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# HIGH-TECHNOLOGY PRODUCTS EXPORT AND ECONOMIC GROWTH: A PANEL DATA ANALYSIS FOR EU-15 COUNTRIES

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***Abstract***

*This study investigates the relationship between high-tech product exports and economic growth in EU-15 countries between 1998-2017. The dataset is composed of gross domestic product (GDP), high-technology exports (HT), labor force (LF), and gross fixed capital formation (PC). Dumitrescu & Hurlin Causality, Westerlund Cointegration and MG Estimator employed for the analyses. Analysis of short-term outcomes revealed a bidirectional causal relationship between (a) HT and GDP, (b) LF and GDP, (c) PC and GDP, (d) LF and HT, (e) LF and PC, and (f) a unidirectional causality from HT to PC. Moreover, (i) a 1% raise in HT causes a 0.49 % increase in GDP, (ii) a 1% raise in LF causes a 0.22 % increase in GDP, (iii) a 1% raise in PC causes a 0.48 % increase in GDP. The long-term causal analyses shows that (i) a 1% raise in HT causes a 0.34 % increase in GDP, (ii)a 1% raise in LF causes a 7.4 % increase in GDP, (iii) a 1% raise in PC causes a 0.33% increase in GDP. High-tech product exports have a significant impact not only on economic growth, but also on gross fix capital formation and employment.*

***Keywords:*** *High-tech exports, economic growth, panel data analysis, export-led growth, EU-15 countries.*

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## *YÜKSEK TEKNOLOJİLİ ÜRÜN İHRACATI VE EKONOMİK BÜYÜME: AB-15 ÜLKELERİ İÇİN PANEL VERİ ANALİZİ*

***Öz***

*Bu çalışma, 1998-2017 dönemini dikkate alarak Avrupa Birliği (AB)-15 ülkelerinde yüksek teknolojili ürün ihracatı ile ekonomik büyüme arasındaki nedensellik ilişkisini hem kısa hem de uzun vade için araştırmaktadır. Veri seti, Gayri Safi Yurtiçi Hasıla (GDP), Yüksek Teknoloji İhracatı (HT), İşgücü (LF) ve Gayri Safi Sabit Sermaye Oluşumu (PC) değişkenlerinden oluşmaktadır. Analizler için Dumitrescu & Hurlin (2012) Granger Panel Nedensellik Testi, Westerlund ECM Panel Eşbütünleşme Testi ve MG Tahmin Edicisi kullanılmıştır. Kısa vadeli analiz sonuçları (a) HT ve GDP, (b) LF ve GDP, (c) PC ve GDP, (d) LF ve HT , (e) LF ve PC değişkenleri arasında çift yönlü ve (f) HT'den PC'ye doğru tek yönlü bir nedensellik ortaya koymuştur. Uzun vadeli sonuçlara göre, (i) HT'de %1'lik artış GDP'de %0.34'lük artışa, (ii) LF'de %1'lik artış GDP'de %7.4'lük artışa, (iii) PC'de %1'lik artış GDP'de %0.33'lük artışa neden olmaktadır. Sonuç olarak bu çalışma, yüksek teknolojili ürün ihracatının sadece ekonomik büyüme üzerinde değil aynı zamanda brüt sabit sermaye oluşumu ve istihdam üzerinde de önemli bir etkisi olduğunu ortaya koymuştur.*

***Anahtar Kelimeler:*** *Yüksek teknoloji ihracatı, ekonomik büyüme, panel veri analizi, ihracata dayalı büyüme, AB-15 ülkeleri.*

## Introduction

Economic growth with its potential of increasing income levels, reducing poverty, and improving the standard of living in societies, is the main focus of policy makers, both in developed and developing countries. According to the economic theory, even small, incremental improvements in growth rates can cause significant changes in the economic welfare of nations. In order to achieve high growth rates it is necessary to develop and use new technologies effectively. The latest developments in the world economy have clearly demonstrated that the new and faster production methods required to produce more output with the same inputs cannot be achieved without the use of technology.

One of the reasons behind the level of economic growth and income differences between developed and developing countries is undoubtedly the technology levels in these countries. Even though other underlying factors such as natural resources, labor force, macro economic and political stability, quality of education, intensity of R&D activities, and innovation play an important role. High-technology production structure has become the strongest element to support the economic growth in both developed and developing countries. This is especially important given the fourth industrial revolution.

The phrase "high technology" (high-tech) means the most advanced, state-of-the-art technology available. The phrase "high technology", which was first used in a New York Times article in 1958, was coined as "high-tech" for the first time in 1969 again in a New York Times article. In 1997, The Organisation for Economic Co-operation and Development (OECD) established a standard definition by classifying high-tech sectors and products. The OECD has formed mainly four different categories (High-tech, medium-high-tech, medium-low-tech, low-tech) taking into account the intensity of research and development activities used in the production process. According to this classification high-tech products include aerospace, computer, pharmaceutical, scientific instruments, electrical machines, medical precision and optical instruments (OECD, 2011: 5).

Due to the increase in globalization and technological development that has accelerated after the 1990's, not only the manufacturing high-tech products is important, but also the trade of these products internationally has become an important driver of economic growth. Developed countries, thanks to their high capital accumulation, advanced technology and qualified human resources, have been able to both produce high-tech products and export these high-value added products. Since an ultimate goal of all countries is to maintain a sustainable rate of economic growth, countries exhibit substantial efforts to develop products with better qualities than other nations. The success of these countries that exhibit higher growth rates can be interpreted as a reflection of the quality and technology differences in these products (Hausmann and Klinger, 2006; Schott, 2004).

The relationship between export and economic growth has been a topic of frequent exploration in economic literature. International trade is generally seen as an important determinant in the growth of the economy and is believed to contribute to economic growth by enabling efficient resource allocation, increasing capacity utilization, helping to product diversification and productive management of companies, creating economies of scale and contributing to the spread of technology, research and development. Cuaresma and Wörz (2005) demonstrated in an empirical study evidence that export composition in favor of high-technologhy products significantly contributes to economic growth, whereas low-technology exports surpass the gains from high-tech exports.

The positive relationship between exports and economic growth is grounded in the Export-Led Growth Hypothesis (ELGH) in the economics literature. ELGH argues that exports is an important determinant of economic growth in an economy. In contrast, the Growth-Led Hypothesis (GLH) supports the idea that economic growth leads to export growth. On the other hand, according to feedback hypothesis there exists a bidirectional causal relationship between economic growth and exports (Dudzevičiūtė et al., 2017: 108).

Even though there is a consensus on contribution of exports to economic growth, the causal relationship between these two variables is still a discussion point between the scholars. Investigating and comprehending the direction of this causality is important to decide whether to focus on export promoting activities or economic growth based production that can contribute to exports.

The same problematic is also pertinent for European Union (EU) due to its highly interconnected economic and political structure. The share of exports in GDP in the Euro Area has shown a dramatic increase over the last 3 decades, rising from 24% in 1997 to 45% in 2017 (World Bank, 2018). However, global growth projections for the next 20 years anticipates slower economic growth rates for developed countries including European countries (Tytell et al., 2018: 3). Therefore, revisiting the growth dynamics in Europe is important to ensure the sustainable growth in these countries.

There are a number of studies that have examined the causal relationship between high-tech exports and economic growth. However, the findings are inconclusive. In a recent study conducted by Kabaklarlı et al. (2018), no relationship was revealed between the high-tech exports and GDP growth in OECD countries, while Satrovic (2018) found a positive and significant relationship between the two variables, both in short and long-term. There exists numerous studies showing the causality between exports and economic growth in the EU. However, to-date, no research has examined the causal relationship between high-tech exports and economic growth. This study aims to fill this gap in economic literature by examining the causal relationship between these two variables in EU-15 countries namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

This paper is divided into two sections. In the first section, the literature on the relationship between high-tech product export and economic growth is discussed. In the second section, both the short-run and long-run causal relationships are examined using a Granger Panel Causality approach.

## 1. Literature Review

The extent literature reveals evidence of a causal link between exports and economic growth across many countries using different methodologies. In order to be consistent with the purpose of this study and to demonstrate the research gap in empirical literature, Table 1 below, lists research that has included high-tech products as a dependent variable and are included in the literature review. Table 1 includes a listing of authors, year of the publication, sample countries, methodologies and the key findings of the relevant literature.

**Table 1.** Literature Review

| AUTHOR/YEAR | PERIOD | SAMPLE | METHOD | FINDINGS |
|---|---|---|---|---|
| **Kabaklarlı, Duran&Üçler (2018)** | 1989-2015 | OECD Countries | Pooled Mean Group Cointegration Analysis | No relationship between HT export and GDP growth |
| **Demir (2018)** | 1995-2015 | 34 Countries | Dynamic Panel Data Analysis | HT products has a significant positive impact on GDP growth |
| **Satrovic (2018)** | 1995-2015 | 70 countries (32 developed, 38 developing) | Panel Data ARDL Model | Positive and significant relationship between GDP and HT in both, short- and long-term |
| **Usman (2017)** | 1995-2014 | Pakistan | ADF, Pearson Correlation Matrix and OLS | Significant positive impact of HT exports on economic growth |
| **Ekananda& Parlinggoman (2017)** | 1992-2014 | 50 Countries | Feasible Generalized Least Square (FGLS) | HT exports has no significant impact on GDP growth |
| **Yang (2017)** | 1995-2015 | Liaoning | Granger causality test | One-way causal relationship between HT product export and GDP growth |
| **Ustabaş&Ersin (2016)** | 1989-2014 | Turkey, South Korea | Structural unit root tests and cointegration methodologies | Positive impact of HT exports on GDP in South Korea both in the long and short-run, for Turkey only in short-run |

| | | | | |
|---|---|---|---|---|
| **Bal et al. (2016)** | 2013-2015 | 10 OECD Countries | System GMM Panel Estimator | HT exports have positive and statistically significant impact on GDP growth |
| **Kılavuz&Topcu (2012)** | 1998-2006 | 22 Developing Countries | Panel Data Analysis (OLS, RE, FE, PCSE methods) | HT export has a significant effect on GDP growth |
| **Jarreau & Poncet (2012)** | 1997-2009 | China | Cross-section analysis | Regions that specialize in more sophisticated goods subsequently grow faster |
| **Yoo (2008)** | 1988-2000 | 91 Countries | Cross-section analysis | HT exports significantly contribute to GDP growth |
| **Falk (2007)** | 1980-2004 | 22 OECD Countries | GMM Panel Estimator | HT exports are significantly positively related to GDP growth |

**Source:** Authors' own construction

## 2. Econometric Analysis

### 2.1. Data Set, Variables, Methodology

The dataset used in this study, which investigates the impact of high technology product exportation on economic growth, covers 450 observations composed of GDP, High-technology exports (HT), labor force (LF), Gross fixed capital formation (PC) of EU-15 countries, between 1998 -2017. The Dataset was compiled from the "World Bank".

Primarily the functional, statistical and VAR models were established. Before proceeding with the long-term and the short-term analysis, a number of pre-tests are required to determine appropriate test methods. These tests are cross-section dependence, stationary of the series, homogeneity of the parameters. Before panel causality tests can be used, the stationary of the series as well as the integration levels needs to be determined. Because panel causality analysis using time-series data which are non-stationary, produces biased results. Moreover, determining integration levels of the series are as crucial as stationary of the series. Stationarity can be evaluated using a Unit Root Test. To decide which unit root test is the best to produce proper results, the existence of the correlation between the units should be tested. To test the correlation between the units, a cross section dependence test is employed. In case of the existence of cross-section dependence, it is recommended to use one of the second-generation unit root test, otherwise the first-generation. In this research a Pesaran (2015) CD Test and Breusch Pagan LM Test were employed to test the existence of cross-section dependence. Pesaran (2007) CADF was implemented to define the stationary of the series.

Homogeneity of the parameters in another crucial pre-test to determine the proper estimation method. Therefore, Swamy S Homogeneity was conducted to determine the homogeneity of the parameters. Based on the pre-test mentioned above, the short-term causal relationship was analysed with the help of Dumitrescu & Hurlin (2012) Granger Panel Causality Test. Before examining the long-term relationship in detail, it is needed to determine the existence of cointegration between the series. For this purpose "Westerlund ECM Panel Co-integration Test" was employed. Finally, according to the results of the tests explained above Mean Group Estimator was chosen as the proper method to produce more detail in both the long-term and the short-term relationships,

**2.2. Model**

While examining the impact of high technology exports on economic growth, the equation based on the Cobb-Douglas function developed by Solow (1957), which is presented in Eq. (1), was implemented.

$$Y_t = A(t)\, K_t^{\alpha}\, L_t^{(1-\alpha)} \quad (1)$$

Solow's equation can be expressed in logarithmic function form as in Eq.(2).

$$LogY_t = LogA(t) + \alpha LogK + (1-\alpha)LogL \quad (2)$$

Accordingly, the functional model that will be used in this study can be described as in Eq.(3). In the model, GDP represents the economic growth and is the predicted variable of the model, while High-technology exports (HT), labour force (LF), Gross fixed capital formation (PC) are the predictor variables of the model.

$$GDP \; = f\,(HT, LF, PC) \quad (3)$$

| | |
|---|---|
| GDP | : Gross Domestic Product (constant 2010 US$) |
| HT | : High-technology exports (current US$) |
| LF | : Labour force |
| PC | : Gross fixed capital formation (current US$) |

Eq(2) can be expressed statistically as in Eq.(4)

$$GDP_{it} = a + \beta_1 HT_{it} + \beta_2 LF_{it} + \beta_3 PC_{it} + u_{it} \quad (4)$$

In Eq.(4) where $a$ represents fixed term and $\beta_1, \beta_2$ and $\beta_3$ are the coefficients of the regression which indicates the sensitiveness of GDP corresponding with per unit change in HT, LF and PC respectively. $t$ symbolizes the time trend and $u$ is the error term, while $i$ represents countries($i = 1 \dots N$).

The static model which is presented in Eq(4) can be described in dynamic equations in VAR System by considering lagged values of the series as in Eqs.(5), (6), (7) and (8) below.

$$dGDP_t = a_{11} + \sum_{l=1}^{n} \beta_{1l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{2l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{3l} dLF_{it-l} + \sum_{l=1}^{n} \beta_{4l} dFC_{it-l} + u_{1t} \quad (5)$$

$$dHT_t = a_{21} + \sum_{l=1}^{n} \beta_{5l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{6l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{7l} dLF_{it-l} + \sum_{l=1}^{n} \beta_{8l} dPC_{it-l} \ u_{2t} \quad (6)$$

$$dLF_t = a_{31} + \sum_{l=1}^{n} \beta_{9l} dLF_{it-l} + \sum_{l=1}^{n} \beta_{10l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{11l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{12l} dPC_{it-l} + u_{3t} \quad (7)$$

$$dPC_t = a_{41} + \sum_{l=1}^{n} \beta_{13l} dPC_{it-l} + \sum_{l=1}^{n} \beta_{14l} dGDP_{it-l} + \sum_{l=1}^{n} \beta_{15l} dHT_{it-l} + \sum_{l=1}^{n} \beta_{16l} dLF_{it-l} + u_{4t} \quad (8)$$

In the VAR Model, $d$ shows "the first differences", $u_{1t}, u_{2t}, u_{3t}$ and $u_{4t}$ are the "error terms", $n$ is "the number of lag-lengths" and $\beta_{1l} \dots \beta_{16l}$ are the coefficients of the model.

### 2.3. Cross-section Dependence Analysis

In order to define the right unit root test method as well as the right panel cointegration method, correlation between the units should be considered. In case the existence of cross-section dependence between the units, the second-generation panel unit root test, otherwise, the first-generation panel unit root test will be employed. Similarly, if there is a cross-sectional dependence between the units, the second-generation cointegration tests, if not, the first-generation cointegration tests should be used. "Pesaran (2015) CD Test and Breusch Pagan LM Test" are employed to determine the correlation between the units and the outcomes are presented in Table 2.

**Table 2.** CD-Test

*(A) Pesaran (2015) CD-Test*

| | CD-test | p-value |
|---|---|---|
| *GDP* | 51.704* | 0.000 |
| *HT* | 42.245* | 0.000 |
| *LF* | 14.548* | 0.000 |
| *PC* | 45.44* | 0.000 |

*(B) Breusch Pagan LM Test*

| *Test* | Stat | p-value |
|---|---|---|
| *LM* | 792* | 0.0000 |
| *LM adj** | 121.6* | 0.0000 |
| *LM CD** | 24.83* | 0.0000 |

Table 2A includes the CD test statistics, p-values of Pesaran (2015) Test. "H0: There is no correlation between the units" has been tested. As it is seen that all the p-values belong to GDP, HT, LF and PC are lower than 5% significance level and therefore, "H0 is rejected". Similarly, the p-values of the test statistics of Breusch Pagan LM Test, which are presented in Table 2B, are lower than 5%. Both methods produced the same result and concluded that there is a correlation between the units.

### 2.4. Stationarity Analysis

It is decided to employ Pesaran (2007) CADF test which is one of the second-generation unit root test that consider the correlation between the units. The outcomes of the test are presented in Table 3.

**Table 3.** Unit Root Test

| | **t-bar** | **cv10** | **cv5** | **cv1** | **Z[t-bar]** | **P-value** |
|---|---|---|---|---|---|---|
| GDPC | -2.196 | -2.140 | -2.250 | -2.450 | -1.702 | 0.044 |
| HT | -2.213 | -2.140 | -2.250 | -2.450 | -1.767 | 0.044 |
| PC | -2.481 | -2.140 | -2.250 | -2.450 | -2.838 | 0.002 |
| LF | -2.392 | -2.140 | -2.250 | -2.450 | -2.482 | 0.007 |

The outcomes of the test shown in Table 3 indicates that GDP, HT, PC and LF are stationary at level since the p-values of Z [t-bar] statistics belong to the series are lower than 5%. In other words, the integration orders of the series are I(0).

### 2.5. Homogeneity Analysis

Determining the heterogeneity or homogeneity of the parameters is crucial issue in order to define the right panel causality method. Accordingly, Swamy S Homogeneity Test was implemented and the outcomes are presented in Table 4.

**Table 4.** Homogeneity Test

| **REG.** | **X2 (70)** | **PROB > X2** |
|---|---|---|
| $\boldsymbol{GDP_{it} = a + \beta_1 GDP_{it-1} + \beta_2 HT_{it-1} + \beta_3 LF_{it-1} + \beta_4 PC_{it-1} + u_{it}}$ | 275.06 | 0.0000 |
| $\boldsymbol{HT_{it} = a + \beta_1 HT_{it-1} + \beta_2 GDP_{it-1} + \beta_3 LF_{it-1} + \beta_4 PC_{it-1} + u_{it}}$ | 167.75 | 0.0000 |
| $\boldsymbol{LF_{it} = a + \beta_1 LF_{it-1} + \beta_2 HT_{it-1} + \beta_3 GDP_{it-1} + \beta_4 PC_{it-1} + u_{it}}$ | 92.01 | 0.0401 |
| $\boldsymbol{PC_{it} = a + \beta_1 PC_{it-1} + \beta_2 HT_{it-1} + \beta_3 LF_{it-1} + \beta_4 GDP_{it-1} + u_{it}}$ | 146.50 | 0.0000 |

Table 5 shows the χ2 (70) and Prob. values of χ2 of the regressions which are seen in the first column of the table. "$H_0$: parameters are homogeneous" is tested against the parameters are heterogeneous. Because all Prob > χ2 are less than 0.05, $H_0$ was rejected and concluded that parameters are heterogeneous, therefore, heterogeneous panel causality and heterogeneous cointegration methods should be implemented.

### 2.6. Short-Term Causality Analysis

In the short-term causality analysis between the series, Dumitrescu & Hurlin (2012) Granger Panel Causality Test, which takes into account the heterogeneity, is employed and the outcomes are shown in Table 5.

**Table 5.** VAR Panel Causality Test Results

| $H_0$: | | | W-bar Stat. | Z-bar Stat. (p-value) | Relationships | | |
|---|---|---|---|---|---|---|---|
| HT | ⇏ | GDP | 12.5129 | 4.3696 (0.0000) | HT | ↔ | GDP |
| GDP | ⇏ | HT | 21.4775 | 13.0496 (0.0000) | | | |
| LF | ⇏ | GDP | 12.4541 | 4.3127 (0.0000) | LF | ↔ | GDP |
| GDP | ⇏ | LF | 21.5863 | 13.1549 (0.0000) | | | |
| PC | ⇏ | GDP | 20.6877 | 12.2848 (0.0000) | PC | ↔ | GDP |
| GDP | ⇏ | PC | 30.1492 | 21.4459 (0.0000) | | | |
| PC | ⇏ | HT | 9.0632 | 1.0294 (0.3033) | PC | ← | HT |
| HT | ⇏ | PC | 18.3215 | 9.9937 (0.0000) | | | |
| LF | ⇏ | HT | 17.0922 | 8.8035 (0.0000) | LF | ↔ | HT |
| HT | ⇏ | LF | 10.3056 | 2.2324 (0.0256) | | | |
| LF | ⇏ | PC | 19.2849 | 10.9265 (0.0000) | LF | ↔ | PC |
| PC | ⇏ | LF | 19.2169 | 10.8607 (0.0000) | | | |

Note: (⇏) refers "does not Granger-cause"

Dumitrescu & Hurlin (2012) Granger Panel Causality Test Results, which are seen in Table 6, indicated:

(a) a two-way causality between HT and GDP,
(b) a two-way causality between LF and GDP,
(c) a two-way causality between PC and GDP,
(d) a one-way causality from HT to PC,
(e) a two-way causality between LF and HT,
(f) a two-way causality between LF and PC.

### 2.7. Long-term Analysis

Existence of long-term relationships were investigated with the help of "Westerlund ECM Panel Co-integration Test", which is one of the second-generation cointegration test method that considers cross-section dependence between the units and the heterogeneity of the parameters. The outcomes of the test are presented in Table 6.

**Table 6.** Westerlund ECM Panel Co-integration Outcomes

| Statistic | Value | z-value | P-value | Robust P-value |
|---|---|---|---|---|
| Gt | -2.680** | -3.670 | 0.000 | 0.030 |
| Ga | -9.002** | -0.739 | 0.230 | 0.040 |
| Pt | -10.782** | -4.335 | 0.000 | 0.030 |
| Pa | -11.765* | -4.597 | 0.000 | 0.000 |

Note: ** and * indicate cointegration at the 5% and 1% significance level respectively.

Table 7 displays the values of test statistics, z-values, p-values and robust p-values of Gt, Ga, Pt and Pa. "$H_0$: no cointegration hypothesis" was tested. Since the robust p-values of Gt, Ga, Pa, which are considered in heterogeneous panel cointegration, are less than 5% the significance level, "The null hypothesis is rejected" and therefore it is concluded existence of co-integration between the units.

Because of the outcomes of Table 6 confirmed a long-term relationship, Mean Group Estimator is employed to get more detail. The outcomes of the MG Estimator are presented in Table 7.

**Table 7.** MG Estimator Outcomes

| dLnGDP | Coef. | Std.Err. | z | P > I z I | [%95 Conf. | Interval] |
|---|---|---|---|---|---|---|
| _ec | | | | | | |
| L. LnHT | .3373107 | .0879829 | 3.83 | 0.000 | .1648675 | .509754 |
| L. LnLF | 7.399851 | 3.659781 | 2.02 | 0.043 | .2268113 | 14.57289 |
| L. LnPC | .3261508 | .1172043 | 2.78 | 0.024 | .4558671 | .0035655 |
| SR | | | | | | |
| _ec | -.1636886 | .0613012 | 2.67 | 0.008 | -.2838367 | -.0435406 |
| d. LnHT | .48686 | .0154644 | 3.15 | 0.002 | .0183764 | .0789956 |
| d. LnLF | .2207495 | .1917353 | 1.15 | 0.250 | -.1550447 | .5965437 |
| d. LnPC | .0480197 | .0130922 | 3.67 | 0.000 | .0223594 | .0736799 |
| d.L. LnGDP | .1183899 | .0833607 | 1.42 | 0.156 | -.044994 | .2817738 |
| d.L. LnHT | -.0231869 | .010314 | -2.25 | 0.025 | -.043402 | -.0029718 |
| d.L. LnLF | -.0561468 | .1153639 | -0.49 | 0.626 | -.2822559 | .1699623 |
| d.L. LnPC | .0025046 | .0093701 | 0.27 | 0.789 | -.0158605 | .0208698 |
| _cons | 1.904871 | 1.82685 | 1.04 | 0.297 | -1.67569 | 5.485432 |

Table 7 displays the outcomes of MG Estimator and includes the long-term and the short-term coefficients, standard errors, z-values, p-values and 95% confident intervals.

The upper part of the Table 8 shows the long-term relationships. Since the p-values are lower than 0.05, the long-term coefficients of the variables are considered to be significant. Taking into account the long-term coefficients, it is deduced that:

(a) a 1% raise in HT causes a 0.34 % increase in GDP
(b) a 1% raise in LF causes a 7,4 % increase in GDP,
(c) a 1% raise in PC causes a 0.33% increase in GDP.

As a result, high-tech exportation, labour force and physical capital have a significant positive impact on economic growth in the long- term.

The second part of the outcomes of the MG Estimator show the short-term relationship. The coefficient of error correction (EC) is negative and p-value of (ec) is 0.008. Therefore, the short-term relationships are significant at 1% level. Considering the short-term coefficients belong to HT, LF and PC it is concluded that:

(a) a 1% raise in HT causes 0.49 % increase in GDP,
(b) a 1% raise in LF causes 0.22 % increase in GDP,
(c) a 1% raise in PC causes 0.48 % increase in GDP,
(d) Although LC itself does not appear significant in the short term (because of the interaction between the HT, LF and PC), the effect of the variables on economic growth in the short-term is positive and significant.
(e) Approximately 16% of the imbalances in a period, because of a shock, can be recovered in the next period.

**Conclusion**

In this paper, the long-term and the short-term relationships between high-tech exportation and economic growth in EU-15 countries were examined. The dataset includes 450 observations from 1988 to 2017 composed of the variables gross domestic product (GDP), high-tech exports (HT), labour force (LF) and gross fixed capital formation (PC).

To reveal short-term causality between the series a Dumitrescu & Hurlin (2012) Granger Panel Causality Test, which takes into account the heterogeneity was performed. To discover the long-term relationships, Westerlund ECM Panel Cointegration Test and MG Estimator were used.

The results of the short-term Granger causal analysis revealed a bidirectional causal relationship between (a) HT and GDP, (b) LF and GDP, (c) PC and GDP, (d) LF and HT, (e) LF and PC, and (f) a unidirectional causality from HT to PC. The short-term outcomes of MG Estimator show that: (1) a 1% raise in HT cause to 0.049 % increase in GDP, (2) a 1% raise in LF cause to 0,22 % increase in GDP, (3) a 1% raise in PC cause to 0,48 % increase in GDP, (4) approximately 16% of the imbalances in a period, because of a shock, can be recovered in the next period. Although LF itself does not appear significant in the short term; however because of the interaction between the HT, LF and PC, the effect of the variables on economic growth in the short-term is positive and significant.

The long term results indicate that (1) a 1% raise in HT cause to a 0.34 % increase in GDP, (2) a 1% raise in LF cause to a 7,4 % increase in GDP, (3) a 1% raise in PC cause to a 0.33% increase in GDP.

The empirical findings of this study can be interpreted as follows. High-tech exportation has a significant impact not only on economic growth, but also on gross fix capital formation and employment. The magnitude of the impact of high-tech export is stronger in the long-term compared to short-term. This confirms that high-export exportation has the potential to increase the long-term growth, boosting the productive capacity in EU-15 countries. Results of the study supports the findings of Demir (2018), Satrovic (2018), Usman (2017), Bal et al. (2016), Kılavuz and Topcu (2012), Yoo (2008) and Falk (2007) who found the importance of high-tech exports on economic growth.

This study also revealed the importance of export diversification and product sophistication. Bidirectional causal relationship between high-tech product export and economic growth shows that the economic policies in EU-15 countries should promote both manufacturing and exportation of high-tech products and also activities that support economic growth. The findings of this study are applicable to countries where the share of high-tech product export is high. Further research is recommended for the rest of the EU countries to examine the impact across a broader range of economies.

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