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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

A CROSS SECTIONAL ANALYSIS ON THE IMPACTS OF ICT ON TURKISH MANUFACTURING INDUSTRY*

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Abstract

This paper aims to examine the impacts of information and communication technologies (ICT) on firm-level productivity in Turkish manufacturing industry. The dataset used in this paper was obtained from merging TURKSTAT's Annual Industry and Services Survey and ICT Usage in Enterprises Survey results. This study examines 2009 and 2019 data and estimates the impacts of ICT usage and ICT using labor on labor productivity to understand if the adoption of digitalization had impacts on firm-level productivity of the manufacturing industry throughout the ten years period. The results of the empirical analysis suggest a positive impact of ICT usage and ICT using labor on all technological levels of the manufacturing industry, however according to two-digit breakdown of manufacturing sectors indicate that only nine out of twenty-two sectors have statistically significant results on ICT usage.

Keywords: ICT, ERP, CRM, Software, Labor productivity, ICT labor, Manufacturing Industry, Turkey
JEL codes: D24, J24, O14

1. Introduction

Industry 4.0 or the Fourth Industrial Revolution became a topic of discussion when the German government promoted the computerization of the manufacturing industry in 2011. The "new" industrial revolution is stimulated by digital technologies, especially robots, artificial intelligence, the internet of things, 3-D printing, cloud computing, different types of software which enable companies to communicate and do business with their partners and customers, and other recent technologies. Using the methods of Information and Communication Technologies (ICT) and digital technologies, especially in the production process, lies at the heart of the Fourth Industrial Revolution.

According to a report from Boston Consulting Group (2015), the impacts of "Industry 4.0" will be significant in the next 10-15 years; the report forecasts that *"in Germany alone "Industry 4.0" will*

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contribute about one percent per year to GDP over ten years, create as many as 390,000 jobs, and add €250 billion to manufacturing investment (or 1 to 1.5 percent of manufacturers' revenues)." [1]

A business survey conducted by Pricewaterhouse Coopers (PWC) in 2016 to more than 2000 enterprises from nine major industrial sectors and 26 countries shows that the developments in digitalization will transform enterprises as well as market dynamics. According to this survey's results, the nine industries which were surveyed and that plan to invest US$907 billion per year globally in Industry 4.0 applications over the next five years were expecting annual digital revenue increases of 2.9 % on average and a minority of the enterprises surveyed expected 50 percent increases in their digital revenues.

By implementing information and communication technologies, organizations become more flexible in the production process and adapt themselves for user-end requirements. ICTs help provide connectivity and interoperability between organizations, their partners, and their customers through facilitating their storing, sharing, and processing information. (Perakovic, et. al. 2019).

Until 2000s, the studies exploring the contribution of ICT and digitalization to productivity did not find a deep impact on productivity. However, after the beginning of 2000s, the studies that are estimating the impacts of ICT on productivity growth have found stronger results (Stiroh, 2002; Brynjollfson and Hitt, 2003; Maliranta and Rouvinen 2004, etc.). Despite a wide range of studies on ICT and productivity in the U.S., Europe and emerging countries, there are only a few studies examining the impacts of ICT on output and productivity in Turkey. The main purpose of this study is to observe the Turkish firm data and the impacts of ICT on firm-level productivity in the Turkish manufacturing industry. It is important to analyze the effects of ICT utilization on firm level since the usage of ICT at the firms operating in manufacturing industry and other sectors became widespread in the past 10 years. This study will examine, how the spread of digitalization had impacts on manufacturing sectors, by different levels of technology. Although many authors have examined the ICT and productivity relationship, there is still a need to explore it by technological breakdown of the sectors considering the fact that different sectors might be affected in diverse levels.

In consideration of the fast adoption of digitalization by Turkish firms, this study's aim is to contribute the literature on the impacts of ICT to productivity analysis in Turkey from the perspective of Industry 4.0 and the digital transformation of Turkish firms. The study is organized as follows. The second section summarizes the related literature on the relationship between productivity and information and communication technologies. Third section provides quick facts and data on the ICT usage in Turkey in recent years. The fourth section is describing the data used in this study and the fifth section presents the results of the cross-section analysis using the data from TURKSTAT. The sixth section concludes the paper.

1 Boston Consulting Group, "Industry 4.0 The Future of Productivity and Growth in Manufacturing Industries", 2015

2. Literature Review

While there are several studies which emphasize the relationship between digitalization and productivity globally, especially in developed countries as United States, European Union countries and Australia, there are few studies conducted in this field in Turkey.

The origin of the impacts of "computer" or the "digital transformation" on production was initiated with Robert Solow's famous quote on New York Times Book Review in 1987: "You can see the computer age everywhere but in the productivity statistics." Solow questioned the reason behind the slowdown in productivity growth in the United States and developed countries in the 1970s and 1980s despite rapid development in the field of information technology. Since then, this idea was conceptualized as the "Solow paradox" to explain the slowdown in the productivity during a period when investment in information technologies is high.

Several studies have analyzed the empirical relationship between ICT and productivity in various performance measures, such as growth, productivity, and profitability. Earlier studies assessing the impacts and contributions of information and communication technologies to firm productivity encountered problems. Especially studies that observe American firm-level productivity data of the 1970s and 1980s had experienced negative correlations with economy wide productivity and information worker productivity (Brynjolffson 1993). Brynjolffson (1993) summarized a review on 18 articles that assess the impacts of IT on manufacturing industries, services sectors and both. He explains the shortfall of IT productivity or the disappointment in IT to the firm productivity levels because of deficiencies in measurement and methodologies used in these previous studies as well as because of mismanagement by developers and users of IT.

Later on, studies in the 2000s observed a significant contribution of IT to the productivity and output growth. The research of Brynjolfsson and Hitt (2003) which focuses on the impacts of computerization to firm-level productivity in the United States between 1987-1994, find out that for a sample of large-size firms, computerization contributed to the productivity and output growth in short term which is consistent with computer investments. Moreover, IT's contribution is even higher over longer-term periods.

A study by Barker, Fuss and Wavermann (2008) analyzed Australian firm data and other 17 OECD countries within a period covering 1980 to 2003. The results of their estimations indicate that the labor productivity increased throughout the years (from 1980 to 2003) with a contribution of ICT investment (IT usage, network penetration, etc.). Besides they also examine the potential spillover network and externality effects of ICT (ICT spillovers).

Maliranta and Rouvinen (2004) explore the use of ICT in Finnish business enterprises and observe the micro-level firm data in Finland between 1992 and 2001. According to the "lower bound estimate" of excess productivity of ICT-equipped labor, the additional productivity of ICT-equipped labor ranges from 8% to 18% where this effect is much higher in younger firms and in ICT-providing activities. Another result they found out from the estimations is that the excess productivity is somewhat higher in the services sector than the manufacturing sector where the manufacturing sector benefits from the ICT-induced efficiency through internal communication while the services sector benefits through external communication.

The studies on developing countries have mixed results. Basant et. al. (2006) study Brazilian and Indian firms by implementing a survey for a three-year period (2001-2003) and find out that in both countries, econometric evidence displays a strong relationship between ICT capital and firm productivity. Crespi & Zuniga (2012) examine the relationship between technological innovation and firm productivity in six Latin American countries (Argentina, Chile, Colombia, Costa Rica, Panama, and Uruguay) since prior studies could not establish the relationship because of survey and sampling methodologies. According to their findings, in all countries they made the research, firms that invest in knowledge and use innovation increased their labor productivity compared to other firms that did not; on the other hand, they found out that firm-level determinants of innovation investment were more heterogenous than in OECD countries.

Another study on Brazilian and Indian firms by Commander, Harrison and Menezes-Filho (2011), uses a unique data set constructed by a survey that has been implemented in both countries between April and May 2005. This study pioneers an innovative way while using the Indian firm data: It investigates the policy implementations and institutional environment on ICT capital investment and productivity. Similar to previous studies in the field; using a production function estimation, they break down the capital into two: Physical capital and ICT capital stock and also use other measures to identify the adoption of ICT with dummy variables. According to their different estimation results – in line with some evidence from studies on developed countries, there have been very high returns to ICT for both countries. Moreover, they analyze the impacts of policy and institutional environment on ICT adoption in India (since they do not have sufficient data for Brazil), and the results suggest that poorer infrastructure quality and pro-worker labor regulation are associated with lower levels of ICT capital intensity.

More recent studies in the 2010s, using a total factor productivity approach, estimate the contribution of ICT to productivity and output growth; while some of them find a smaller contribution to the TFP growth (Hawash, Lang, 2020), some of them have much more optimistic results where they find the significant contribution of ICT (Gal, et al., 2019). Hawash and Lang (2020), using panel data of 76 developing countries from 1991 to 2014, estimate the impact of ICT on total factor productivity (TFP) by three different approaches. In contrast to prior studies that were involved in the impacts of ICT on productivity, their results show that ICT has a limited impact on TFP growth. The estimation results reveal that both ICT investments and physical ICT usage of households' variables are significant and have a positive impact on TFP, however, it is a diminishing and modest impact.

Tambe and Hitt (2012), in their study, using a dataset they created themselves by matching firm-level IT employee data from a large sample of information technology workers (that they collect through an online job-search website) and with production inputs for approximately 1,800 firms across 20 years (from 1987 to 2006) in the United States. Since IT-using workers are subject to endogeneity bias, they found that the endogeneity does not substantively affect current IT estimates. The second finding in their study is that large and midsize firms are doing similar IT investments, although large firms have greater marginal products from these investments, while midsize firms benefit from these investments in the short-run. Their third finding is that the marginal product of IT using workers is higher (and accelerating) in the period 2000-2006 than in the prior years (1987-1999) in firms of all sizes, which contradicts the previous works suggest that the link between IT spending and productivity may have changed since 2000 (Jorgenson et al. 2008).

Harrigan, Reshef and Toubal (2018), using French firm data between 2009 and 2013, analyze the impacts of firm-level choices of ICT, R&D, exporting and importing on the evolution of productivity. To estimate firm-level productivity, they use a methodology allowing to measure both Hicks-neutral and skill-augmenting technology differences. They measure the adoption of ICT in the firms through the workers using ICT, whom they call "techies". According to their estimation results, both employment of "techies" and offshoring (exporting and importing) are orienting the firms to employ more skilled and unskilled workers. The results of the estimation also show that in between French firms which employ "techies" have skill-augmenting productivity which is 60 percent higher compared to the firms which do not employ "techies".

Aboal and Tacsir (2018) study Uruguayan firm data to understand the determinants of investments in ICTs and in other innovation activities at the firm level in both manufacturing and services sector. To assess the Uruguayan firm level data, they use a unified econometric framework based on a version of the CDM model (based on the "Crépon, Duguet and Mairesse" study in 1998). According to their results, "The *ICTs seem to be more important for innovation and productivity in the services sector than in the manufacturing sector. Second, investment in all other innovation activities is more important for the introduction of technological innovations in the manufacturing sector than in the services sector. Third, non-technological innovations are more important for productivity in the services sector than in the manufacturing sector.*" Their findings suggest that investment in ICT increases the probability of both technological and non-technological innovations in manufacturing. In the same direction as Alvarez (2016) and Polder et al. (2009), they find that ICT investment seems to foster innovation in the services sector.

There are few studies focusing on Turkey where the results indicate that the impacts of ICT on firms' efficiency or productivity were positive. Atasoy, Banker and Pavlou (2016) examine the longitudinal role of IT use in the firm's total number of employees. They use Information and Communication Technologies Usage in Enterprises Survey from TURKSTAT, which covers the period of 2007-2011 and establish a panel data set from it. To analyze the effects of IT use on firm-level employment, they use a "firm fixed effects model". The aim to use this model is to identify the within-firm changes in IT use and firm-level employment over time, and not by permanent unobserved differences across firms. The estimation differs by IT application types and moderated by three factors: Firm size, average wage rate, and industry technology intensity. According to their results, the use of enterprise applications affects firm-level employment over time, whereas the effects of the use of Web applications materialize in the current year. They found a positive relationship between IT use and firm-level employment on average, and the relationship varies by the category of IT applications.

The study of Kılıçaslan, Sickles, Kayış, and Üçdoğruk Gürel (2017) examines the impacts of ICT on labor productivity growth in the Turkish manufacturing sector. Using TURKSTAT's firm data from Annual Industry and Services Statistics, they develop a measure of the stock of capital, separating it as "conventional capital" and "ICT capital". They construct capital stock series by using the perpetual inventory methodology; they use the yearly amortization allowances to measure the capital stock and derivate the ICT investment from the investment, which includes office and computing equipment, communication equipment, and software investment. Two different models are estimated in the study, the first is the growth accounting approach, while the latter is using the generalized methods of moments method to estimate the impacts of ICT on labor productivity. According to their growth accounting model results, ICT capital has no special contribution compared to conventional capital in value-added growth in the Turkish manufacturing industry with some exceptions. However, according to the static and dynamic panel data models, the ICT capital's contribution to labor productivity in the manufacturing industry is around 15-20 percent larger than the conventional capital's contribution.

Most recently, Taştan and Gönel (2020) analyze the impacts of information and communication technologies on firm-level productivity in Turkey, using firm-level data sets and constructing an unbalanced panel data set covering the period 2007-2014. This study includes parameters to estimate the impacts of ICT, such as software investments, indicators for the usage of enterprise system applications (ERP, CRM, SCM), and ICT labor. According to their estimation results, there is a positive relationship between firm productivity and ICT use; the empirical results also support the complementarity hypothesis between ICT labor and software usage variables. They had similar results as existing studies for developed and developing countries that find a positive relationship between ICT usage and productivity. In addition, they also find out that, while the ICT investments and usage have positive returns in both manufacturing and services sectors, the effect is higher for the firms in the services sector.

In most recent study of Taştan (2021), he uses a descriptive model where he investigates the impacts of ICT on firm productivity. The ICT indicators are classified under three groups: Software, infrastructure and organizational structure. This study only observes 2017 data and estimates the impacts of ICT on labor productivity. According to the estimation results, in both manufacturing and services sectors, the intensity of ICT usage and the share of ICT using labor in total have a complementary relationship. Although this study does not imply there is a causality between ICT and productivity, the results indicate ICT using firms have relatively higher levels of productivity.

The related literature which analyzes the relationship between ICT and productivity in Turkey mostly focuses on aggregate productivity and the firm productivity on the manufacturing and services sector. This study will contribute the literature by examining the manufacturing industry on sectoral and technological level based on NACE Rev. 2 two-digit level and according to their technological intensity based on Eurostat classification.

3. The ICT Usage in Turkey in Recent Years

In Turkey, the ICT sector started to improve and increase at a faster pace in the mid-2000s. According to Informatics Industry Association in Turkey (TUBISAD), in the past five years, the market size of ICT in Turkey increased with an average pace of 23 percent (TUBISAD, 2013 & 2020). The information technologies (computer equipment, software, and other services) market size increased with a faster average pace of 29 percent while the communication technologies' market size increased with an average pace of 19 percent between 2017-2021.

According to TURKSTAT data, the usage of both Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) in all sectors increased in the recent years [2]. While ERP usage in enterprises increased from 17.8 percent share in 2012 to 28 percent in 2021 in all sectors, CRM usage increased from 9.2 percent share in 2012 to 10.6 percent in 2021. Although the usage of Supply Chain Management (SCM) was only asked in 2012 and 2017, a decrease of share in the total and in the manufacturing, sector is observed, which implies that sectors are probably shifting from SCM usage to ERP and CRM. The usage of ERP and CRM increased higher in the manufacturing sector compared with the total. (See Table 1.) TURKSTAT provides the following data starting from 2012

Table 1: The Share of Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Supply Chain Management (SCM) Software Usage in All Sectors and Manufacturing Sector from 2012 to 2021

All sectors				Manufacturing (Section C)			
Period	**ERP**	**CRM**	**SCM**	**Period**	**ERP**	**CRM**	**SCM**
2012	17.8	9.2	17.5	**2012**	21.7	7.3	19.3
2013	18.7	8.8	-	**2013**	22.7	7.8	-
2014	14.3	7.5	-	**2014**	14.2	5.5	-
2015	20.1	9.2	-	**2015**	24.3	7.5	-
2016	-	-	-	**2016**	-	-	-
2017	13.9	18.8	9.0	**2017**	16.1	18.5	8.2
2018	-	-	-	**2018**	-	-	-
2019	20.5	18.5	-	**2019**	25.9	19.4	-
2020	-	-	-	**2020**	-	-	-
2021	28.0	10.6	-	**2021**	30.9	9.8	-

Source: Turkish Statistical Institute (TURKSTAT), Survey on Information and Communication Technology (ICT) Usage in Enterprises, 2022

Note: All values reflect economic activity (NACE Rev.2. Period is the reference period.

2 TURKSTAT's "Survey on Information and Communication Technology (ICT) Usage in Enterprises" do not include agriculture, banking, and finance sectors.

According to TURKSTAT data, the usage of internet in Turkish enterprises increased from 90.9 percent in 2010 to 94.9 percent in 2019 while the rate of firms that use platforms for web sales increased from 12.3 percent in 2010 to 77.1 percent in 2019. The latter data indicate a fast adoption of digitalization in most of the enterprises (which indicates a fast spread of e-commerce) even though Turkey might be classified as a late adopter in terms of digitalization. Due to differentiating survey questions, TURKSTAT provides the proportion of enterprises employing ICT/IT specialists by size group from 2014 to 2022. While the proportion of enterprises employing an IT/ICT specialist was 10.5 percent in 2014, it increases to 13.7 percent in 2019 and to 17.8 in 2022. The increase is much more distinguishable in large size firms (employing over 250 people), the share of enterprises employing an IT/ICT specialist increases from 53.7 percent in 2014 to 72.6 percent in 2022, while it increases from 7.1 percent to 13.8 percent for small size firms and 20.5 percent to 32.3 percent for medium size firms.

4. TURKSTAT Data and Descriptive Statistics

In this study, two datasets from the Turkish Statistical Institute (TURKSTAT) obtained from annual surveys conducted to all enterprises in Turkey are merged and combined. The first dataset is the Annual Industry and Service Statistics which is based on Turkish Revenue Administration and Social Security Institution's administrative data and Annual Industry and Service Statistics Investment Expenditure Survey results. It provides data on the turnover, the number of persons employed, the number of employees, value-added at factor cost, production value, personnel cost, total purchases of goods and services, change in stocks of goods and services. The sectors of the enterprises are classified by NACE Rev.2.

The second dataset is extracted from the Information and Communication Technologies Usage in Enterprises Survey which is in line with European Statistical Office (Eurostat) methodology. This dataset covers the enterprises and businesses from the manufacturing, construction, retail and wholesale trade and services sectors. TURKSTAT states that they use Stratified Random Sampling by taking into account the economic activities (in accordance with NACE Rev.2) and enterprise size according to the number of employees. The size-classes used are small enterprises (10–49 persons employed), medium-sized enterprises (50–249 persons employed) and large enterprises (250 or more persons employed). All censuses for enterprises with 250+ persons employed are included meanwhile they used sampling for 10-49 and 50-249 size groups. TURKSTAT states they applied weighting method to obtain parameters from the dataset resulting from sampling so as to represent the universe. [3] These parameters include design weights [4], adjustments for non-response, external distribution checks and ultimate multiplying factor. For instance, there are 6,054 observations in the 2009 dataset and 12,336 observations in the 2019 dataset.

3 Details of TURKSTAT's weighting method are provided in the "Accounting Conventions" of ICT Usage Bulletin: https://data.tuik.gov.tr/Bulten/Index?p=Girisimlerde-Bilisim-Teknolojileri-Kullanim-Arastirmasi-2022-45585

4 Since weighted data is used in the regression, heteroskedasticity test cannot be run, therefore the t statistics results are checked.

Both surveys include same enterprises' dataset; however, since ICT Usage in Enterprises Survey do not include the enterprises' value-added, turnover, total number of employee information, both survey datasets are combined by using a key code provided by TURKSTAT. Following parameters from the ICT Usage in Enterprises Survey are used in this study's analysis: Software usage, using webpage to sell online, and the share of internet using personnel or employees.

Three software are included in the ICT Usage in Enterprises Survey. Enterprise Resource Planning (ERP) helps an enterprise for purchases, sales, marketing, finance, management, human resources and organizes these activities under an integrated system and reports. ERP software supports managers to provide information much more quickly for their decision-making. Thus, it promotes the productivity and the profitability of enterprises through which increases their competitivity in their sector. ERP is used by enterprises since the 1990s. Customer Relationship Management (CRM) is saving, evaluating, reporting, and analyzing the data deduced from all the interaction of the business and its customers. There is less costing CRM software in recent years thus it is accessible for small-sized enterprises as well. Supply Chain Management (SCM) software is the software tools or modules used in executing supply chain transactions, managing supplier relationships, and controlling associated business processes in all sectors. Supply chain management maximizes the efficiency of business activities that include planning and management of the entire supply chain which helps businesses in product development, sourcing, production, and logistics by automating operations. Therefore, it increases the physical flow of business as well as informative flow.

Using a webpage to sell the products or services online is an indicator that is used to observe the impacts of digital infrastructure on the firms' profitability and efficiency. Similarly, the share of the personnel using internet is used to observe the impacts of internet/digitalization on the firms' productivity.

Other essential indicators such as internet speed which allows businesses to facilitate their business processes are also provided in the ICT Usage in Enterprises Survey after 2012. Grimes, Ren and Stevens (2012) found out from their analysis on 6,000 firms in New Zealand (from a survey conducted in 2006) that broadband adoption boosts firm productivity by 7-10%; effects are consistent across urban versus rural locations and across high versus low knowledge-intensive sectors. Although Bertschek, Cerquera and Klein (2013) found out from their analysis on German firm data (between 2001-2003) that broadband Internet has no impact on firms' labor productivity, whereas it exhibits a positive and significant impact on their innovation activity. The employment of information technologies (IT) personnel and providing education to IT personnel are also the indicators that are provided in the ICT Survey after 2012. In this study's cross-sectional analysis, the latter indicators were not available since they are provided in the surveys after 2012. An extended model for the 2019 dataset, adding these indicators, were presented in the fourth section. To understand if the adoption of digitalization had impacts on firm-level productivity throughout the ten years period, this study examines 2009 and 2019 data and estimates the impacts of ICT usage and ICT using labor on labor productivity.

Table 2: The Percentage of ICT Using Firms (2009 – 2019)

Year	ICT	All firms N	All firms (%)	Manufacturing firm N	Manufacturing firms (%)	High-tech (%)	Mid-high tech (%)	Mid-low tech (%)	Low tech (%)
2009	ERP	6.054	23%	2.267	31%	58%	44%	31%	25%
	CRM	6.054	14%	2.267	11%	18%	16%	9%	10%
	Web Page	6.054	67%	2.267	75%	88%	89%	80%	66%
	Web Order	6.054	12%	2.267	10%	10%	13%	10%	8%
2019	ERP	12.644	44%	4.386	56%	61%	68%	57%	49%
	CRM	12.644	31%	4.386	32%	40%	37%	33%	29%
	Web Page	12.644	73%	4.386	81%	92%	89%	85%	74%
	Web Order	12.644	13%	4.386	11%	11%	10%	8%	12%
	IT Specialist	12.644	39%	4.386	46%	51%	55%	46%	41%
	Internet Speed	12.644	56%	4.386	54%	62%	60%	54%	51%

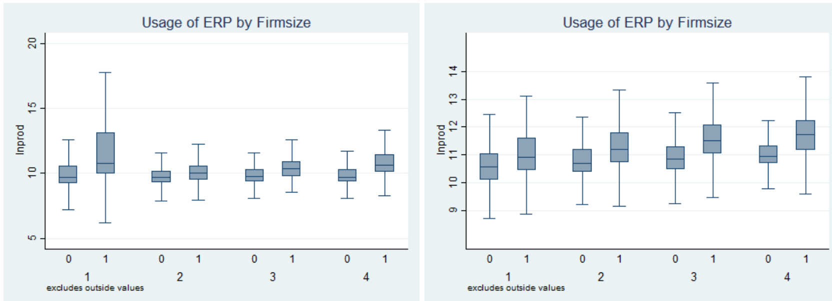
Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

TURKSTAT's ICT Usage in Enterprises 2009 dataset covers 6,054 observations, and 2019 dataset covers 12,644 observations. From these datasets, it can be observed that the share of ERP and CRM using enterprises in total increases in 10 years from 23 percent to 44 percent and from 14 percent to 31 percent respectively. Meanwhile for the manufacturing sector it is more distinguishable; the share of ERP using firms increases from 31 percent in 2009 to 56 percent in 2019 and the share of CRM using firms increases from 11 percent in 2009 to 32 percent in 2019. (See Table 2).

According to firm size differentiation, it is observed that the logarithm of the value added at factor cost per employees (labor productivity) of the firms using ERP software is higher in all size of firms. In 2019, the gap of labor productivity increases (See Figure 1.a). Similar results are observed for the firms that are using CRM in 2009 and 2019; the labor productivity of the firms using CRM software is higher than the ones that are not using in both 2009 and 2019 (See Figure 1.b). However, in 2019, the gap between the firms using CRM software and the firms that are not using is very low.

Figure 1: The Boxplot of Labor Productivity (natural logarithm) and Usage of ERP by Firm Size (2009 and 2019)

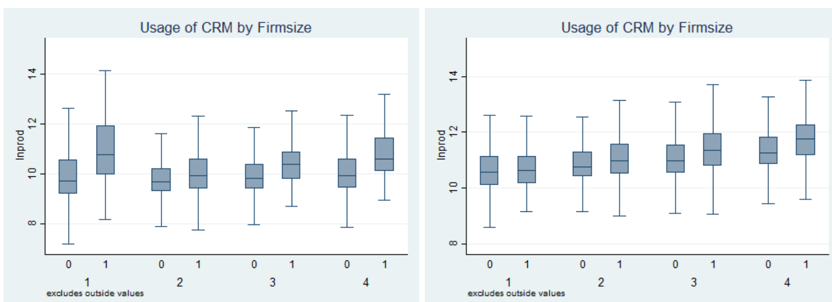
a) Usage of ERP by Firm Size



Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Notes: 0 and 1 represents the firm not using or using ERP software. The firm size is classified as micro sized (0-9 employees) as 1, small sized (10-49 employees) as 2, medium sized (50-249 employees) as 3 and large sized (250 and over employees) as 4.

b) Usage of CRM by Firm Size



Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Notes: 0 and 1 represents the firm not using or using CRM software. The firm size is classified as micro sized (0-9 employees) as 1, small sized (10-49 employees) as 2, medium sized (50-249 employees) as 3 and large sized (250 and over employees) as 4.

5. An Empirical Analysis on Firm Productivity in Turkey Using Digitalization Data

The cross-sectional regression helps to explain observations collected from many different individuals, or in our case enterprises, at a given time. Since the data from ICT Usage in Enterprises Survey includes observations from many different businesses each year and it also lacks some of the indicators every year, the cross-sectional analysis is the eligible method to observe the data in time.

Following the related literature and former studies, this study investigates if the firms that adopted a digitalization method (the software ERP, the software CRM, the webpage, the share of the personnel which uses the internet while executing their tasks) have higher productivity level. Therefore, two models to examine the relationship between ICT indicators and firm productivity in the manufacturing sectors separately are built, the latter including additional indicators.

5.1 Baseline Model

The model in this study is similar to one used by Taştan (2021), which observes the impacts of ICT usage on firm productivity. Since the dataset of ICT Usage in Enterprises Survey includes binary variables such as "using a software" (where the answer is Yes or No), and numerary variables such as "the number of personnel using internet", a linear regression model is the most applicable for this study. To observe the productivity level of the enterprises, the value added of each firm is divided by the total number of their employees. Then, the logarithm of the labor productivity and share of the internet using employees in total are taken since the range of values of the productivity level and the number of employees between the enterprises are large, and through logarithmic estimates the distribution of values is less skewed. The first model is as follows:

$$logproductivity_i = \beta_0 + \beta_1 ERP_i + \beta_2 CRM_i + \beta_3 WebPage_i + \beta_4 shareinternetemployee_i + u \quad \text{(Model 1)}$$

Where "log productivity" is the natural logarithm of labor productivity (which is measured by dividing the value added of each firm by their number of personnel) of firm "i", "ERP" and "CRM" are the software use as the indicators of ICT usage of firm "i", "Web Page" indicates the firm "i" using a webpage of their own or outsource it to sell their products online, "share internet employee" is the share of the internet using employees in total of firm "i" and u is the error term.

In the following ordinary least squares (OLS) estimation, the indicator "factor" (which is the coefficient for micro, small and medium-sized firms) is used, since TURKSTAT only gathers information from a representative number of firms from SME sized firms in the ICT Usage in Enterprises Survey. The t statistics computed from heteroskedasticity robust standard errors under the OLS for each estimation are checked and when the t statistics are higher than 0.05, the indicator is considered as statistically insignificant. The results from the estimations are grouped by the technology classification from Eurostat. Table 3 below provide the results of the OLS estimation of the baseline model for the years 2009 and 2019.

Table 3: OLS Estimation Results for Baseline Model by Technological Breakdown of Manufacturing Industry – 2009 Results

Technology level	High technology	Medium-high technology	Medium-low technology	Low technology
ERP	1.020***	0.454***	0.600***	0.287**
	(0.307)	(0.109)	(0.146)	(0.113)
CRM	0.340	-0.025	0.049	0.095
	(0.353)	(0.162)	(0.232)	(0.117)
WebPage	0.643***	0.323**	0.246**	0.219***
	(0.238)	(0.150)	(0.104)	(0.060)
shareintemployee	0.011***	0.080***	0.113***	0.111***
	(0.000)	(0.022)	(0.023)	(0.026)
Constant	9.548***	9.540***	9.629***	9.510***
	(0.184)	(0.140)	(0.078)	(0.046)
Observations	49	424	669	1,058
R-squared	0.512	0.153	0.134	0.152

Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Note: Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3: (Continued): OLS Estimation Results for Baseline Model by Technological Breakdown of Manufacturing Industry – 2019 Results

Technology level	High technology	Medium-high technology	Medium-low technology	Low technology
ERP	0.608***	0.355***	0.429***	0.388***
	(0.174)	(0.106)	(0.091)	(0.079)
CRM	0.102	-0.045	-0.041	-0.084
	(0.192)	(0.110)	(0.086)	(0.128)
WebPage	0.399**	0.557***	0.327***	0.395***
	(0.175)	(0.084)	(0.099)	(0.079)
shareintemployee	0.607***	0.062***	0.039*	-0.052
	(0.227)	(0.004)	(0.022)	(0.056)
Constant	10.708***	10.738***	10.762***	10.605***
	(0.169)	(0.066)	(0.085)	(0.044)
Observations	302	846	1,056	2,018
R-squared	0.536	0.159	0.110	0.092

Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Note: Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

According to estimation results for the cumulative technological breakdowns, usage of ERP software is statistically significant and has a positive sign for all technological levels of manufacturing sectors. On the other hand, usage of CRM is statistically insignificant for all technological levels. Owning a web page is also statistically significant and has a positive sign for all technological levels, however, share of internet using employees which is statistically significant becomes insignificant for low technology and medium-low technology manufacturing sectors in 2019. Therefore, more detailed sectoral estimations are conducted.

OLS estimation results of the NACE-2 two-digit sector breakdown of the manufacturing industry are in line with estimation results for the technological breakdown. The results for two sectors – production of tobacco (12) and production of petroleum products (19) were omitted due to lack of observations. Manufacturing industry sectoral breakdown's estimation results are presented in the Appendix (See Tables A.1 and A.2). For some sectors, there are interesting results:

High-technology sectors (21, 26):

According to estimation results, ERP usage and share of internet using employees are statistically significant for both high-technology sectors (pharmaceuticals – 21 and computers – 26) in 2009 and 2019. While using CRM and owning a web page are only statistically significant for computers sector (26) in 2009, they are only statistically significant for pharmaceuticals (21) in 2019.

Medium-high technology sectors (20, 27, 28, 29, 30):

For the medium-high technology sectors, the estimation results indicate that ERP usage is statistically significant for all medium-high technology sectors in 2009 except for manufacture of electrical equipment (27) in which CRM usage is statistically significant. In 2019, the ERP usage becomes statistically insignificant for all of them except it becomes significant for electrical equipment sector (27). The results are not in line with the cumulative "medium-high technology" estimation.

Medium-low technology sectors (19, 22, 23, 24, 25, 33):

While ERP usage is statistically significant for the sectors "rubber and plastic products" (22), in both 2009 and 2019, it is significant for "fabricated metal products, except machinery and equipment" (25) sector in 2019. The webpage indicator is statistically significant for "rubber and plastic products" (22) in 2019. The share of internet using employees is significant in 2009 and insignificant in 2019, which is in line with the cumulative "medium-low technology" estimation.

Low-technology sectors (10, 11, 12, 13, 14, 15, 16, 17, 18, 31, 32):

The estimation results show that the ERP usage is statistically significant and has a positive sign for the sectors food products (10), wood and of products of wood and cork, except furniture (16), and paper and paper products (17) in 2009; and ERP usage becomes statistically significant and has a positive sign for sectors textiles (13), wearing apparels (14), in 2019.

First model's estimation results indicate that both in 2009 and 2019, nine manufacturing sectors (out of 20 sectors that were eligible to conduct an estimation) that using the software ERP have a positive returns to their labor productivity. Having a webpage also have a positive returns to the labor productivity of nine sectors in 2019.

5.2. Extended Model

Extended model includes more indicators representing firm digitalization. This model was only able to be executed for the year 2019 since 2009 data do not cover the following additional indicators. The second model is as follows:

$$logproductivity = \beta_0 + \beta_1 ERP_i + \beta_2 CRM_i + \beta_3 webpage_{\ i} + \beta_4 shareinternetemployees_i + \beta_5\, internet\ speed_i + \beta_6\, ITspecialist_i + u$$

(Model 2)

This model includes two more indicators to the first one where "internet speed" is the indicator which shows if the internet speed of firm "i" is higher than 30 megabits per second, "IT specialist" indicates if the firm "i" hires an information technology specialist or more than one employee (the exact number of employee is not provided in the Survey), and "u" is the error term. IT employee's educational training was also used in the estimation however excluded due to the correlation with the "IT specialist" indicator. The results are included in the Appendix (See Table A.3).

OLS estimation results for all manufacturing industry sectors in 2019 indicate that employing an IT/ICT specialist is statistically significant for ten out of twenty the manufacturing industry sectors (that were eligible to conduct an estimation), while the internet speed is only statistically significant for six sectors. For both high-technology manufacturing sectors employing an IT specialist and using a high speed internet connection are statistically significant and have positive signs, and surprisingly, only for some medium-low and low-technology sectors employing an IT/ICT specialist is statistically significant.

Although this study is the first which is observing the breakdown of the manufacturing industry based on NACE Rev. 2 sectors in two-digits, the results are in line with previous studies on the impacts of ICT to productivity. The results do not imply a direct relationship between ICT and firm-level productivity in whole manufacturing sector, but it is observed that using a software (especially ERP) in this case has a broad-based impact on the manufacturing sector, meanwhile the share of internet using personnel and the employment of an IT personnel has an impact on the labor productivity of some sectors.

The results of OLS estimation from baseline model indicate that the labor productivity level of high technology sectors pharmaceuticals (21) and computers (26), and medium-high technology level sector electrical equipment (27) are consistently and positively impacted by the usage of ERP software. Since these mentioned sectors were stated to have high labor productivity levels and to invest more in research and development (Doğruel and Doğruel, 2008), the estimation results are coherent with former studies. The estimation results also indicate that for sectors medium-low technology level sectors rubber and plastic products (22), and fabricated metal products, except machinery and equipment (25) and low-technology level sectors food products (10), textiles (13); and paper and paper products (17), the usage of ERP has positive impacts on the labor productivity.

Although the estimation results do not imply a direct relationship between the labor productivity and ICT indicators such as ICT usage and share of internet using employees in total, it is observed by the technological breakdown and sectoral breakdown that ERP using firms and the share internet using employees in total have positive impacts on the labor productivity of the firms with higher technology. Therefore, the estimation results of this study indicate that firms that are investing on ICT software (ERP) and ICT infrastructure (internet speed) would have higher level of labor productivity, in line with former studies on Turkey. The relationship might also be the reverse, the firms with higher level of labor productivity would invest to ICT software and ICT infrastructure to increase their output and profit. One of the issues about calculations is that the ICT capital is not observed from the datasets, and this prevents to measure its impacts on productivity.

6. Conclusion

In this study, the impacts of ICT on firm-level productivity in Turkish manufacturing industry based on NACE Rev. 2 two-digit level are analyzed with an aim to observe if ICT has differing impacts on different technological intensity levels. Our approach is similar to previous studies, especially Taştan's (2021) recent study on the firm-level evidence from Turkey, and Maliranta and Rouvinen's (2004) article about the use of ICT in Finnish business enterprises.

Unfortunately, the lack of data and observations prevents doing a more comprehensive research using other ICT indicators. An extended model using additional indicators for 2019 dataset was also carried out. The analysis shows that internet speed and IT employment are statistically significant for some of the sectors and have a positive impact on productivity. This should be assessed carefully because the lack of data (about the investments of the enterprise, the age of the enterprise, the organizational structure, etc.) prevents to do a more detailed research.

Based on the aforementioned estimation results, some policies for the enterprises and policymakers might be suggested. Given that the software usage, especially the Enterprise Resource Planning has a positive impact on labor productivity on more than half of the manufacturing industry in Turkey, training to improve the personnel that are using the software would be strongly recommended. Since the adoption of ICT-usage has a positive impact on firm productivity, central government and policymakers might implement policies that will encourage the firms to adopt more digitalization; these policies will include technology-based incentives, loans and increasing the technological infrastructure of the organized industrial zones.

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Appendix

Table A.1: OLS Estimation Results for Baseline Model by Sectoral Breakdown of Manufacturing Industry – 2009

Technology level	Low technology										
NACE Code	10	11	12	13	14	15	16	17	18	31	32
Sector	Food products	Beverages	Tobacco products	Textiles	Wearing apparel	Leather and related products	Wood and of products of wood and cork, except furniture	Paper and paper products	Printing and reproduction of recorded media	Furniture	Other manufacturing
ERP	0.939**	0.124		0.242*	0.077	-0.083	3.036***	1.955***	0.175	0.377	-0.014
	(0.399)	(0.799)		(0.143)	(0.156)	(0.158)	(0.155)	(0.547)	(0.220)	(0.244)	(0.329)
CRM	-0.335	2.690**		0.520**	0.047	0.014	-0.585***	-0.844	-0.153	-0.139	0.344
	(0.216)	(0.797)		(0.203)	(0.131)	(0.136)	(0.023)	(0.522)	(0.209)	(0.307)	(0.300)
WebPage	0.408***			0.364**	-0.025	0.148	0.257	0.446	0.359	0.029	0.725*
	(0.124)			(0.143)	(0.098)	(0.197)	(0.272)	(0.377)	(0.234)	(0.309)	(0.404)
shareintemployee	0.096***	0.781***		0.141***	0.039	0.106	-0.463	-0.680***	0.220	0.265***	-0.477*
	(0.030)	(0.082)		(0.013)	(0.035)	(0.179)	(0.988)	(0.233)	(0.355)	(0.072)	(0.241)
Constant	9.584***	10.080***		9.495***	9.554***	9.531***	9.325***	9.648***	9.448***	9.326***	9.266***
	(0.093)	(0.422)		(0.112)	(0.069)	(0.162)	(0.289)	(0.311)	(0.249)	(0.300)	(0.377)
Observations	204	7		239	256	42	37	40	101	94	36
R-squared	0.276	0.951		0.323	0.022	0.029	0.055	0.368	0.062	0.244	0.231

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Table A.1: (Continued): OLS Estimation Results for Baseline Model by Sectoral Breakdown of Manufacturing Industry – 2009

Technology level	Medium-low technology						Medium-high technology					High-technology	
NACE Code	19	22	23	24	25	33	20	27	28	29	30	21	26
Sector	Coke and refined petroleum products	Rubber and plastic products	Other non-metallic mineral products	Basic metals	Fabricated metal products, except machinery and equipment	Repair and installation of machinery and equipment	Chemicals and chemical products	Electrical equipment	Machinery and equipment n.e.c.	Motor vehicles, trailers and semi-trailers	Other transport equipment	Basic pharmaceutical products and pharmaceutical preparations	Computer, electronic and optical products
ERP		0.694***	0.612*	0.573	0.426*	0.594	1.271***	-0.220	0.311**	0.823***	1.593***	1.298***	0.761**
		(0.182)	(0.321)	(0.429)	(0.222)	(0.725)	(0.329)	(0.245)	(0.155)	(0.236)	(0.315)	(0.321)	(0.272)
CRM		0.310	0.039	0.830*	-0.034	-1.419*	-0.439	0.604**	-0.161	0.167	-0.289	-0.171	0.761**
		(0.335)	(0.460)	(0.465)	(0.259)	(0.836)	(0.320)	(0.237)	(0.198)	(0.390)	(0.340)	(0.316)	(0.276)
WebPage		0.215	-0.005	0.874**	0.409**	0.007	-0.435	1.008***	0.333*	0.592	-0.833***	0.525	0.770***
		(0.201)	(0.230)	(0.338)	(0.181)	(0.312)	(0.400)	(0.177)	(0.200)	(0.448)	(0.267)	(0.329)	(0.216)
shareintemployee		0.084***	0.080***	0.110**	0.394***	0.508***	0.092***	0.321***	0.066***	-0.173	0.248	0.427***	0.012***
		(0.020)	(0.022)	(0.052)	(0.098)	(0.041)	(0.011)	(0.038)	(0.022)	(0.639)	(0.338)	(0.087)	(0.000)
Constant		9.584***	9.754***	9.265***	9.393***	9.731***	10.353***	9.101***	9.542***	9.065***	10.186***	9.705***	9.294***
		(0.178)	(0.139)	(0.243)	(0.152)	(0.201)	(0.323)	(0.094)	(0.178)	(0.453)	(0.191)	(0.269)	(0.034)
Observations		170	174	99	189	36	74	78	151	101	20	23	26
R-squared		0.257	0.116	0.277	0.153	0.456		0.402	0.136	0.278	0.615	0.784	0.685

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Table A.2: OLS Estimation Results for Baseline Model by Sectoral Breakdown of Manufacturing Industry – 2019

Technology level	**Low technology**										
NACE Code	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**31**	**32**
Sector	**Food products**	**Beverages**	**Tobacco products**	**Textiles**	**Wearing apparel**	**Leather and related products**	**Wood and of products of wood and cork, except furniture**	**Paper and paper products**	**Printing and reproduction of recorded media**	**Furniture**	**Other manufacturing**
ERP	0.615***	0.025		0.311***	0.416**	0.155	0.240	0.848***	0.258	0.070	0.018
	(0.226)	(0.710)		(0.092)	(0.200)	(0.222)	(0.199)	(0.187)	(0.182)	(0.097)	(0.331)
CRM	-0.030	-1.056**		0.107	-0.738	0.486*	0.158	-0.366*	0.061	-0.059	0.248
	(0.159)	(0.385)		(0.112)	(0.600)	(0.259)	(0.137)	(0.202)	(0.197)	(0.096)	(0.310)
WebPage	0.397	0.837**		0.199*	0.582***	-0.088	0.427**	0.319	0.257	0.232**	0.551**
	(0.249)	(0.389)		(0.105)	(0.155)	(0.191)	(0.187)	(0.294)	(0.159)	(0.105)	(0.219)
shareintemployee	-0.111	0.281		-0.004	0.014	0.799*	0.467*	-0.282***	-0.049	-0.058	0.324
	(0.102)	(0.577)		(0.148)	(0.196)	(0.475)	(0.253)	(0.097)	(0.229)	(0.080)	(0.413)
Constant	10.511***	11.282***		11.006***	10.414***	10.740***	10.365***	10.907***	10.703***	10.682***	10.398***
	(0.068)	(0.395)		(0.093)	(0.096)	(0.088)	(0.147)	(0.274)	(0.140)	(0.091)	(0.155)
Observations	452	21		479	457	49	104	132	71	182	67
R-squared	0.078	0.639		0.112	0.146	0.257	0.146	0.261	0.081	0.058	0.286

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Table A.2 (Continued): OLS Estimation Results for Baseline Model by Sectoral Breakdown of Manufacturing Industry – 2019

Technology level	Medium-low technology						Medium-high technology					High-technology	
NACE Code	**19**	**22**	**23**	**24**	**25**	**33**	**20**	**27**	**28**	**29**	**30**	**21**	**26**
Sector	**Coke and refined petroleum products**	**Rubber and plastic products**	**Other non-metallic mineral products**	**Basic metals**	**Fabricated metal products, except machinery and equipment**	**Repair and installation of machinery and equipment**	**Chemicals and chemical products**	**Electrical equipment**	**Machinery and equipment n.e.c.**	**Motor vehicles, trailers and semi-trailers**	**Other transport equipment**	**Basic pharmaceutical products and pharmaceutical preparations**	**Computer, electronic and optical products**
ERP		0.403***	0.503*	0.374	0.344***	0.740*	0.651	0.621***	0.194	0.257	0.451	0.669***	0.451***
		(0.155)	(0.280)	(0.276)	(0.103)	(0.404)	(0.477)	(0.179)	(0.144)	(0.178)	(0.455)	(0.190)	(0.132)
CRM		-0.253	0.092	0.079	-0.022	-0.310	0.269	0.050	-0.231	0.009	0.262	0.401**	0.104
		(0.195)	(0.215)	(0.333)	(0.104)	(0.386)	(0.496)	(0.147)	(0.157)	(0.171)	(0.389)	(0.169)	(0.188)
WebPage		0.475***	0.426	0.233	0.231*	-0.161	0.866*	0.346*	0.637***	0.317***	0.424	0.556***	0.284
		(0.164)	(0.275)	(0.191)	(0.132)	(0.318)	(0.485)	(0.202)	(0.110)	(0.112)	(0.334)	(0.137)	(0.290)
shareintemployee		0.191	0.026***	0.344**	0.074	0.695*	-0.496	-0.165	0.117*	0.062***	0.787	1.109***	0.606**
		(0.544)	(0.007)	(0.136)	(0.262)	(0.387)	(0.949)	(0.256)	(0.068)	(0.003)	(0.578)	(0.126)	(0.260)
Constant		10.675***	10.543***	10.810***	10.836***	10.964***	10.783***	10.669***	10.733***	10.902***	10.461***	10.435***	10.785***
		(0.194)	(0.223)	(0.051)	(0.119)	(0.230)	(0.358)	(0.170)	(0.082)	(0.107)	(0.230)	(0.123)	(0.288)
Observations		219	238	154	356	85	89	150	255	293	59	43	259
R-squared		0.188	0.142	0.108	0.080	0.143	0.221	0.303	0.176	0.096	0.280	0.922	0.480

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Table A.3: OLS Estimation Results for Extended Model by Sectoral Breakdown of Manufacturing Industry – 2019

Technology level	Low technology										
NACE Code	10	11	12	13	14	15	16	17	18	31	32
Sector	Food products	Beverages	Tobacco products	Textiles	Wearing apparel	Leather and related products	Wood and of products of wood and cork, except furniture	Paper and paper products	Printing and reproduction of recorded media	Furniture	Other manufacturing
ERP	0.433**			0.319***	0.300	0.198	0.184	0.792***	0.248	0.058	-0.099
	(0.186)			(0.095)	(0.204)	(0.149)	(0.200)	(0.204)	(0.238)	(0.099)	(0.298)
CRM	-0.014	-0.952**		0.073	-0.802	0.464	0.107	-0.386*	0.050	-0.142	0.064
	(0.152)	(0.436)		(0.105)	(0.625)	(0.277)	(0.147)	(0.207)	(0.200)	(0.098)	(0.251)
WebPage	0.349	0.853**		0.214**	0.522***	-0.144	0.424**	0.308	0.326*	0.204*	0.664***
	(0.264)	(0.381)		(0.102)	(0.143)	(0.126)	(0.190)	(0.290)	(0.189)	(0.104)	(0.210)
IT Specialist	0.576***	-0.017		-0.056	0.278	0.538**	0.867***	0.176	-0.098	0.196	0.341
	(0.187)	(0.743)		(0.117)	(0.170)	(0.239)	(0.179)	(0.196)	(0.173)	(0.138)	(0.264)
internet speed	0.092	-0.141		0.219**	0.256	0.197*	-0.124	-0.046	0.203	0.166**	0.420**
	(0.164)	(0.332)		(0.111)	(0.171)	(0.116)	(0.178)	(0.154)	(0.217)	(0.083)	(0.171)
share int employee	-0.117	0.229		0.011	0.026	0.623	0.508*	-0.307***	-0.072	-0.060	0.117
	(0.097)	(0.646)		(0.142)	(0.193)	(0.394)	(0.291)	(0.103)	(0.244)	(0.080)	(0.293)
Constant	10.480***	11.321***		10.924***	10.339***	10.647***	10.391***	10.938***	10.601***	10.641***	10.214***
	(0.090)	(0.408)		(0.088)	(0.129)	(0.101)	(0.151)	(0.289)	(0.157)	(0.097)	(0.184)
Observations	452	21		479	457	49	104	132	71	182	67
R-squared	0.093	0.643		0.140	0.164	0.441	0.188	0.268	0.113	0.090	0.385

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.

Table A.3 (Continued): OLS Estimation Results for Extended Model by Sectoral Breakdown of Manufacturing Industry – 2019

Technology level	**Medium-low technology**						**Medium-high technology**					**High-technology**	
NACE Code	**19**	**22**	**23**	**24**	**25**	**33**	**20**	**27**	**28**	**29**	**30**	**21**	**26**
Sector	**Coke and refined petroleum products**	**Rubber and plastic products**	**Other non-metallic mineral products**	**Basic metals**	**Fabricated metal products, except machinery and equipment**	**Repair and installation of machinery and equipment**	**Chemicals and chemical products**	**Electrical equipment**	**Machinery and equipment n.e.c.**	**Motor vehicles, trailers and semi-trailers**	**Other transport equipment**	**Basic pharmaceutical products and pharmaceutical preparations**	**Computer, electronic and optical products**
ERP		0.321**	0.436	0.115	0.239**	0.659	0.989**	0.572***	0.193	0.020	0.053	0.506***	0.312**
		(0.159)	(0.297)	(0.233)	(0.100)	(0.403)	(0.411)	(0.178)	(0.152)	(0.237)	(0.625)	(0.161)	(0.128)
CRM		-0.282	0.100	-0.058	-0.034	-0.224	0.197	0.033	-0.295**	0.030	0.161	0.018	-0.016
		(0.204)	(0.215)	(0.310)	(0.105)	(0.407)	(0.393)	(0.157)	(0.146)	(0.183)	(0.386)	(0.215)	(0.157)
WebPage		0.412**	0.431	0.163	0.226*	0.007	0.471	0.343*	0.617***	0.359***	0.342	0.406***	0.188
		(0.162)	(0.274)	(0.214)	(0.129)	(0.293)	(0.393)	(0.200)	(0.115)	(0.118)	(0.340)	(0.087)	(0.298)
IT Specialist		0.398**	0.129	0.603**	0.328**	0.631	-0.733**	0.225	0.046	0.554***	0.609	0.485***	0.360***
		(0.192)	(0.234)	(0.285)	(0.130)	(0.495)	(0.297)	(0.184)	(0.140)	(0.208)	(0.518)	(0.163)	(0.127)
internet speed		-0.067	0.233	0.136	-0.112	-0.245	0.655*	-0.266*	0.256**	-0.052	0.235	0.323***	0.385**
		(0.142)	(0.194)	(0.249)	(0.110)	(0.273)	(0.366)	(0.141)	(0.113)	(0.134)	(0.342)	(0.078)	(0.168)
share int employee		0.198	0.025***	0.371***	0.072	0.562	-0.548	-0.090	0.142**	0.057***	0.670	0.825***	0.574**
		(0.548)	(0.007)	(0.138)	(0.257)	(0.379)	(0.687)	(0.266)	(0.070)	(0.002)	(0.583)	(0.176)	(0.240)
Constant		10.727***	10.440***	10.782***	10.862***	10.947***	10.843***	10.749***	10.627***	10.862***	10.376***	10.472***	10.614***
		(0.189)	(0.260)	(0.035)	(0.112)	(0.208)	(0.260)	(0.187)	(0.094)	(0.122)	(0.207)	(0.087)	(0.307)
Observations		219	238	154	356	85	89	150	255	293	59	43	259
R-squared		0.222	0.158	0.240	0.107	0.177	0.381	0.353	0.212	0.134	0.327	0.943	0.514

Robust standard errors in parentheses

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

Source: Author's calculations based on TURKSTAT Annual Industry and Services Survey and ICT Usage in Enterprises Survey 2009 and 2019 datasets.