

ICT AND EXPORT PERFORMANCE: FIRM-LEVEL EVIDENCE FROM TÜRKİYE*

Hikmet KAYA¹, Feride GÖNEL²

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Abstract

This study analyzes the impacts of information and communication technologies (ICTs) on the export behavior of Turkish firms. We combine five firm-level data sets compiled by Turkish Statistical Institute and construct an unbalanced panel data set covering the period 2009-2019 for firms operating in manufacturing industry. We use enterprise resource planning (ERP) as the proxy for the firm's ICT capacity, which is a more sophisticated indicator than the tools commonly used in the literature such as internet, e-mail and website. We estimated both pooled probit and random effects (RE) probit models as well as the dynamic panel probit model that allows us to control for sunk costs associated with export market entry. Our results from pooled and RE probit models confirm that ERP is positively and significantly associated with the probability of firms being exporters. The results of the dynamic model confirm the existence of hysteresis in export market.

Keywords: Information and communication technology (ICT), export performance, enterprise resource planning (ERP), firm behavior

JEL Classifications: C33, D22, F10, F14, O14

BİT VE İHRACAT PERFORMANSI: TÜRKİYE İÇİN FİRMA DÜZEYİNDE KANIT

Öz

Bu çalışma, bilgi ve iletişim teknolojilerinin (BİT), Türk firmalarının ihracat davranışları üzerindeki etkilerini analiz etmektedir. Bu amaca yönelik olarak, Türkiye İstatistik Kurumu tarafından derlenen firma düzeyinde beş veri seti birleştirilerek imalat sanayinde faaliyet gösteren firmalar için 2009-2019 dönemini kapsayan dengesiz bir panel veri seti oluşturduk. Firmaların BİT kapasitesinin proksisi olarak literatürde yaygın olarak kullanılan internet, e-posta ve web sitesi gibi araçlara kıyasla daha gelişmiş bir gösterge olan kurumsal kaynak planlamasını (ERP) kullanıyoruz. Havuzlanmış probit ve rassal etkiler probit modellerinin yanı sıra ihracat pazarına girişle ilişkili batık maliyetleri kontrol etmemizi sağlayan dinamik panel probit modelini de tahmin ettik. Havuzlanmış ve rassal etkiler probit modellerinden elde ettiğimiz sonuçlar, ERP ile firmaların ihracatçı olma olasılığı arasında pozitif ve anlamlı bir ilişkili olduğunu göstermektedir. Dinamik modelin sonuçları ise ihracat piyasasına ilişkin histerinin varlığını doğrulamaktadır.

Anahtar Kelimeler: Bilgi ve iletişim teknolojileri, ihracat performansı, kurumsal kaynak planlaması, firma davranışı

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¹ Research Assistant, Yıldız Technical University, Department of Economics, hikmet.kaya@yildiz.edu.tr, ORCID: 0000-0001-6852-7982

² Professor, Yıldız Technical University, Department of Economics, gonel@yildiz.edu.tr, ORCID: 0000-0001-7946-9298

1. Introduction

Information and communication technologies (ICTs) have a significant capacity in terms of their ability to affect trade by reducing trade costs arising from the distance between trade partners. World Trade Organization (2018) decomposes trade costs into six components: Transport costs, logistics costs, border costs, information and transaction costs, trade policy barriers, and other costs. According to the report, among these five components, information and communication costs are the second largest cost for exports of goods at around 20% and the largest cost for exports of services at around 30%. It is expected that ICT adoption is likely to decrease these costs and facilitate trade. Given that the World Trade Organization attributes the 15% reduction in international trade costs between 1996 and 2014 to the ICT revolution, this gives sufficient ground to analyze the impact of ICT on trade for firms.

Although Türkiye is classified as a late-adopter in the field of ICT compared to developed countries, it has experienced a rapid adaptation process during the last two decades in terms of both households and firms. For example, according to the World Bank classification, the rate of individuals using the internet in Türkiye, which is in the upper middle-income group, increased from 4% in 2000 to 81% in 2021, while the average of countries in its income group has reached around 75%. A similar situation exists for mobile cellular subscriptions per 100 people. In 2021, while the number of individuals who subscribe to cell phones is 102 per 100 people, it was around 25 in 2000 (World Bank, 2023). In terms of firms, we see that ICT adoption and utilization rates are increasing in many indicators. For example, computer ownership and internet usage rates are above 96% as of 2022. The rate of firms employing IT specialists has increased from around 10% in 2014 to 18% in 2022. In addition to these, firms have increased their investments in artificial intelligence and robot technology, especially in the manufacturing industry, in recent years (TurkStat, 2022). All these advances have a considerable potential to reduce transaction costs arising from the distance between countries in foreign trade.

In the 1990s, “the death of distance” (Cairncross, 1997) and “the end of geography” (O’Brien, 1992) have emerged as the two most striking concepts that emphasizes the declining significance of location in terms of foreign trade. Cairncross asserted that some costs pertaining to distance such as transportation and communication would tend to fall in parallel with the advancements in information technologies, which makes the geographical location of trading countries less significant to some extent. Similarly, while his focus is on financial integration and innovation, O’Brien argues that the introduction of modern payment systems has facilitated trade with distant parties compared to the past when physical meetings were necessary for exchanging handwritten documents and cash. In addition, Friedman (2005) characterized the world as flat to emphasize competition in commerce is a “level playing

field” at which competitors have equal opportunities so that competition among countries is unconnected with their location. On the contrary, Venables (2001) argues that while new technologies may lead to the relocation of some economic activities and contribute more to the economic development of some nations or regions, the notion of the ‘death of distance’ argument would be unrealistic. He argues that this concept implies a convergence that is not supported empirically. Similarly, Agnew (2011) approaches from a historical perspective and argues that similar approaches to the importance of distance were put forward at various critical junctures (such as roads, railways, telegraphy, etc.), but ultimately there was no effect as much as it was thought. Therefore, he argued that ‘distance did not die’ and technological innovations have not rendered the importance of location but rather reformulated it. In their article, Leamer and Levinsohn (1995) argue that there are no convincing findings that the world is shrinking in terms of trade and the impact of distance is diminishing. In a meta-analysis conducted by Disdier and Head (2008), which examines 1,467 gravity equations from 103 papers covering the period from 1870 to 2001, it is observed that despite the general negative relationship between distance and trade, the effect of distance on trade decreased slightly until 1950 and then began to rise afterward, a phenomenon is known as the “distance puzzle” in international trade. However, it is important to note that the findings of this study are for the pre-2001 period and therefore we expect to see the impact of the ICT revolution on trade costs, and hence on distance, more in the 21st century.

Until recently, due to data availability constraints, the effect of ICT has been analyzed with the most basic indicators such as computer ownership, internet access, website ownership, and e-mail use. However, considering the present state of technological advancement, almost all firms within countries adopt and utilize advanced technologies that surpass the basic ones. Therefore, any analysis that solely relies on these basic indicators may fail to account for firm heterogeneity and is unlikely to reach a robust causal inference. Besides, more recently, panel data at the firm level has become more available and this gives the opportunity to analyze firm dynamics over time.

Our empirical analysis is based on an econometric model that uses a novel panel data set which never been used before. We combine five firm-level data sets compiled by Turkish Statistical Institute (TurkStat) and reach an unbalanced panel data set covering the period 2009-2019. This final data set is obtained by merging the ICT Usage in Enterprises survey, Foreign Trade Statistics, Company Accounts Statistics, Annual Industry and Service Statistics (AISS), and Annual Business Registers Framework. The dataset contains a total of 14,575 firms operating in the manufacturing industry, both small and medium-sized enterprises (SMEs) and large firms with more than 250 employees. Whether the firm uses Enterprise Resource Planning (ERP) software or not, which is recognized as the most effective and

inclusive enterprise system, is the ICT indicator in our analysis. Our results suggest that there is a positive and significant relationship between the probability of firms being exporters and ICT use.

There is limited empirical evidence in the literature on ICT and firms' export performance focusing on developing countries. We contribute to the literature by filling this gap through the case of Türkiye as a developing country. Our second contribution is to analyze the impact of ICT on the probability of firms' being exporters in a more robust way by using advanced software such as ERP instead of very basic indicators that are often preferred in the literature. Finally, another notable contribution of this study is that, for the first time, five basic datasets are combined and analyzed for Türkiye. Although the use of this type of data set in firm-based studies in developing countries has been increasing in recent years, this is the first time that such a combined data set has been used for Türkiye.

The rest of the paper is structured as follows: In the next section, we briefly review the theoretical literature and present related empirical studies. Section 3 describes the data used in the analysis and discusses some summary statistics. Section 4 introduces the econometric model used to estimate the ICT-export relationship. Empirical results are presented and discussed in section 4. Finally, section 5 provides a conclusion.

2. Review of Literature

There exists a vast amount of both theoretical and empirical literature related to the effect of ICT on a broad range of economic activities such as determinants of ICT adoption, ICT-productivity relationship or ICT usage, and its effect on various fields such as education, agriculture, energy, etc. In terms of empirical studies, there has been a significant increase in studies based on observational data with the recent proliferation of panel data in this field (albeit mostly for developed countries). However, a complete review of ICT literature is beyond the scope of this study and therefore, we only review and present a subset of the literature focusing on studies that are investigating the relationship between ICT and export performance of firms.

When we examine the theoretical and empirical literature separately, the ICT-export relationship has been theoretically analyzed through the effect of ICT on trade costs. What is meant by trade costs in this context are not the costs related to the production process or the ones incurred by firms as a result of some policies that impede free trade among countries such as tariffs or non-tariff barriers. Rather, these are transaction costs that arise due to the existence of distance between parties (Anderson & van Wincoop, 2004) and they make up a

significant proportion of total foreign trade cost. The higher these costs, the more difficult it is to establish a trade relationship and the lower the volume of trade is expected to be.

One of the most important transaction costs is the search cost and it plays an important role in the decision-making processes related to foreign trade activity. This is because all considerations, from the quality of the traded good to whether the price of the good is competitive or not, can be considered within the scope of search costs and affect the economic cost of the good. Besides, as Besedeš (2008) points out, most foreign trade relationships usually start with small volumes and short terms, and therefore looking for and finding a reliable and suitable foreign trading partner is important for the long-term relationship. Therefore, while high search costs may lead a firm to decide not to enter the foreign trade market, ICT can facilitate trade by reducing costs through its role in significantly reducing the information friction about the market, players, and products, which is the main cause of search costs (Aker, 2010; Allen, 2014; Jensen, 2007).

The other transaction cost where the role of ICT is crucial is the communication cost. The impact of communication on trade has either been ignored in theoretical models or seen as part of transportation costs. Harris (1995), in his pioneering work where he incorporates communication into the trade model, lists a number of reasons why the communication cost should not be seen as a transportation cost, the most important of which is that the communication cost is actually a fixed cost. Because once the necessary infrastructure is established, the marginal cost of using this network is very low or even zero. However, when we distinguish between supply-side and demand-side approaches, Harris' approach might be correct from a supply-side perspective if communication was only a tool used in the process of searching for a trading partner. When we consider the entire process from market research to the delivery of the product to the buyer, there is constant communication between buyer and seller, which affects variable costs (Mupela & Szirmai, 2012). Therefore, we can say that the communication cost on the demand side is a variable cost, and Fink et al. (2005), who modeled the cost of communication on this distinction and examined its impact on trade, empirically showed that decreases in the cost of communication increase international trade.

In the empirical literature, studies have mostly focused on the impact of ICT use on bilateral trade within the framework of gravity models (Bojnec & Fertő, 2009; Martínez-Zarzoso & Márquez-Ramos, 2005; Ozcan, 2018; Xing, 2018; Yushkova, 2014). In the absence of firm-level data, the gravity model approach can be useful in understanding the impact of a specific policy on trade between two countries or, more broadly, between groups of countries, as in the case of ICT. As an example of such studies, Rodriguez-Crespo et al. (2021), using panel data covering the period 1996-2014 for 121 countries, find a positive relationship

between internet use and exports, and show that this effect is higher in developed countries than in developing countries. With a similar approach, Vemuri and Siddiqi (2009) analyzed the bilateral trade of 64 countries at different levels of development for the period 1985-2005 and found that telephone lines, internet users, and computers positively affect the volume of trade. Freund and Weinhold (2004) examined the impact of the internet on bilateral trade through web host ownership of 56 countries for the period 1997-1999 and found that a 10% increase in a country's web host ownership increases exports by 0.2%. In an earlier study, the same researchers examined the impact of the Internet on exports in the service sector for the US covering the period 1995-1999 and found that a 10% increase in Internet penetration increased service exports by 1.7% and imports by 1.1% (C. Freund & Weinhold, 2002).

Although cross-country studies show the average effect of ICT on export performance, when we take into account the fact that the share of exporting firms among all firms operating in the country is very small and even within exporting firms, a large share of total exports are made by a limited number of very large firms, studies of the above-mentioned type are insufficient to reflect the average firm performance of that country. In order to overcome the shortcomings of these studies with aggregated data in reflecting firm performance, microdata at the firm level are needed, and with the proliferation of such data in recent years, there has been an increase in firm-level studies. For instance, Clarke (2008) examines the effect of the Internet on exports at the firm level in low and middle-income countries from Eastern Europe and Central Asia and finds that firms with Internet access are more likely to export than those without. He also shows that firms that are already exporting do not export more when they have internet access, suggesting that the impact of the internet is related to the decision to export rather than the amount the firm exports. Yadav (2014) argues that e-mail usage and website ownership have a similar effect on firms' export and import behavior for 52 developing countries from Asia and Sub-Saharan Africa using World Bank Enterprise Surveys data for the period 2006-2010.

As can be seen in the studies mentioned so far, indicators of ICT usage consist of very basic tools such as the Internet, website, and e-mail. In recent years, more comprehensive ICT indicators have been collected from firms through surveys. As an example of studies using these data, Hagsten and Kotnik (2017) examined SMEs operating in 12 European countries. In addition to basic indicators such as website ownership, they also examined the impact of relatively more advanced indicators such as e-sales, number of employees using the internet, number of employees with ICT training on exports, which they call ICT capacity, and found that ICT capacity positively affects the export performance of SMEs. More importantly and interestingly, they find that advanced ICT indicators affect export intensity,

which is the share of exports in total output, more than firms' decisions on whether to become exporters or not.

The business and marketing literature has shown interest in the ICT-export relationship and firm-level studies have also been conducted in this field (Bianchi & Mathews, 2016; Racela & Thoumrungroje, 2020; Trainor et al., 2011). However, these studies have been subject to methodological criticism because they use Likert scales in their questionnaires. Besides, they measure the level of ICT use of the firm only with the internet, which is another reason of criticism toward these studies. Hence, even if these studies might show the direction of the relationship between ICT and export, they fail to reveal the magnitude of the relationship in a robust way.

There are a limited number of studies focusing on Türkiye in the literature. Studies analyzing the role of the internet on Türkiye's bilateral trade use the gravity model framework and find a positive relationship between them (Aykulteli & Töngür, 2020; Şeker, 2017). On the other hand, studies (Basılğan, 2020; Melemen, 2006) using firm-level data based on questionnaires either concentrate on a specific industry or are very descriptive and far from understanding the extent of the relationship.

Until recent years, ICT adoption and utilization of firms have been measured in empirical studies with tools such as computer ownership, e-mail usage, internet access and website ownership. However, when we consider the present level of technology, we see that almost all firms in an upper-middle income country like Türkiye have such tools. Therefore, empirical studies focusing on firms' ICT use need more complex indicators than these basic tools to adequately reflect the firm heterogeneity. At this point, data availability is still a serious concern for developing countries, in particular. In this study, we argue that whether a firm uses ERP or not is an important tool to understand the level of ICT utilization of that firm.

Briefly describing what kind of a system ERP is will also reveal why we use ERP as a proxy for ICT. ERP is characterized as a comprehensive and multidimensional system that encompasses the planning, control, and optimization of production processes. It plays a crucial role in facilitating the flow of information among all functions within a firm. Kurbel (2013) states that the most important factor in the emergence of ERP is the need for integration. The main feature of similar software before ERP was that they were stand-alone systems. Such systems caused problems such as storing the same data by different departments within the organization or storing the same data in different ways. This could cause extra workload for the organization and even lead to making wrong decisions. On the contrary, ERP enables a firm to control all processes such as sales, distribution, quality management, human resources, finance, accounting, and inventory through a single database. In the

absence of ERP, the lack of integration between departments will increase transaction costs within the organization. Therefore, ERP has a productivity-enhancing and cost-reducing role for the company. When we consider the hardware, software and human capital requirements that ERP needs while performing this role for the firm, it is clear why ERP is superior to the basic tools mentioned above in terms of reflecting the level of ICT usage of the firm.

To the best of our knowledge, there is no study in the literature that examines the impact of ERP on export performance of firms. Besides, a complete review of the ERP implementation literature is beyond the scope of this study, as we use ERP only as a proxy for ICT. Nevertheless, we can say that numerous studies have examined the impact of ERP on various measures of firm performance from both financial and non-financial perspectives (Aburub, 2015; Hunton et al., 2003; Poston & Grabski, 2001). In the financial dimension, especially the effect of ERP on firm profitability has been the subject of examination, while in the non-financial dimension, the effect of ERP on operational, managerial, and organizational decisions of the firm has been examined. Overall, studies conducted since the early 2000s have consistently revealed a significant difference between companies that adopt ERP and those that do not.

3. Data and Summary Statistics

To analyze the ICT-export relationship empirically, we combine five micro data sets compiled by the Turkish Statistical Institute to reach a firm-level panel data set for the period 2009-2019. The panel data set is constructed by matching firms in the ICT Usage in Enterprises survey, Foreign Trade Statistics, Company Accounts Statistics, Annual Industry and Service Statistics (AISS), and Annual Business Registers Framework. The period 2009-2019 is chosen as the analysis period since it is the intersection of the five data sets.

The ICT usage survey has been conducted annually to determine the extent to which firms adopt and use information technologies. The surveys collect data from firms with 10 or more employees. While TurkStat applies a sampling procedure for firms with less than 250 employees, it includes all firms with 250 or more employees. The survey includes ICT usage-related questions such as the number of employees using computers and/or the internet, whether the firm has a website (and, if so, for what purposes), the type of internet connection as well as whether the firm employs any ICT specialist. However, the main reason why we use this dataset is that it has firms' Enterprise Resource Planning (ERP) usage data, which for us is a proxy for the level of technology usage of firms.

The foreign trade statistics cover cross-border trade in goods between Türkiye and other countries. The data set includes normal exports and imports, inward and outward processing

regimes, financial leasing, non-monetary gold, and border trade. Transactions under \$100 are not included in the statistics and the micro data set does not cover service export and import, therefore only good export and import are included in the data set. All transactions are recorded at NUTS3 (province) level.

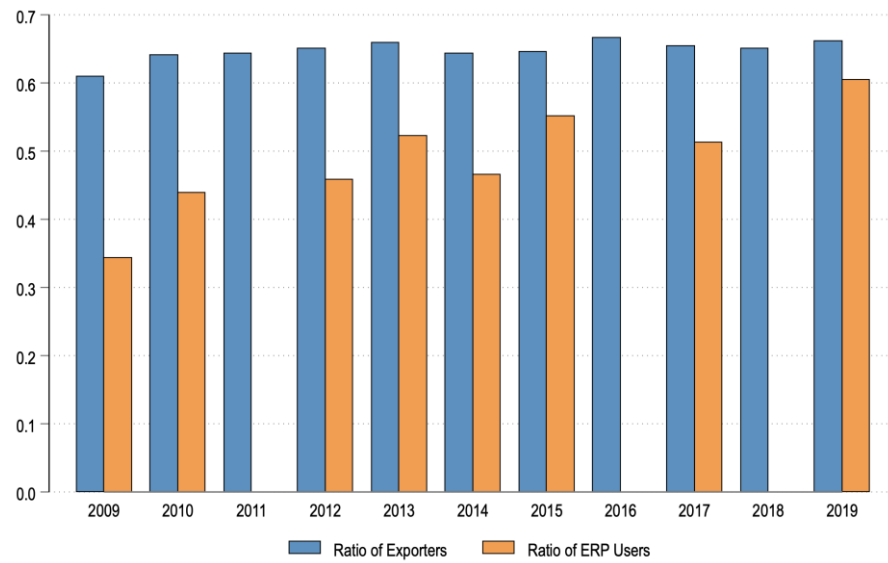
The AISS statistics contain data on various firm characteristics such as the number of employees, turnover, value added at factors costs, changes in stocks of goods and services, personnel costs, total purchase of goods and services, and production value. The statistics are compiled by administrative records and include data for more than 3,2 million enterprises.

The main purpose of the Company Accounts Statistics is to monitor the developments of real sector firms through balance sheets and income statements. The data set includes financial statements of 860,382 firms. Lastly, the Annual Business Registers Framework will be used for mainly two variables: the commencement date of the firm to measure the age of the enterprises, and the address of the firms at the city level, which is critical for studying at the regional level.

All data sets are matched using a unique firm identifier provided by TurkStat. The merged data set is an unbalanced panel because TurkStat uses a sampling procedure for firms with less than 250 employees in the ICT usage survey. Consequently, some firms were surveyed in all years, while others were only surveyed in certain years of the analysis period.

The merged data set includes 49,321 firms and 96,923 observations for all sectors. Our analysis, however, focuses on the manufacturing industry, thus excluding firms belonging to all other sectors (construction, wholesale and retail trade, services, and others) resulting in 15,795 firms and 34,673 observations. The number of firms for each year varies from a low of 2065 in 2009 to a high of 3912 in 2019. Similarly, the number of exporting firms gradually increases over the years from a low of 1259 in 2009 to a high of 2586 in 2019.

Figure 1 shows the shares of exporters and ERP users in all firms over the period 2009-2019. While the share of exporter firms hovered slightly above 60% on average throughout the period, the share of firms using ERP increased significantly from around 34% in 2009 to more than 60% in 2019. Indeed, the main motivation of this study is whether this dramatic increase in the proportion of firms using ERP over time has an impact on firms' exporting behavior.

Figure 1: Share of Exporters and ERP Users, 2009-2019

Source: Authors' own calculations

Table 1 and 2 summarize export behavior of Turkish manufacturing firms in our sample covering the period 2009-2019. Table 1 shows that around 2% of firms in the sample exported each year, while 46% of firms never exported during the analysis period. The export behavior of the remaining 52% of the firms changes from being exporter to being non-exporter, or vice versa.

Table 1: Export behavior of firms, 2009-2019

	No. of firms	% of firms
Firms that export in all years	291	1.84
Firms that never export	7,260	45.96
Firms that change export behavior	8,244	52.19

Source: Authors' own calculations

Table 2: Transitions in export behavior of firms (in percentage), 2009-2019

Year t	Year t+1	2009-	2010-	2011-2012	2012-2013	2013-2014
Non- Exporter	Non- Exporter	84.38 15.63	79.45 20.55	77.98 22.02	80.00 20.00	76.60 23.40
	Non- Exporter	4.73 95.27	4.26 95.74	4.35 95.65	5.60 94.40	5.42 94.58
Year t	Year t+1	2014-2015	2015-	2016-2017	2017-2018	2018-2019
Non- Exporter	Non- Exporter	78.83 21.17	78.31 21.69	82.30 17.70	82.12 17.88	79.95 20.05
	Non- Exporter	5.17 94.83	4.49 95.51	6.72 93.28	4.41 95.59	4.84 95.16

Source: Authors' own calculations

Table 2 provides transition rates into and out of exporting. Columns 1 and 2 indicate the initial and following year export status, respectively. The first row of the table shows that approximately 80% of the firms that did not export in a given year also did not export in the following year. A similar situation is also observed for exporters. Around 95% of the firms that exported in a given year continued to be exporter in the following year. This demonstrates a significant level of persistence in the export status of firms and implies the existence of sunk costs in entering export markets. In the subsequent section, our econometric model will further examine how these sunk costs proxied by prior exporting experience influence the likelihood of becoming an exporter.

Table 3: Export behavior of sectors by firm size, 2009-2019

Sector	All firms		SMEs		Large firms	
	% of obs. (1)	% of exporters (2)	% of obs. (3)	% of exporters (4)	% of obs. (5)	% of exporters (6)
10 Food	10,71	57,5	9,51	34,7	12,28	80,4
11 Beverages	0,53	70,2	0,49	49,0	0,57	94,1
12 Tobacco	0,13	100,0	0,02	100,0	0,28	100,0
13 Textiles	11,39	70,0	6,99	50,2	17,11	80,5
14 Wearing apparel	10,65	58,6	8,49	44,5	13,45	70,2
15 Leather	1,31	58,2	1,70	46,2	0,81	90,9
16 Wood	1,91	54,2	2,61	41,9	1,01	95,4
17 Paper	2,80	79,8	3,12	70,1	2,38	96,3
18 Printing	2,03	39,0	3,11	34,2	0,61	70,7
19 Coke and refined petroleum	0,12	55,0	0,13	44,0	0,10	0,0
20 Chemicals	2,35	80,6	2,17	68,1	2,59	94,3
21 Pharmaceutical	1,00	86,6	0,34	59,7	1,85	93,1
22 Rubber and plastic	5,30	71,8	5,33	57,5	5,25	90,7
23 Other non-metallic minerals	6,63	55,4	5,65	34,8	7,91	74,5
24 Basic metals	4,05	77,8	2,59	57,6	5,94	89,2
25 Fabricated metals	7,39	63,9	8,51	50,9	5,95	88,0
26 Computer, electronic and optic	6,32	64,0	10,44	62,2	0,97	88,4
27 Electrical products	3,77	78,8	3,13	63,8	4,60	92,2
28 Machinery and equipment n.e.c.	6,18	74,2	7,52	67,0	4,44	90,1
29 Motor vehicles and trailers	6,68	74,7	6,74	61,9	6,61	91,8
30 Other transport equipment	1,33	58,0	1,50	45,7	1,11	79,5
31 Furniture	3,95	56,3	4,92	49,7	2,68	72,1
32 Other manufacturing	1,80	63,7	2,50	61,4	0,90	71,9
33 Repair and installation of machinery and equipment	1,67	30,1	2,48	24,6	0,61	59,3
Total	100	65,1	100	51,6	100	82,7

Source: Authors' own calculations

Table 3 presents how the distribution of firm-year observations across sub-sectors of the manufacturing industry varies by firm size. Columns (1), (3), and (5) display the distribution of observations across different subsectors in the dataset, while columns (2), (4), and (6) provide the percentage of firms that are exporters within each subsector. Nearly half of the observations are concentrated in the food, textiles, wearing apparel, fabricated metals, and motor vehicles and trailers sectors. This distribution is similar for both SMEs and large firms,

with the notable exception that approximately 10% of the observations for SMEs are in the computer, electronic, and optical sectors. In terms of exports, what is most striking is that the share of exporting observations is much higher in large firms than in SMEs in all sectors excluding coke and refined petroleum. Almost 83% of the observations belonging to large firms are exporters, while about 52% of the observations belonging to SMEs are exporters.

Table 4 provides descriptive statistics for the key variables used in the analysis. There are significant differences between exporters and non-exporters. The percentage of firm-year observations that use the ERP system is about 50% for the whole sample and it is around 62% and 29% for exporters and non-exporters, respectively. The reason for the low number of observations for ERP compared to the other variables is that there is no data for the years 2011, 2016, and 2018³. In terms of age, exporters are older compared to non-exporters on average with a mean of 18.6 years for exporters and 14.7 years for non-exporters. There are similar differences in terms of both capital intensity and labor productivity, suggesting that exporting firms are more productive. We also observe that exporting firms have much more ICT labor proxied by the number of internet-using employees.

Table 4: Summary statistics

Variable	All firms			Exporters			Non-exporters		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
ERP	24,147	0.505	0.500	15,833	0.619	0.486	8,314	0.291	0.454
Age	34,630	16.911	9.673	22,513	18.641	9.907	12,117	13.698	8.316
Log Capital per Worker	29,888	7.605	2.544	20,981	7.779	2.474	8,907	7.193	2.655
Log Value Added per Worker	33,681	10.869	1.048	22,134	11.087	0.986	11,547	10.450	1.037
Log Leverage Ratio	26,128	-0.552	0.560	18,553	-0.571	0.531	7,575	-0.507	0.624
Log Return on Assets (ROA)	27,365	-3.354	1.471	18,144	-3.269	1.430	9,221	-3.521	1.535

Source: Authors' own calculations

In this study, there are two variables representing the financial health of the firm. The leverage ratio is defined as total debts divided by total assets. It shows the degree to which a firm's operations are funded by debt. Therefore, the lower its leverage ratio, the better the

³ The lack of data for ERP usage in the years 2011, 2016, and 2018 is attributable to the TurkStat removing the corresponding question from its survey during these periods. TurkStat has not offered any explanation for this decision.

firm's financial health. Return on assets (ROA) is defined as the firm's net profit over total assets. It is one of the most widely used profitability ratios and measures a firm's ability to use of its assets to make a profit. As the summary statistics show, exporting firms are in a healthier financial position on average, both in terms of firms' indebtedness and profitability.

4. Econometric Approach

The econometric model consists of regressing the export participation decision on the main variable of interest (ERP) and a set of control variables expected to be determinants of the export decision. The econometric equation is

$$XD_{it}^* = \beta_0 + \beta_1 ERP_{i(t-1)} + \beta_2 \log(K/L)_{i(t-1)} + \beta_3 \log(Y/L)_{i(t-1)} + \beta_4 Age_{it} + \beta_5 Age_{it}^2 + \beta_6 \log ROA_{i(t-1)} + \beta_7 S + \varepsilon_{it} \quad (1)$$

where XD_{it}^* represents the probability of exporting with the observed variable takes the value of 1 if the firm i is an exporter at time t and 0 otherwise:

$$XD_{it} = \begin{cases} 1 & \text{if } XD_{it}^* > 0 \\ 0 & \text{otherwise} \end{cases}$$

We are mainly interested in the parameter estimate on *ERP* usage. β_1 measures the effect of ERP usage on the probability of being an exporter, where ERP is a dummy variable that takes the value of 1 if the firm uses the ERP system and 0 otherwise. As a highly complex information systems, ERP is one of the keys to global competition. To improve firm efficiency, several companies use ERP as a coordination and integration factor. Firms activate all functions of internal and external management processes within the scope of ERP (Hitt et al., 2002). By employing ERP, these fundamental business processes of the company are detailed within a software system. This comprehensive information is accessible to the entire company management, fostering enhanced coordination and efficiency. Consequently, this increase in productivity contributes to the export potential for the company. Therefore, it is expected that a strong and positive association between ERP and export probability.

K/L is the capital stock per worker, and we use tangible fixed assets on the firms' balance sheets as the proxy of capital stock. Y/L is labor productivity, measured as value added (at factor cost) per worker. Heterogeneous firm theories, particularly those initiated by Melitz (2003), posit that the most efficient firms self-select into export markets. In this regard, both labor productivity and capital intensity variables enable us to test the self-selection hypothesis. The significance of firms' productivity in facilitating export entry was also emphasized on numerous empirical studies. For instance, Ottaviano and Martincus (2011) shows that

labor productivity (total sales divided by employment) is positively and significantly associated with the probability of exporting for Argentina. Another study by Eliasson et al. (2012) shows that more capital-intensive firms (in terms of physical capital) tend to become exporters in the Swedish manufacturing sector.

Age is the firm age in years. In some research, such as the works of Majocchi et al. (2005) and D'Angelo et al. (2013), age is acknowledged as a proxy for a firm's internationalization experience, showing a positive correlation with the scope of the firm's trade connections. Since it will take time for companies to recognize and learn the foreign market culture, languages and distribution system, older and experienced companies will be more likely to export. On the other hand, the age of a firm also mirrors its conservative identity, suggesting a potential association with the firm's resistance to behavioral changes. Consequently, the likelihood of a firm becoming an exporter may be adversely influenced (Love et al., 2016; Williams, 2011). The model also includes the squared value of the age to test whether age is curvilinearly related to export decision (Kapri, 2019). \mathbf{S} is a vector of time and sector dummies. Sector dummies are defined at 2-digit based on NACE Rev.2 classification. They are included to control for any fixed effects common across industries and years.

As mentioned above, there are two variables in our dataset that capture the financial health of the firm: Leverage ratio and ROA. In the literature, the relationship between a firm's financial health and export behavior has been addressed from two perspectives: First, as an element of firm characteristics that constitute the determinants of firms' entry into the export market, and second, as an element of changes in firms' financial health after they enter the export market. The latter approach is beyond the scope of this study and there are numerous studies on the former approach in the literature. These studies emphasize that the sunk costs that firms must incur when entering the export market can only be borne by financially sound firms, highlighting that firms with high profitability and low leverage are more likely to become exporters (Bellone et al., 2010; Chaney, 2016; Srinivasan & Archana, 2011).

When estimating the econometric models, we started with the ROA and then re-estimated all the models by replacing ROA with the leverage ratio and checked whether there were any changes in the estimates. Lastly, ε is assumed to be independent and identically distributed. In all specifications, all explanatory variables except for age are lagged one year. This is primarily due to the effects of the variables in the model that we think affect the firm's export behavior are lagged. In particular, it is reasonable to see the effect of a software such as ERP with a lag. In addition, the use of lagged variables will reduce the simultaneity problem.

The theoretical and empirical literature on firm-level international trade has confirmed the significance of sunk costs' role for firms' export market participation decision (Bernard

& Wagner, 2001; Roberts & Tybout, 1997). The existence of these costs is mainly related to the lack of complete information about the new market that the firm planning to export is trying to enter. When entering a new market, firms invest to comply with the regulations and standards of that country, research foreign demand characteristics, appeal to the tastes of that country's consumers, and establish new distribution and marketing channels (Fichera & Shevtsova, 2020). Therefore, the probability of a firm being an exporter that has incurred such costs by exporting before will be different from the probability of a firm that will start exporting for the first time. To control for this, we also estimate the dynamic panel probit model by adding the firm's export status in the previous year to the equation (1):

$$\begin{aligned}
 XD_{it}^* = & \beta_0 + \beta_1 XD_{i(t-1)}^* + \beta_2 ERP_{i(t-1)} + \beta_3 \log(K/L)_{i(t-1)} \\
 & + \beta_4 \log(Y/L)_{i(t-1)} + \beta_5 Age_{it} + \beta_6 Age_{it}^2 + \beta_7 \log ROA_{i(t-1)} \quad (2) \\
 & + \beta_8 \mathbf{S} + \varepsilon_{it}
 \end{aligned}$$

An important consideration when estimating equation (2) is the potential bias caused by the initial conditions problem and the potential correlation between the unobserved heterogeneity term and the covariates. Initial conditions problem arises due to the fact that we observe the firms in the middle of their existence rather than from the beginning of their potential life. Therefore, the start of the observation period does not coincide with the true start of the process. This leads to bias because the initial state (export status of the firm) is not independent of the unobserved heterogeneity. In order to address these concerns, we adopt the approach outlined by Wooldridge (2005). This approach builds on the random effects specification by including the initial condition and the time-variant variables' averages over time as additional regressors.

Overall, we employ a progressive estimation strategy, in the sense that we try to address the econometric issues in different steps. Firstly, to provide some baseline estimates, we neglect both endogeneity and unobserved heterogeneity and estimate the models as if all explanatory variables are strictly exogenous (pooled probit model). This model assumes that errors are independent over time and uncorrelated with the exogenous variables. Causal inferences cannot be deduced from the pooled probit model due to possible endogeneity and reverse causality. Consequently, the findings from this model indicate only an association rather than causality and should only be used as a benchmark. Even if we corrected for clustering in the pooled probit model, which considers that observations for the same firm are not independent, it does not address the unobserved heterogeneity. In the second step, we exploited the longitudinal information of the data, and we used panel probit model with random effects. We conducted separate estimations for both SMEs and large firms. SMEs are defined as firms

that have a workforce ranging from 10 to 250 employees. On the other hand, large firms are characterized by having 250 or more employees. Our objective was to investigate the potential variations in the impact of ERP usage based on firm size.

5. Results and Discussion

Table 5 displays the marginal effects derived from estimating the model in equation (1) using pooled probit and random effect probit, as well as the model in equation (2) with dynamic RE probit. We calculate the marginal effects at the sample averages of the explanatory variables. The decrease in the total number of firms and observations in all estimations can be attributed to the absence of ERP data in 2011, 2016, and 2018, as well as the incorporation of lags in explanatory variables. Furthermore, the decline in the number of observations for SMEs can be attributed to the sampling procedure employed in the ICT Usage Survey for firms with less than 250 employees.

According to the pooled probit results, the main variable of interest, ERP, is significant at the 1% significance level and has a positive sign for all firms. This result implies that after controlling for time, sector, and other effects, ERP users are 6.8 percentage point more likely to be exporters than non-users. However, considering the assumptions of the pooled probit model and its limitations in terms of its power to make causal inferences, it would be more appropriate to use the coefficient here to infer the direction of the relationship rather than causality. When we look at the results of the RE probit model, the effect of ERP usage is positive and statistically significant. The ERP coefficient in the second column shows that firms that use ERP are 3.9 percentage points more likely to be exporters than those that do not. If we look at the marginal effects of explanatory variables, the results of both models are similar. We observe that variables other than ROA behave as expected. While the effect of age is positive and significant, the age squared variable has a negative and significant relationship with the export decision, suggesting the existence of an inverted-U quadratic relationship between firm age and export decision. Labor productivity and capital intensity variables are also positively and significantly associated with the probability of exporting. Only in the RE probit model, labor productivity is significant at the 10 percent significance level. Departing from the findings in the literature, both models show that firm profitability is not associated with exporting behavior.

When we look at the results separately by firm size, the pooled probit model shows that for large firms, there is a 5.7 percentage point difference between ERP users and non-users in favor of ERP, while for SMEs, the difference is 5 percentage points (even if significant at the 10% significance level). In the RE probit model, the effect of ERP usage is statistically

significant for large firms but statistically insignificant for SMEs. According to this result, ERP users in large firms are 3 percentage points more likely to be exporters than non-users. However, we would expect ERP, which we use as a proxy for the level of technology use of firms in terms of the internationalization of SMEs, to be significant in line with the findings in the literature. The unexpected result of the random effects probit model may be attributed to the sampling procedure used for SMEs in the dataset. When we look at the control variables, we observe that the effects of all variables except age squared in the pooled probit model results for SMEs are statistically significant and in line with expectations (in terms of showing the direction of the relationship). The results of the random effects probit model show that the probability of firms becoming exporters increases as both capital and labor productivity increase. This result indicates that productivity variables are more important than technology utilization level in the export market participation behavior of SMEs. While the age variable itself is significant at the 10 percent level, the age squared variable is not statistically significant, indicating that there is no quadratic relationship between age and exporting behavior for SMEs. Finally, the profitability variable is statistically insignificant.

When we examine how the control variables behave in the estimations for large firms, we first observe that the effect of age on exporting behavior is quadratic according to the results of both pooled probit and random effects probit models. In other words, as the age of the firm increases, the probability of becoming an exporter increases, while the effect of age turns negative after a certain level. The pooled probit results indicate a positive and significant association between capital intensity and exporting behavior, while labor productivity and profitability are found to be insignificant. Random effects probit results show that the effect of labor productivity is positive and statistically significant, while the effects of capital intensity and profitability are statistically insignificant.

The results of the dynamic model estimated for all firms (column 3) show that the probability of being an exporter is 10 percentage points higher on average for firms that exported in the previous year compared to non-exporters in the previous year. While we observe the same effect for large firms (column 9), the results of the model for SMEs (column 6) reveal that previous export experience is insignificant in explaining the behavior of becoming an exporter. When we estimate all models with leverage ratio instead of ROA as the indicator of the financial health of the firm (Table A1), the results are almost identical in terms of the direction of the coefficients. There is little difference between the results of the two sets of models in terms of the magnitude of the marginal effects. The only significant difference is that the lag of exports is significant in the dynamic model estimated for SMEs in contrast to the model estimated with ROA. Apart from the lagged export status, the insignificance of all variables, including the main variable interest ERP, underscores the validity of the sunk cost

Table 5: ERP and export market participation decision by firm size

Dependent variable: Export decision	All firms			SMEs			Large firms		
	Pooled Probit (1)	RE Probit (2)	Dynamic RE Probit (3)	Pooled Probit (4)	RE Probit (5)	Dynamic RE Probit (6)	Pooled Probit (7)	RE Probit (8)	Dynamic RE Probit (9)
Exported Last Year			0.099*** (0.021)			0.008 (0.009)			0.102*** (0.026)
ERP	0.068*** (0.013)	0.039*** (0.010)	0.006 (0.008)	0.050* (0.029)	0.042 (0.026)	-0.017 (0.020)	0.057*** (0.015)	0.030*** (0.010)	0.009 (0.008)
Age/10	0.075*** (0.011)	0.077*** (0.009)	-0.039 (0.029)	0.100* (0.060)	0.107* (0.059)	0.003 (0.057)	0.068*** (0.012)	0.066*** (0.010)	-0.053* (0.031)
Age-squared/100	-0.003*** (0.001)	-0.003*** (0.001)	0.003 (0.006)	-0.009 (0.016)	-0.009 (0.015)	0.019 (0.017)	-0.003*** (0.001)	-0.002*** (0.001)	0.003 (0.006)
Log Capital per Worker	0.008*** (0.003)	0.004* (0.002)	-0.001 (0.002)	0.011** (0.006)	0.012* (0.005)	0.001 (0.003)	0.008*** (0.003)	0.003 (0.002)	-0.002 (0.002)
Log Value Added per Worker	0.032*** (0.013)	0.032*** (0.009)	0.007 (0.005)	0.135*** (0.029)	0.113* (0.027)	-0.017 (0.019)	0.014 (0.012)	0.016** (0.008)	0.009 (0.006)
Log Return on Assets (ROA)	-0.002 (0.005)	-0.001 (0.003)	-0.001 (0.002)	-0.023** (0.011)	-0.015 (0.010)	0.005 (0.005)	0.001 (0.005)	0.001 (0.003)	-0.001 (0.003)
Constant	-1.566	-3.555	-3.277	-5.404	-12.170	-5.819	-0.580	-1.238	-2.879
Number of firms	2495	2495	2499	922	922	923	1788	1788	1803
Observations	7273	7273	7290	1311	1311	1312	5930	5930	5978
Log likelihood	-2885.57	-2173.43	-1181.76	-667.80	-598.85	-135.23	-2172.47	-1565.48	-944.80
LR chi2	279.31	220.35	1590.85	107.32	28.76	446.50	196.92	188.00	1848.31
Prob > chi2	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00

SMEs stands for small and medium-sized enterprises (10-249 employees) and LARGE stands for firms with 250 or more employees. Robust standard errors are shown in parentheses. Year dummies and sector dummies defined at 2-digit based on NACE Rev.2 classification are included in all models. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

approach discussed by Roberts and Tybout (1997), which posits the existence of sunk costs associated with entering export markets. Additionally, the estimates in Table 5 and Table A1 reveal that these sunk costs are more significant for large firms compared to SMEs.

Overall, we are unable to conduct a comparative analysis of our findings due to the absence of a literature review that specifically investigates the impact of ERP implementation on exports. Nevertheless, our results align with those of studies (Clarke, 2008; Hagsten & Kotnik, 2017; Yadav, 2014) that demonstrate the positive effect of ICT on exports, despite employing traditional metrics to assess the extent of ICT utilization.

6. Conclusion

This paper provides an empirical investigation of the relationship between firms' ICT usage and export performance. We merge five firm-level data sets compiled by the Turkish Statistical Institute and construct an unbalanced panel data set that encompasses the period from 2009 to 2019 for firms operating in the manufacturing industry. We estimate pooled probit, random effects probit models, and dynamic panel probit model that allows us to control for sunk costs related to export market entry. A limited number of studies in the literature examine the ICT-export relationship with firm-level evidence. In addition, due to data availability, studies have generally measured the ICT usage level of firms with basic indicators such as internet, e-mail usage and website ownership, which are owned by a large proportion of firms today and therefore lack firm heterogeneity. The contribution of this study to the literature is not only to provide empirical evidence at the firm level but also to measure the ICT utilization level of firms with ERP software, which is a more sophisticated tool compared to other indicators. Moreover, its focus on a developing country like Türkiye addresses another gap in the literature. We estimate our models with different samples based on firm size in terms of the number of employees, which allows us to test whether the direction and/or the magnitude of the relationship varies by firm size. Overall, our results confirm that ERP is positively and significantly associated with the probability of firms being exporters.

The findings of our study have several policy implications for firm managers and policy makers. Considering the pace of digitalization in the world, the adoption of more sophisticated technology tools is not an option for businesses seeking to expand internationally, but rather a requirement. Given that the level of ERP usage among firms, especially SMEs, is still low, we can say that companies in the Turkish manufacturing industry still have a long way to go. In this context, it is crucial that policy makers take steps to strengthen firms' ability to change their technological infrastructure when designing incentive and credit policies.

One of the restrictions of our study is related to the data we use for the econometric analysis. In particular, the absence of ERP usage data in three of the eleven years has led to a serious loss of observations since we use lagged values of explanatory variables in the models. In addition, the lack of information on the organizational structure of firms, which is important in the decision-making processes of firms, which we think is important in the internationalization of firms, and the lack of data on foreign ownership are other restrictive factors. Therefore, future studies in which these limitations arising from the data are eliminated will allow the use of more robust methods and will be able to reveal the nature of the ICT-export relationship more accurately. Furthermore, it is also worth examining in future studies whether firms self-select into the export market or learn by exporting, in order to identify the source of firms' productivity gains and to establish its relationship with ICT.

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Appendix

Table A1: ERP and export market participation decision by firm size (Financial health variable: Leverage ratio)

Dependent variable: Export decision	All firms			SMEs			Large firms		
	Pooled Probit (1)	RE Probit (2)	Dynamic RE Probit (3)	Pooled Probit (4)	RE Probit (5)	Dynamic RE Probit (6)	Pooled Probit (7)	RE Probit (8)	Dynamic RE Probit (9)
Exported Last Year			0.125*** (0.025)			0.079*** (0.036)			0.109*** (0.028)
ERP	0.070*** (0.013)	0.032*** (0.009)	-0.002 (0.007)	0.050* (0.028)	0.041 (0.026)	-0.021 (0.022)	0.058*** (0.014)	0.023*** (0.009)	0.001 (0.006)
Age/10	0.063*** (0.010)	0.064*** (0.009)	-0.029 (0.027)	0.113*** (0.057)	0.137*** (0.055)	-0.070 (0.082)	0.054*** (0.011)	0.048*** (0.009)	-0.017 (0.027)
Age-squared/100	-0.002*** (0.001)	-0.002*** (0.001)	0.006 (0.005)	-0.014 (0.014)	-0.018 (0.014)	0.020 (0.023)	-0.002*** (0.001)	-0.002*** (0.000)	0.004 (0.005)
Log Capital per Worker	0.007*** (0.003)	0.004* (0.002)	-0.000 (0.002)	0.012** (0.005)	0.010** (0.005)	0.002 (0.005)	0.006** (0.003)	0.002 (0.002)	-0.001 (0.002)
Log Value Added per Worker	0.036*** (0.010)	0.034*** (0.007)	0.006 (0.005)	0.098*** (0.022)	0.086*** (0.021)	0.016 (0.013)	0.022** (0.010)	0.019*** (0.007)	0.002 (0.005)
Log Leverage Ratio	0.019 (0.013)	0.011 (0.010)	0.012 (0.009)	0.024 (0.027)	0.018 (0.024)	0.017 (0.023)	0.019 (0.014)	0.010 (0.010)	0.012 (0.009)
Constant	-1.735	-3.319	-3.229	-3.584	-7.096	-5.740	-1.020	-1.376	-2.826
Number of firms	2423	2423	2427	881	881	882	1808	1808	1812
Observations	7733	7733	7756	1274	1274	1275	6458	6458	6481
Log likelihood	-2957.52	-2230.12	-1277.40	-650.87	-590.97	-164.99	-2261.74	-1633.00	-1006.05
LR chi2	288.81	239.69	1755.66	110.09	39.94	611.24	212.18	206.68	1523.05
Prob > chi2	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00

SMEs stands for small and medium-sized enterprise (10-249 employees) and LARGE stands for firms with 250 or more employees. Robust standard errors are shown in parentheses. Year dummies and sector dummies defined at 2-digit based on NACE Rev.2 classification are included in all models. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$