THE JOURNAL OF INTERNATIONAL TRADE & ECONOMIC DEVELOPMENT
2022, VOL. 31, NO. 2, 277–298
https://doi.org/10.1080/09638199.2021.1965645

The impact of digitalization on export of high technology products: A panel data approach*

Seren Özsoy [a], Oylum Şehvez Ergüzel [a,b], Ahmet Yağmur Ersoy [a] and Metin Saygılı [c]

[a]Sakarya Business School, Sakarya University, Sakarya, Turkey; [b]Master of Economics and Finance, Charles University, Prague, Czechia; [c]Faculty of Applied Sciences, Sakarya University of Applied Sciences, Sakarya, Turkey

ABSTRACT

This study argues that easy access to new information using information and communication technologies (ICT) will bring both more technological development and information about new markets, together catalyzing high technology (high-tech) production. This paper aims to show the impact of digitalization on the technology intensity of export. We use the ICT Development Index (IDI) as a proxy for the digitalization level of a country and the value of the exports of high-tech products as a proxy for the technology intensity of export. IDI comprises three components, including ICT access, usage and skills. These statistics reflect the ICT development of the country. To analyze the relevant relationship, we use panel data on countries between 2007 and 2017. The system-generalized method of moments (system GMM) dynamic panel estimator is utilized in the estimations, permitting us to control for potential endogeneity problems between the main dependent and independent variables. Results show that in developing countries, IDI has a significant effect on the export of high-tech products. In addition, the significance of the main components of IDI varies. These results suggest that developing countries striving to increase the export of high-tech products should invest more in ICT.

KEYWORDS Information and communication technologies (ICT); digitalization; innovation; exports of high technology products

JEL CLASSIFICATIONS F10, F14, O30

ARTICLE HISTORY Received 14 August 2020; Accepted 4 August 2021

Introduction

Technological developments and digitalization that accelerated with globalization caused a transformation in trade. This development and 'competitiveness', which is a requirement of our age, also induced a change in the variety of products exported. According to Tebaldi (2011), high-tech product trade provides information about a

CONTACT Oylum Şehvez Ergüzel oylume@sakarya.edu.tr

*This article is the enhanced version of the paper presented at the "International Symposium on Business & Economics", Ankara Turkey.

country's overall competitiveness and position in the global technology market. It also contributes to understanding the comparative advantages created by innovations and high technology across countries. In addition, the export of technological products, which provide more added value, contributes to the economic performance of countries in foreign trade (Falk 2009). Countries strive to focus on the export of high-tech and more complex products that require developing technology, information and digitalization, rather than products that are mostly labor-intensive and do not require much information. The export of high-tech products is important not only in terms of economic growth but also in the way countries can evolve into a modern society. Hidalgo (2015) stated that building a modern society is dependent on the use of knowledge, and the criterion of modernity of individual societies should be understood in terms of their ability to use collective and shared knowledge. Also, Nour (2005) states that the most important way to catch up to the industrial economies is development in information and technology. Accordingly, Zeufack (2002) expresses the transition from the traditional economy to the modern economy as a shift to the production of high-technology and complex products with changes in the structure of simple export products. For this reason, exports of high-technology products are considered as a factor affecting economic development and growth.

It has been proposed that the most important determinant of development is knowledge accumulation, which is directly related to the products produced and exported in the country (Ferrarini and Scaramozzino 2016; Bournakis and Tsoukis 2016; Ozsoy, Fazlioglu, and Esen 2020). In this way, countries aim to achieve economic and social progress by concentrating on exporting products with high added value, based on technology and digitalization, rather than exporting products with lower added value. Based on this relationship, this study aims to reveal the effect of ICT and digitalization on high-tech-based product exports in developed and developing countries.

High added-value and technologically based products are based on ICT and digitalization. Knowing the countries' digitalization and technology development levels is important in terms of their competitiveness and reveals their potential to export high-tech products. The most critical stage in revealing the relationship in question is to find the variable that will correctly express the ICT as a proxy variable (Freunda and Weinhold 2004; Seyoum 2005; Abedini 2013). In this study, the IDI set forth by ITU is used as the variable representing the most comprehensive ICT. It is a global indicator that shows the ICT level of countries. It consists of three main indicator categories and sub-categories that reflect their features. The main indicator categories are determined according to the ICT development stages of the countries as ICT access, ICT usage and ICT skills (ITU 2016).

Although few studies analyze the role of digitalization on export, some studies use proxy variables that reflect digitalization, such as internet subscription (Freunda and Weinhold 2004), telecommunication access, or technological infrastructure quality (Seyoum 2005; Abedini 2013). Unlike these studies, we use a more comprehensive digitalization variable that reflects a country's digitalization level, called IDI. Although some studies develop and use a comprehensive ICT development index (Mattes, Meinen, and Pavel 2012; Nath and Liu 2017; Ozcan 2018), none consider the technology intensity of export. Mattes, Meinen, and Pavel (2012) demonstrated the effect of IDI on trade in the European Union (EU) and between the EU and its main trading partners through the gravity model. The results show that ICT has a significant impact on EU trade. In another study, Liu and Nath (2013) indicated the impact of information and communication on international trade in emerging markets using a similar ICT index. Using panel data for 40 emerging market economies (EMEs) between 1995 and 2010, the positive relationship between ICT and international trade has been revealed by the GMM method. Also, Nath and Liu (2017) empirically examine the effects of ICT on service sector exports and imports in their study on panel data for 49 countries from 2000 to 2013. Their study shows that ICT development significantly and positively affects the export of other business services, transportation services, insurance services, telecommunication services and travel services. Ozcan (2018) indicates the positive and significant effects of ICT on Turkey's import and export volume for 2000–2014.

To the best of our knowledge, this paper is the first study that analyzes the impact of IDI and its main indicator categories on the export of high-tech products. This study argues that easy access to new information using ICT will bring more technological development and information about new markets. In this way, we consider that countries may be more eager for high-technology production and export to gain more competitive advantage.

This study differs from the others in terms of methodology. Most previous studies implement gravity model analysis (Freunda and Weinhold 2004; Choi 2010; Mattes, Meinen, and Pavel 2012; Ozcan 2018; Rodriguez-Crespo and Zarzoso 2019) to reveal the relationship between ICT and trade. GMM (Liu and Nath 2013), Tobit Model (Dettmer 2013), and structural equation model (Bankole, Osei-Bryson, and Brown 2013) are other methods used to explore these relationships. Unlike previous studies, we conduct a panel data analysis of 122 countries from 2007 to 2017 to analyze the relevant relationships. Moreover, we utilize the system GMM dynamic panel estimator that permits us to control for potential endogeneity problems between main dependent variables and independent variables (Arellano and Bover 1995; Blundell and Bond 1998). The system GMM estimator is designed for panels with short time series, models with dynamic processes and non-exogenous states of variables (Roodman 2009). Several papers use system GMM estimation for this purpose (see, among others, Bertrand and Zuniga 2006; Falk 2009; Meschi, Taymaz, and Vivarelli 2011; Iwamoto and Nabeshima 2012; Zhu and Fu 2013; Hsu and Chuang 2014).

According to the technology gap approach, 'catching-up' countries can grow faster than developed, 'leader' countries that have completed their industrialization using advances in existing knowledge and technology (Harbi, Anderson, and Amamou 2014). Abramovitz (1986) stated that a country's development potential emerges based on three factors: resource-based infrastructure, adequate national capacity and technological development. Accordingly, a well-developed ICT sector offers significant development opportunities for developing countries under favorable conditions. It is important to establish the comparative impact of ICT on developed and developing countries in this context. This study also aims to show whether the impact of digitalization differs with respect to the development level of the countries. To this end, we re-run our regression model for sub-samples of countries according to development level by United Nations (UN) classification.

Based on all this information, this article aims to show the impact of digitalization on the technology intensity of exports in developed and developing countries. To this end, we use the IDI as a proxy for the digitalization level of a country and the value of the exports of high-tech products as a proxy for the technology intensity of export. Namely, we investigate the impact of IDI on exports of high-tech products. Next, because the main categories of the IDI that reflect on the ICT development stages of the countries

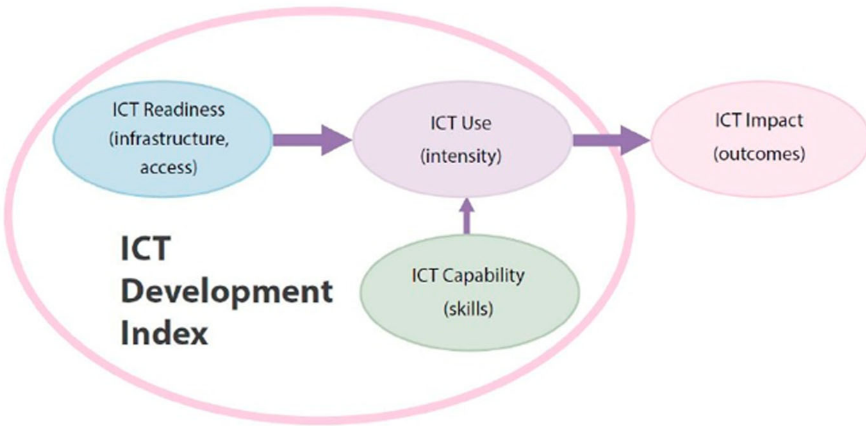

Figure 1. Three stages in the evolution towards an information society. Source: ITU (2016).

are important, we also analyze the impact of IDI components to reveal the effect on the export of high-tech products.

Data

In line with the purpose of this study, we use the IDI as a proxy for the digitalization level of a country and the value of high-tech product exports as a proxy for the technology intensity of export.

First, the indicator used as the dependent variable in the study is the logarithm of the current value of high-tech product exports (High-Tech Export). Exports of high-tech products are defined as 'exports of products with high R&D intensity such as aviation, computers, pharmaceuticals, scientific instruments, electrical machines, chemistry, non-electrical machines and armament' (World Bank (WB) 2020).

Secondly, IDI, which the ITU developed to reveal the digitalization levels of the countries, is used as the main independent variable. It was created to reflect the development stages of ICT globally shown in Figure 1.

The levels in Figure 1 are important to compare the ICT levels of countries to determine their stages and follow their progress. The classification and opportunity to compare provided by IDI are the most important reasons for its selection.

The ICT development process and the transformation of a country into an information society can be depicted using the three-stage model shown in the figure above (ITU 2017):

- Stage 1: ICT readiness – reflects the level of network-related infrastructure and access to ICTs;
- Stage 2: ICT use (intensity) – reflects the level of ICT usage in the community,
- Stage 3: ICT effect – reflects the results (s) of ICT use more efficiently and effectively.

As seen in Table 1, IDI consists of three main components and sub-groups of components, which enable countries to access the different dimensions of their digitalization levels.

Table 1. Weights used for the indicators and sub-indices included in the IDI.

Indicators/Sub-indicators	Weights (Sub-indicators)	Weights (Indicators)
ICT Access		0.40
Fixed-telephone subscriptions per 100 inhabitants	0.20	
Mobile-cellular telephone subscriptions per 100 inhabitants	0.20	
International Internet bandwidth per Internet user	0.20	
Percentage of households with a computer	0.20	
Percentage of households with Internet Access	0.20	
ICT usage		0.40
Percentage of individuals using the Internet	0.33	
Fixed-broadband Internet subscriptions per 100 inhabitants	0.33	
Active mobile-broadband subscriptions per 100 inhabitants	0.33	
ICT skills		0.20
Mean years of schooling	0.33	
Secondary gross enrollment ratio	0.33	
Tertiary gross enrollment ratio	0.33	

Source: ITU (2016).

The first dimension refers to infrastructure and access, one of the basic indicators of technology and digitalization level (ICT readiness). The second stage (ICT use) indicates the intensity of digitalization and technology use. Being able to evolve into an information society also requires ICT capability, a third aspect. All three components (access, use and capability) are closely linked and complementary (Mattes, Meinen, and Pavel 2012). The ICT infrastructure and access component consists of sub-indicators such as 'fixed-telephone subscriptions', 'mobile-cellular telephone subscriptions', 'international Internet bandwidth per Internet user', 'households with a computer', and 'households with Internet access'. ICT usage includes 'individuals using the Internet', 'fixed-broadband subscriptions', and 'mobile-broadband subscriptions'. ICT skill consists of mean years of schooling, gross secondary enrollment, and gross tertiary enrollment indicators (ITU 2016).

Finally, we use a set of control variables to check the robustness of our results, such as general government final consumption expenditure (% of GDP), gross domestic savings (% of GDP), gross capital formation (% of GDP), inflation, GDP deflator (annual %), ICT goods imports (% of total goods imports) and Political Stability Index.

Table 2 gives definitions, sources and descriptive statistics of variables included in the study.

Methodology

In line with the study's main purpose, four different estimation models are utilized where the subscript i denotes countries and t signifies years.

The first model is the main model the significance of IDI is investigated.

$$Highex_{i,t} = \alpha + \beta_1 IDI_{i,t} + \delta Controls + \varepsilon_{i,t} \qquad \text{(Model (1))}$$

The other models are constructed to measure the impact of the IDI components access, use and skill on high-technology export. These models are listed as Model (2)

Table 2. Definitions, sources and descriptive statistics of variables.

Variable	Description		Mean	Std. Dev.	Min	Max	Observations	Sources
The dependent variable								
High-Tech Export	Logarithm of Export of High Technology Products (Current US $)	overall	19.0039	4.102289	3.78419	27.20942	$N = 1387$	WB, WDI
		between		4.363097	3.78419	26.98245	$n = 162$	
		within		0.898818	13.37935	24.71448	T-bar = 8.56173	
The Explanatory Variables								
Variable	Description		Mean	Std. Dev.	Min	Max	Observations	Sources
IDI	Logarithm of ICT Development Index (IDI)	overall	1.331189	0.5787279	−0.3147107	2.181547	$N = 1623$	ITU
		between		0.5604472	−0.0816464	2.133315	$n = 163$	
		within		0.1744697	0.7883992	1.832925	T-bar = 9.95706	
Access	Logarithm of ICT Access	overall	1.468575	0.5388014	−0.2231435	2.236445	$N = 1623$	ITU
		between		0.5087489	0.2468601	2.205755	$n = 163$	
		within		0.1995118	0.6349497	2.088029	T-bar = 9.95706	
Use	Logarithm of ICT Usage	overall	0.4639046	1.363944	−4.60517	2.190536	$N = 1623$	ITU
		between		1.187599	−3.157951	2.060271	$n = 163$	
		within		0.6822532	−2.817956	3.296912	T-bar = 9.95706	
Skill	Logarithm of ICT Skill	overall	1.79295	0.4191259	−0.597837	2.294553	$N = 1617$	ITU
		between		0.4072363	0.1590671	2.270777	$n = 163$	
		within		0.1263285	0.9090726	3.119391	T-bar = 9.92025	

Investment	Logarithm of Gross capital formation (% of GDP)	overall	3.15109	0.3737977	−2.302585	4.443827	$N = 1841$	WB, WDI
		between		0.3105977	2.253508	3.953895	$n = 175$	
		within		0.2209795	−1.862067	4.058249	T-bar = 10.52	
Saving	Logarithm of Gross domestic savings (% of GDP)	overall	2.941622	0.8471821	−4.60517	4.475403	$N = 1619$	WB, WDI
		between		1.042843	−3.016143	4.277408	$n = 167$	
		within		0.3652881	−1.193189	6.007236	T-bar = 9.69461	
Deflator	Logarithm Inflation, GDP deflator (annual %)	overall	1.333587	1.174213	−4.60517	6.617483	$N = 1892$	WB, WDI
		between		0.8264654	−0.8597984	3.897869	$n = 201$	
		within		0.8500122	−4.870501	4.612504	T-bar = 9.41294	
Gov. Spending	Logarithm of General government final consumption expenditure (% of GDP)	overall	2.730623	0.4025677	0.7178398	4.371597	$N = 1841$	WB, WDI
		between		0.374528	1.671164	4.011443	$n = 176$	
		within		0.1404648	0.9438675	4.098538	T-bar = 10.4602	
P.Stability	Political Stability Index	overall	−0.059987	1.004437	−3.314937	1.965062	$N = 2138$	WB, WGI
		between		0.9727557	−2.833379	1.858402	$n = 195$	
		within		0.2733474	−1.37661	1.818495	T-bar = 10.9641	
ICT_GI	ICT goods imports (% total goods imports)	overall	1.642634	0.6895771	−2.407946	3.948548	$N = 1658$	WB, WDI
		between		0.6680733	−1.422474	3.768826	$n = 176$	
		within		0.2340541	0.5000668	2.851112	T-bar = 9.42045	

to Model (4) as follows:

$$Highex_{i,t} = \alpha + \beta_1 Access_{i,t} + \delta Controls + \varepsilon_{i,t} \qquad \text{(Model (2))}$$

$$Highex_{i,t} = \alpha + \beta_1 Use_{i,t} + \delta Controls + \varepsilon_{i,t} \qquad \text{(Model (3))}$$

$$Highex_{i,t} = \alpha + \beta_1 Skill_{i,t} + \delta Controls + \varepsilon_{i,t} \qquad \text{(Model (4))}$$

As mentioned earlier, we also aim to analyze whether the impact of IDI and its components on high-technology export varies according to different development levels of countries. For this purpose, we first divide all samples into two groups as developed and developing countries according to countries' UN development levels. Then, we re-estimate all models for 32 developed and 90 developing countries separately.

To examine the relationships, we use panel data of 122 countries from 2007 to 2017. The use of panel data in econometric analysis has important advantages, such as applicability in dynamic processes (Baltagi 2008). This study applies dynamic specification because of the dynamic relationship between digitalization and the export of high-tech products. Namely, digitalization may promote the export of high-tech products, and the export of high-tech products may promote ICT development and facilitate the digitalization process. Therefore, we apply a dynamic specification where the lag of the dependent variable is included in the estimation model. This type of dynamic panel data specification can be written as equation (1):

$$\begin{aligned} Y_{it} &= \alpha Y_{i,t-1} + ßX'_{it} + U_{it}, \\ U_{it} &= \mu_i + u_{it}. \end{aligned} \qquad (1)$$

where Y_{it} is the export of high-tech products in country i and year t, X'_{it} is a vector of digitalization indicators and control variables, and U_{it} is an i.i.d. error term.

It should be noted that the estimation method should be chosen carefully because the lagged values of the dependent variable are among the independent variables. Because the dependent variable Y_{it} is associated with the error term 'U_{it}' containing individual effects 'μ_i', and because $Y_{i,t-1}$ has a correlation with the error terms, the basic assumption of the OLS estimator, 'the presence of uncorrelated error terms and explanatory variables' is violated. Therefore, the standard estimators in ordinary least squares (OLS) that produce biased and inconsistent results cannot be trusted. Alternatively, a fixed-effect estimator that eliminates country-specific effects cannot be used as the existence of the lagged dependent variable will continue to cause bias. To overcome this bias, Arellano and Bond (1991) developed a GMM estimator known as 'difference GMM'. Difference GMM uses the first differences of variables as an instrument to eliminate bias and estimate consistent parameters.

The Arellano–Bond difference GMM estimator was designed for panels with short time series models with dynamic processes and a non-exogenous state of variables. However, one problem of the difference GMM estimator is that lagged levels are poor instruments for first differences if the variables are close to a random walk (Roodman 2009). Another problem is that the first difference data transformation causes excessive data loss in unbalanced panel data or when the time dimension of the data is small. To solve these problems, Arellano and Bover (1995) and Blundell and Bond (1998) developed the system GMM, which first combined regressions at differences and levels. System GMM has some advantages with respect to 'difference GMM'. Unlike difference GMM, system GMM uses the lagged levels of the series in the first differenced equation as instruments and the lagged differences of the series in the level equation as instruments to control the endogeneity. Moreover, system GMM allows the use of the orthogonal deviations transformation instead of the first difference transformation. In system GMM, the difference of the previous period from the current period is not taken. Instead, all possible future values of a variable are averaged. In this way, data loss caused by the transformation in the 'difference GMM' is prevented in unbalanced panel data with gaps. Another advantage of the system GMM method occurs when the sample size is relatively small. As is known, the system GMM derives instrument variables for each variable and lag distance. This situation increases efficiency in the large sample. However, as the number of instrument variables approaches the number of observations in relatively small sample sets, it may cause biased estimates. The system GMM also allows using additional commands (such as 'collapse') that allow reducing the number of instrument variables for such sample sets. In this way, an unbiased and consistent estimation coefficient can be reached.

This study applies dynamic specification because of the dynamic relationship between digitalization and export of high-tech products. In line with the advantages of the system GMM estimator, all of the estimations are performed by the system GMM estimator to increase efficiency in dynamic regression models. The consistency of the system GMM estimator depends on the three basic conditions. The first is that over-identification restrictions are valid. The second is that there is no second-order autocorrelation among the idiosyncratic error terms. The last is that the number of groups in data should be higher than the number of instruments. Therefore, Hansen's (1982) J test is applied in this study for the validity of over-identification restrictions. In addition, the presence of second-order autocorrelation between idiosyncratic error terms is tested by Arellano and Bond's (1991) AR tests. Hansen J statistics and AR test statistics are presented in the Estimation section. Briefly, all estimation results confirm these two criteria.

In addition, robustness analysis was performed for all regression models using the two-step system GMM approach. Although the two-step system GMM estimator is asymptotically more efficient, it has downward standard errors (Arellano and Bond 1991; Blundell and Bond 1998). The two-step system GMM is utilized with Windmeijer's robust standard errors[1] to prevent the downward bias.

Estimation

In line with the main research question, which is whether the digitalization level, namely IDI, affects the export of high-tech products, we first run regressions on the whole sample. In Table 3, the first four columns show the impact of IDI on high-tech export for all countries. As seen from Table 3, IDI has a significant positive effect on high-tech export for all countries. Notably, the significance of IDI does not change even after adding control variables such as Investment, Deflator, Saving and Gov. Spending. This result suggests that the IDI may contribute to more high-tech product exports of countries. IDI reflects the advancement in information technology of a country that will facilitate the use and absorption of knowledge and technology (ITU 2017). In other words, the level of digitalization of countries is a factor that accelerates the access to new information and thus contributes to the increase of high-technology exports. Technology, digitalization and innovation activities will rapidly develop economies. Therefore, countries' easy access to information and technology and their ability to process and use information

Table 3. The impact of IDI on the high technology export for all, developed and developing countries.

	1	2	3	4	5	6
Sample	All countries				Developed cuntries	Developing countries
Variables	High-tech export				High-tech export	High-tech export
L.High-Tech Export	0.477***	0.466***	0.459***	0.456***	1.015***	0.293
	(0.112)	(0.149)	(0.152)	(0.125)	(0.108)	(0.192)
IDI (ICT Development Index)	**2.438*** **	**2.665*** **	**3.011*** **	**2.016*** **	**0.522**	**2.180** **
	(0.513)	(0.802)	(1.000)	(0.576)	(1.039)	(0.957)
Investment	0.0955	0.749	0.954	−1.016	−0.0809	−2.217
	(0.603)	(0.628)	(0.613)	(0.649)	(0.297)	(1.897)
Deflator		0.160	0.0951	−0.110	0.100*	−0.470
		(0.210)	(0.198)	(0.141)	(0.0567)	(0.537)
Gov. Spending			−1.262	0.219	−0.934	−0.762
			(1.088)	(0.873)	(0.763)	(2.192)
Saving				0.537**	−0.401	0.807*
				(0.210)	(0.292)	(0.477)
Constant	6.370**	4.162	6.962*	9.500***	2.839	18.55**
	(2.904)	(2.692)	(3.898)	(3.397)	(2.796)	(7.286)
# of Obs.	1024	916	911	845	270	575
T	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.006	0.008	0.008	0.016	0.021	0.052
Arellano–Bond test for AR(2) (*p*-value)	0.423	0.349	0.368	0.624	0.516	0.411
Hansen Test	0.149	0.353	0.320	0.371	0.202	0.574
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.

and technology have an impact on their high-tech exports. This relationship is important because it includes the externalities that provide economic growth, development and social modernization (Hidalgo 2015; Nour 2005).

A well-developed ICT sector offers significant development opportunities for developing countries under favorable conditions. It is important to establish the comparative impact of ICT on developed and developing countries in this context. Hence, we also analyze the impact of IDI on high-tech export according to the different development levels of countries. Particularly, we question whether there are any systematic differences in the impact of IDI on high-tech exports between developed and developing countries. To this end, we divide our sample into two sub-samples as developed and developing countries according to UN classification. Then, regressions are run for both samples separately. Table 3, column (5) shows the estimation results for developed countries and column (6) indicate the results for developing countries. According to these results, whereas the coefficient of IDI was not statistically significant for developed countries, the coefficient of IDI is positive and statistically significant only for developing countries. These results can be attributed to the fact that IDI or digitalization is a promotive factor for high-technology export in developing countries. This result is not surprising because the developed countries have certain saturation in terms of ICT development and other technologies that contribute to high-technology exports. This result is also supported by the technology gap approach. Developing countries can replicate the existing advanced technology of the developed countries; increasing high-tech product exports allow developing countries to replicate the advanced technologies they export. Therefore, developing countries close the gap with developed countries by exporting high-tech products. For this reason, the effect of technology on the economies of developing countries is greater and more transformative than the effect in developed countries that have reached saturation in this regard.

The estimation results presented in Table 3 are statistically reliable in terms of the Hansen test, the AR(2) Autocorrelation test and the Wald Test. Hansen test statistics indicate that over-identification restrictions are valid. Also, the AR(2) Autocorrelation test and the Wald Test signify that there is no autocorrelation problem, and the regression model is significant as a whole, respectively. To sum, these results show that IDI may enhance the level of high-technology export for only developing countries. Developed countries have achieved competence in this field. However, when the increasing technological development in developing countries is combined with cost advantages such as low labor force and raw material costs, it may have an increasing effect on high-tech exports. Therefore, progress in ICT may have a greater leverage effect in developing countries than developed countries. Because the developed countries have more technical knowledge and infrastructure, more investment in R&D and more financial capacity to produce and export high-tech goods, the impact of ICT development level on their high-tech goods may be invisible.

Motivated by the idea that ICT access, ICT usage and ICT skills will affect the transformation into an information society that serves high-technology export, we are also interested in the impact of IDI's components on high-tech export. To reveal these relationships, we run the regression for all developed and developing countries separately. The results from these estimations are reported in Table 4, where every three columns show outcomes for all countries, developed and developing countries, respectively. According to these results, the IDI components of access, use and skill have a statistically significant and positive effect on high-tech product exports for all countries. The access, use and skill components illustrate the ICT development process and the impact of the components necessary for a country's transformation into an information society. Access reflects ICT infrastructure and the level of access to ICT, use reflects the intensity of usage of ICT, and skill reflects the skill level required for ICT absorption and dissemination. All these variables are statistically positive and significant; this fact shows that ICT infrastructure, ICT use and the skill that will trigger new knowledge are components that contribute to the export of high-tech products in a holistic manner. The coefficients of access, use and skill are only positively significant for developing countries. The first producers of technologies are also the first exporters, and these are developed countries. For this reason, developed countries are countries with advanced ICT infrastructures as the main exporters. However, in developing countries, increasing ICT investments, low production costs, increasing demand and positive externalities are the driving force in the increase of high-tech exports.

An evaluation of these results shows that the main component of IDI that affects high-technology export is access, followed by skill. In developing countries, the use component is less effective on high-tech product exports alone.

As a robustness check, we re-run all regressions by adding additional control variables such as ICT Good Import (ICT_GI) and Political Stability Index. The estimated results from Tables A3–A6 in the Appendix, A2, show that our initial results do not change.

Table 4. The impact of IDI components on the high technology export for all, developed and developing countries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	All countries			Developed countries			Developing countries		
Variables	High-tech export			High-tech export			High-tech export		
L.High-Tech Export	0.444***	0.508***	0.516***	1.093***	0.893***	0.872***	0.275	0.320*	0.266
	(0.127)	(0.105)	(0.117)	(0.134)	(0.0740)	(0.0477)	(0.200)	(0.183)	(0.205)
Access	**2.390*** **			**−0.635**			**2.599** **		
	(0.691)			(1.250)			(1.193)		
Use		**0.743*** **			**0.853**			**0.958** **	
		(0.194)			(0.539)			(0.384)	
Skill			**1.610*** **			**0.593**			**2.363** **
			(0.584)			(0.452)			(1.045)
Investment	−0.931	−1.104*	−1.527**	−0.300	−0.0570	−0.0316	−2.223	−2.079	−2.791
	(0.681)	(0.631)	(0.671)	(0.328)	(0.315)	(0.220)	(1.825)	(1.896)	(1.957)
Saving	0.556***	0.599***	0.712***	−0.158	−0.460	0.0819	0.716	0.761	1.102**
	(0.209)	(0.201)	(0.173)	(0.287)	(0.545)	(0.299)	(0.483)	(0.488)	(0.515)
Gov.Spending	0.0778	0.370	0.732	−0.691	−1.213	−0.409	−1.138	−0.981	−0.620
	(0.895)	(0.912)	(0.754)	(0.699)	(1.143)	(0.536)	(2.264)	(2.122)	(2.251)
Deflator	−0.0729	−0.209	−0.247	0.110*	0.106**	0.0679**	−0.328	−0.560	−0.604
	(0.135)	(0.161)	(0.168)	(0.0649)	(0.0508)	(0.0341)	(0.570)	(0.524)	(0.556)
Constant	8.925***	10.69***	7.980**	2.553	6.123	2.674	18.99***	20.94***	18.28**
	(3.377)	(3.586)	(3.121)	(2.519)	(4.578)	(2.379)	(7.318)	(7.595)	(7.843)
# of Obs.	845	845	844	270	270	270	575	575	574
T	11	11	11	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.017	0.011	0.008	0.027	0.021	0.006	0.066	0.046	0.042
Arellano–Bond test for AR(2) (*p*-value)	0.648	0.595	0.573	0.589	0.684	0.767	0.473	0.347	0.224
Hansen Test	0.25	0.359	0.347	0.328	0.256	0.22	0.559	0.789	0.661
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.

Moreover, to further examine the robustness of the estimates, we repeat the same exercises with the two-step system GMM with Windjmeijer robust standard errors. Results are also robust with this method. The results from the estimations are presented in Tables A1 and A2 in the Appendix, A1.

Conclusion and recommendation

In terms of economies, while export is ex-post, production is an ex-ante concept. An increase in exports is possible by increasing the level of production. Therefore, economies that want to take part in global competition with high value-added products instead of traditional and low value-added products must prioritize knowledge and information-based production models. For this reason, the harmonization of information and knowledge with contemporary production technologies, that is, digitalization, is vital in increasing the level of exports. It is possible to increase the export with traditional production structures, but increasing the value of exports is only possible with high-tech products imposed by the global market. This mechanism leads us to the trilogy of ICT and digitalization. In this respect, knowing the digitalization and technology development levels of the countries in the field is important in terms of their competitiveness and revealing their high-tech product export potential. For this reason, this study aims to reveal the effects of ICT developments on countries' export of high-tech products.

The analysis results show that IDI has a statistically positive and significant effect on high-tech product exports. However, this significance changes when countries are divided into different groups according to their level of development. This result can be interpreted as the level of digitalization of countries is a factor that accelerates the access of countries to new information and thus contributes to the increase of high-tech exports. Inevitably, technology, digitalization and innovation activities will rapidly develop economies. In parallel with the technological developments, the increase in R&D expenditures, innovation (Sandu and Ciocanel 2014; Tebaldi 2011; Gökmen and Turen 2013) and the technological infrastructure (Portugal-Perez and Wilson 2012; Francois and Manchin 2013) also affect the product variety exported by the countries and increases the technology-intensive product production and export.

When countries are considered according to their development level, the contribution of IDI to high-tech products is statistically significant only in developing countries. Most of the studies in the literature support this result, showing that high-tech export is concentrated in developing countries, and these countries have become important high-tech exporters (Srholec 2007; Fu, Wu, and Tang 2012; Sandu and Ciocanel 2014;). However, studies show that the factors that transform developing countries into high-tech exporter countries are not their existing technological equipment and competencies. ICT investments in developing countries stand out in the literature as one of the most important factors increasing high-tech exports in these countries. Investments in ICT and digitalization made in developed countries also affect the technological development of countries. This relationship has been revealed in different ways in the literature (Farooqi, Makhdum, and Yaseen 2020; Kamel, Rateb, and El-Tawil 2009; Alraja, Hammami, and Samman 2016). Multinational companies will be more effective in technological progress than domestic companies; they have implemented R&D and have more endowment in terms of patents, branding, skilled workforce and financial resources to support digitalization and ICT (Carr, Markusen, and Maskus 2001; Gani 2009).

The most important high-tech export driving force in developing countries is that multinational companies endowed with digital technology expand their production segments globally, focusing on cost and the accompanying FDI investments (Kızılkaya, Ay, and Sofuoğlu 2017). Therefore, the technology spillover effect, which is created in developing countries with the FDI investments of multinational companies, is an important factor for these countries to become high-tech product exporters. For this reason, the determinants of the technological product specialization in developing countries are again foreign multinational companies (Srholec 2006). In addition to this, according to a model developed by Wang and Blomstrom (1992), the technology spillover effect, created by multinational companies, makes progress endogenously through the relationship between a foreign subsidiary and the host country firm.

This situation is also compatible with the technology gap theory. Technology transfer from a foreign company to a domestic company is positively associated with the level of learning investment of the domestic firm and the cost effectiveness of the foreign firm. However, the higher the operational risks in the developing country, such as political instability, high inflation, and low economic growth rate, the more foreign companies will be reluctant to participate in technology transfer. In addition, the greater the technology gap, the larger the technology spillover effect from the foreign firm to the domestic firm will be. Foreign direct investment data for 2019 around the world confirm this development. While FDI investments in the developed countries like the USA and many EU countries decrease, FDI investments made by multinational foreign companies in countries such as Mexico, Brazil, India, Indonesia, Singapore, Hong Kong, Kenya, Morocco, and Egypt are increasing (UNCTAD 2019).

With the technology spillover effect brought along by these companies, the economic, political and social transformation in these developing countries has also started. With the positive impact that high-tech export has made on developing countries' economic growth and development, from skilled human resources to modernization processes, developing countries have started implementing a series of economic and social policies such as tax incentives and labor market regulations to attract foreign direct investments.

Note

1. Windmeijer finite sample correction for the two-step covariance matrix corrects the downward bias (Roodman 2009; Windmeijer 2005).

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Seren Özsoy http://orcid.org/0000-0001-6642-7195
Oylum Şehvez Ergüzel http://orcid.org/0000-0001-9266-8267
Ahmet Yağmur Ersoy http://orcid.org/0000-0002-7865-6574
Metin Saygılı http://orcid.org/0000-0001-6920-822X

References

Abedini, J. 2013. "Heterogeneity of Trade Patterns in High-Tech Goods Across Established and Emerging Exporters: A Panel Data Analysis." *Journal Emerging Markets Finance and Trade* 49 (4): 4–21.

Abramovitz, M. 1986. "Catching Up, Forging Ahead, and Falling Behind." *The Journal of Economic History. The Tasks of Economic History* 42 (2): 385–406.

Alraja, M. N., S. Hammami, and H. M. A. Samman. 2016. "Investment in ICT in Developing Countries: The Effect of FDI: Evidence from Sultanate of Oman." *International Journal of Economics and Financial Issues* 6 (4): 1632–1636.

Arellano, M., and S. Bond. 1991. "Some Tests of Specification For Panel Data: Monte Carlo Evidence and an Application to Employment Equations." *The Review of Economic Studies* 58 (2): 277.

Arellano, M., and O. Bover. 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models." *Journal of Econometrics* 68: 29–51.

Baltagi, B. H. 2008. "Forecasting with Panel Data." *Journal of Forecasting* 27 (2): 153–173.

Bankole, F. O., K.-M. Osei-Bryson, and I. Brown. 2013. "The Impact of Information and Communications Technology Infrastructure and Complementary Factors on Intra-African Trade." *Information Technology for Development* 21 (1): 12–28.

Bertrand, O., and P. Zuniga. 2006. "R&D and M&A: Are Cross-Border M&A Different? An Investigation on OECD Countries." *International Journal of Industrial Organization* 24 (2): 401–423.

Blundell, R., and S. Bond. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics* 87: 115–143.

Bournakis, I., and C. Tsoukis. 2016. "Government Size, Institutions, and Export Performance among OECD Economies." *Economic Modelling* 53 (C): 37–47.

Carr, D., J. Markusen, and K. Maskus. 2001. "Estimating The Knowledge-Capital Model of the Multinational Enterprise." *American Economic Review* 91 (2): 693–708.

Choi, C. 2010. "The Effect of the Internet on Service Trade." *Economics Letters* 109 (2): 102–104.

Dettmer, B. 2013. "International Service Transactions: Is Time a Trade Barrier in a Connected World?" *International Economic Journal* 28 (2): 225–254.

Falk, M. 2009. "High-Tech Exports and Economic Growth in Industrialized Countries." *Applied Economics Letters* 16 (10–12): 1025–1028.

Farooqi, Z., M. Makhdum, and M. R. Yaseen. 2020. "Impact of Information and Communication Technology (ICT) Investment on Different Components of Human Development in Developing Countries." *International Review of Management and Business Research* 9 (12): 108–129.

Ferrarini, B., and P. Scaramozzino. 2016. "Production Complexity, Adaptability and Economic Growth." *Structural Change and Economic Dynamics* 37 (C): 52–61.

Francois, J., and M. Manchin. 2013. "Institutions, Infrastructure, and Trade." *World Development* 46: 165–175.

Freunda, C. L., and D. Weinhold. 2004. "The Effect of the Internet on International Trade." *Journal of International Economics* 62 (1): 171–189.

Fu, D., Y. Wu, and Y. Tang. 2012. "Does Innovation Matter for Chinese High-Tech Exports? A Firm-Level Analysis." *Frontiers of Economics in China* 7 (2): 218–245.

Gani, A. 2009. "Governance and Foreign aid in Pacific Island Countries." *Journal of International Development* 21: 112–125.

Gökmen, Y., and U. Turen. 2013. "The Determinants of High Technology Exports Volume: A Panel Data Analysis of EU-15 Countries." *International Journal of Management Economics and Social Sciences* 2 (3): 217–232.

Hansen, L. P. 1982. "Large Sample Properties of Generalized Methods of Moments Estimators." *Econometrica* 50 (4): 1029–1054.

Harbi, E. S., R. A. Anderson, and M. Amamou. 2014. "Innovation Culture in Small Tunisian ICT Firms." *Journal of Small Business and Enterprise Development* 21 (1): 132–151.

Hidalgo, C. 2015. *Why Information Grows: The Evolution of Order, from Atoms to Economies*. Kindle Edition. New York: Penguin Press. Accessed August 13, 2020. https://tcdata360.worldbank.org/indicators/TX.VAL.TECH.CD?country = BRA&indicator = 2009&viz = line_chart&years = 1988,2018.

Hsu, J., and Y. P. Chuang. 2014. "International Technology Spillovers and Innovation: Evidence from Taiwanese High-Tech Firms." *The Journal of International Trade & Economic Development* 23 (3): 387–401.

ITU. 2016. Measuring the Information Society Report.

ITU. 2017. Measuring the Information Society Report.
Iwamoto, M., and K. Nabeshima. 2012. "Can FDI Promote Export Diversification and Sophistication of Host Countries?: Dynamic Panel System GMM Analysis." IDE Discussion Papers 347, Institute of Developing Economies, Japan External Trade Organization(JETRO).
Kamel, S., D. Rateb, and M. El-Tawil. 2009. "The Impact of ICT Investments on Economic Development in Egypt." *Electronic Journal on Information Systems in Developing Countries (EJISDC)* 36 (1): 1–21.
Kızılkaya, O., A. Ay, and E. Sofuoğlu. 2017. "Yüksek Teknolojili Ürün İhracatı Üzerinde Doğrudan Yabancı Sermaye Yatırımları ve Dışa Açıklığın Etkisi: Gelişmekte Olan Ülkelerde Panel Veri Analizi." *Doğuş Üniversitesi Dergisi* 18 (1): 63–78.
Liu, L., and H. K. Nath. 2013. "Information and Communications Technology and Trade in Emerging Market Economies." *Emerging Markets Finance and Trade* 49 (6): 67–87.
Mattes, A., P. Meinen, and F. Pavel. 2012. "Goods Follow Bytes: The Impact of ICT on EU Trade." Discussion Paper 1182. Accessed August 13, 2020. https://ideas.repec.org/p/diw/diwwpp/dp1182.html.
Meschi, E., E. Taymaz, and M. Vivarelli. 2011. "Trade, Technology and Skills: Evidence from Turkish Microdata." *Labour Economics* 18: S60–S70.
Nath, H. K., and Li Liu. 2017. "Information and Communications Technology (ICT) and Services Trade." *Information Economics and Policy* 41: 81–87.
Nour, S. S. O. M. 2005. "Science and Technology Development Indicators in The Arab Region: a Comparative Study of Arab Gulf and Mediterranean Countries, Science." *Science, Technology and Society* 10 (2): 249–276.
Ozcan, Burcu. 2018. "Information and Communications Technology (ICT) and International Trade: Evidence from Turkey." *Eurasian Economic Review No 5* 8 (1): 93–113.
Ozsoy, S., Fazlioglu, B., Esen, S. 2020. "Do FDI and Patents Drive Sophistication of Exports? A Panel Data Approach." Prague Economic Papers, University of Economics, Prague, vol. 0.
Portugal-Perez, A., and J. S. Wilson. 2012. "Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure." *World Development* 40 (7): 1295–1307.
Rodriguez-Crespo and Zarzoso. 2019. "The Effect of ICT on Trade: Does Product Complexity Matter?" *Telematics and Informatics* 41: 182–196.
Roodman, D. 2009. "How to Do xtabond2: An Introduction to Difference and System GMM in Stata." *Stata Journal* 9 (1): 86–136.
Sandu, S., and B. Ciocanel. 2014. "Impact of R&D and Innovation on High-Tech Export." *Procedia Economics and Finance* 15: 80–90.
Seyoum, B. 2005. "Determinants of Levels of High Technology Exports an Empirical Investigation." *Advances in Competitiveness Research* 13 (1): 64–75.
Srholec, M. 2006. "Global Production Systems And Technological Catching-Up: Thinking Twice About High-Tech Industries In Emerging Countries." In *The Knowledge-Based Economy in Central and East European Countries: Countries and Industries in a Process of Change*, edited by K. Piech and S. Radoševič, 57–78. New York: Palgrave Macmillan.
Srholec, M. 2007. "High Technology Exports from Developing Countries: A Symptom of Technology Spurts or Statistical Illusion?" *Review of World Economics* 143 (2): 227–255.
Tebaldi, E. 2011. "The Determinants of High-Technology Exports: A Panel Data Analysis." *Atlantic Economic Journal* 39: 343–353.
UNCTAD. 2019. World Investment Report (WIR) Key Messages and Overview.
Wang, J.-Y., and M. Blomstrom. 1992. "Foreign Investment and Technology Transfer: A Simple Model." *European Economic Review* 36 (1): 137–155.
Windmeijer, F. 2005. "A Finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators." *Journal of Econometrics* 126: 25–51.
World Bank. 2020. Accessed August 13, 2020. https://tcdata360.worldbank.org/indicators/TX.VAL.TECH.MF.ZS?country = BRA&indicator = 2010&viz = line_chart&years = 1988,2018.
Zeufack, A. 2002. "Export Performance in Africa and Asia's Manufacturing: Evidence from Firm-Level Data." *Journal of African Economies* 10 (3): 258–281.
Zhu, S., and X. Fu. 2013. "Drivers of Export Upgrading." *World Development* 51: 221–233.

Appendix

A1. The robustness analysis as using two-step system GMM with Windmeijer's Standard Deviations

Table A1. The impact of IDI on the high technology export for All, developed and developing countries: robustness check with Windmeijer's Std. Dev.

Sample	All countries				Developed cuntries	Developing countries
Variables	High-tech export				High-tech export	High-tech export
L.High-Tech Export	0.477***	0.464***	0.460***	0.454***	1.017***	0.351**
	(0.111)	(0.150)	(0.152)	(0.125)	(0.0805)	(0.144)
IDI (ICT Development Index)	**2.446*****	**2.709*****	**3.042*****	**1.983*****	**0.384**	**2.352*****
	(0.523)	(0.797)	(0.997)	(0.578)	(0.919)	(0.700)
Investment	0.0958	0.758	0.963	−1.017	−0.0849	−2.479
	(0.609)	(0.601)	(0.590)	(0.672)	(0.363)	(2.505)
Deflator		0.154	0.0928	−0.115	0.0641	−0.840*
		(0.203)	(0.191)	(0.135)	(0.0817)	(0.446)
Gov. Spending			−1.278	0.214	−0.814	−2.519
			(1.102)	(0.883)	(0.693)	(2.293)
Saving				0.529**	−0.345	0.450
				(0.209)	(0.325)	(0.429)
Constant	6.379**	4.182	7.009*	9.620***	2.593	24.43***
	(2.902)	(2.741)	(3.962)	(3.503)	(2.806)	(7.696)
# of Obs.	1,024	916	911	845	270	575
T	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.026	0.045	0.048	0.016	0.039	0.002
Arellano–Bond test for AR(2) (*p*-value)	0.461	0.418	0.432	0.633	0.787	0.452
Hansen Test	0.149	0.353	0.320	0.371	0.202	0.574
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.

Table A2. The impact of IDI components on the high technology export for all, developed and developing countries: robustness check with Windmeijer's Std. Dev.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample	All countries			Developed countries			Developing countries		
Variables	High-tech export			High-tech export			High-tech export		
L.High-Tech Export	0.443***	0.508***	0.516***	1.082***	0.920***	0.891***	0.346**	0.380***	0.316*
	(0.128)	(0.104)	(0.118)	(0.118)	(0.0838)	(0.0575)	(0.158)	(0.131)	(0.188)
Access	**2.386*** **			**−0.612**			**2.773*** **		
	(0.719)			(1.050)			(0.800)		
Use		**0.743*** **			**0.759***			**1.025*** **	
		(0.196)			(0.420)			(0.254)	
Skill			**1.624*** **			**0.512**			**2.323** **
			(0.599)			(0.601)			(0.967)
Investment	−0.930	−1.076*	−1.519**	−0.275	0.0311	−0.0736	−2.383	−1.950	−2.794
	(0.702)	(0.626)	(0.672)	(0.313)	(0.403)	(0.261)	(2.407)	(2.296)	(2.408)
Saving	0.553***	0.594***	0.715***	−0.0679	−0.481	−0.0329	0.304	0.351	0.771
	(0.204)	(0.200)	(0.170)	(0.364)	(0.450)	(0.416)	(0.442)	(0.416)	(0.509)
Gov.Spending	0.0823	0.378	0.741	−0.564	−1.309	−0.598	−2.757	−3.007	−1.118
	(0.908)	(0.915)	(0.756)	(0.652)	(1.009)	(0.781)	(2.192)	(1.909)	(2.170)
Deflator	−0.0757	−0.217	−0.254	0.0768	0.0924	0.0605	−0.744	−0.887**	−0.733
	(0.134)	(0.164)	(0.171)	(0.0829)	(0.0668)	(0.0449)	(0.483)	(0.359)	(0.589)
Constant	8.956***	10.63***	7.932**	2.047	5.839	3.550	24.21***	26.43***	19.87**
	(3.389)	(3.693)	(3.121)	(2.434)	(4.072)	(3.808)	(7.463)	(7.735)	(7.882)
# of Obs.	845	845	844	270	270	270	575	575	574
T	11	11	11	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.016	0.013	0.008	0.051	0.04	0.016	0.004	0.002	0.012
Arellano–Bond test for AR(2) (*p*-value)	0.655	0.605	0.582	0.855	0.79	0.8	0.517	0.372	0.364
Hansen Test	0.25	0.359	0.347	0.328	0.256	0.22	0.559	0.789	0.661
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.

A2. The robustness analysis as adding new control variables to one-step system GMM estimations

Table A3. The impact of IDI on the high technology export for all, developed and developing countries: robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Sample	All countries				Developed countries				Developing countries			
Variables	High-tech export				High-tech export				High-tech export			
L.High-Tech Export	0.456***	0.455***	0.401***	0.399***	1.015***	0.931***	1.047***	0.962***	0.293	0.294	0.305	0.302
	(0.125)	(0.126)	(0.150)	(0.153)	(0.108)	(0.0767)	(0.124)	(0.0821)	(0.192)	(0.187)	(0.187)	(0.200)
IDI (ICT Development Index)	2.016***	2.024***	1.774***	1.850**	0.522	1.079	−0.109	0.415	2.180**	2.133**	1.991**	2.006**
	(0.576)	(0.661)	(0.645)	(0.726)	(1.039)	(1.086)	(1.168)	(1.288)	(0.957)	(0.934)	(0.930)	(1.016)
Investment	−1.016	−1.013	−1.273*	−1.234*	−0.0809	−0.0792	−0.0164	−0.00822	−2.217	−2.275	−2.344	−2.600
	(0.649)	(0.655)	(0.752)	(0.726)	(0.297)	(0.312)	(0.327)	(0.333)	(1.897)	(1.987)	(2.045)	(2.254)
Deflator	−0.110	−0.111	−0.180	−0.185	0.100*	0.109*	0.106*	0.116*	−0.470	−0.493	−0.500	−0.589
	(0.141)	(0.140)	(0.147)	(0.151)	(0.0567)	(0.0572)	(0.0635)	(0.0636)	(0.537)	(0.531)	(0.578)	(0.669)
Gov. Spending	0.219	0.224	0.447	0.492	−0.934	−0.372	−0.632	−0.00997	−0.762	−0.855	−0.593	−1.072
	(0.873)	(0.920)	(1.005)	(1.070)	(0.763)	(0.887)	(0.907)	(1.001)	(2.192)	(2.642)	(2.266)	(3.229)
Saving	0.537**	0.537**	0.653***	0.655***	−0.401	0.147	−0.518	0.0484	0.807*	0.799*	0.793*	0.795
	(0.210)	(0.213)	(0.206)	(0.208)	(0.292)	(0.336)	(0.371)	(0.318)	(0.477)	(0.481)	(0.463)	(0.498)
P.Stability		−0.00883		−0.0854		−0.438*		−0.462		0.0962		0.312
		(0.333)		(0.391)		(0.240)		(0.335)		(1.468)		(1.688)
ICT_GI			0.541	0.548			0.536	0.589			0.131	−0.0971
			(0.583)	(0.595)			(0.401)	(0.454)			(1.283)	(1.494)
Constant	9.500***	9.469***	9.910***	9.593**	2.839	0.612	1.544	−0.932	18.55**	19.12*	18.39**	21.17
	(3.397)	(3.656)	(3.839)	(4.016)	(2.796)	(3.010)	(3.085)	(3.388)	(7.286)	(11.36)	(8.290)	(15.58)
# of Obs.	845	845	833	833	270	270	270	270	575	575	563	563
T	11	11	11	11	11	11	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.016	0.016	0.026	0.027	0.021	0.015	0.029	0.019	0.052	0.037	0.051	0.036
Arellano–Bond test for AR(2) (*p*-value)	0.624	0.624	0.649	0.651	0.516	0.243	0.379	0.218	0.411	0.406	0.425	0.384
Hansen Test	0.371	0.375	0.300	0.289	0.202	0.321	0.408	0.490	0.574	0.594	0.435	0.585
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.

Table A4. The impact of access on the high technology export for all, developed and developing countries: robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Sample	All countries				Developed countries				Developing countries			
Variables	High-tech export				High-tech export				High-tech export			
L.High-Tech Export	0.444***	0.445***	0.391**	0.392**	1.093***	1.081***	1.090***	1.081***	0.275	0.278	0.296	0.290
	(0.127)	(0.129)	(0.152)	(0.154)	(0.134)	(0.120)	(0.128)	(0.119)	(0.200)	(0.195)	(0.188)	(0.206)
Access	2.390***	2.268***	2.153***	2.105**	−0.635	−0.599	−0.629	−0.600	2.599**	2.436**	2.175**	2.214*
	(0.691)	(0.729)	(0.809)	(0.840)	(1.250)	(1.213)	(1.247)	(1.212)	(1.193)	(1.122)	(1.064)	(1.197)
Investment	−0.931	−0.979	−1.219	−1.247	−0.300	−0.270	−0.301	−0.270	−2.223	−2.388	−2.302	−2.657
	(0.681)	(0.695)	(0.775)	(0.770)	(0.328)	(0.298)	(0.333)	(0.299)	(1.825)	(1.960)	(1.980)	(2.280)
Deflator	−0.0729	−0.0622	−0.141	−0.135	0.110*	0.109*	0.108*	0.109*	−0.328	−0.402	−0.375	−0.497
	(0.135)	(0.133)	(0.144)	(0.146)	(0.0649)	(0.0641)	(0.0639)	(0.0646)	(0.570)	(0.555)	(0.570)	(0.677)
Gov. Spending	0.0778	−0.0290	0.325	0.278	−0.691	−0.439	−0.681	−0.438	−1.138	−1.382	−0.713	−1.406
	(0.895)	(1.000)	(1.004)	(1.129)	(0.699)	(0.767)	(0.690)	(0.751)	(2.264)	(2.772)	(2.277)	(3.365)
Saving	0.556***	0.547**	0.673***	0.669***	−0.158	0.0137	−0.122	0.0129	0.716	0.697	0.672	0.674
	(0.209)	(0.224)	(0.204)	(0.220)	(0.287)	(0.349)	(0.286)	(0.365)	(0.483)	(0.495)	(0.459)	(0.504)
P.Stability		0.145		0.0670		−0.134		−0.135		0.272		0.433
		(0.317)		(0.369)		(0.249)		(0.227)		(1.467)		(1.709)
ICT_GI			0.446	0.431			−0.0680	0.00376			0.335	0.00444
			(0.626)	(0.647)			(0.304)	(0.242)			(1.335)	(1.565)
Constant	8.925***	9.522**	9.524**	9.827**	2.553	1.478	2.592	1.468	18.99***	20.60*	17.95**	21.90
	(3.377)	(3.907)	(3.786)	(4.276)	(2.519)	(2.843)	(2.563)	(2.713)	(7.318)	(11.74)	(8.272)	(16.39)
# of Obs.	845	845	833	833	270	270	270	270	575	575	563	563
T	11	11	11	11	11	11	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.017	0.018	0.028	0.030	0.027	0.026	0.024	0.024	0.066	0.047	0.059	0.044
Arellano–Bond test for AR(2) (*p*-value)	0.648	0.642	0.657	0.654	0.589	0.511	0.616	0.504	0.473	0.457	0.511	0.451
Hansen Test	0.250	0.243	0.252	0.245	0.328	0.207	0.283	0.172	0.559	0.648	0.405	0.617
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.

Table A5. The impact of use on the high technology export for all, developed and developing countries: robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Sample	All Countries				Developed Countries				Developing Countries			
Variables	High-Tech Export				High-Tech Export				High-Tech Export			
L.High-Tech Export	0.508***	0.509***	0.444***	0.444***	0.893***	0.832***	0.925***	0.862***	0.320*	0.320*	0.333*	0.335*
	(0.105)	(0.106)	(0.136)	(0.137)	(0.0740)	(0.0769)	(0.0832)	(0.0695)	(0.183)	(0.179)	(0.181)	(0.183)
Use	0.743***	0.683***	0.634**	0.611**	0.853	0.948	0.373	0.558	0.958**	0.969***	0.767**	0.771**
	(0.194)	(0.208)	(0.249)	(0.259)	(0.539)	(0.643)	(0.532)	(0.657)	(0.384)	(0.355)	(0.341)	(0.325)
Investment	−1.104*	−1.168*	−1.352*	−1.385*	−0.0570	−0.0427	−0.00853	−0.00531	−2.079	−2.046	−2.069	−1.891
	(0.631)	(0.648)	(0.740)	(0.730)	(0.315)	(0.318)	(0.335)	(0.318)	(1.896)	(1.934)	(2.005)	(2.069)
Deflator	−0.209	−0.193	−0.261	−0.254	0.106**	0.118**	0.110*	0.120**	−0.560	−0.549	−0.543	−0.485
	(0.161)	(0.155)	(0.172)	(0.174)	(0.0508)	(0.0556)	(0.0596)	(0.0589)	(0.524)	(0.500)	(0.569)	(0.595)
Gov. Spending	0.370	0.277	0.569	0.530	−1.213	−0.357	−0.785	−0.0876	−0.981	−0.935	−0.586	−0.284
	(0.912)	(0.991)	(1.031)	(1.123)	(1.143)	(0.873)	(1.145)	(0.851)	(2.122)	(2.560)	(2.033)	(2.695)
Saving	0.599***	0.592***	0.706***	0.703***	−0.460	0.233	−0.524	0.125	0.761	0.764	0.675	0.674
	(0.201)	(0.210)	(0.195)	(0.204)	(0.545)	(0.416)	(0.537)	(0.272)	(0.488)	(0.480)	(0.464)	(0.445)
P.Stability		0.172		0.0748		−0.520		−0.476		−0.0518		−0.225
		(0.301)		(0.357)		(0.446)		(0.403)		(1.514)		(1.577)
ICT_GI			0.633	0.622			0.709	0.564			0.490	0.622
			(0.701)	(0.716)			(0.530)	(0.517)			(1.370)	(1.439)
Constant	10.69***	11.16***	10.90***	11.14**	6.123	2.930	3.651	1.228	20.94***	20.67*	19.02**	17.23
	(3.586)	(3.945)	(4.207)	(4.509)	(4.578)	(3.728)	(4.283)	(3.331)	(7.595)	(11.27)	(7.993)	(13.57)
# of Obs.	845	845	833	833	270	270	270	270	575	575	563	563
T	11	11	11	11	11	11	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.011	0.011	0.019	0.019	0.021	0.013	0.029	0.020	0.046	0.033	0.046	0.036
Arellano–Bond test for AR(2) (*p*-value)	0.595	0.594	0.620	0.620	0.684	0.380	0.395	0.282	0.347	0.348	0.413	0.444
Hansen Test	0.359	0.345	0.301	0.278	0.256	0.363	0.328	0.271	0.789	0.730	0.674	0.601
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.

Table A6. The impact of skill on the high technology export for all, developed and developing countries: robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Sample	All Countries				Developed Countries				Developing Countries			
Variables	High-Tech Export				High-Tech Export				High-Tech Export			
L.High-Tech Export	0.516***	0.519***	0.443***	0.445***	0.872***	0.874***	0.870***	0.871***	0.266	0.250	0.274	0.272
	(0.117)	(0.118)	(0.141)	(0.144)	(0.0477)	(0.0483)	(0.0508)	(0.0570)	(0.205)	(0.190)	(0.204)	(0.193)
Skill	**1.610*** **	**1.390** **	**1.087** **	**0.971* **	**0.593**	**0.600**	**0.554**	**0.523**	**2.363** **	**2.817** **	**2.239** **	**2.379** **
	(0.584)	(0.671)	(0.477)	(0.552)	(0.452)	(0.489)	(0.436)	(0.464)	(1.045)	(1.133)	(1.137)	(1.053)
Investment	−1.527**	−1.573**	−1.571**	−1.617**	−0.0316	−0.0457	−0.0424	−0.0745	−2.791	−2.351	−2.857	−2.242
	(0.671)	(0.691)	(0.749)	(0.751)	(0.220)	(0.228)	(0.215)	(0.225)	(1.957)	(1.919)	(2.019)	(1.953)
Deflator	−0.247	−0.222	−0.321*	−0.304*	0.0679**	0.0674*	0.0678**	0.0668*	−0.604	−0.432	−0.585	−0.382
	(0.168)	(0.164)	(0.169)	(0.170)	(0.0341)	(0.0351)	(0.0334)	(0.0349)	(0.556)	(0.607)	(0.597)	(0.627)
Gov. Spending	0.732	0.579	0.952	0.869	−0.409	−0.656	−0.391	−0.733	−0.620	0.177	−0.624	0.375
	(0.754)	(0.821)	(0.881)	(0.999)	(0.536)	(0.636)	(0.525)	(0.669)	(2.251)	(2.655)	(2.276)	(2.670)
Saving	0.712***	0.691***	0.787***	0.775***	0.0819	−0.0890	0.141	−0.0480	1.102**	1.211**	1.108**	1.130**
	(0.173)	(0.190)	(0.172)	(0.190)	(0.299)	(0.273)	(0.260)	(0.318)	(0.515)	(0.522)	(0.513)	(0.466)
P.Stability		0.258		0.154		0.137		0.201		−0.910		−0.863
		(0.356)		(0.387)		(0.261)		(0.246)		(1.796)		(1.719)
ICT_GI			1.154**	1.115*			−0.0971	−0.200			0.104	0.478
			(0.581)	(0.602)			(0.314)	(0.307)			(1.289)	(1.352)
Constant	7.980**	8.927**	7.787**	8.404**	2.674	3.819	2.789	4.588	18.28**	13.30	18.32**	12.16
	(3.121)	(3.528)	(3.324)	(3.760)	(2.379)	(2.615)	(2.614)	(2.948)	(7.843)	(12.15)	(7.842)	(12.47)
# of Obs.	844	844	832	832	270	270	270	270	574	574	562	562
T	11	11	11	11	11	11	11	11	11	11	11	11
Arellano–Bond test for AR(1) (*p*-value)	0.008	0.009	0.014	0.015	0.006	0.005	0.014	0.012	0.042	0.040	0.051	0.050
Arellano–Bond test for AR(2) (*p*-value)	0.573	0.581	0.668	0.672	0.767	0.620	0.779	0.595	0.224	0.212	0.229	0.269
Hansen Test	0.347	0.324	0.333	0.249	0.220	0.217	0.162	0.179	0.661	0.689	0.562	0.521
Wald-test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Standard errors are in brackets. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.
Source: Authors' calculations.