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An Analysis of Digitalization and Firm Performance in Finland's Private Service Industries

Natalia Kuosmanen (corresponding author)
ETLA Economic Research, Finland
natalia.kuosmanen@etla.fi

Mika Pajarinen
ETLA Economic Research, Finland
mika.pajarinen@etla.fi

Almas Heshmati
Jönköping International Business School, Jönköping, Sweden
almas.heshmati@ju.se

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Abstract

The service sector is undergoing rapid changes attributed to digitalization. This study examines the relationship between digitalization and the performance of the Finnish private service firms from 2015 to 2021 using linked employer-employee data, financial data and an IT usage survey. Our descriptive and regression analyses reveal significant variability in the level and areas of digital adoption across service industries. Information and communication, and professional activities are found highly digitalized, while accommodation and food service activities, and transportation and storage lag in digitalization intensity. Additionally, we find a strong positive correlation between firms' digitalization and revenues, particularly for firms with higher digital intensity. This correlation persisted throughout the COVID-19 pandemic. We also observe a positive correlation between digitalization and productivity in the early years, but more recent data suggest a weakening of this association, possibly due to increased digital adoption among less productive firms during the pandemic. Finally, our analysis indicates that larger firms, or those with a larger market share or international activities, tend to have higher levels of digitalization. Thus, investment in digitalization is recommended to enhance service sectors performance.

Tiivistelmä

Analyysi digitalisaatiosta ja yritysten menestyksestä Suomen yksityisillä palvelualoilla

Palvelualoilla tapahtuu huomattavia muutoksia digitalisaation myötä. Tässä tutkimuksessa tarkastellaan digitalisaation ja Suomen yksityisten palvelualojen yritysten menestyksen välistä suhdetta vuosina 2015–2021 hyödyntäen yhdistettyä työnantaja-työntekijä -aineistoa, tilinpäätösdatoja sekä tietotekniikan käyttö yrityksissä -kyselyä. Sekä kuvailevan tilastollisen tarkastelun että regressioanalyysien tulokset paljastavat merkittävää vaihtelua digitaalisten teknologioiden käyttöönotossa ja hyödyntämisessä palvelualoilla. Informaation ja viestinnän sekä ammatillisen, tieteellisen ja teknisen toiminnan toimialat ovat vahvasti digitalisoituneita. Sen sijaan majoitus- ja ravitsemistoiminta sekä kuljetus ja varastointi ovat jääneet digitalisaatiossa jälkeen. Lisäksi havaitsemme vahvan positiivisen yhteyden yritysten digitalisaation ja liikevaihdon välillä erityisesti niillä yrityksillä, jotka hyödyntävät monipuolisesti erilaisia digitaalisia teknologioita. Tämä yhteys on säilynyt koko COVID-19-pandemian ajan. Havaitsemme positiivisen korrelaation myös digitalisaation ja tuottavuuden välillä tutkimusjakson alkuvuosina, mutta viime vuosien tietojen perusteella tämä yhteys vaikuttaisi heikentyneen. Tämä voi mahdollisesti johtua digitaalisten teknologioiden käyttöönoton lisääntymisestä vähemmän tuottavilla yrityksillä pandemian aikana. Analyysimme tulokset viittaavat lisäksi siihen, että suuremmilla yrityksillä tai niillä, joilla on suurempi markkinaosuus tai joilla on kansainvälistä toimintaa, on yleensä korkeampi digitalisaation taso. Tulosten perusteella panostukset digitalisaatioon ovat suositeltavia palvelualojen yritysten kasvun ja tuottavuuden vauhdittamiseksi.

Ph.D. **Natalia Kuosmanen** is a Chief Research Scientist at Etla Economic Research.

M.Sc. (Econ.) **Mika Pajarinen** is a Researcher at Etla Economic Research.

Ph.D. (Econ.) **Almas Heshmati** is a Professor of Economics at Jönköping International Business School.

MMT **Natalia Kuosmanen** on Elinkeinoelämän tutkimuslaitoksen tutkimuspäällikkö.

KTM **Mika Pajarinen** on Elinkeinoelämän tutkimuslaitoksen tutkija.

Ph.D. (Econ.) **Almas Heshmati** on professori Jönköping International Business School:issa.

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Keywords: Digitalization, Firm performance, Productivity, Private service industry, Finland

Asiasanat: Digitalisaatio, palveluala, Suomi, tuottavuus, yrityksen menestyminen

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1 Introduction

The global service sector, a critical driver of economic growth, is undergoing a significant transformation driven by the increasing adoption of digital technologies (Vu et al., 2020; Rha and Lee, 2022; Chin et al., 2023). This phenomenon by using digital technologies is reshaping business models across industries worldwide without a physical presence, enhancing firms' operational efficiency, customer experiences, and creating new opportunities for value creation (Zaki, 2019; Mattila et al., 2022). To remain competitive in this evolving market, service providers must embrace digital transformation and develop effective digital strategies (Zaki, 2019; Soto Setzke et al., 2023).

The COVID-19 pandemic further accelerated this transformation, forcing businesses worldwide to rapidly adopt and utilize digital tools to maintain operations and customer engagement (Cambra-Fierro et al., 2022; Kronblad and Pregmark, 2021). Social distancing measures and lockdowns have highlighted the critical role of digital technologies in ensuring business resilience and continuity (Almeida et al., 2020; Kim, 2020; Amankwah-Amoah et al., 2021; Bai et al., 2021). This rapid change highlights the potential of digital technologies to improve the efficiency, productivity, and overall competitiveness of the service sector, with broader implications across various industries (Blichfeldt and Faullant, 2021). Koski and Fornaro (2024) found that firms with greater pre-pandemic investments in data assets experienced significantly higher labor productivity growth during the first year of the pandemic, particularly in the service sector, emphasizing the importance of digital investments for firms' readiness, resilience, and productivity.

Finland, known for its technological expertise and well-established innovation ecosystem (Oksanen and Hautamäki, 2014; Khan et al., 2021), consistently ranks high in international comparisons. This is reflected in its top-ranking status among EU Member States based on the 2022 Digital Economy and Society Index,[1] and its strong performance in digital utilization according to the Digibarometer 2022 (Mattila et al., 2022). This national leadership in digital technology undoubtedly shapes the country's general digital landscape. However, a systematic understanding of how this leadership translates into digital adoption across specific service industries is lacking.

[1]European Commission, Digital Economy and Society Index 2022: `https://digital-strategy.ec.europa.eu/en/policies/desi-finland`.

This study aims to bridge this knowledge gap by examining the digitalization of the Finnish private service sector at disaggregate firm level. We use data from the Finnish Information Technology in Enterprise Surveys (2015–2021) to calculate the Eurostat Digital Intensity Index (DII) for each participating firm. This index provides a quantitative measure of digital maturity across several dimensions. To gain a deeper understanding, we enrich this data by merging it with financial statement panel and individual-level data obtained from Statistics Finland.

This merged dataset allows us to pursue three key objectives:

i) Examine trends in DII across various private service industries in Finland, identifying both leaders and laggards in digital adoption.

ii) Explore the relationship between a firm's DII and three key performance indicators, productivity of labor, total factor productivity, and firm revenues.

iii) Identify factors associated with a firm's DII to understand the potential drivers of digital transformation and productivity growth in the Finnish private service sector.

The remainder of this paper is organized as follows. Section 2 describes the data sources and how firms' digital intensity is calculated. Sections 3 and 4 present and discuss the main results of the study. Finally, Section 5 presents our conclusions.

2 Data and methods

2.1 Data sources

We utilize three data sources from Statistics Finland. First, we use the survey on the Use of Information Technology in Enterprises (2015–2021).[2] This survey provides detailed information on the use of information and communication technology (ICT) and e-commerce by enterprises across various service industries. It includes information on internet connectivity, online presence, social media usage, cloud services, electronic data interchange (EDI), e-commerce activities, internal software development, and other information. The survey

[2]Statistics Finland, Use of Information Technology in Enterprises: `https://stat.fi/en/statistics/icte`.

is standard, and the data collection process is consistent across all EU countries. The survey includes all firms with a minimum of 100 employees. A sampling method is applied to smaller firms with 10-99 employees. The survey results can be adjusted to represent the entire industry and the size categories of the surveyed firms using specific coefficients (or weights).

The second data source used in this study is Financial Statement Panel data, which covers all enterprises operating in Finland. This panel provides detailed firm-level financial information, as well as the number of personnel, industry codes, year of observation, ownership, and other related statistics. The third data source is individual-level data on the structure of the population and employment statistics of individuals. These data include information on persons' occupations, age, educational level, and ICT-related job positions. Using firm-specific ID codes, we merge the data from these three sources into a dataset, resulting in 5,126 firms (with 10,459 firm-year observations). This dataset covers the period from 2015 to 2021 across various service industries, as classified by the NACE Rev. 2 industrial classification. Table 1 presents the descriptive statistics of the key variables used in the empirical analysis part in this study.

Table 1. Summary statistics of the key variables.

Variable	Mean	Std. Dev.	10th Percentile	90th Percentile
Employees (full-time eq.)	158.676	485.921	10.000	332.780
Materials (10^3€)	34 700.166	126 504.069	516.948	61 972.538
Machinery and equipment (10^3€)	2 735.223	29 809.128	13.662	2 900.704
Value added (10^3€)	11 507.918	37 526.003	539.370	25 381.831
Revenue (10^3€)	9 881.269	0.005	1 281.439	89 549.541
EU SME-classification:				
Small (ref)	0.433	0.496	0.000	1.000
Medium	0.276	0.447	0.000	1.000
Large	0.291	0.454	0.000	1.000
Firm type:				
Foreign-owned	0.216	0.412	0.000	1.000
International business	0.578	0.494	0.000	1.000
Share of R&D workers	0.054	0.130	0.000	0.138
Market share (%)	1.525	5.413	0.033	3.057
Age of firm (years)	26.535	21.431	8.000	49.000
Industry type(%):				
Trade	0.376	0.484	0.000	1.000
Logistic	0.110	0.312	0.000	1.000
Accommodation & Restaurants	0.091	0.288	0.000	0.000
Information & Communication	0.170	0.376	0.000	1.000
Real Estate	0.033	0.179	0.000	0.000
Professional Activities	0.116	0.321	0.000	1.000
Support Services	0.104	0.303	0.000	1.000

Notes: The NACE Rev. 2 industries listed in the table are: *Wholesale and retail trade; repair of motor vehicles and motorcycles* (G45–47); *Transportation and storage* (H49-53); *Accommodation and food service activities* (I55–56); *Information and communication* (J58–63); *Real estate activities* (L68); *Professional, scientific, and technical activities* (M69–74) (excluding industry 75); *Administrative and support service activities* (N77–82); and *Repair of computers and communication equipment* (S951). Firm market share is calculated as the share of industry revenue at the 3-digit level according to the NACE classification system (firm revenue/industry revenue). Firm size is defined based on the EU SME classification, and the share of R&D workers is calculated as the ratio of R&D workers to total employment. For international business, the variable is set to one if the firm has exports from Finland or subsidiaries abroad, and zero otherwise. All monetary values are deflated using the Consumer Price Index (CPI) with 2021 as the base year (2021=1).

2.2 Digital intensity index

To quantify the digital intensity of Finnish service firms, we utilize the Eurostat's Digital Intensity Index (DII).[3] This composite index is derived from the survey on ICT usage and

[3]Eurostat, Digital Intensity Index: `https://ec.europa.eu/eurostat/cache/metadata/en/isoc_e_dii_esmsip2.htm`.

e-commerce in enterprises, as discussed above. It is computed at the firm level and based on 12 specific criteria (see Appendix A), including factors such as internet access for employees, employment of ICT specialists, website presence, and e-commerce activities. Each criterion met earns a firm one point, with a maximum score of 12 points. The firms are then classified into four digital intensity groups:

- Very low digital intensity: 0-3 points,
- Low digital intensity: 4-6 points,
- High digital intensity: 7-9 points,
- Very high digital intensity: 10-12 points.

Table 2 presents the share of firms across these digital intensity categories from 2015 to 2021, categorized by industry. This table reveals the diverse patterns of digital adoption among industries. For instance, firms in the *Information and Communication*, *Real Estate*, and *Professional Activities* industries are predominantly in the high and very high digital intensity categories. In contrast, *Logistics* and the *Accommodation and Restaurant* industries tend to have lower digital intensity.

Moreover, within each industry, there is a range of digital maturity levels, indicating varying degrees of digital base and transformation. The data also show fluctuations in the DII over time, reflecting the dynamic and heterogenous digital transformation trends in these industries. However, some of these fluctuations may be attributable to adjustments in the survey data using specific coefficients or changes in the survey questions over time. Therefore, we prefer to specify and estimate models on a yearly basis as cross-sections rather than pooling the data and applying panel data estimation methods. For instance, the share of firms with a very high digital intensity score in the *Real Estate* industry dropped abruptly to 2.7% in 2021, which is a significant decline compared to the shares in previous years. Similarly, unusual cases are observed in the *Professional Activities* industry, where the share of firms with a very high digital intensity score was 7.7% in 2019, and the *Support Services* industry, where the shares of firms with a very high digital intensity score were 11.1% and 6.4% in 2017 and 2019, respectively.

Table 2. Percentage shares of Finnish private service firms by digital intensity category across industries (2015–2021).

DII	2015	2016	2017	2018	2019	2020	2021
Trade							
Very low	8.9	3.1	2.9	1.6	4.0	1.4	4.9
Low	28.5	22.4	20.4	16.9	15.6	18.9	16.8
High	38.9	47.2	38.9	42.4	45.9	54.0	35.5
Very high	23.8	27.3	37.8	39.1	34.5	25.7	42.8
Logistic							
Very low	15.7	14.6	16.6	6.9	12.2	7.1	18.1
Low	25.9	24.6	23.4	27.4	20.7	23.3	22.0
High	17.3	24.8	16.9	23.6	27.2	33.6	21.7
Very high	41.1	36.1	43.2	42.2	39.9	36.0	38.3
Accom. & Rest.							
Very low	19.0	13.7	20.7	5.9	13.8	7.4	17.9
Low	37.3	32.4	34.9	29.8	32.3	45.3	25.9
High	36.4	40.1	33.6	50.9	41.9	34.8	29.7
Very high	7.3	13.8	10.7	13.5	11.9	12.4	26.5
Inform. & Comm.							
Very low	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Low	5.9	2.4	4.7	3.4	3.1	1.3	10.7
High	41.5	41.5	43.3	34.7	52.9	42.9	54.3
Very high	52.6	56.1	52.1	61.8	44.2	55.8	34.9
Real Estate							
Very low	5.9	1.9	6.2	1.6	2.7	0.0	3.0
Low	40.7	16.6	24.7	12.8	23.8	8.8	36.3
High	38.1	44.7	37.4	43.5	45.3	71.6	58.0
Very high	15.3	36.9	31.7	42.2	28.2	19.7	2.7
Prof. Activities							
Very low	4.7	1.2	1.3	0.7	1.5	0.6	2.2
Low	19.4	15.3	25.4	7.8	7.6	5.3	22.9
High	60.9	65.7	47.7	64.9	83.2	66.5	50.1
Very high	14.9	17.8	25.6	26.6	7.7	27.5	24.8
Support Services							
Very low	12.6	6.1	6.6	5.0	8.1	3.7	11.9
Low	26.7	22.1	25.7	18.9	16.1	16.7	31.2
High	40.4	51.3	56.6	47.5	69.5	58.0	43.9
Very high	20.3	20.5	11.1	28.5	6.4	21.6	12.9

Notes: The NACE Rev. 2 industries listed in the table are: *Wholesale and retail trade; repair of motor vehicles and motorcycles* (G45–47); *Transportation and storage* (H49–53); *Accommodation and food service activities* (I55–56); *Information and communication* (J58–63); *Real estate activities* (L68); *Professional, scientific, and technical activities* (M69–74) (excluding industry 75); *Administrative and support service activities* (N77–82); and *Repair of computers and communication equipment* (S951).

2.3 Regression models

In our empirical analysis, we explore the relationship between digital intensity and firms' economic performance, followed by an examination of the factors influencing a firm's level of digitalization.

Digital intensity and economic outcomes

To investigate the relationship between digital intensity and firms' economic outcomes (Y_i), we use a linear regression model estimated by ordinary least squares (OLS) with robust standard errors. The dependent variable is the natural logarithm of a specific outcome measure (e.g., revenue, labor productivity, total factor productivity). The independent variables are dummy variables representing the different levels of digital intensity each year for each firm i. Specifically,

- $DII = 1$ (Very Low) - serves as the reference category,
- $DII = 2$ (Low),
- $DII = 3$ (High),
- $DII = 4$ (Very High).

The regression model is specified as follows:

$$\ln(Y_i) = \beta_0 + \beta_1 \cdot DII_{2i} + \beta_2 \cdot DII_{3i} + \beta_3 \cdot DII_{4i} + \boldsymbol{\gamma} \cdot \boldsymbol{X}_i + u_i, \tag{1}$$

where β_1, β_2, and β_3 are the coefficients of the dummy variables indicating the digital intensity levels (compared to the reference category, very low). A positive coefficient (β_1, β_2, β_3) indicates that firms with higher digital intensity have better economic outcomes than the reference group. The model also includes a vector of control variables ($\boldsymbol{X}_i$) that may influence a firm's economic performance (e.g., firm size, age, and industry). Including these control variables helps isolate the specific effect of the level of digital intensity on the outcome variable. The error term (u_i) captures unobserved factors that influence the outcome.

Determinants of digitalization level

We then examine the factors associated with a firm's level of digitalization. The dependent variable is the continuous digitalization score (0–12), with higher scores indicating a greater

degree of digitalization. The score is simple and constructed assuming the same weight given to each of the 12 indicators. We use the digitalization score as the dependent variable:

$$\ln(Y_i) = \boldsymbol{\beta} \cdot \mathbf{X}_i + u_i, \tag{2}$$

where $\boldsymbol{\beta}$ represents the coefficient vector of firm characteristics ($\mathbf{X}_i$). A positive and statistically significant coefficient suggests that firms with higher values of a specific characteristic tend to have higher digitalization scores, everything else given.

It is important to note that these regressions reflect statistical associations, and not necessarily causal relationships. For instance, a positive association between labor productivity and digitalization score does not necessarily imply that higher productivity causes firms to become more digitalized or vice versa. Other unobserved factors could have influenced both variables.

3 Estimation results

3.1 Firm digital intensity and revenues

In this subsection, we examine the relationship between varying levels of digital intensity and firms' performance measured as revenue among Finnish service firms from 2015 to 2021. Table 3 presents the results of the regression analysis, highlighting how different digital intensity levels (represented by dummy variables) and various firm characteristics correlate with firm revenue. The table presents the results of seven yearly regressions, one for each year from 2015 to 2021, with the dependent variable being the natural logarithm of the revenue.

Our analysis reveals that firms with higher digital intensity levels (DII=3 and DII=4) consistently demonstrate greater revenue generation compared to those with lower digital intensity levels. Firms categorized as "very high" in digital intensity (DII=4) exhibit the strongest positive correlation with revenue across years, indicating the substantial benefits of advanced digitalization. In addition to digital intensity, several firm characteristics are found to be associated with revenue. Older firms generally show a positive, though less consistent, association with their revenue. Mid-sized and large firms exhibit a robust positive correlation with revenue, suggesting advantages related to economies of scale and an established market

presence. Furthermore, foreign-owned firms and those engaged in international business activities tend to achieve higher revenues, suggesting the potential benefits of global market penetration, competition, and diversified revenue streams. The presence of R&D workers yields mixed results, often lacking statistical significance. This suggests that merely having R&D staff may not be directly associated with higher revenue without the effective utilization of their capabilities. Conversely, higher market share shows a systematic positive association with revenue, indicating potential advantages related to market dominance.

Table 3. Regression results for revenue.

Variable	2015	2016	2017	2018	2019	2020	2021
DII=2 (low)	0.247***	0.199**	0.169**	0.454***	0.340***	0.186	0.256***
	(0.072)	(0.101)	(0.081)	(0.136)	(0.097)	(0.129)	(0.082)
DII=3 (high)	0.526***	0.454***	0.503***	0.661***	0.519***	0.356***	0.498***
	(0.082)	(0.102)	(0.085)	(0.138)	(0.094)	(0.129)	(0.083)
DII=4 (very high)	0.813***	0.673***	0.783***	0.758***	0.688***	0.574***	0.864***
	(0.097)	(0.112)	(0.102)	(0.147)	(0.106)	(0.144)	(0.101)
ln(Age)	0.057*	0.056*	0.075**	0.048	0.089**	0.049	0.037
	(0.032)	(0.032)	(0.033)	(0.035)	(0.035)	(0.038)	(0.036)
Size: Medium	1.258***	1.343***	1.271***	1.388***	1.302***	1.390***	1.239***
	(0.051)	(0.053)	(0.052)	(0.054)	(0.053)	(0.054)	(0.053)
Size: Large	2.104***	2.290***	2.024***	2.180***	2.215***	2.180***	2.047***
	(0.077)	(0.072)	(0.073)	(0.075)	(0.071)	(0.072)	(0.072)
Foreign-owned	0.328***	0.335***	0.258***	0.309***	0.358***	0.292***	0.379***
	(0.064)	(0.061)	(0.060)	(0.063)	(0.056)	(0.060)	(0.063)
International business	0.371***	0.388***	0.417***	0.478***	0.408***	0.386***	0.423***
	(0.061)	(0.059)	(0.058)	(0.063)	(0.063)	(0.060)	(0.064)
Share of R&D workers	0.280	-0.330	0.269	0.096	0.223	0.037	-0.169
	(0.240)	(0.223)	(0.198)	(0.226)	(0.191)	(0.178)	(0.213)
Market share	0.063***	0.059***	0.072***	0.070***	0.071***	0.066***	0.055***
	(0.007)	(0.008)	(0.010)	(0.009)	(0.010)	(0.012)	(0.008)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,553	1,489	1,471	1,533	1,506	1,414	1,493
Wald (F)	216.273***	211.027***	215.710***	212.877***	210.258***	203.000***	229.760***
R^2(adj)	0.706	0.719	0.711	0.701	0.697	0.703	0.706

Notes: This table presents the results of seven OLS regressions, one for each year from 2015 to 2021. The dependent variable is the natural logarithm of revenue. The table shows the estimated coefficients, with robust standard errors in parentheses. Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

The use of dummy variables in categorization of digitalization and modelling its effects and employing cross sectional approach allows estimation of heterogenous digitalization effect across industries. Both slopes and intercepts, like in the case of random coefficients approach differs. It is preferred to Pooled OLS, in which the intercept is variable, but slopes are restricted to being constant over time. As a robustness check, we performed an alternative regression analysis using a continuous digitalization score ranging from 0 to 12 (see Table B1

in Appendix B). While the use of dummy variables for digital intensity levels permits direct and heterogenous observation of the associations between low, high, and very high digital intensity levels and firm revenue, captured in the form of intercept heterogeneity, modeling digital intensity using a continuous score allows us to examine the relationship beyond categorical differentiation. The estimated digitalization effect is part of the slope, and the effect is constant across industries but variable over time attributed to cross sectional modelling. The robustness check using the continuous digitalization score assuming homogenous effect reinforces our primary finding that digitalization enhances firm revenue. In line with the findings in Table 3, the digitalization score has a positive and highly significant association with firm revenue across all years, suggesting that a higher digital intensity is strongly linked to increased firm revenue (Table B1).

3.2 Firm digital intensity and productivity

This subsection examines the relationship between different levels of digital intensity and productivity among Finnish service firms for the same period (2015–2021). We utilize dummy variables to represent different digital intensity levels, with DII = 1 (very low digital intensity) serving as the reference category. We analyze both labor productivity and Total Factor Productivity (TFP). Labor productivity is calculated as the ratio of firm value added (deflated by the consumer price index) to the number of employees (in full-time equivalents). TFP is estimated parametrically using the Ackerberg-Caves-Frazer method (Ackerberg et al., 2015; Manjón and Manez, 2016). This method leverages a production function with value added as output and labor (measured by the number of full-time equivalent employees) and capital (represented by the value of machinery and equipment) as inputs. To account for industry-specific effects and capture changing dynamics over time, we estimate these production functions for each year for the seven specified industries, using the value of firms' raw materials and intermediate goods as the control variable.

The results of the seven yearly regressions for 2015–2021 for labor and TFP are presented in Tables 4 and 5, respectively. Our analysis using the DII reveals a positive association between higher digital intensity and productivity, although with variations across years. Table 4 indicates that firms with high (DII=3) and very high (DII=4) digital intensity tend to have higher labor productivity. However, the relationship between digital intensity

and labor productivity varies by year, with some years showing non-significant coefficients. Notably, firms with low digital intensity generally do not have a significantly higher labor productivity. In some years, such as 2016, a significant negative association is observed, suggesting that low digital intensity may hinder productivity in certain situations.

Table 4. Regression results for labor productivity.

Variable	2015	2016	2017	2018	2019	2020	2021
DII=2 (low)	0.030	-0.091**	-0.016	0.015	-0.044	0.020	-0.048
	(0.033)	(0.042)	(0.034)	(0.045)	(0.040)	(0.091)	(0.039)
DII=3 (high)	0.102***	-0.047	0.077**	0.043	0.067	0.110	-0.020
	(0.038)	(0.045)	(0.038)	(0.045)	(0.041)	(0.091)	(0.039)
DII=4 (very high)	0.182***	0.073	0.185***	0.053	0.104**	0.133	0.010
	(0.047)	(0.050)	(0.046)	(0.050)	(0.048)	(0.098)	(0.049)
ln(Age)	0.005	0.025*	0.035**	0.025	0.017	0.010	-0.007
	(0.015)	(0.015)	(0.015)	(0.017)	(0.016)	(0.019)	(0.018)
Size: Medium	-0.015	0.063**	-0.016	0.016	0.014	0.034	0.025
	(0.026)	(0.027)	(0.027)	(0.026)	(0.027)	(0.034)	(0.031)
Size: Large	-0.051*	0.026	-0.041	-0.024	-0.045	0.028	0.057*
	(0.031)	(0.028)	(0.029)	(0.029)	(0.029)	(0.034)	(0.033)
Foreign-owned	0.209***	0.203***	0.110***	0.168***	0.196***	0.162***	0.184***
	(0.034)	(0.032)	(0.030)	(0.030)	(0.029)	(0.036)	(0.035)
International business	0.102***	0.098***	0.158***	0.210***	0.167***	0.168***	0.157***
	(0.028)	(0.026)	(0.026)	(0.028)	(0.027)	(0.033)	(0.031)
Share of R&D workers	0.532***	0.474***	0.498***	0.578***	0.482***	0.344***	0.235**
	(0.112)	(0.112)	(0.097)	(0.106)	(0.092)	(0.091)	(0.106)
Market share	0.003	0.005*	0.007*	0.007**	0.002	0.007*	0.006*
	(0.003)	(0.002)	(0.004)	(0.003)	(0.002)	(0.004)	(0.003)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,553	1,489	1,471	1,533	1,506	1,414	1,493
Wald (F)	35.416***	32.515***	39.882***	40.669***	44.877***	39.528***	33.705***
R^2(adj)	0.241	0.235	0.251	0.247	0.267	0.294	0.242

Notes: This table presents the results of seven OLS regressions, one for each year from 2015 to 2021, with the dependent variable being the natural logarithm of firms' labor productivity. The table shows the estimated coefficients, with robust standard errors in parentheses. Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Regarding TFP, the results in Table 5 show that firms with higher digital intensity tend to have higher TFP than those with lower digital intensity, although this relationship is inconsistent with expected one across years. For example, in 2016, the estimated coefficients for digital intensity were negative and statistically significant for every digital intensity level, indicating that during this year, higher digital intensity did not translate into higher TFP. One possible explanation for this inconsistency is that our DII changed somewhat with each survey period, as some questions in the survey were updated or modified. These changes can affect the composition and measurement of digital intensity, potentially leading to variations in the relationship between digital intensity and productivity outcomes, and the estimated

DII effect.

Table 5. Regression results for Total Factor Productivity (TFP).

Variable	2015	2016	2017	2018	2019	2020	2021
DII=2 (low)	0.199***	-0.269***	-0.007	-0.163**	-0.257***	0.202	0.069
	(0.052)	(0.062)	(0.034)	(0.080)	(0.073)	(0.135)	(0.067)
DII=3 (high)	0.407***	-0.306***	0.075*	-0.122	-0.164**	0.215	0.137**
	(0.062)	(0.065)	(0.039)	(0.078)	(0.071)	(0.135)	(0.066)
DII=4 (very high)	0.369***	-0.157**	0.159***	-0.080	-0.114	0.264*	0.198**
	(0.077)	(0.073)	(0.047)	(0.082)	(0.078)	(0.146)	(0.090)
ln(Age)	-0.007	0.006	0.017	0.054**	0.053**	-0.051*	0.074**
	(0.027)	(0.021)	(0.015)	(0.021)	(0.024)	(0.027)	(0.033)
Size: Medium	0.018	-0.134***	-0.120***	-0.112***	-0.075**	-0.010	0.034
	(0.044)	(0.034)	(0.028)	(0.030)	(0.034)	(0.042)	(0.048)
Size: Large	0.058	-0.367***	-0.221***	-0.225***	-0.213***	-0.041	0.147**
	(0.062)	(0.043)	(0.030)	(0.037)	(0.043)	(0.052)	(0.058)
Foreign-owned	0.254***	0.215***	0.098***	0.164***	0.168***	0.132**	0.223***
	(0.066)	(0.044)	(0.031)	(0.036)	(0.042)	(0.053)	(0.061)
International business	0.147***	0.011	0.143***	0.199***	0.166***	0.224***	0.132***
	(0.050)	(0.036)	(0.027)	(0.034)	(0.039)	(0.046)	(0.051)
Share of R&D workers	1.498***	0.566***	0.474***	0.549***	0.437***	0.335***	0.252
	(0.383)	(0.137)	(0.099)	(0.119)	(0.108)	(0.108)	(0.189)
Market share	0.003	-0.005	0.001	-0.006	-0.013*	0.013**	-0.007
	(0.008)	(0.007)	(0.003)	(0.007)	(0.008)	(0.006)	(0.007)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,553	1,489	1,471	1,533	1,506	1,414	1,493
Wald (F)	292.080***	234.567***	58.324***	234.451***	197.314***	241.552***	396.381***
R^2(adj)	0.846	0.764	0.325	0.695	0.740	0.714	0.838

Notes: This table presents the results of seven OLS regressions, one for each year from 2015 to 2021. The dependent variable is the natural logarithm of firms' TFP. The table shows the estimated coefficients, with robust standard errors in parentheses. Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Tables 4 and 5 show a noteworthy trend: the coefficients for DII tend to become insignificant, negative, or decrease in magnitude in later years, particularly from 2020 onwards. This coincided with the COVID-19 pandemic. A plausible explanation for this weakening association could be forced digitalization across firms at all productivity levels during the pandemic. Traditionally, firms with higher digital intensity are more productive. However, when the pandemic hit, even less productive firms were pressured to adopt digital tools and processes to maintain operations or survive. This rapid and potentially unplanned digitalization might not have been as effective for these firms, leading to a dilution of the positive association between the DII and productivity observed in earlier years.

Tables 4 and 5 also report the coefficients of other firm characteristics. Foreign ownership is consistently associated with higher productivity, suggesting that firms with foreign investments might benefit from additional resources or expertise that enhances their pro-

ductivity. Similarly, firms engaged in international business activities generally show higher productivity, indicating that exposure to global markets may positively contribute to firm efficiency. The share of R&D workers in a firm consistently shows a positive association with productivity, underlining the importance of innovation and research in boosting productivity. However, market share has a weak and inconsistent association with productivity, suggesting that market dominance does not necessarily translate into higher productivity.

Tables B2 and B3 in Appendix B offer a complementary perspective on digitalization by employing a continuous digitalization score instead of the DII-level categories used in Tables 4 and 5. This score generally exhibits a positive association with productivity in most years for both labor productivity (Table B2) and TFP (Table B3). However, the strength and significance of this association fluctuate across years. A noteworthy trend emerges when examining both measures of digitalization (DII levels and digitalization score): a weakening of the positive association with productivity in later years, particularly from 2020 onwards. This observation aligns with the previously discussed potential dilution effect. The forced digitalization of many firms during the pandemic, regardless of their pre-existing productivity levels, might explain these weakening tendencies. These firms might have adopted basic digital tools to maintain operations, but these efforts may not have been strategically implemented or optimized for maximum productivity gains compared with the more deliberate digitalization strategies observed in earlier years before the pandemic.

4 Determinants of digitalization level

This section presents the results of our examination of the factors that influence a firm's digitalization level. We employ OLS estimation method with robust standard errors, as specified in Equation (2) of Section 2.3. The analysis examines how various firm characteristics are associated with the continuous digitalization score (0–12), with higher scores indicating a greater degree of digitalization within the firm.

To shed light on which firm characteristics are most strongly associated with a firm's digitalization level, Table 6 presents the estimated coefficients, robust standard errors, and significance levels for each variable included in the regression model. The key findings are as follows. A positive and statistically significant association between labor productivity and digitalization score is observed across most years, suggesting that firms with higher

labor productivity tend to have higher digitalization scores. This relationship weakens in 2020 and is not statistically significant in 2021, which is similar to the findings observed in Tables 4 and 5, where the impact of digitalization on economic outcomes appeared to lessen in later years. This suggests a potential saturation effect. Firms may have already achieved significant productivity gains from initial digitalization efforts, leading to a weaker association or marginal effects from additional digitalization between the two variables in recent years. Alternatively, the economic disruptions of the COVID-19 pandemic in 2020 and 2021 may have obscured the relationship between labor productivity and digitalization.

We also find a positive and significant association between firm size and digitalization scores. Mid-sized and large firms consistently have higher digitalization scores than small firms. This indicates that larger firms may have more resources, are better able to utilize the economies of scale effect of investment in digitalization technologies, and have higher incentives to invest in digital technology. Foreign-owned firms show a positive association with digitalization scores in some years, suggesting that they might be more likely to adopt digital technologies, potentially due to the influence of global corporate standards or access to more advanced technologies from their parent companies.

Firms engaged in international business activities have a consistently positive and significant association with digitalization scores across all years, suggesting that firms operating internationally are more likely to be digitalized. This could be due to the need for more sophisticated digital tools to manage cross-border operations and communication. A positive and significant association exists between market share and digitalization scores in most years. Firms with a larger market share tend to have higher digitalization scores, indicating that market leaders may adopt digital technologies to maintain their competitive edge and improve their economies of scale and efficiency.

There are significant differences across the private service industries. The information and communication sector consistently showed the highest digitalization scores, which aligns with expectations, as this sector inherently involves digital technology. In contrast, the logistics sector had the lowest digitalization scores, suggesting that firms in this sector may face unique challenges in adopting digital technologies or may not perceive as much benefit from digitalization compared to other service sectors.

Overall, the analysis highlights that firm size, international business activities, market

share, and industry type are important determinants of digitalization levels, while the impact of labor productivity on digitalization appears to have weakened in recent years, potentially due to the saturation of initial digitalization benefits or disruptions caused by the COVID-19 pandemic.

Table 6. Regression results for the continuous digitalization score (0-12).

Variable	2015	2016	2017	2018	2019	2020	2021
ln(Labor Productivity)	0.649***	0.429***	0.759***	0.267**	0.510***	0.184**	0.096
	(0.136)	(0.134)	(0.138)	(0.126)	(0.125)	(0.093)	(0.109)
ln(Age)	0.010	0.060	0.116	0.061	0.054	-0.060	-0.071
	(0.071)	(0.068)	(0.073)	(0.075)	(0.077)	(0.063)	(0.085)
Size: Medium	1.144***	0.700***	0.874***	0.862***	0.705***	0.528***	1.207***
	(0.137)	(0.132)	(0.140)	(0.129)	(0.145)	(0.111)	(0.139)
Size: Large	1.565***	1.211***	1.738***	1.381***	1.422***	1.158***	1.852***
	(0.141)	(0.138)	(0.136)	(0.131)	(0.140)	(0.105)	(0.145)
Foreign-owned	0.603***	0.130	0.783***	0.262**	0.533***	0.116	0.171
	(0.146)	(0.135)	(0.140)	(0.132)	(0.132)	(0.106)	(0.132)
International business	1.538***	1.097***	1.086***	0.938***	1.117***	0.769***	1.157***
	(0.138)	(0.127)	(0.133)	(0.127)	(0.136)	(0.103)	(0.139)
Share of R&D workers	0.991**	0.375	0.842**	-0.149	0.063	0.363	0.540
	(0.470)	(0.425)	(0.396)	(0.468)	(0.394)	(0.308)	(0.410)
Market share	0.044***	0.034***	0.040***	0.054***	0.034**	0.029***	0.049***
	(0.009)	(0.009)	(0.008)	(0.007)	(0.014)	(0.008)	(0.012)
Logistic	-1.709***	-2.150***	-1.748***	-1.405***	-1.339***	-1.023***	-1.826***
	(0.215)	(0.208)	(0.233)	(0.198)	(0.219)	(0.183)	(0.225)
Accom. & Rest.	-0.185	0.090	-0.526**	-0.080	-0.314	-0.505**	-0.297
	(0.189)	(0.235)	(0.230)	(0.219)	(0.258)	(0.209)	(0.252)
Inform. & Comm.	1.128***	1.289***	0.708***	1.124***	0.689***	1.197***	0.285*
	(0.146)	(0.140)	(0.150)	(0.141)	(0.139)	(0.106)	(0.151)
Real Estate	0.263	0.932***	-0.015	0.527*	-0.290	0.786***	-0.070
	(0.286)	(0.317)	(0.317)	(0.277)	(0.299)	(0.203)	(0.229)
Prof. Activities	-0.395*	0.044	-0.554***	0.167	-0.156	0.661***	-0.286
	(0.206)	(0.203)	(0.191)	(0.206)	(0.190)	(0.130)	(0.182)
Support Services	-0.361*	0.209	-0.372**	0.074	-0.260	0.229	-0.722***
	(0.208)	(0.198)	(0.183)	(0.201)	(0.210)	(0.157)	(0.217)
Obs.	1,553	1,489	1,471	1,533	1,506	1,414	1,493
Wald (F)	100.670***	53.671***	71.502***	50.962***	48.452***	52.141***	47.419***
R^2(adj)	0.415	0.316	0.387	0.291	0.290	0.345	0.312

Notes: This table presents the results of seven OLS regressions, one for each year from 2015 to 2021, with the dependent variable being the digitalization score ranging from 1 to 12. The table shows the estimated coefficients, with robust standard errors in parentheses. Significance levels are indicated as follows: * p $<$ 0.10, ** p $<$ 0.05, and *** p $<$ 0.01. The NACE Rev. 2 industries listed in the table are: *Wholesale and retail trade; repair of motor vehicles and motorcycles* (G45–47) (serves as the reference category); *Transportation and storage* (H49–53); *Accommodation and food service activities* (I55–56); *Information and communication* (J58–63); *Real estate activities* (L68); *Professional, scientific, and technical activities* (M69–74) (excluding industry 75); *Administrative and support service activities* (N77–82); and *Repair of computers and communication equipment* (S951).

5 Conclusions

This study examined digital transformation in Finland's service sector between 2015 and 2021, aiming to understand digitalization across a range of service industries and its implications for firm performance. By merging data from IT usage surveys, financial statements, and employment statistics, we created a rich merged dataset including both employer and employee information. This allowed us to analyze the relationship between varying levels of digital intensity and economic outcomes such as revenue, labor productivity, and total factor productivity, as well as the factors associated with a firm's digitalization score.

Our analysis reveals significant variability in digital adoption across service industries. Firms with higher levels of digital intensity consistently exhibit superior economic performance compared to those with lower digital intensity. This aligns with theoretical expectations and underscores the potential advantages of digitalization for service firms. However, the association between digital intensity and economic outcomes fluctuates over the years analyzed, indicating that other contextual factors may influence the impact of digitalization. Notably, while the correlation between digitalization and productivity has been strong in the earlier years, recent data indicate a weakening of this relationship. This could be attributed to a saturation effect, where firms have already achieved initial productivity gains from digitalization, or to the economic disruptions caused by the COVID-19 pandemic.

Additionally, our findings identify several firm characteristics that are positively associated with higher digitalization scores. These include labor productivity (in most years), firm size, foreign ownership (in some years), international business activities, market share, and industry sector (particularly information and communication). Mid-sized and large firms, as well as those engaged in international business, tend to have higher digitalization scores, suggesting that resources and global exposure play critical roles in facilitating digital transformation.

In conclusion, our findings suggest the advantages of digitalization for service firms, highlighting the potential benefits of continued investment in digital technologies for enhancing economic performance of private service industries. The effect of digitalization on the performance of firms is heterogenous and variable over time. However, the observed variability in the impact of digitalization over time and across different contexts suggests that a one-size-

fits-all approach may not be effective. Estimation of the model on a yearly basis allows for both intercept and slope heterogeneity which is found preferred to pooled data and estimation method assuming constant effects. Further research is needed to explore the long-term effects of digitalization and to identify best practices for sustaining digital advancements in the service sector.

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References

Ackerberg, D. A., Caves, K., and Frazer, G. (2015). Identification properties of recent production function estimators. *Econometrica*, 83(6):2411–2451.

Almeida, F., Santos, J. D., and Monteiro, J. A. (2020). The challenges and opportunities in the digitalization of companies in a post-covid-19 world. *IEEE Engineering Management Review*, 48(3):97–103.

Amankwah-Amoah, J., Khan, Z., Wood, G., and Knight, G. (2021). Covid-19 and digitalization: The great acceleration. *Journal of business research*, 136:602–611.

Bai, C., Quayson, M., and Sarkis, J. (2021). Covid-19 pandemic digitization lessons for sustainable development of micro-and small-enterprises. *Sustainable production and consumption*, 27:1989–2001.

Blichfeldt, H. and Faullant, R. (2021). Performance effects of digital technology adoption and product & service innovation–a process-industry perspective. *Technovation*, 105:102275.

Cambra-Fierro, J., Gao, L., Melero-Polo, I., and Patrício, L. (2022). Theories, constructs, and methodologies to study covid-19 in the service industries. *The Service Industries Journal*, 42(7-8):551–582.

Chin, H., Marasini, D. P., and Lee, D. (2023). Digital transformation trends in service industries. *Service Business*, 17(1):11–36.

Khan, I. S., Kauppila, O., Majava, J., Jurmu, M., Blech, J. O., Annanperä, E., Jurvansuu, M., and Pirttikangas, S. (2021). Industry 4.0 in finland: towards twin transition. In *Industry 4.0 in SMEs Across the Globe*, pages 13–27. CRC Press.

Kim, R. Y. (2020). The impact of covid-19 on consumers: Preparing for digital sales. *IEEE Engineering Management Review*, 48(3):212–218.

Koski, H. and Fornaro, P. (2024). Digitalization and resilience: Data assets and firm productivity growth during the covid-19 pandemic. Technical report, ETLA Working Papers.

Kronblad, C. and Pregmark, J. E. (2021). Responding to the covid-19 crisis: the rapid turn toward digital business models. *Journal of Science and Technology Policy Management*, (ahead-of-print).

Manjón, M. and Manez, J. (2016). Production function estimation in stata using the ackerberg–caves–frazer method. *The Stata Journal*, 16(4):900–916.

Mattila, J., Pajarinen, M., Seppälä, T., Vallin, V., Bützow, A., Hynönen, K., and Puittinen, M. (2022). Digibarometer 2022: A digital green transition. *Taloustieto Oy, Helsinki, Finland*.

Oksanen, K. and Hautamäki, A. (2014). Transforming regions into innovation ecosystems: A model for renewing local industrial structures. *The Innovation Journal*, 19(2):1.

Rha, J. S. and Lee, H.-H. (2022). Research trends in digital transformation in the service sector: a review based on network text analysis. *Service Business*, 16(1):77–98.

Soto Setzke, D., Riasanow, T., Böhm, M., and Krcmar, H. (2023). Pathways to digital service innovation: The role of digital transformation strategies in established organizations. *Information Systems Frontiers*, 25(3):1017–1037.

Vu, K., Hanafizadeh, P., and Bohlin, E. (2020). Ict as a driver of economic growth: A survey of the literature and directions for future research. *Telecommunications policy*, 44(2):101922.

Zaki, M. (2019). Digital transformation: harnessing digital technologies for the next generation of services. *Journal of Services Marketing*, 33(4):429–435.

Appendix A

Table A1. Measuring digitalization in Finnish service firms: Eurostat's Digital Intensity Index (DII) criteria.

Criteria	Description
1. Internet usage	More than 50% of employees use computers with internet access for business purposes.
2. ICT specialists	Employ ICT specialists or outsource ICT functions.
3. Internet speed	Contracted download speed of the fastest internet connection is at least 30 Mb/s.
4. Mobile connectivity	Provide more than 20% of employees with portable devices for internet connection via mobile networks.
5. Website presence; ICT security awareness	Have a website; make employees aware of their obligations in ICT security.
6. Website content, electronic orders (web or EDI) from customers in other EU countries	Website includes relevant content like goods/services descriptions, price lists, order tracking, and personalized content.
7. Social media usage	Use any social media and have links to social media profiles on the website; use of 3D printing.
8. Enterprise software; cloud computing (CC) services	Have Enterprise Resource Planning (ERP) software packages, buying medium-high CC services.
9. CRM Integration; E-commerce	Utilize Customer Relationship Management (CRM) software; Engage in eInvoicing.
10. Digital marketing; supply chain collaboration	Share Supply Chain Management (SCM) information electronically, pay for internet advertising.
11. Digital sales engagement	Enterprises where computer network sales are more than 1% of total turnover.
12. Strategic e-commerce presence and data analytics	Enterprises where web sales are more than 1% of the total turnover and B2C web sales more than 10% of the web sales; analyze big data.

Appendix B

Table B1. Regression results for revenue.

Variable	2015	2016	2017	2018	2019	2020	2021
Digitalization score (0-12)	0.103***	0.087***	0.109***	0.079***	0.081***	0.077***	0.108***
	(0.011)	(0.012)	(0.011)	(0.012)	(0.011)	(0.015)	(0.011)
ln(Age)	0.060*	0.055*	0.078**	0.046	0.088**	0.048	0.050
	(0.032)	(0.032)	(0.033)	(0.035)	(0.035)	(0.037)	(0.035)
Size: Medium	1.239***	1.335***	1.254***	1.376***	1.296***	1.390***	1.213***
	(0.051)	(0.053)	(0.051)	(0.054)	(0.053)	(0.054)	(0.056)
Size: Large	2.080***	2.271***	1.998***	2.151***	2.189***	2.175***	2.011***
	(0.077)	(0.072)	(0.073)	(0.076)	(0.071)	(0.073)	(0.072)
Foreign-owned	0.315***	0.328***	0.245***	0.299***	0.335***	0.286***	0.382***
	(0.064)	(0.060)	(0.060)	(0.063)	(0.056)	(0.060)	(0.063)
International business	0.343***	0.377***	0.400***	0.457***	0.389***	0.381***	0.397***
	(0.061)	(0.060)	(0.058)	(0.063)	(0.063)	(0.060)	(0.064)
Share of R&D workers	0.225	-0.342	0.279	0.103	0.242	0.032	-0.172
	(0.236)	(0.221)	(0.198)	(0.226)	(0.190)	(0.178)	(0.211)
Market share	0.062***	0.059***	0.071***	0.068***	0.070***	0.066***	0.055***
	(0.007)	(0.008)	(0.009)	(0.008)	(0.010)	(0.012)	(0.008)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,553	1,489	1,471	1,533	1,506	1,414	1,493
Wald (F)	252.328***	243.209***	248.688***	247.550***	244.260***	234.021***	266.458***
R^2(adj)	0.709	0.720	0.715	0.703	0.699	0.704	0.709

Notes: This table presents the results of seven OLS regressions, one for each year from 2015 to 2021, with the dependent variable being the natural logarithm of revenue and digitalization is a continuous measure. The table shows the estimated coefficients, with robust standard errors in parentheses. Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table B2. Regression results for labor productivity.

Variable	2015	2016	2017	2018	2019	2020	2021
Digitalization score (0-12)	0.025***	0.018***	0.028***	0.011**	0.021***	0.017**	0.005
	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.008)	(0.005)
ln(Age)	0.006	0.026*	0.037**	0.025	0.018	0.010	-0.006
	(0.015)	(0.015)	(0.015)	(0.017)	(0.016)	(0.019)	(0.018)
Size: Medium	-0.021	0.056**	-0.019	0.013	0.014	0.037	0.023
	(0.027)	(0.027)	(0.027)	(0.026)	(0.027)	(0.033)	(0.031)
Size: Large	-0.057*	0.024	-0.044	-0.031	-0.049*	0.031	0.055
	(0.031)	(0.028)	(0.029)	(0.030)	(0.029)	(0.034)	(0.034)
Foreign-owned	0.207***	0.201***	0.111***	0.166***	0.189***	0.164***	0.184***
	(0.034)	(0.032)	(0.030)	(0.030)	(0.029)	(0.036)	(0.035)
International business	0.095***	0.095***	0.156***	0.205***	0.165***	0.172***	0.155***
	(0.028)	(0.026)	(0.026)	(0.028)	(0.027)	(0.033)	(0.031)
Share of R&D workers	0.515***	0.455***	0.501***	0.578***	0.487***	0.343***	0.235**
	(0.111)	(0.112)	(0.097)	(0.105)	(0.092)	(0.092)	(0.106)
Market share	0.003	0.005**	0.007*	0.007**	0.002	0.007*	0.006**
	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,553	1,489	1,471	1,533	1,506	1,414	1,493
Wald (F)	40.206***	35.372***	45.310***	47.047***	51.347***	44.541***	38.164***
R^2(adj)	0.244	0.228	0.251	0.249	0.267	0.293	0.242

Notes: This table presents the results of seven OLS regressions, one for each year from 2015 to 2021, with the dependent variable being the natural logarithm of firms' labor productivity and digitalization is a continuous measure. The table shows the estimated coefficients, with robust standard errors in parentheses. Significance levels are indicated as follows: * p < 0.10, ** p < 0.05, and *** p < 0.01.

Table B3. Regression results for Total Factor Productivity (TFP).

Variable	2015	2016	2017	2018	2019	2020	2021
Digitalization score (0-12)	0.049***	-0.003	0.024***	0.011	0.005	0.007	0.020**
	(0.008)	(0.008)	(0.005)	(0.007)	(0.008)	(0.012)	(0.009)
ln(Age)	-0.007	0.007	0.019	0.054**	0.057**	-0.052*	0.075**
	(0.027)	(0.021)	(0.015)	(0.021)	(0.024)	(0.027)	(0.032)
Size: Medium	0.020	-0.146***	-0.123***	-0.116***	-0.076**	-0.005	0.036
	(0.044)	(0.034)	(0.027)	(0.030)	(0.034)	(0.042)	(0.048)
Size: Large	0.047	-0.363***	-0.224***	-0.229***	-0.216***	-0.029	0.147**
	(0.063)	(0.043)	(0.030)	(0.037)	(0.043)	(0.052)	(0.058)
Foreign-owned	0.246***	0.215***	0.099***	0.163***	0.163***	0.130**	0.225***
	(0.066)	(0.045)	(0.031)	(0.036)	(0.043)	(0.052)	(0.060)
International business	0.136***	0.008	0.141***	0.195***	0.168***	0.230***	0.134***
	(0.050)	(0.036)	(0.026)	(0.034)	(0.039)	(0.046)	(0.051)
Share of R&D workers	1.501***	0.530***	0.477***	0.539***	0.434***	0.338***	0.255
	(0.382)	(0.138)	(0.099)	(0.119)	(0.108)	(0.108)	(0.189)
Market share	0.002	-0.004	0.001	-0.006	-0.013	0.013**	-0.007
	(0.008)	(0.007)	(0.003)	(0.007)	(0.008)	(0.006)	(0.007)
Industry indicators	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	1,553	1,489	1,471	1,533	1,506	1,414	1,493
Wald (F)	339.581***	259.874***	66.057***	269.296***	215.705***	274.355***	451.315***
R^2(adj)	0.845	0.759	0.326	0.694	0.737	0.714	0.838

Notes: This table presents the results of seven OLS regressions, one for each year from 2015 to 2021, with the dependent variable being the natural logarithm of the firms' TFP and digitalization is a continuous measure. The table shows the estimated coefficients, with robust standard errors in parentheses. Significance levels are indicated as follows: * p < 0.10, ** p < 0.05, and *** p < 0.01.

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Tel. +358-9-609 900
www.etla.fi
firstname.lastname@etla.fi

Arkadiankatu 23 B
FIN-00100 Helsinki