relationship between the broader financial data and the specific business question, as well as the analysis of the underlying mechanism at play. As a result, the methodology commonly employed relies on panel-type models, which are more appropriate for examining causal correlations compared to cross-sectional data. It is imperative to acknowledge, that the two methodologies exhibit inherent distinctions and that the studies are undertaken with distinct objectives. However, it is frequently seen that the outcomes of both methodologies exhibit a high degree of similarity, leading to comparable conclusions.

Multiple studies have indicated that IT investments have contributed to a notable increase in productivity growth when compared to the final years of the 20th century (Bartel et al., 2007; Oliner & Sichel, 2000; Zeng et al., 2022). According to McAfee and Brynjolfsson (2012), the utilization of digital processes and the increased accessibility of data can potentially yield a substantial competitive edge by enabling the derivation of fresh insights. In the study conducted by Rajan and Wulf (2006) the authors' most important finding, from an information technology and technology standpoint, was the correlation between modern IT systems and decentralized decision-making processes among various divisions of the organization, resulting in increased autonomy, which aligns with the findings of Szukits and Móricz (2023) who found that data-driven decision making is independent of centralized data usage. In their study, Bartel et al. (2007) found, that the implementation of novel IT systems centered around IT-driven production, resulted in enhanced business models and increased productivity.

Research question and hypotheses

The primary research question of this study is how supplementary IT investments affect the competitiveness of businesses. Competitiveness, in the context this study refers to, strictly corresponds to ex-ante competitiveness during the examination. This study defines competitiveness as a set of KPIs that collectively indicate future profitability, thereby reflecting the current level of competitiveness of a firm.

Given the absence of dependable financial data, our hypotheses center on the quantifiable financial impacts of the recently enhanced capabilities, which have a noteworthy influence in the background. This statement is consistent with Teece's (2014) concept that IT investments primarily affect a company's resources, with a secondary focus on enhancing core capabilities. Furthermore, it expands on Barney's (1991) theoretical framework, which highlights the significance of resources in establishing a competitive edge. This study hypothesizes that additional IT investments and digitalization have a positive impact on efficiency, market opportunity identification which results in more rapid revenue growth, and capital accumulation. We measure efficiency with revenue per employee.

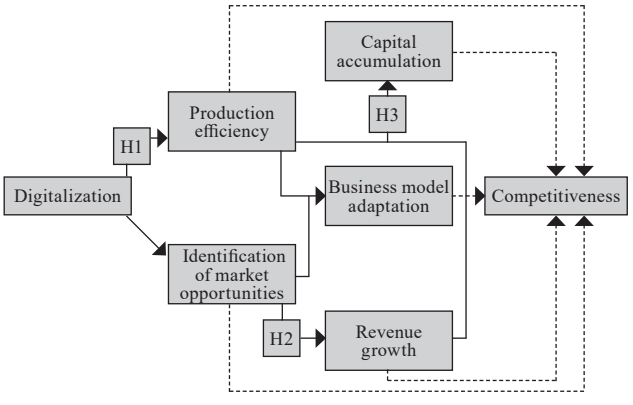
Digitalization, specifically the process of converting information into a digital format known as digitization, has a twofold impact on improving production efficiency and identifying market opportunities. These effects ultimately result in optimizing the business model (Rachinger et al., 2019). In our view, digitalization has the potential to improve understanding and adaptability in meeting consumer expectations, thereby exerting a substantial influence on a company's business model and strategy. Companies engage in a process of evaluating and adjusting their company strategy after acquiring new and distinct knowledge, thus increasing their intellectual capital (Boda et al., 2009) to reposition themselves in the market. It is essential to comprehend that digitization does not directly lead to the creation or modification of the business model. Nevertheless, the modification in the business model is a direct consequence of gaining supplementary knowledge that stems from digitization.

This study hypothesizes the subsequent impact mechanism to explain the effects of IT investments and digitalization, with the hypotheses stated formally (Figure 1):

- *H1: Additional IT investments have a positive effect on production efficiency.*
- *H2: Additional IT investments have a positive effect on market opportunity identification, which results in a positive effect on revenue growth.*
- *H3: Additional IT investments have a positive effect on capital accumulation, which happens through the simultaneous combination of improvements in production efficiency (H1) and the recognition of market opportunities (H2).*

Figure 1

Hypothesis map



Source: own compilation

The correlation between IT investments from 1999 to 2014 and digitalization may not be immediately evident. However, it is worth considering the progression of IT and the factors that contributed to the complete digitalization of services and the adoption of data-driven decision-making. The issue originated in the year 2000 due to the constraints of the IT systems of the 1990s (Anderson et al., 2006). The incapability of numerous IT systems to process dates beyond 31.12.1999 highlighted the necessity for new IT systems. Companies began making substantial investments in information technology, leading to the process of digitization (Diermeier & Goecke, 2017). Through the acquisition of new investments, companies were able to collect a greater amount of data and information on their customers, resulting in an enhanced understanding of customer needs (Matt et al., 2015; Rachinger et al., 2019). The proliferation of newly acquired data has necessitated the development of data processing skills and the implementation of digital automation, hence facilitating the digitalization of internal operations. Additionally, the analysis of consumer data has indicated a demand for digitalized services among customers. Consequently, this resulted in the adoption of data-driven decision-making and the incorporation of big data analytics findings into the development of corporate strategies (Adaga et al., 2024; Woerner & Wixom, 2015). Based on this logical progression, we can infer that the IT investments made from 1999 to 2014 were primarily related to digitization if not digitalization itself. Studies such as Anderson et al. (2006) have provided evidence indicating that organizations that made greater investments in information technology (IT) at the start of the 21st century tend to become more competitive in the years that followed.

Materials and methods

This study aims to examine the effects of IT investments on company-level competitiveness, specifically in terms of growth, efficiency, and economies of scale. In order to assess the direct impact of IT investments, we used a database that encompasses data on companies who have explicitly expressed intentions to invest in IT, as well as whether these investments were carried out or not. Additionally, the database includes financial information on these companies. The dataset used in this study includes data on 65536 Hungarian firms from 1999 to 2014, after the completion of data cleansing procedures 38866 companies' data were used. The integration of more up-to-date data into the database necessitates the gathering of more recent data from the European Union. However, given the interdependence of the data with the financing cycles of the EU, the database including more recent data will only be accessible within the next few years. The data was obtained from the database maintained by the Central European University.

This study applied a methodology known as causal econometrics. During the modeling process, the technique effectively manages all key influencing elements, ensuring that variations across organizations are solely considered for the specific variable being investigated. This is achieved through 84 dummy variables, with 81 of them specifically designed to account for variations in geography and industry categorization, where the field of activity is identified by NACE codes. The inclusion of 3 more dummy variables enabled the categorization of enterprises into 4 distinct groups based on the extent of their supplementary IT investment: small (less than 25% of the previous year's revenue), medium (25%-75% of the previous year's revenue), large (more than 75% of the previous year's revenue), and none. Following the completion of data cleansing procedures and the establishment of all necessary control variables, the final dataset comprises a total of 54406934 data points.

The main goal of the methodology is to detect the consequence of an unambiguous and quantifiable change in the operation, thereby discovering a cause that would otherwise be unobservable (Borenstein et al., 2010). This is achieved by employing fixed-effect long panel models in conjunction with matching methodology, which pairs businesses that have made the supplementary IT expenditure with nearly equivalent companies that have not made the supplementary IT investment.

This study employs a proxy to represent the supplementary IT investment, which is defined as a subsidy received from the European Union specifically for IT advancements. By employing this definition, we can differentiate between firms that have made an increased amount of IT investments during a specific timeframe and those who have solely planned it. In order to qualify for EU subsidies, enterprises were required to submit a comprehensive business plan as part of their application. This strategy should encompass the long-term utilization and future expansion of the substantially refinanced investment. The presence of legally enforceable agreements ensures that investments have been made and that firms have effectively integrated newly acquired tangible and intangible assets into their operational frameworks. This offers the chance to examine the differences between companies that have made these investments and those that have not.

Capital accumulation is mainly connected with tangible resources, however capabilities that are required by IT developments are usually connected to human capital resources or organizational capital resources, therefore they serve as part of intellectual capital (Stocker, 2013) which is included in the extended production function of firms (Boda et al., 2009). Hence, in this study, we decided to use total assets as a proxy for capital accumulation in order to encompass all the quantifiable values of all forms of capital throughout the production process in our analysis.

When using econometric models, it is desirable to closely replicate a randomized experiment by ensuring that the treated and control groups have similar distributions of covariates. The term used to describe this process is "matching methodology". The objective of the matching methodology is to mitigate the natural bias, resulting from the covariates, by matching organizations based on several factors that may impact the variable being studied. In this way, the control group will serve as a representation

of the alternative reality experienced by, in our case, the enterprises who received the EU subsidies. Please refer to the following papers for a comprehensive methodological explanation: Stuart (2010), Chiappori & Salanié (2016), and Gertler et al. (2011). The companies were paired according to the following criteria:

- The data regarding the subsidy's fiscal year is available, and the following criteria will be applicable henceforth.
- The NACE code remains consistent for both companies.
- All years exhibit a consistent alignment between the NACE code of the companies and their operational regions.
- The company's revenue is comparable for both companies, with a maximum differential of 15%.
- The total assets of the corporation exhibit similar magnitudes for both companies, with a maximum differential of 15%.
- The per capita revenue of the company is similar for both companies, with a maximum differential of 15%.

Despite the strong limitations, a total of 2487 out of the subsidized 3050 companies were paired, whereas 229 companies emerged as the most suitable match for multiple supported entities. The companies that experienced several matches were incorporated into the modeling database with a corresponding number of entries equal to the frequency of their matches with subsidized companies. It was imperative to maintain an equal representation of subsidized and non-subsidized enterprises in the modeling database to prevent any potential bias in estimating the effects of additional IT investment. Given the disparity in the timing of subsidies received by the companies, it was necessary to introduce an additional variable that may assess the impact of the supplementary IT investments, regardless of the specific year in which the companies got them. To address this problem, we examined the impact of additional IT investments using 13 dummy variables that represent the years before and after the subsidy, without specifying the precise years. Due to the utilization of a matching methodology, this approach facilitates the comparability of effects by ensuring that the study group and control group possess identical compositions, hence minimizing inherent biases. This implies that the methodology successfully handles the issue of varying timing of subsidies. The findings are consistent regardless of the year in which the subsidies were provided, consistently demonstrating a relative disparity between enterprises that received subsidies and those that did not.

Findings

The general impact of additional IT investments

Initially, we must examine the overall effects of the additional IT investment (Table 1), prior to digging into the detailed analysis of the effects. According to the hypotheses, revenue increase is the result of new capabilities that enable enterprises to identify market possibilities effectively. Regrettably, the financial data included in the database does not allow the examination of the impact of digitalization on the identification of market opportunities. According to the studies conducted by Lee-Kelley et al. (2003), Teece (2007, 2016), Lepak et al. (2007), and Rachinger et al. (2019) there is an undeniable connection between investments in information technology and the ability to identify market opportunities. Therefore, this study will include this relationship in its argument.

Enterprises that have made additional IT investments have observed improvements in their revenue, total assets, and operational efficiency. The primary effect of these investments manifests in the context of physical capital, which is reflected in the total assets within the framework of this study. Given that investments in information technology are long-term investments, a 20% increase in asset valuation seems realistic and justifiable. Furthermore, it is important to mention that the additional IT projects resulted in a significant improvement in efficiency. The observed improvement in efficiency indicates that although firms use additional human labor to achieve the 20% increase in revenue, they necessitate a reduced number of new employees to attain increases in revenue per unit compared to the previous state.

Table 1

The effects of additional IT investments

	Revenue	Total assets	Efficiency
Subsidy	0.197773 *** (0.0183023)	0.202419 *** (0.0158060)	0.0498102 *** (0.0126329)
Observations	64670	64670	64670
	78.9%	86.4%	76.6%
Within	8.1%	44.7%	3.6%

****Statistical significance at a confidence level of no less than 99% (p-value <0.01)*

Source: own compilation

After conducting an analysis of the overall impacts of the supplementary IT investments, we have proceeded to examine the specific effects associated with various investment sizes, as presented in Table 2. It seems, that the main goal of a modest IT investment is to procure equipment. The data suggests that asset purchases increase the revenue of businesses but in a smaller proportion. Furthermore, the absence of advancement in terms of efficiency indicates that a small investment may not be enough for enterprises to obtain assets that would permanently boost their return on assets. Hence, it can be concluded that this type and size of resource allocation towards information technology has not resulted in a significant improvement regarding the added value of human capital.

Supplementary IT investments of medium magnitude appear to be the most efficient. The data indicates that the increase in income surpasses the growth in assets. This indicates that the new technology yields a higher percentage of value-added activities when compared to the previous technology. Moreover, it is important to mention that significant enhancements in efficiency are found in this scenario. Consequently, an IT investment of this magni-

tude leads to the growth of value generated by both physical and human capital.

For substantial expenditures on IT, the asset growth surpassing revenue growth can be explained by two independent theories. One argument posits that a fraction of the investment was allocated not towards production or services, but rather towards convenience. This assertion is substantiated by the fact that the rise in revenue is limited to the level of a moderate-sized investment. Another possible interpretation could be that the substantial investment in assets indicates a profound technological transformation. In this case, the consequences of the technological shift also entail the advancement of novel internal operational procedures, which may not have been accurately represented in the existing dataset.

Table 2

The effects of the IT subsidies by size

	Revenue	Total assets	Efficiency
small/modest subsidy	0.122710 *** (0.0324430)	0.150532 *** (0.0283965)	0.00553048 (0.0220165)
medium-sized subsidy	0.227048 *** (0.0266258)	0.189909 *** (0.0235643)	0.0600914 *** (0.0180315)
substantial subsidy	0.237999*** (0.0323209)	0.276174 *** (0.0269746)	0.0833444 *** (0.0220022)
Observations	64670	64670	64670
	78.9%	86.4%	76.6%
Within	8.2%	44.8%	3.7%

****Statistical significance at a confidence level of no less than 99% (p-value <0.01)*

Source: own compilation

Upon evaluating the overall impact of IT investments, the results correspond to the expected predictions outlined in the first three hypotheses. Regrettably, the database does not permit the examination of the business model adaptation. Consequently, other researchers' studies will support this theory.

Discussion

The findings of this study align with those of Bartel et al. (2007), indicating that investments in information technology have a favorable effect on productivity, contingent upon the presence of suitable organizational adaptation. Chen et al. (2009) assert that the integration of technology and IT capabilities with other forms of capabilities within organizations can be effectively achieved. As a result of the constraints imposed by the database, this study was unable to investigate this matter. However, the consistent findings imply that this association is also plausible in this instance.

The results of this study are consistent with the conclusions of Zeng et al. (2022), who provide evidence that digitalization has a positive effect on the financial performance of companies. The results also align with the fundings of Rachinger et al. (2019) who also found evidence that digitalization has a positive effect on revenue growth.

The main factor driving the fast increase in income may be explained by the findings of Teece (2016), who suggests that dynamic capabilities play a pivotal role in sensing market prospects, seizing upon them, and then orchestrating them into operational frameworks (reconfiguring). The research conducted by Lawrence and Tar (2010) and Lee-Kelley et al. (2003) demonstrates the significant influence of digital information technology in the development of dynamic capabilities. The findings of their study indicate that companies that prioritized these capabilities from the beginning experienced accelerated growth, demonstrated a deeper comprehension of market demands, and consequently garnered support that facilitated their further expansion. As a result, these companies sustained their rapid growth trajectory, outperforming their counterparts that did not receive similar support. According to Danneels (2015), the assertion is substantiated by the fact that technology dynamism enables organizations to effectively navigate through periods of turbulence and effectively cater to emerging markets.

In general, the outcomes of this research exhibit several parallels with esteemed authors in the scholarly literature, and the results are mutually corroborative of the investigations put forth. It also provides a unique opportunity to study the effects of subsidization policies. The EU subsidies were effective in increasing productivity in Hungarian firms. However, there is potential for the government to fine-tune subsidization policies to increase their efficiency and move toward the empirical optimum in the size of subsidies.

Business model adaptation as a result of the increased understanding of market needs

Although we were unable to test for these effects due to the constraints of our database, it is important to mention the potential business model adaptation as a consequence of additional IT investments. Businesses frequently encounter market uncertainty, making it vital for them to not only achieve stability but also generate new prospects for growth and sustained profitability. Primarily, this necessitates adaptability (Cavalcante et al., 2011; Pohle & Chapman, 2006), but also foster additional dynamic capabilities including the ability and skill to implement changes (Zahra et al., 2006). The ability of a corporation to thrive in an ever-changing environment typically hinges on its capacity to understand and interpret shifts in the market, and subsequently, execute the adjustments that are required (Zahra et al., 2006; Zott, 2003).

Teece (2010) argues that a company's ability to develop its dynamic capacities allows it to maintain a competitive advantage, while it is in close relation with the adaptation of its business model as well. Pohle and Chapman (2006) argue that when a company integrates the potential to reinvent its business model into its basic operations, it gets embedded in the company's corporate culture and can result in a continuous innovation of the business model. Thus, business models, especially significant innovations of the business model, which often occurs as a result of internationalization (Trąpczyński & Wrona, 2013), might result in long-lasting competitive advantage (Asemokha et al., 2019; Zott & Amit, 2008).

IT investments may speed up data gathering and processing operations, leading to more accurate projections and expectations of the future. Consequently, the response time for implementing changes can be accelerated (Matt et al., 2015; Parida et al., 2019; Rabetino et al., 2018; Rachinger et al., 2019). The empirical evidence presented earlier in the study has demonstrated that investing in IT leads to superior operational efficiency, resulting in increased productivity and higher incomes. Developing IT capabilities can result in improved capabilities in other areas of a company, as well as the desired ability to be flexible and adaptable (Teece, 2007). The combined effect of these factors, including the firm's potential to generate long-term profits, indicates that the impact is not solely due to IT investments and digitalization, but rather the result of the accompanying business model innovation (Gozman et al., 2018; Teece, 2010).

Limitations and further research

This study is not without limitations that present multiple research avenues. Firstly, the correlations posited are underpinned by theories of competitiveness, yet there is a dearth of empirical evidence validating the postulated relationships underlying the two distinct approaches. To substantiate these claims, it would be necessary to possess a quantitative, disaggregated database including the activities of many companies, together with a comprehensive understanding of the underlying concepts and business models governing these operations, as well as how they are measured.

Secondly, the data is solely obtained from Hungary. Although the extensive size of the database is convincing and enables robust statistical modeling, the strength of the conclusions is constrained by their reliance on data from a single country, so diminishing the strength of the findings. An international database might increase our understanding of the impacts on IT investments across different market conditions and varying levels of digitalization.

Thirdly, the inclusion of EU subsidies in the model may be concerning. However, in the absence of a scientific technique to classify IT investments based on their necessities under various circumstances, it is not possible to precisely evaluate the impacts of various types and sizes of IT investments. This presents a potential area for future research that could improve our understanding of the effects of information technology concerning market conditions, customer expectations, internal resources and capabilities, and managerial decision-making regarding the timing of investments in different IT and digital solutions.

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