THE ANALYSIS OF MAIN DETERMINANTS OF HIGH TECHNOLOGY EXPORTS: A PANEL DATA ANALYSIS

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ABSTRACT | Export competitiveness is important in globalizing world. High technology exporter countries can increase their export volume and value more easily than the countries exporting primary goods because of high income elasticity in high-technology products. In this context this study investigates the main determinants of high-technology exports by using a wide panel data set and a wide range of economic, political and institutional variables for 48 countries which cover %90 percent of total high-technology/total manufactured export ratio. To this aim, panel ARDL methodology have been employed to examine the long run effect of indicators such as, schooling, per capita income, trade openness, foreign direct investments, domestic saving, political stability, reel effective exchange rate and patent applications for the period from 1980 to 2017. Estimation results show that trade openness, FDI inflows, per capita income and schooling are the important factors that affect high-technology export performance of sample countries.

Keywords: High Technology Exports, Panel ARDL Estimation

Jel codes: *F14, F43, C33*
Scope: *Economics*
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YÜKSEK TEKNOLOJİ İHRACATININ TEMEL BELİRLEYİCİLERİNİN ANALİZİ: BİR PANEL VERİ ANALİZİ

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ÖZ| Küreselleşen dünyada ihracatta rekabetçi olmak önemlidir.Yüksek-teknoloji ürün ihracatçısı ülkeler, yüksek-teknoloji ürünlerin gelir esnekliğinin birincil mallara göre daha yüksek olması nedeniyle hem ihracat hacmini hem de toplam ihracat gelirini daha kolay arttırabilmektedir. Bu kapsamda, çalışmada toplam yüksek teknoloji ihracatının yaklaşık %90'ını temsil eden 48 yüksek teknoloji ihraç eden ülke için, geniş bir panel veri seti ile ekonomik, politik ve kurumsal değişkenler kullanılarak, yüksek teknoloji ihracatını belirleyen temel unsurlar araştırılmıştır. Bu amaçla, 1980-2017 dönemi için okullaşma oranı, kişi başına düşen milli gelir, ticari açıklık, doğrudan yabancı yatırımlar, ulusal tasarruflar, politik istikrar, reel efektif döviz kuru, ve patent başvurularının yüksek teknoloji ihracatına uzun dönem etkilerini analiz etmek için panel ARDL yöntemi kullanılmıştır. Tahmin sonuçları; ticaret açıklığın, doğrudan yabancı yatırım (DYY) girişinin, kişi başına düşen gelir ve okullaşma oranının örneklem ülkelerinin yüksek teknoloji ihracat performansını etkileyen en önemli faktörler olduğunu göstermektedir.

Anahtar Kelimeler: Yüksek Teknoloji İhracatı, Panel ARDL Tahmini

JEL Kodu: F14, F43, C33
Alanı: *İktisat*
Türü: *Araştırma*

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1. INTRODUCTION

The integration of financial markets through capital mobility has been affecting sovereign states' not only economic but also political decisions. New liberal structure of global economic environment increased the importance of export-led growth policies. The most important challenge nowadays is that how a country can increase its export competitiveness and get the lion share from this increasing world trade volume. However, achieving an increase in export volume is necessary but not enough to improve the well-being of the society because of the possibility of the existence of immiserizing growth (Bhagwati, 1958). So, not only increase in the export performance but also increase in value added in export became the goal of the countries. To achieve this goal; countries try to increase their exports' sophistication level. OECD classifies the manufacturing industry products according to their technology level as high, medium high, medium low and low technology. This classification can be seen in Appendix 1.

Total export volume of high technology products has risen sharply from $ 1.158 billion in 2000 to $ 1.947 billion in 2016 (Worldbank, 2018). It is a clear fact that the global economic structure has been changing rapidly. The age of Industry 4.0 increased the importance of high technology production capability as well. High technology exporter countries can increase their export volume and value more easily than the countries exporting primary goods because of high-income elasticity in high-tech products. Technology capability and knowhow in high technology industries accumulate so slowly that a country should not expect sharp shift or leapfrogging in its export structure from low technology to high technology in the short run. That's why the main aim of this study is to explore the leading long run factors that affect country's high technology export capability.

This study aims to contribute to the existing empirical literature on the determinants of high-technology exports in several aspects. Firstly, a large set of panel data is used which covers 48[1] countries, covering almost 90 percent of total world high-technology exports in total manufactured exports. Secondly, the time period ranges from 1980 to 2017 which is relatively longer than many other studies. Thirdly, this study employs panel ARDL methodology to estimate the long run determinants for high-technology exports while previous studies mostly used time-series and cross-section methods. Panel data methods are more advantageous and yields more reliable estimates since they utilize from both

[1] The list of countries are given in appendix2.

time-series and cross-section variation in the data. Panel ARDL estimator allows us to estimate dynamic models with both I(0) and I(1) explanatory variables controlling country-specific effects. Besides, it yields robust estimates against potential endogeneity problems. As it is aforementioned, high technology export capability is a long run issue. So, ARDL cointegration method is appropriate to reveal the long run determinants of the high technology exports.

The paper proceeds as follows: Section 2 provides a theoretical background of factors that expected to affect countries high technology export performance. Section 3 summarizes the findings of recent empirical studies. Section 4 describes data and methodology and discusses the empirical findings of the model. Section 5 concludes.

2. THEORATICAL FRAMEWORK

The theoretical literature about the determinants of high technology export varies widely. While Seyoum (2004) relies on Porter model (2008) to search the determinants of high technology export variables, Tebaldi (2011) adopts Eaton and Kortum (2001)'s approach which focuses on the importance of technology and innovation capability. Beside the differences in theoretical backgrounds, many diverse proxy variables have been used in empirical literature due to data constraints. In this study, a wide set of variables are investigated as potential determinants of high-technology exports which include per capita income, trade openness, schooling (human capital), domestic saving, reel effective exchange rate, political stability (polity), FDI (ratio of foreign direct investment inflows to GDP) and patent applications. The motivation behind the inclusion of these variables and theoretical linkages between these factors and high technology exports are explained below.

The export function includes price and foreign demand variables. The easiest way to increase export volume is to achieve a fall in price, which can be achieved through domestic currency depreciation. Reel exchange rate is widely used to measure the effect of price changes on export. When high technology export is taken into consideration, the change in reel exchange rate may not effect high technology export performance because high technology products are expected to be more income elastic rather than price elastic. Even so, reel effective exchange rate is employed as proxy variables of price (Allard, Catalan, Everaert & Sgherri, 2005; Bayoumi, Harmsen, & Turunen, 2011).

Domestic demand conditions (to measure the sophistication level of buyers) are also used as a determinant of exports in empirical trade models. A rise in domestic demand is expected to increase domestic production capability. “Linder hypothesis” emphasis the importance of the level and the composition of GDP for the existence of trade. As the similarity in countries’ production pattern gets increased, the intra industry trade among them increases because of the consumer demand variety (Linder, 1961). When consumers’ demand shifts from low-quality products to high-quality products, producers are obliged to change their production structure and increase their product quality by learning by doing. If the domestic market sophistication level increases, the capability of high technology export is expected to increase as well. Therefore, per capita income is used in this study as a proxy variable to represent for both demand and supply factors.

Another factor that affect countries’ high technology export level is trade openness. Producers can use the best quality intermediate goods through importing in case of absence of domestic production. Trade openness also increases competition. High level of competition with the existence of international trade may increase productivity, efficiency and innovation capacity of even monopoly type domestic producers (Metcalfe, 1998; Nickell, et al.,1997). Monopolies have more motivation to make innovation in case of foreign threat (Schumpeter, 1975). The intense competition causes an increase in value-added in domestic production and export performance. Moreover, open countries have an ability to finance their investments through foreign saving with a lower cost and longer maturity. In other words, an increase in production capability can be achieved through foreign funds and that may support high technology export at the end.

An improvement in human capital leads to an increase in productivity and innovation capability of the country. Not only in endogenous growth models but also in trade models, human capital variable has been employed (Blanchard & Olney, 2017; Auer, 2015). Kremer’s O-Ring theorem explains the effect of an improvement in human capital through positive assortative matching production function which means that workers are employed according to their skill level (skill matching rather than skill mixing). When high technology producers employ high skilled workers, productivity increases sharply. These firms can pay a higher wage to these highly skilled workers and they can produce more sophisticated and qualitative products which lead to an increase in total revenue. This situation explains the reason of brain drain from low technology firms (or countries) to high technology firms (or countries). High skilled labors work more productively and earn higher wages at high technology companies (Todaro & Smith, 2011). Then low technology producers (or countries) may fall into low skill trap. That's why the acquisition of human capital is essential for high technology production. Low technology exporter country may escape from this poverty gap through improving both quantity and quality of education. In this study schooling have been employed as a proxy variable of human capital.

Both patent and R&D expenditure are widely used to measure the innovation capacity of the countries (Falk, 2009). High technology export performance is regarded as an important measure of innovation as well. The literature mentions about statistical illusion which indicates that high technology exports co-exist with the low level of research and development investment spending (Sandu & Ciocanel, 2014). Some studies even state as "Assembled High-Tech" production instead of High-Tech production. The main argument behind this is that many components are imported and final assembly or low-value chain part has been done in the high technology exporter country (Xing, 2012). The statistical illusion problem can be a result of data aggregation problem as well. Although the goods are not classified into high technology category, domestic authorities may include it into high technology segment because of political reasons. The patent is considered as a more robust variable than R&D expenditures in this study. The patent shows one step further stage of a new product than R&D expenditures. Patents are the result of high effort in research and development facilities for years and years. That is why patent applications is used in this model as an indicator of innovation capability of the country.

FDI inflows are another variable of the high-tech model which has been used by most of the other studies as well. The effects of FDI have been widely discussed in growth and trade literature (Herzer, 2012). As known, FDI investments can be vertical or horizontal. Vertical FDI (international outsourcing) fragments each production stage into different countries. If the concerned inward FDI is vertical, the multinational firms decrease their production cost and increase their competitiveness by employing countries' low cost factors of production like labor and raw materials. The existence of external economies of scales in clusters may also attract FDI investments. Horizontal FDI produces same products in multiple countries (Lipsey, 2004). The aim of the international investor is to be close to consumers' market, which is called as Proximity concentration trade-off theory (Brainard, 1993). Neoclassical growth theory argues that an inflow of FDI stimulates economic growth by increasing the capital stock (de Mello, 1997). On the other hand, FDI investments may crowd out domestic investment if they get additional tax exemptions and subsidies. If existing domestic firms have been sold to foreigners, there will be no increase in capital stock (Agosin & Machado, 2005). Besides, profit repatriation of foreign firms may result in huge capital outflows from the country which may increase macroeconomic fragility. In endogenous growth models, in contrast, it is argued that FDI inflows give the opportunity to the domestic firms to get an advantage of the technology and knowledge externalities (spillover effect) and increase employment and export performance (Aizenman & Noy, 2006, Ford, Rork & Elmslie, 2008). However, Harrison and Rodríguez-Clare (2010) shows that most of the empirical study finds negative or statistically insignificant spillover effect of FDI. When high technology sectors (Aerospace, Computers, office machinery, Electronics-communications, Pharmaceuticals) are considered, it is subject to debate whether FDI inflows improve high technology export performance or not which is discussed in section 4.

An increase in domestic saving level and achievement of political stability (polity2) are expected to increase high technology export performance indirectly. If domestic saving is used for feasible technologically advanced investment projects, domestic production capability of high technology products may improve. Political stability perceived as a proxy for institutional quality which increases efficiency and productivity of whole economic agents. Macroeconomic climate created by institutional quality increases investment and the innovative production capacity of a state as well.

Consequently, as discussed above, per capita income, openness to trade (ratio of trade volume to GDP), years of schooling (as a measure of human capital), domestic saving, reel effective exchange rate, political stability (polity), FDI (ratio of foreign direct investment inflows to GDP) and patent applications are among the main indicators that lead to increase high-technology export performance of countries directly or indirectly. The following section summarizes the empirical results of previous studies.

3. LITERATURE OVERVIEW

A wide range of macroeconomic and institutional variables are used by previous studies to investigate the determinants of high technology exports. Seyoum (2004) finds that scientists and engineers per million, quality of math and science education, research and collaboration, telephone lines (as a proxy for infrastructure), fdi inflows, and consumption expenditure (as a proxy for demand conditions) have positive and statistically significant effect on high technology exports. Braunerhjelm and Thulin (2008) employ totally different set of variables and find that research and development expenditures have positive and significant effect on high technology exports. Tebaldi (2011) investigates the determinants of high technology export per worker and finds that human capital, trade openness; fdi inflows have positive impact on high technology exports.

Srholec (2007) points out those technologically intensive activities are sticky and remain localized in the home country of large multinational corporations. Developing countries have to improve their national technological capabilities and factor conditions especially in labor force to catch up the technology in developed countries. Zhang (2007) states that inward FDI inflows have no effect on complex export share in the total manufacturing sector for the period from 1985 to 1998. This study concludes “FDI inflows may help rise per capita value of complex exports”.

As it is stated, there is a wide range group of countries and variables in empirical literature. There is no consensus among the methods used in neither the empirical studies nor the variables. The summary of the selected empirical results is given in Table1.

Table 1: Summary of Empirical Literature

Study	Country and Period	Variables	Results
Seyoum (2004)	1996-1998 54 High Technology Exporter Country	-Scientist and Engineers per million -Quality of Math and Science Education -Research and Collaboration -Physical Infrastructure (Proxy telephone lines) -FDI inflows -Domestic Rivalry -Demand Conditions (Proxy consumption expenditures -Exchange Rate	-Except Domestic Rivalry and Exchange rate whole variables are positive and statistically significant
Seyoum (2005)	55 Countries Cross Section	-FDI inflows -Home Demand Conditions -Technological Infrastructure	Whole variables are positive and statistically significant

Zhang (2007)	1985-1998 Cross Country Data	-FDI inflows -Skills -Industrial Technological Capability	-Industrial Technological Capability positive effect -FDI inflows has no effect on complex export share in total manufacturing sector
Braunerhjelm andThulin (2008)	1981-1999 19 OECD Countries	-R&D investment -Market Size -Outward flow of FDI/GDP	-R&D investment is positive and statistically significant -Market Size and Outward flow of FDI/GDP statistically insignificant
Tebaldi (2011)	1980-2008 USA and Trade Partners Fixed Effect Panel Estimation	-Human Capital -FDI Inflows -Trade Openness -Institutions -Macroeconomic Stability -Saving -Gross Capital Formation	Human Capital, trade openness, FDI inflows has a positive impact on high tech exports per worker
Sandu and Ciocanel (2014)	2006-2010 EU-27(except Luxemburg) Panel Estimation	-Government R&D -Private R&D	Government and Private R&D positive and statistically significant
Sertic, Vuckovic and Peric (2015)	2000-2011 EU -27	-Lagged High Technology Export -Foreign Demand -Exchange Rate -Industrial Production -Labor cost -Domestic Demand	-Industrial Production and Domestic Demand robust positive and statistically significant effect
Kızılkaya,Sofuoğlu and Ay (2017)	2000-2012 12 Developing Countries Panel Cointegration	-Trade Openness -FDI inflows -Per capita income -Patent -R&D	Except R&D whole variables are positive and statistically significant
Kabaklarlı,Duran and Üçler (2017)	1989-2015 14 OECD Panel Cointegration	-FDI inflows -Patent -Growth rate -Gross Capital Formation	-FDI inflows and Patent positive and statistically significant -Growth rate and Gross Capital Formation negative and statistically insignificant

4. ANALYSIS

4.1. Data and model

48 countries with the highest HTE/manufacturing ratios which almost constitute 90 percent of total world high technology exports are selected for analysis for the period from 1980 to 2017. The sample covers the features of the population strongly.

The Panel ARDL (p,q,q,…,q) modelcan be written as;

$$hte_{i,t} = \sum_{j=1}^{p} \alpha\, hte_{i,t-j} + \sum_{j=0}^{q} \delta' X_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (1)$$

where *i* denotes countries, *t* denotes time, *hte* denotes high-tech exports (% of manufactured goods), *X* represents a vector of explanatory variables, ε is the error term, and μ_i represent the fixed effects.

The model can be reparametrized into an error correction model as,

$$\Delta hte_{i,j} = \Phi\left(hte_{i,t-1} - \beta' X_{it}\right) + \sum_{j=1}^{p-1} \alpha^* \Delta hte_{i,t-j} + \sum_{j=0}^{q-1} \delta^{*\prime} \Delta X_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (2)$$

Here, Φ is the error correction term and β's are the long run coefficient estimates. The explanatory variables are; FDI inflows, (FDI), per capita real GDP (lnpcgdp) , trade opennes (trade), years of schooling (as a mesure of human capital), domestic saving (domsav), political stability (polity2), real effective exchange rate (Reer), number of patent applications (patent). The description and the sources of the variables are given in Table 2. Previous theoretical and empirical literature show that per capita income, trade openness, human capital and FDI inflows are among the most pronounced determinants of high-technology exports of countries. Therefore, in the baseline model 1, these basic four variables on high-technology exports have been employed. Then, other variables have been added one by one to model 1.

Table 2: Variables and Their Description

Variable	Description	Source
HTE	High-tech exports, % of manufacturing goods	World Development Indicator (WDI)
FDI	Foreign direct investment inflows as a percentage of GDP, ratio	WDI
Trade	Sum of exports and imports of goods and services measured as a share of GDP, ratio	WDI
Percapita GDP	GDP divided by midyear population, expressed in logarithms	WDI
Schooling	Average years of schooling	Barro-Lee (2016)
Domsav	Gross domestic savings as a percentage of GDP, ratio	WDI
Polity2	Adjusted combined index of democracy and autocracy	World Governance Indicators
Reer	Real effective exchange rate, expressed in logarithms	Bank of International Settlements
Patent	Patent applications, expressed in logarithms	WDI

4.2. Methodology

We first test for cross-section dependency in the errors of our regressions which can arise due to the presence of common shocks or unobserved component that can become a part of the error term. We employ CD (cross-sectional dependence) test of Pesaran (2004) which is proposed for N>T panels. CD statistic of Pesaran (2004) can be written as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{\rho_{ij}}\right)}$$

where $\widehat{\rho_{ij}}$ is the sample estimate of the pairwise correlation of the residuals. The value of the CD statistic is 42.368 for the our baseline regression which implies that we reject the null hypothesis of no cross-section dependency.

Then, the stationary of series is analyzed by CADF (cross-sectionally-augmented ADF) panel unit root test of Pesaran (2007) which accounts for the cross-section dependency by expanding the standard ADF regression with cross-section averages of the lagged levels and first-differences of the regressors. CADF test has non-standard distribution because of the common factor and it is referred as one of the second-generation panel unit root tests. CADF test is mainly proposed for panels with N>T which is valid for our data.

CADF test with trend and intercept specification is expressed as follows (Pesaran, 2007):

$$\Delta y_{it} = \alpha_i y_{it-1} + \delta_{0i} + \delta_{1i}t + \sum_{j=1}^{p}\beta_{ij}\Delta y_{it-j} + c_i\bar{y}_{t-1} + \sum_{j=1}^{p}d_{ij}\Delta\bar{y}_{it-j} + \epsilon_{it} \quad (7)$$

ϵ_{it}; refers idiosyncratic shocks, i= 1,2,…,N ; t= 1,2,…,T.

$c_i\bar{y}_{t-1}$, denotes one period lagged ADF; $\sum_{j=1}^{p}d_{ij}\Delta\bar{y}_{it-j}$, is common factor eliminates the problem of autocorrelation.

Panel statistic is computed as;

$$CADF_i = t_i(\alpha_i) = \frac{\hat{\alpha}_i}{se\,(\hat{\alpha}_i)} = \frac{\Delta y_i'\bar{M}_w y_{i,-1}}{\sqrt{\hat{\sigma}^2_{\varepsilon,i}(y'_{i,-1}\bar{M}_w y_{i,-1})}} \quad (8)$$

where $M_A = I_T - A(A'A)^{-1}A'$ and hence

$M_{wi} = I_T - w_i(w_i'w_i)^{-1}w_i'$; $\hat{\sigma}^2_{\varepsilon,i}=T^{-1}\Delta y_i' M_{wi}\Delta y_i$

$w_i = (Z_t, \Delta y_{i,-1}, \ldots, \Delta y_{i,-pi}, \bar{y}_{-1}, \Delta\bar{y}, \ldots, \Delta\bar{y}_{-pi}$; $T = T - p_i - 1$

The null hypotheses of these tests were "there is unit root for the panel". In the analysis, three tests were conducted at the same time and all alternative situations were taken into consideration. The Panel ARDL model requires that the series are I(1) or I(0). A negative and statistically significant error correction term ,Φ, ensures that there is cointegration among the dependent variable and explanatory variables (Pesaran and Shin, 1995; Pesaran, Shin and Smith, 1999). Therefore, we focus on the sign and significance of the error correction terms of the regressions estimated when we are testing for the cointegration. We also conduct the panel cointegration test of Pedroni (2007) for the baseline model. The results of Pedroni (2007) are given in appendix4. The lag order of ARDL model is chosen based on the unrestricted ARDL model given in (1) as suggested by Pesaran and Shin (1995). Maximum lag length is chosen as 2 and we assumed that the lag orders are equal for all variables. Accordingly, the optimal lag order is chosen as 1 by the Akaike Iformation Criteria for all models. Then, we estimate Panel ARDL (1,1,1,1,1) model[2].

4.3. Empirical Results

Table 3 shows the summary statistics of the variables. There is a significant variation in Hte variable which ranges from 0.09 to 74.994. Similarly, trade, fdi and domsav variables have large variations.

Table 3: Summary Statistics of Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Hte	1279	16.549	13.486	0.09	74.994
Schooling	1776	3.345	1.369	0.56	8.5
Trade	1629	77.404	56.690	11.545	441.604
Lnreer	1502	4.559	0.214	3.719	5.619
Percapita	1634	9.133	1.269	5.271	11.543
Fdi	1603	3.206	5.678	-15.989	87.442
lnpatent	1567	8.372	1.859	3.091	14.103
domsav	1629	25.660	8.571	7.654	101.797
Polity2	1685	6.468	5.679	-10	10

The results of CADF panel unit root test are given in Table 4. According to the results, HTE, schooling, trade openness, real per capita income and patent applications are integrated of order 1 while, fdi, domestic saving, and real effective exchange rate are integrated of order zero. Since some part of the regressors are I(0) while some part are I(1), panel ARDL method can be applied to our context[3].

[2] There is not any significant change in long run coefficients when we consider different lag lenghts for different variables.

[3] Since political stability is integrated of order 2, we have to exclude it from the ARDL analysis.

Table 4: CADF Panel Unit root Test

Variables	Level		First Difference	
	Constant	**Constant and Trend**	**Constant**	**Constant and Trend**
HTE	0.051 (0.520)	-2.313 (0.01)*	-11.239 (0.00)*	-8.174 (0.00)*
Schooling	3.563 (1.00)	6.921 (1.00)	-12.408 (0.00)*	-11.749 (0.00)*
Trade	-1.842 (0.03)**	-0.402 (0.34)	-16.324 (0.00)*	-13.756 (0.00)*
Lnpercapita	-3.967 (0.00)*	-0.615 (0.269)	-13.860 (0.00)*	-12.207 (0.00)*
Fdi	-6.304 (0.00)*	-4.369 (0.00)*	-23.159 (0.00)*	-20.592 (0.00)*
Domsav	-3.502 (0.00)*	-1.401 (0.08)*	-15.365 (0.00)*	-12.267 (0.00)*
Polity2	13.431 (1.00)	14.744 (1.00)	8.537 (1.00)	9.211 (1.00)
Lnpatent	-0.491 (0.312)	-1.191 (0.11)	-14.313 (0.00)*	-11.281 (0.00)*
lnreer	-3.776 (0.00)*	-1.848 (0.03)**	-14.089 (0.00)*	-11.880 (0.00)*

Notes: *,**,*** indicates rejection of null hypothesis of unit root at the significance levels of 1%, 5 % and 10% level, respectively. The values in parentheses are probability values. The lag lengths in the ADF equations are chosen by Akaike Information criteria.

The estimates of Panel ARDL model is represented in Table 5. Model 1 is the baseline model in which schooling, trade, FDI and per capita GDP are used as the explanatory variables. In models 2-4, other potential determinants of high-tech exports which are domestic saving, real effective exchange rate, number of patent applications have been added one by one. We also include time dummies to the regressions which account for time-effects and partially offset cross-section dependency.

The error correction term is negative and statistically significant in all models which show that periodical deviations in the long run series have disappeared and there exists a long run relationship among the variables. We focus on the long run coefficients of the models since we basically deal with the long run determinants of high-technology exports of countries. In the baseline model (model 1), schooling, trade openness and per capita GDP are positive and statistically significant. This finding is consistent with Tebaldi (2011) and Mehrara (2017). In models 2-4, the variables which represent reel exchange rate (lnreer), domestic savings (domsav) and patent applications (lnpatent) are found statistically insignificant.The coefficient of FDI is statistically significant but negative in all specifications except model 4. This finding is discussed in the next section.

Regrading the short-run coefficients of the models, trade openness is the only factor which is estimated to be positively and significantly affect high-tecnology exports of countries in the short run. This is an expected results since it is reasonable to expect other variables' effect such as schooling and per capita gdp to work in the longer term.

Table 5: Panel ARDL Estimates, The Determinants of High-tech Exports

Long Run	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Fdi	-0.184 (0.07)***	-0.187 (0.05)**	-0.201 (0.05)**	-0.132 (0.21)
Schooling	2.902 (0.00)*	2.623 (0.00)*	2.658 (0.07)***	3.507 (0.00)*
Trade	0.02 (0.02)**	0.09 (0.02)**	0.062 (0.06)***	0.061 (0.08)***
lnPcgdp	8.582 (0.00)*	5.722 (0.01)**	7.368 (0.00)*	8.457 (0.00)*
Lnreer		0.684 (0.86)	-	-
Domsav			0.224 (0.10)	-
lnPatent				0.515 (0.55)

Short run	Model 1	Model 2	Model 3	Model 4
Δfdi	0.013 (0.43)	0.016 (0.32)	0.015 (0.36)	0.009 (0.53)
Δschooling	-0.007 (0.98)	0.247 (0.54)	0.005 (0.99)	0.022 (0.95)
Δtrade	0.023 (0.07)***	0.029 (0.02)**	0.024 (0.06)***	0.021 (0.06)***
ΔlnPcgdp	- 0.021 (0.97)	0.460 (0.69)	-0.140 (0.86)	-0.138 (0.85)
Δlnreer	-	-0.658 (0.67)	-	-
Δdomsav	-	-	-0.013 (0.73)	-
ΔlnPatent	-	-	-	-0.119 (0.69)
ECT_{t-1}	-0.175 (0.00)*	-0.184 (0.00)*	-0.177 (0.00)*	-0.151 (0.00)*

Notes: The dependent variable is HTE in each column. Probabilities are in parentheses. *,**,*** indicates significance at the 1%, 5 % and 10% level, respectively.

4.4. The relationship between FDI inflows and high technology exports

Except Model 4, FDI inflows are found to have a negative impact on high-tech exports of countries. In order to clarify the reasons of this finding, the industrial composition of FDI inflows of the countries has been analyzed. Due to data constraint, the industrial distribution of FDI for only 31 of the 48 countries is examined and reported in Figure 1. FDI inflows are divided into 3 segments which are primary, secondary and tertiary which represents commodity, manufacturing and service sector respectively (Sub components of the fdi classifications are given in Appendix 3). It is clearly seen from Figure 1 that the share of manufacturing sector in FDI inflows is sharply lower than the service sector.

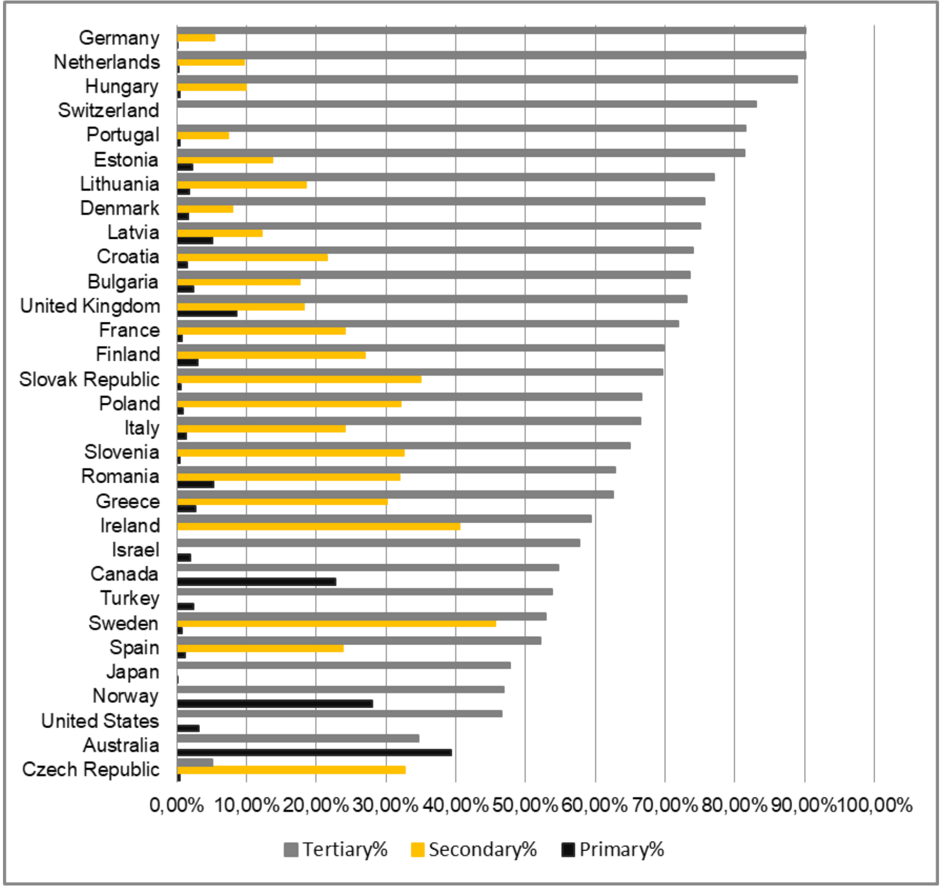

Figure 1: The Industrial Distribution of FDI for Countries, 2016
Source: Investment Map-International Trade Statistics (www.investmentmap.org), 2018.
Note: Industrial classification of the countries is defined by United Nations Statistics Division and is a standard classification of economic activities (including both merchandise and services).

FDI inflows goes overwhelmingly on the tertiary sector (especially on finance, wholesale and retail trade, business activities) in 2016. When not only FDI inflow but also FDI stock value is considered, the lion share (almost % 80) goes to the tertiary sector. As it is seen from data, foreign contribution to value-added in manufacturing sectors is much lower than the foreign value added contribution in tertiary sectors. When the share of FDI in the sub-sectors of the secondary (manufacturing) sectors is analyzed, it is observed that most of the foreign investment goes to sectors that are classified in medium technology (for example; metal, chemical, petroleum and plastic products, motor vehicles, manufacture of general-purpose machinery etc.) rather than in high technology.

FDI investments lead to an increase in countries' production capability and improve export performance in many fields. When high technology export performance is considered, it seems that strategic innovative part of the production is done in the main country.

High technology products have widely known brand names which give the impression to consumers that they are high quality. The variation in the quality of the product may damage their market power and reputation which is a product of long years of effort. As it is advocated by "O- Ring Theorem", skill matching improves productivity and quality rather than skill mixing. That is why multinational firms invest and produce in clusters where the technological capability of human capital level is higher than in other regions. Results indicate that strategic research and development facilities and innovative stage of the production are done in the mainland country. The low technology part of the production chain of high technology product is done in other countries. A number of studies also show that although developing countries 'export sophistication level is improving, their terms of trade is deteriorating. (Li, Huang & Li, 2007; Lemoine & Kesenci, 2008; Amiti & Freund, 2007; Saadi, 2012).

Foreign direct investment inflows into medium technology manufacturing and tertiary sector may divert human capital stock from domestic firms to foreign firms which may cause a decrease in high technology production capability and productivity in these countries because of the scarcity of human capital. It seems that domestic factors like per capita income and schooling are the most important variables in explanation of high technology exports. To put it more clearly, high-quality education is prerequisite to increase the supply of skilled human capital in these countries. Then production pattern may evolve from low technology goods to more sophisticated goods with counter interaction between producers and consumers.

5. CONCLUSION

Countries' export competitiveness and innovation performance have been examined through tremendous amount of empirical researches and international reports like global competitiveness index, global innovation index report, etc. These reports rank countries competitiveness according to not only price related factors but also many non-price related factors like institutional quality, infrastructure, efficiency, innovative capacity and so on. High technology exports are concentrated in certain countries like Germany, Switzerland, Singapore, United Kingdom which are ranked in top ten in these competitiveness reports as well. High technology export performance correlates with international competitiveness. Therefore; the factors that makes a country both high technology exporter and competitive has become the main concern of many studies. In this context, this study aims to contribute empirical literature in this field by employing a wide range of variables and covering a wide country set and time period.

Panel ARDL estimations show that schooling, per capita GDP, and trade openness increase the high-tech export performance of countries. However, the effect of other factors; real exchange rate, domestic saving, and patent applications, are not found statistically significant. Beyond this, FDI inflows are found statistically significant (except model 4) but it has a slightly negative impact on the high-technology export performance.

In this study it is seen that per capita income is the most important variable as a determinant of high technology export capability. Per capita income combines the effect of both supply and demand conditions in an economy. Sophisticated domestic demand leads to change in domestic production structure which evolves and catches the production capability of high technology in the long run. The economic complexity index[i] ranks the countries according to product diversity and ubiquity and assumes that higher income correlates with sophisticated production pattern. Therefore, as supported by our findings, countries' real per capita GDP is the most important determinant of the countries' high technology export performance.

High technology export requires high quality of human capital which is also supported by our estimation results. When high technology producers employ high skilled workers, an improvement in productivity and innovation capability of the country can be achieved. In sum, it is seen that schooling as a proxy variable of human capital is the second most important variable in determination of high technology export performance.

Another factor that leads to an increase in countries' high technology export level is the countries' level of trade openness. Higher level of trade openness enables a country to import some parts of the products from abroad which increase the quality of intermediate goods used in the production process. So, findings of this study supports that higher openness increases productivity, efficiency and high technology export capacity.

FDI inflows are found to have a slightly negative impact on high technology exports of countries. When the composition of FDI inflows of the countries analyzed, it is seen that major part of FDI investments of the countries is done on tertiary (e.g. finance, wholesale and retail trade, business activities) sector. Most of the foreign investments are done in sectors that are classified in medium technology rather than in high technology. Therefore, foreign direct investment inflows into medium technology manufacturing and tertiary sector may divert human capital from domestic firms to foreign firms which may cause a decrease in high technology production capability in these countries.

Consequently, Panel ARDL estimation results strongly indicate that long run determinants of high technology exports for countries are per capita income level and schooling respectively. It seems that rather than searching external sources; achieving an improvement in domestic factor conditions and production structure are the most important ways to increase high technology export performance. In sum, an increase in value added through high technology export necessitates high effort and implementation of long run strategic development policies especially on quality of education and product sophistication.

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APPENDIX1.

Manufacturing industries classified according their global technological intensity (ISIC Revision 2)

High-technology CITI Revision 2
1. Aerospace 3845
2. Computers, office machinery 3825
3. Electronics-communications 3832
4. Pharmaceuticals 3522

Medium-high-technology
5. Scientific instruments 385
6. Motor vehicles 3843
7. Electrical machinery 383-3832
8. Chemicals 351+352+3522
9. Other transport equipment 3842+3844+3849
10.Non-electrical machinery 382-3825

Medium-low-technology
11. Rubber and plastic products 355+356
12. Shipbuilding 3841
13. Other manufacturing 39
14. Non-ferrous metals 372
15. Non-metallic mineral products 36
16. Fabricated metal products 381
17. Petroleum refining 351+354
18. Ferrous metals 371

Low-technology
19. Paper printing 34
20. Textilee and clothing 32
21. Food, beverages, and tabacco 31
22. Wood and furniture 33

APPENDIX2.

Table2A: Country list

Argentina	Estonia	Japan	Portugal	Thailand
Australia	Finland	Kazakhstan	Romania	Turkey
Austria	France	Korea, Rep.	Russian Federation	United Kingdom
Brazil	Germany	Latvia	Saudi Arabia	United States
Bulgaria	Greece	Lithuania	Singapore	
Canada	Hungary	Malaysia	Slovak Republic	
China	India	Mexico	Slovenia	
Costa Rica	Indonesia	Netherlands	South Africa	
Croatia	Ireland	Norway	Spain	
Czech Republic	Israel	Philippines	Sweden	
Denmark	Italy	Poland	Switzerland	

APPENDIX3.

Sub components of the classification of FDI (ISIC Revision 3.0)

Primary Sector

1. Agriculture and hunting
2. Forestry and Fishing
3. Mining and quarrying
4. Petroleum
5. Unspecified primary

Secondary Sector

1. Food,beverages and tobacco
2. Textiles, clothing and leather
3. Wood and wood products
4. Publishing, printing and reproduction of recorded media
5. Coke, petroleum products and nuclear fuel
6. Chemicals and chemical products
7. Rubber and plastic products
8. Non-metallic mineral products
9. Metal and metal products
10. Machinery and equipment
11. Electrical and electronic equipment
12. Precision instruments
13. Motor vehicles and other transport equipment

14. Other manufacturing
15. Recycling
16. Unspecified secondary

Tertiary Sector

1. Electricity, gas and water
2. Construction
3. Wholesale and retail trade
4. Hotels and restaurants
5. Transport, storage and communications
6. Finance
7. Business activities
8. Public administration and defence
9. Education
10. Health and social services
11. Community, social and personal service activities
12. Other services
13. Unspecified tertiary
14. Transportation services (trade data)
15. Travel services, business & personal (trade data)
16. Other commercial services (trade data)

APPENDIX4:

Table 4A: Pedroni (2007) cointegration test results

Panel-v	-2.1*
Panel-rho	3.85*
Panel-pp	-0.75
Panel-adf	1.08
Group-v	-
Group-rho	6.22*
Group-pp	-0.31
Group-adf	-0.99

Note: * denotes significance at 1% sigificance level. The null hypothesis is no cointegration amog the variables.