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The Determinants of High Technology Exports Volume: A Panel Data Analysis of EU-15 Countries

Yunus Gökmen

Ufuk Turen*
Turkish Military Academy, Turkey

High technology exports (HTX) are considered as an important factor for sustainable economic growth for a country. One of the most important prerequisite to high tech manufacturing and export is technology ownership. Technology ownership can be gained through technology transfer by the way of inward foreign direct investments (FDI). Although many scholars emphasize foreign direct investments as a cheap and easy way of technology transfer, the role of human capital of the host country is considered as an important factor in this process. Another important aspect is economic freedom level (EFL) of the host country which is associated with FDI attraction of the host country. Here, we hypothesize that HTX are a longitudinal function of a country's level of inward FDI, EFL and human development level (HDL). We examine the associations among above mentioned variables using a panel data of EU-15 countries for the period 1995-2010 and find that EFL, HDL and FDI aggregately have a statistically significant positive impact on HTX by conducting panel cointegration method. Additionally, we employ panel causality test and see that there is long-run Granger causality running from FDI, HDL and EFL to HTX, and similarly from HTX, FDI and EFL to HDL.

Keywords: High Technology Exports, Foreign Direct Investments, Human Development Level, Economic Freedom, EU-15 Countries, Panel Data Analysis

JEL: C81, F21, O15

The capacity of a country to develop its economy depends on multiple factors. Having high technology sectors and competency in exporting high value added, high technology products is considered as one of these important factors for an economy. High technology competency is seen as one of the principle driving forces of economic development, especially, in countries practicing export-led growth strategies (Hobday, 2001). Increasing share of high technology products in their total and enhancing productivity are main objectives of today' s fast growing countries in order to compete in new and high technology segments of industries (Sara *et al.*, 2012). Positive associations between high technology exports and other economic performance displays are reported in the literature (Eaton and Kortum, 2001; Spulber, 2008; Yoo, 2008; Zhang, 2007; Falk, 2009). For example, Yoo (2008) and Falk (2009) show that the share of high technology exports significantly increase GDP.

Capability to manufacture and export high technology products in today' s competitive global markets basically is an indicaton of innovation power of a country. High technology

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*Corresponding author Email: uturen2011@gmail.com

exports volume (HTXV) is known as one of the final products for commercialization of national innovation capability (Furman *et al.*, 2002).

Innovation power necessitates technology accumulation in a country. Technology accumulation requires domestic and foreign technology oriented investments. But investors simply want to ensure their funds and sustainability of their investments. Thus, economic freedom (EF) is considered as one of determinants of an economy being perceived as suitable for local or international investments. EF is known as not only a solid determinant of inward FDI accumulation (Bengoa and Sanchez-Robles, 2003; Quazi, 2007; Caetano and Caleiro, 2009; Ramirez, 2010) but also a significant display for the decision of where to invest (Gokmen *et al.*, 2011, Turen *et al.*, 2012a). Additionally, EF provides a suitable environment for domestic capital to be invested domestically.

Similarly, FDI is considered one of most efficient ways of inward technology transfer (Globerman, 1979; Blomström and Kokko, 1997; Razin and Sadka, 2007: 124). Inward technology transfer can feed innovation capability (Turen *et al.*, 2012b). So, directly or indirectly FDI accumulation can increase high technology exports of a country.

Technology transfer through FDI is dependent on the human development level (HDL) divide between foreign party and the host. Studies, exploring the effects of FDI on a diverse set of economic variables such as productivity, knowhow and technology transfer, mostly emphasize on the human capital characteristics of host nation or sector which is mediating the process of any type of transfer of knowledge (Edwards, 1998; Kinoshita, 2000; Kathuria, 2002; Wooster and Diebel, 2010; Yokota and Tomohara, 2010). It is generally accepted that the technology transfer between these two parties is highly sensitive to human development level discrepancy. Higher level discrepancy in favor of foreign party reduces speed of technology transfer while lower level discrepancy increases it. This is why the effect of FDI on national innovation capability is traced much more prominent in high developed countries (Gokmen *et al.*, 2012). HDL can directly affect HTXV through the processes of research and development and production of high technology products. It may have impact on marketing and sales of them globally too (Tebaldi, 2011).

There may be causal loop style effects among these variables. Increasing HTXV may increase EF, HDL and FDI as well. Increase in prosperity by the way of HTXV may encourage governments to chase more FDI and/or establish more suitable market environments to increase EF and/or develop projects to increase HDL of the citizens. These interactions may be long-term or delayed. Tebaldi (2011) finds significant and positive impact of openness, human capital and inward FDI on HTXV in his panel data study. Here, we ask similar questions but employ different variables. We ask two questions. First, do EF, HDL and FDI positively and significantly increase HTXV? Second, does one or more of these variables have an impact on each other?

The fundamental goal of this paper is to examine the impact of EF, HDL and FDI on HTXV. The main contribution of our paper is to

model relationship between EF, FDI, HDL as independent and HTXV as dependent variable concerning EU-15 countries using panel data regression. The significance of our study is that it represents the first analysis exploring this association using the economic freedom and human development level concepts in the technology management and/or national development literature. Parallel with the exploration of the theory we also scrutinize the validity of these two concepts in an econometrical model. We prefer to employ EU-15 countries panel to cover a set of countries having better time based data than the others.

In the next section, we provide an overview of the related literature on HTXV, FDI, HDL and EF. In Section 3, we discuss the data set and we present the model. In Section 4, we conduct panel unit root tests, panel cointegration tests, FMOLS panel long-run estimators and panel Granger causality test respectively. In Section 5, we discuss the results and provide some concluding remarks.

LITERATURE REVIEW

Economic Freedom, Foreign Direct Investment and High Technology Exports

EF concept frames an economic and political environment in which individuals have right to chase their fortunes and goals through their own will and decision. The success and failure are based on the challenge and ability of individuals or other economic actors. Discrimination against any sect of the society is fully prohibited. Thus, the merit owned by individuals is main determinant of success. Decision processes in governmental domain is dominated by the understanding of openness and transparency. This shared understanding supports equal opportunity which can be considered as the most powerful eraser of discrimination, favoritism and corruption. The free and dispersed economic decision of actors in business domain allows them to optimize their resource allocation and production in free and neutral competition (Miller and Kim, 2011).

The economies with higher EF can make the market operate well through well-defined trade rules and secured property rights (Kirzner, 1997; Gwartney *et al.*, 1999). The three principles of EF are empowering the individual, erasing any type of discrimination and securing open competition (Miller and Kim, 2011). The positive effects of EF are explored by many scholars. Islam (1995), de Haan and Sturm (2000) and Gwartney (2009) report that EF has a positive and significant association with per capita income and economic growth rate. Wheeler and Mody (1992), and Kapuria (2007) show that Foreign Direct Investment positively relates with increase in certain components of EF. On the other hand, Sala-i-Martin *et al.* (2004) claim that growth rate is not strongly sensitive to degree of capitalism, political rights and dummy variable of socialism in their analysis employing data from 88 countries between 1960-1996.

Economic agents playing in an environment with higher economic freedom meaning fiercer market competition have to improve production efficiency as a result of resource reallocation in order to survive. From macro perspective, the advances in economic freedom enable an

economy to facilitate a technology market well and also to foster innovation cooperation across various agents. Because, rigid competition in the market increases more entrepreneurial discovery of new and improved technologies in terms of products, processes or services. This mechanism supports national innovation system. The studies done by Kim (1997), Freeman (2002), Salmenkaita and Salo (2002) support the dynamics of this mechanism. These scholars also emphasize on the high level of coordination and cooperation efforts between science/knowledge producing and industry circles which are ignited and elevated by economic freedom. Advance in national innovation system elevates HTXV.

Bengoa and Sanchez-Robles (2003) report that economic freedom is a key determinant for attracting FDI in their empirical research based on 18 Latin American Nations. The same conclusion is claimed by Ramirez (2010), who investigates 10 Latin American Nations. They both use longitudinal analysis. In a cross national research Gokmen *et al*. (2012) report that foreign direct investor's country selection decision is influenced by economic freedom level of the host nations. In other words, the higher level of economic freedom attracts the higher volume of inward FDI. A commonplace and widely accepted vision here tells that more open economies have a greater capacity to absorb new ideas from the rest of the world, and a higher steady state level of knowledge. This openness is also effective in terms of FDI accumulation, since FDI accumulation is known to be a means of technology transfer to host country. While scholars such as Globerman (1979), Kokko (1994), Kokko and Blomström (1995), Blomström and Kokko (1997), Razin and Sadka (2007) defend this opinion, dependency school members such as Lenin, Karl Marks, Paul Baran, Andre Gunder Frank and Samir Amin regard FDI as extensions of the developed countries and as harmful to economic growth of developing nation in the long-run (Chilcote, 2002). According to this point of view, large global companies' penetration into host nations' economies may allow them to control national resources on behalf of developed nations that might otherwise have been used for development of host nation (Cardoso, 1973: 142-176; Evans, 1979: 16-17; Cardoso and Dornbusch, 1989; 1387-1439; Fan, 2002).

We encounter some other studies claim that FDI provide limited or no technology transfer based on their empirical findings. For example, Damijan *et al*. (2003) investigate the association between inward FDI and technology transfer based productivity raise by using firm level data from eight transition countries. They find that technology transfer is realized through FDI only to direct subordinate firms and no trace of positive intra-industry spillovers for domestic firms.

Here we develop the hypotheses below:

H_1: EFL increases inward FDI

H_2: EFL increases HTXV

H_3: FDI increases HTXV

Human Development Level and High Technology Exports

Human development means an environment in which humans can develop their capabilities to

participate in production. This environment lets them to create lives in accord with their desires and interest. In this paradigm, human beings are considered as the most important and valuable assets of nations. Thus, empowering people in order to reach much more alternatives, to make decisions with freewill, to access knowledge, better nutrition and health services are important aspects but not enough. Human development paradigm also requires providing people with a secure livelihoods, physical security against crime and violence, leisure hours to refresh, political and cultural freedom. The aim of human development concept is to provide people with a proper environment making them to enjoy long, healthy and satisfactory lives (UNDP, 2011).

There is a bunch of studies emphasizing the importance of host nation' s human capital in the process of gaining technology and high technology manufacturing (Barkley *et al.*, 1988; Papaconstantinou, 1997; Rasiah, 2004; Archibugia and Cocoa, 2005; Purlys, 2007; Ferragina and Pastore, 2007).

Most of them claim that FDI is one of the most efficient ways of technology transfer and knowledge absorbing capacity of host party is as important as the willingness of technology owner party to share its knowhow. Xu (2000) performs a longitudinal analysis using the data collected from 40 countries from 1966 to 1994 in which US Multi National Enterprises (MNEs) have been operating, finds that US MNEs contribute to the productivity growth in developed countries but not in low developed countries and claims that a country needs to reach a minimum human capital threshold level in order to be a receiver of US MNEs originated technology transfer. Sinani and Klaus (2004) examine the relationship between foreign presence and productivity through host nation' s human capital and emphasize human capital' s catalyst effect to this association. Seyoum (2004) investigates the role of factor conditions (human resources and technology), inward investment, domestic rivalry, home demand and exchange rate in export performance in high-technology industries. He finds that the level of human resources and technology in a country is a significant predictor of export performance in high technology. He also reports that inward investment, domestic rivalry and home demand also influence high-technology export. Similarly, Yokota and Tomohara (2010) report that technology transfer through FDI is related to host countries' skilled work force capital. They claim that nations having highly skilled labor force may get the spillover effect in high-tech industries while others may get the same effect only in low-tech industries.

By the way of technology transfer through FDI or domestic research and development efforts we claim that human development level of a country is an important factor for developing high technology industries and HTXV. We also expect that higher HTXV can be a driver for more efforts to generate high skilled work force and higher research and development investments. Thus, HTXV can be a factor increasing HDL.

Here we develop the hypotheses below:

H_4: HDL increases HTXV

H_5: HTXV increases HDL

In this study we investigate the relationship

among IEF, FDI, HDI and HTXV. As an ultimate predictor for national innovation capability. HTXV can be considered as a function of IEF, FDI, and HDI. Thus, relationship can be proposed as following function:

$$HTXV = f\ (FDI, IEF, HDI) \text{ --------- (i)}$$

METHODOLOGY

EF approach can be effective for establishing an economic and politic environment well suited for innovation capability. Innovation capability of nations is measured by Global Innovation Index prepared and published by Institute Européen d'administration des Affaires (INSEAD) since 2009. As it is very new indicator, GII is not convenient for panel data analysis. Thus, we chose high technology export volume (HTXV) which is produced and published by the World Bank since 1980. We believe that this indicator is as meaningful as national innovation capability as dependent variable. Since, it is considered as a very important leverage factor for national GDP growth (Falk, 2009) and a kind of final product of national innovation system. Similarly, Stern *et al*. (2000) report that HTXV is influenced by the level of national innovative capacity and stimulate economic development. Tebaldi (2011) suggests that proper environment for high-tech exports growth can be created by fostering human capital accumulation and opening the economy for both FDI and international trade.

Since EU had 15 members in 1995, the annual data for the period of 1995- 2010 belonging to EU-15 countries are used in this research. High-Technology Exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals etc. The data of HTXV in terms of US Dollars for 1995-2010 period are gathered from the World Bank (2010) official website. UNCTAD database collects and publishes FDI data belonging to most of the countries yearly. The data of countrie' s FDI in terms of US Dollars for 1995-2010 period are gathered from UNCTAD (2010) formal website. Then, we divided FDI value by nation' s capita which are gathered from US Census Bureau (2010).

In order to employ a metric to measure nations EFL, we use Index of Economic Freedom (IEF), data retrieved from The Heritage Foundation (2010) formal website that evaluates economic freedom around the world with The Wall Street Journal by constituting Index of Economic Freedom.

To measure HDL we use Human Development Index (HDI) (a composite measurement consisting of education, literacy, and income component), data belonging to 1995-2010 term is gathered from United Nations Development Programme (UNDP) (2011) official website. The descriptive statistics of data is indicated in Table 1 (see Appendix-I).

In this study, in order to scrutinize the explanatory power of independent variables (IEF, FDI and HDI) on dependent variable we conduct panel data analysis for EU-15 countries for the period of 1995-2011. The main reasons of using panel data analysis are stated below (Gujarati, 2004: 637; Baltagi, 2005: 1-3; Brooks, 2008: 488)

a. The method of panel data estimation can control heterogeneity by allowing for individual-specific variables.

b. Panel data provides more informative data, more variability, more efficiency, more degrees of freedom, less collinearity among the variables.
c. Panel data are convenient to check the dynamics of adjustment.
d. Panel data are better able to determine and measure effects that are not determined simply by conducting pure cross-section or pure time-series data.
e. Panel data is suitable to tackle with more complex behavioral models.
f. It also provides comprehensive tools to examine how variables, or the relationships between them, change dynamically.
g. Structuring the panel data model in a convenient way, one can remove the effect of certain forms of omitted variables bias in regression results.

Considering main advantages of panel data expressed above, in order to investigate associations of our research variables, we decide to employ panel data analysis instead of multiple regression analysis.

Since the variables in the regression model have different measurement units (e.g. IEF (0-100 point), FDI per capita ($/capita), HTXV per capita ($/capita), HDI (0.000-1.000 point), we suggest a logarithmic panel data (time-series cross-section) regression model as indicated in Equation 2.

$$\ln HTXV_{it} = \beta_0 + \beta_1 \ln FDI_{it} + \beta_2 \ln IEF_{it} + \beta_3 \ln HDI_{it} + \varepsilon_{it} \quad \text{.... (2)}$$

$\ln HTXV_{it}$: The natural logarithm of HTXV per capita of i^{th} country related to t^{th} term.

$\ln FDI_{it}$: The natural logarithm of FDI per capita of i^{th} country related to t^{th} term.

$\ln IEF_{it}$: The natural logarithm of IEF Score of i^{th} country related to t^{th} term.

$\ln HDI_{it}$: The natural logarithm of HDI Score of i^{th} country related to t^{th} term.

ε_{it} : is the error (residual) term in the panel data regression model.

ECONOMETRIC ANALYSIS AND RESULTS

The main objective of our study is to examine whether there is long-run and dynamic causal relationships of FDI and IEF on HTXV in EU-15 countries for 1995-2010 term using panel data regression. Panel data analysis is widely used for last decade and primary form of panel data regression differs from a regular time-series or cross-section regression in that it has a double subscript on its variables as shown in Equation 3 (Baltagi, 2005: 11).

$$y_{it} = \alpha + X'_{it}\beta + u_{it} \quad i = 1,...,N; \quad t = 1,...,T \quad \text{.....(3)}$$

Where, i indicate households, individuals, firms etc. and t indicate time. The i subscript, therefore, denotes the cross-section dimension whereas t denotes the time-series dimension. α is a scalar, β is K×1 and X_{it} is the it_{th} observation on K explanatory variables and u_{it} is error term. Research to achieve our aim consists of four steps, namely panel unit root tests, panel cointegration tests, long-run elasticities and panel Granger causality tests.

Panel Unit Root Test

In panel data regression, firstly, the panel unit root test must be performed in order to determine whether the relevant variables are stationary. If variables are non-stationary, it may cause spurious regressions and cointegration in

regression analysis (Baltagi, 2005: 237). There are two types of panel unit root tests. When the persistent parameters are common across cross-section, this type of process is called a common unit root test. Levin, Lin and Chu (LLC) (2002) develop a common unit root process by using this assumption. Otherwise, when the persistent parameters freely move across cross section then this type of unit root process is called an individual unit root process. The Im, Pesaran and Shin (IPS) (2003), Fisher-ADF and Fisher-PP test are based on this form. The common and individual unit root test's results are reported in Table 2.

performed, we see that all of the variables turn into stationary. Thus, we may have conclusion that each variable is integrated of order one.

Cointegration Test

One can draw an inference from the results in Table 2 that all of the series are integrated of order one I(1) offering the basic requirements of the cointegration test. Thus, the next step is to test if there is a long-run relationship between the variables. There are different testing procedures for cointegration such as Maddala and Wu (1999), Kao (1999) and Pedroni (1999) but the conintegration test proposed by Pedroni (1999) and Kao (1999) were widely used in previous

	Common Unit Root Test		**Individual Unit Root Tests**					
	Levin Lin &Chu		Im, Pesaran & Shin		ADF Fisher** Chi-square		PP Fisher** Chi-square	
Vaiables	Statistic	*p*	Statistic	*p*	Statistic	*p*	Statistic	*p*
Level								
lnHTXV	-3.34937	**0.0004***	-3.68220	**0.0001***	28.0400	0.5683	32.9369	0.3253
lnFDI	-8.60451	**0.0000***	-3.12613	**0.0009***	64.3506	**0.0003***	119.573	**0.0000***
lnIEF	-0.05214	0.4792	0.54675	0.7077	20.6877	0.8974	18.7520	0.9450
lnHDI	-3.92838	**0.0000***	-6.25956	**0.0000***	90.9001	**0.0000***	79.9512	**0.0000***
1st Difference								
ΔlnHTXV	-8.34708	**0.0000***	-6.42595	**0.0000***	101.757	**0.0000***	118.957	**0.0000***
ΔlnFDI	-5.06149	**0.0000***	-5.77508	**0.0000***	92.5543	**0.0000***	227.037	**0.0000***
ΔlnIEF	-14.8046	**0.0000***	-12.6564	**0.0000***	170.392	**0.0000***	170.191	**0.0000***
Δ lnHDI	-5.57703	**0.0000***	-6.92461	**0.0000***	99.5298	**0.0000***	107.024	**0.0000***

Null Hypothesis: Unit Root
*The test values are significant at .01 level.
**Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.
Automatic lag length selection based on SIC

Table 2: Results of Panel Unit Root Test

We see that lnFDI and lnHDI is stationary in level form. It means that the null hypothesis is rejected at 0.01 significance level for lnFDI and lnHDI variables. Namely, lnFDI and lnHDI variables do not have unit root and it is stationary in level form. The others are non-stationary in level form. When first-order differencing is

studies. Due to this fact, we decide to conduct Pedroni and Kao cointegration tests in our study.

Pedroni (1999) suppose a cointegration test by following panel regression model as indicated below:

$$\ln HTXV_{it} = \alpha_i + \beta_i \ln FDI_{it} + \varphi_i \ln IEF_{it} + \vartheta_i \ln HDI_{it} + \varepsilon_{it} \quad \ldots\ldots\ldots (4)$$

The test for cointegration consist of five step (Narayan and Wong, 2009).

a. Estimate Equation 4 and store residuals ($\hat{\varepsilon}_{it}$) of equation.

b. Compute the residual for the differenced regression expressed in Equation 5.

$$\Delta \ln HTXV_{it} = \alpha_i + \beta_i \Delta \ln FDI_{it} + \varphi_i \Delta \ln IEF_{it} + \vartheta_i \Delta \ln HDI_{it} + \eta_{it} \quad \ldots\ldots(5)$$

c. Calculate $\hat{L}_{11i}$ as long run variance of $\hat{\eta}_{it}$, by using any kernel estimator.

d. Use residual (ε_{it}) of the original cointegration equation in order to estimate proper autoregressive model.

e. Using each of these step perform test statistics proposed in Pedroni (1999).

Kao (1999) determines two tests for examining the null hypothesis of no cointegration for panel data. One is a Dickey-Fuller type test and another is an Augmented Dickey-Fuller type test.

The panel cointegration test' s results are presented in Table 3. According to the results, the null hypothesis that assumes no cointegration is rejected at 0.05 level. Namely, there is a long-run cointegration relationship between the variables taking part in panel regression model.

FMOLS Panel Long-Run Estimators

To predict the long-run elasticities between variables, the panel-based Fully-Modified Ordinary Least Square (FMOLS) proposed by Pedroni (2000) is carried out. Generally, FMOLS estimator for a panel is stated in Equation 6 and 7 (Narayan and Wong, 2009).

$$Y_{it} = \alpha_{it} + \beta X_{it} + \varepsilon_{it} \quad \ldots\ldots(6)$$

$$X_{it} = X_{it-1} + \varepsilon_{it} \quad \ldots\ldots(7)$$

Where $i=1,2,\cdots,N$ countries over time ($t=1,2,\cdots,T$). In Equation 6-7, $Z_{it} = (Y_{it}, X_{it})' \sim I(1)$ and $\varpi = (\varepsilon_{it}, \mu_{it})' \sim I(0)$ with long run covariance matrix $\Omega_i = L_i L_i'$ where L_i is the lower triangular decomposition of Ω_i which can also be decomposed as $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i'$ where Ω_i^0 is the simultaneous covariance and Γ_i is a weighted sum of autocorrelation. In summary, it can be calculated the desired statistics by applying the following stages (Pedroni, 2000).

a. Estimate the panel regression and gather the residuals,

b. Estimate the long run covariances and

Pedroni Residual Cointegration Test*					
Panel (within dimension)			**Group (between dimension)**		
Statistics	Value	*p*	Statistics	Value	*p*
Trend and intercept					
Panel PP-stat.	-3.625215	**0.0001****	Group ADF-stat.	-11.50413	**0.0000****
Panel ADF-stat.	-6.505404	**0.0000****	Group PP- stat.	-4.221424	**0.0000****
No trend or intercept					
Panel PP-stat.	-2.470766	**0.0067****	Group ADF-stat.	-2.764774	**0.0028****
Panel ADF-stat.	-3.354594	**0.0004****	Group PP- stat.	-1.715640	**0.0431****
Kao Residual Cointegration Test					
ADF	-2.845518	**0.0022****			

Null Hypothesis: No Cointegration
*Automatic lag length selection based on AIC
**The test values are significant at α=.05 level.

Table 3: Results of Panel Cointegration Tests

autocovariances of the errors,

c. Construct the estimator.

The coefficients of the panel FMOLS estimator are shown in Pedroni (2000) and more detail information about FMOLS is explained for interested reader in this study. Panel long-run elasticities based on the FMOLS estimator's results are reported in Table 4.

	Variable	β_i	*t*-Statistic	*p*
Panel Group	lnFDI	0.439999	4.466538	**0.0000***
	lnIEF	27.27746	6.259398	**0.0000***
	lnHDI	4.770753	3.840163	**0.0002***

*The test values are significant at α=0.01 level.

Table 4: Panel Long-Run Elasticities (Based on FMOLS Estimator)

All coefficients are significant at 0.01 significance level. It can be seen that all variables have a significant positive effect on HTXV. Furthermore, one percent change in FDI induces 0.44 percent change in HTXV and one percent change in IEF induces 27.28 percent change in HTXV in the same direction. Similarly, one percent change in HDI induces 4.77 percent change in HTXV in the same direction.

Panel Granger Causality Test

According to Engle and Granger (1987), the short-run fluctuation and long-run equilibrium can be determined with an Error Correction Model (ECM), if the variables are cointegrated. Moreover, cointegrated variables indicates that the existence of error correction mechanism preventing error growth in long-run term. The panel Granger causality test's results are indicated in Table 5 (see Appendix-II).

In the short-run, it can be seen that there is bidirectional causality between HTXV and FDI at 1 percent significance level. It expresses that an increase in HTXV induces an increase in FDI and an increase in FDI induces an increase in HTXV at the same significance level. Similarly, an increase in HTXV leads to an increase in HDI and vice versa at 1 percent significance level. Likewise, there are bidirectional causality relationships between HTXV and IEF, and between FDI and HDI pairs at 1 percent significance level. But there are single directional causality associations between HDI and IEF, and between IEF and FDI pairs at 1 percent significance level. Short-run causality relationship of the variables is indicated in Figure 1.

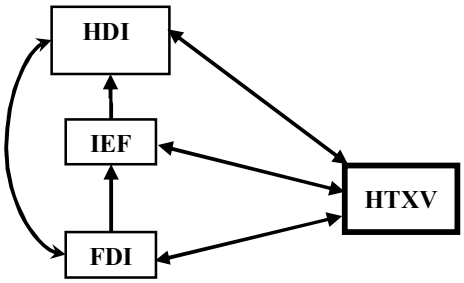

Figure 1: Short-Run Causality Relationship of the Variables

In the long-run, by the way of the lagged error correction term, FDI, HDI and IEF are the causalities to HTXV where as HTXV, FDI and IEF are the causalities to HDI at 1 percent significance level. Long-run causality relationship of the variables is presented in Figure 2.

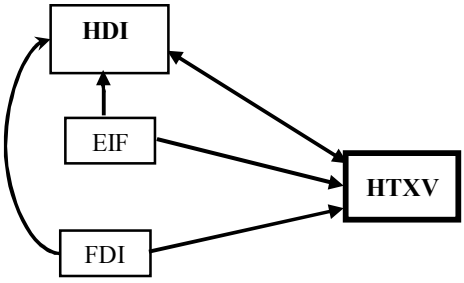

Figure 2: Long-Run Causality Relationship of the Variables

CONCLUSION AND DISCUSSION

The literature that examines the determinants of national innovation capability is growing and is an important one. The impacts of FDI, HDL and EFL concepts on innovation capacity are traced in many above mentioned studies. Our aim was to contribute to this literature from a different perspective. We examined this relationship through including two different variables to measure HDL and EFL concepts as independent variables, namely Human Development Index Scores and Index of Economic Freedom Scores. We use panel data econometric analysis to see the associations among variables. But, we see that FDI and HDI variables are stationary and IEF and HTXV are non-stationary. Thus, we decide that data are not suitable to perform panel regression analysis and decide to perform cointegration analysis. We conclude that FDI, HDI and IEF each have a significant and positive effect on HTXV. This finding is almost similar with the work of Tebaldi (2011). In his panel data study he concludes that human capital, FDI inflows, and openness to international trade have a positive and significant impact on high-tech exports. The direction of association between FDI and HTXV we found in our analysis is consistent with the finding of Seyoum (2005). He reports that inward foreign direct investment has a significant and positive effect on high technology exports. The causality between HDL and HDXV which we reveal here is also consistent with his statement emphasizing on the importance of improving human capital to sustain a dynamic export base and with the findings of Sara *et al*. (2012). The significant effect of EFL on HTXV is consistent with the findings of Ferragina and Pastore (2007).

Then, we conducted panel Grangers causality test to see the long term causality associations among variables. Panel Grangers causality test shows that HDI, FDI, IEF each has significant long-term causality impact on HTXV. Same test also shows that FDI, IEF and HTXV each have significant long-term causality impact on HDI. The reason behind long run causal relationships may be the delay between variables. In socio-economic systems the impact of dependent variable on target variable often takes time. Especially policy makers should be aware of the delays in the impact of one variable on another. These delays can make policy maker impatient and anxious. This mood of them can make them change their decisions and abdicate their strategic plans and policies. This type of policy changes make the system undulating in terms of performance indicator. The expected result of performance indicator usually comes after they change their mind and abandon the predetermined course of action.

IMPLICATIONS

One of the originality of this paper lays in the use the scores of composite indexes such as Human Development Index and Index of Economic Freedom in a panel data analysis with other displays. Although, we did not develop these indexes we first use them in a panel regression model. Those indexes mentioned cover many dimensions in terms of their ontological domains. Thus, usage of these indexes, significant results and parallel findings in this paper may encourage other researches to employ these in their future

works. Other originality of this work is its nonlinear approach to research questions unlike most of the works in the literature. We explore the impact of HTXV, FDI and EFL on HDL and find a significant long term causality relationship. Thus we highlight the important and centric role of HDL besides HTXV in our model.

From a politics view point, in order to increase HTXV, governments should design and perform long term policies using the framework presented and tested here. Shortly, we can say that government should emphasize on progression of HDL in order to boost HTXV while increasing economic freedom level and inward FDI. If macro level policy makers underestimate the importance of HDL in high technology export oriented economic growth model, they probably make mistake. They chase FDI in order to make technology transfer to their country but they probably see that multinational companies investing in their land rarely diffuse the high technology since there is not enough human capital to absorb it. They chase FDI but if they ignore the importance of economic freedom level of the country they will face the result that a few multinational investors desire to invest their country. These policy makers will also see domestic capital try to find out a way of investing abroad in order to protect and nurture its investments. Consequently, it should be understood that policy maker should watch the levels of these four variables, parallel with the other ones which are out of the scope of this study and manage, and control them consistently and in balance.

LIMITATIONS

This study has some limitations to be mentioned here; it only contains EU-15 countries and is related to 1995-2010 term. Thus, those limitations should be kept in mind before making generalizations. In future studies, we suggest that the explanatory power of each component of HDL and EF may be examined by using panel data regression for acquiring more specific details in order to make political analysis. Besides, we propose that the data set may be widened by using other countries' data, in order to enhance the explanatory power of panel data analysis.

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Appendix–I

	HTXV [($/capita) 1995-2010 Term of EU-15 Countries]*				FDI [($/capita) 1995-2010 Term of EU-15 Countries]**			
Country	**Mean**	**S.D.**	**Max**	**Min**	**Mean**	**S.D.**	**Max**	**Min**
AUT	1228,75	488,13	1867,88	555,41	8883,90	6792,49	19812,11	2417,90
BEL	2103,27	597,02	3091,78	1315,94	33961,63	25355,28	82818,85	5956,98
DNK	1537,98	450,22	2230,64	891,19	16800,03	9082,17	29709,20	4221,76
FIN	1804,74	577,69	2673,60	969,51	8611,83	5804,17	17505,64	1658,23
FRA	1040,58	251,38	1539,88	710,85	10061,44	5968,44	19789,72	3205,94
DEU	1342,56	475,29	1979,68	741,93	4905,57	2508,03	8440,40	1940,11
GRC	75,20	30,77	120,43	30,44	2329,07	1242,36	4970,98	1049,08
IRL	6585,70	1456,15	8950,30	3984,12	35345,66	15840,96	55679,12	12226,85
ITA	377,43	70,08	495,53	280,56	3379,17	1906,95	6475,11	1141,00
LUX	2331,24	372,92	3003,85	1806,26	141534,50	54978,30	230517,84	77579,28
NLD	2953,61	808,60	4214,93	1733,68	23945,20	12916,74	46263,78	7506,92
PRT	168,77	84,18	305,59	80,30	5639,92	3306,05	10834,89	1885,79
ESP	193,38	41,14	245,25	127,89	7385,51	4284,15	13714,35	2626,18
SWE	1585,45	266,16	2036,72	1125,58	17664,42	12045,27	38424,66	3496,62
GBR	1120,06	248,20	1911,29	886,29	10860,47	5660,57	20293,28	3433,28

	HDI Score (1995-2010 Term of EU-15 Countries)***				IEF Score (1995-2010 Term of EU-15 Countries)****			
Country	**Mean**	**S.D.**	**Max**	**Min**	**Mean**	**S.D.**	**Max**	**Min**
AUT	0,851	0,034	0,921	0,801	68,55	2,39	71,60	64,00
BEL	0,876	0,028	0,935	0,840	67,81	3,28	72,50	62,90
DNK	0,865	0,027	0,921	0,821	72,54	4,44	79,60	67,30
FIN	0,866	0,032	0,925	0,810	70,12	4,43	74,60	63,50
FRA	0,863	0,034	0,924	0,807	60,68	2,34	64,70	57,40
DEU	0,885	0,027	0,921	0,820	68,88	2,10	71,10	64,30
GRC	0,833	0,035	0,881	0,761	60,33	1,33	63,40	58,70
IRL	0,881	0,028	0,916	0,799	78,67	4,26	82,60	68,50
ITA	0,850	0,031	0,909	0,795	62,20	1,80	64,90	58,10
LUX	0,861	0,029	0,924	0,812	75,77	2,62	80,10	72,40
NLD	0,887	0,022	0,931	0,853	72,91	3,54	77,40	63,60
PRT	0,795	0,038	0,874	0,745	64,53	0,98	66,00	62,40
ESP	0,854	0,030	0,908	0,789	66,71	3,37	70,10	59,60
SWE	0,893	0,022	0,936	0,843	67,97	3,31	72,40	61,80
GBR	0,854	0,035	0,923	0,823	77,90	1,36	80,40	76,20

*The World Bank (2010)

**UNCTAD (2010)

***UNDP (2011)

****Heritage Foundation (2010)

Table 1: Descriptive Statistics of Data Set

Appendix-II

	ΔHTXV	ΔFDI	ΔHDI	ΔIEF	ECM_{t-1}
ΔHTXV	-	0.250593 (0.0000)**	5.524462 (0.0001)**	4.800621 (0.0000)**	-0.023368 (0.0021)**
ΔFDI	0.590359 (0.0000)**	-	11.15847 (0.0000)**	1.927282 (0.0266)*	-0.103293 (0.0295)*
ΔHDI	0.009328 (0.0001)**	0.007835 (0.0000)**	-	0.089279 (0.0003)**	-0.006296 (0.0000)**
ΔIEF	0.611209 (0.0003)**	0.043594 (0.0000)**	0.008743 (0.0437)*	-	-0.004350 (0.0290)*

*, **The test values are significant at .05 and .01 level.

Table 5: Panel Granger Causality Results