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Effect of High-Tech Exports and R&D Expenditures on Sustainable Economic Growth-Case Study of BRICS Countries and Turkey

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Abstract: Research & Development (R&D) expenditures and technological development and innovation are crucial for higher and sustainable economic growth of countries. This paper aimed to study the effects of R&D expenditures and high-tech product exports on economic growth rates. Vector autoregressive model (VAR) analysis was made using annual data between 2000-2021 in sampled BRICS countries and Turkey. It was determined that a country's economic growth rates significantly affected R&D expenditures. In addition, R&D expenditures and high-tech exports had no significant effect on economic growth rates. With economic development, the R&D expenditures increased, which was in line with expected results.

Keywords: Research & Development (R&D) expenditures; High-tech exports; Sustainable economic growth; Vector Autoregressive Model (VAR)

1. Introduction

R&D activities of a country are an important indicator in determining its international development level. According to international statistics, the developed countries have the highest proportion of R&D expenditures in national incomes and are more competitive than their rivals. From this point of view, it is very important for other countries to benefit from R&D activities through foreign trade (Diao et al., 1999).

A development strategy is export-based growth strategy, which was introduced as an alternative to import substitution programs in the late 1970s, aiming to increase production capacity through foreign trade (Palley, 2011).

In today's world, the competitiveness of countries depends on the extent to which their goods and services contain high technology. Therefore, the advanced technology-based struggle in sectors has turned into a struggle for survival (Baumol, 2002).

Technology and innovation have significantly boosted productivity and economic growth. R&D spending is thought to have enhanced innovation and have a favorable impact on economic growth (Bilbao-Osorio & Rodríguez-Pose, 2004).

Barro (1990) attempted to explain the impact of government investments in innovation, education, and technological advancement on economic growth, and thought only innovation could realize economic growth. Therefore, according to endogenous growth models, R&D was the driving force of growth. In the models, sustainable growth was subject to certain conditions, such as physical and human capital, level of public expenditures, export rate, population growth rate, openness, political stability, and patent protection (Grossman & Helpman, 1994).

Literature review has found several studies investigating the relationship between R&D expenditures and economic growth. It is generally accepted that R&D expenditures contribute to economic expansion (Freire-Serén, 1999; Griliches, 1998; Luh & Chang, 1997). However, a number of studies do not think there is relationship between these two variables (Aghion & Howitt, 1992; Sylwester, 2001; Samimi & Alerasoul, 2009).

In the increasingly interconnected world today, innovation is significantly affected by competitiveness and

significantly contributes to development. Competitiveness, which is the capabilities required to sustain long-term economic growth in an internationally competitive environment, is seriously affected by innovation and significantly contributes to development through innovation. Entrepreneurs cannot realize sustainable economic development unless they increase their productivity through innovation and respond to the demand of the market. At the same time, innovation has a multiplicative effect on the rate at which technology spreads from wealthy countries to poor countries (Fan et al., 2009).

In endogenous growth models, R&D and inventive activities are viewed as the most crucial factor in long-term economic growth. Technological innovation has significant and beneficial effects on economic performance at the corporate, industrial and national level (Wong et al., 2005).

2. Dataset and Method

The BRICS countries and Turkey were used as a case study. Annual data for relevant countries between 2000 and 2021 was collected from the World Bank Open Data (https://data.worldbank.org) website. This paper made VAR analysis of variables, such as GDP growth (annual%), R&D expenditures (percentage of GDP), and high-tech exports (percentage of exports), which represented the country's economic growth rates.

Augmented Dickey-Fuller (ADF) unit root test was carried out before the analysis. Time series included in the analysis must be stationary and free of unit roots. Because it had been determined that the time series did not satisfy the stationarity condition at the level, the first-order differences were taken to make them stationary.

After the time series satisfied the stationarity condition, it was necessary to determine the correct lag length and incorporate it into the model. Therefore, the lag length, which was first and foremost confirmed by information criteria, should be selected as the appropriate and incorporated into the model. The following table was used to determine the appropriate lag duration and incorporate it into the model.

According to the Table 1, lag length 1 was confirmed for the first time by the SC and HQ information criteria. Based on those two information criteria, 1 was determined as the appropriate lag length and incorporated in the model.

In Table 2, the result of the VAR Granger causality/block externality Wald test is presented. According to the analysis results, the model, with R&D Expenditures (Percentage of GDP) as dependent variable, was found to be statistically significant as a whole (Probe < 0.05). In this model, it is seen that the independent variable affecting dependent variable is economic growth rate. The economic growth rates of countries in the analysis affected the level of R&D Expenditures (Percentage of GDP). The model, with economic growth as dependent variable, was not statistically significant as a whole (Prob. > 0.05). The model, with High-Tech Exports (Percentage of Exports Produced) as dependent variable, was not statistically significant as a whole (Prob. > 0.05).

Table 1. VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-250.7878	NA	35.57094	12.08513	12.20925	12.13063
1	-86.00510	298.1782	0.021387	4.666909	5.163386*	4.848888*
2	-74.45281	19.25381*	0.019085*	4.545372*	5.414207	4.863834
3	-69.30842	7.839064	0.023361	4.728972	5.970165	5.183919
4	-58.80398	14.50614	0.022520	4.657332	6.270883	5.248762
5	-51.58009	8.943865	0.025981	4.741909	6.727817	5.469823
6	-44.50101	7.753270	0.031167	4.833382	7.191647	5.697779

Table 2. VAR granger causality/block exogeneity Wald tests

Dependent variable: GDP			
Excluded	Chi-sq	df	Prob.
R&D expenditures	2.707562	2	0.2583
High-tech exports (percentage of exports)	2.351311	2	0.3086
All	5.054768	4	0.2817
Dependent variable: R&D Expenditures (Percentage of GDP)			
Excluded	Chi-sq	df	Prob.
GDP	13.13746	2	0.0014
High-tech exports (percentage of exports)	0.138231	2	0.9332
All	14.53920	4	0.0058
Dependent variable: High-Tech Exports (Percentage of Exports)			
Excluded	Chi-sq	df	Prob.
GDP	8.084113	2	0.0176
R&D Expenditures (Percentage of GDP)	1.553435	2	0.4599
All	9.015237	4	0.0607

3. Impulse Response Analysis Results

With impulse-response analysis, if a standard deviation shock is applied to one of the variables, the reactions of itself and other variables to this change are measured. Thus, the method allows the observation of dynamic relationships between variables (Warne, 2004).

Compared with other methods, VAR analysis has an advantage in revealing dynamic relationships between variables. The reactions of one variable and others to a one-unit shock occurring in one of the variables over time can be observed.

In Table 3, Table 4 and Table 5, the results of the tabular values of the impulse-response analyzes are presented and interpreted.

In Table 3 above, the reactions of other variables to a standard error shock arising from the economic growth rates of the countries are observed. The variable R&D Expenditures (Percentage of GDP) had directional reaction to the shock caused by economic growth in the first two periods. In all subsequent periods, the direction of the reaction was + and the reaction continued with increasing intensity.

This paper observed the reactions of other variables to the one-unit shock originating from the variable R&D Expenditures (Percentage of GDP). In the 1st period, economic growth rates did not respond to the shock caused by variable R&D Expenditures (Percentage of GDP). The response, measured at +0.458703 in the 2nd period, was the strongest in all periods. The severity of the reaction was measured at 0.068885 in the 3rd Period, -0.099091 in the 4th Period, -0.151271 in the 5th Period, -0.202852 in the 6th Period, -0.238037 in the 7th Period, -0.256306 in the 8th Period, -0.265841 in the 9th Period, and -0.269798 in the 10th Period. It was noteworthy that the High-Tech Exports (Percentage of Exports) responded to the shock caused by variable R&D Expenditures (Percentage of GDP) in a + direction in every period and the severity of the reactions continued to increase over time.

Table 3. Responses of other variables to the GDP-induced shock

Period	GDP	R&D Expenditures (Percentage of GDP)	High-Tech Exports (Percentage of Exports)
1	3.301611	-0.026587	-0.297173
2	1.366232	-0.014942	-0.389499
3	0.712729	0.006985	-0.006033
4	0.573021	0.017617	0.101074
5	0.358091	0.024198	0.159051
6	0.196463	0.029432	0.221323
7	0.100889	0.033121	0.265641
8	0.034787	0.035700	0.296797
9	-0.011739	0.037599	0.321256
10	-0.043042	0.039030	0.340813

Table 4. Reactions of other variables to the shock from R&D expenditures

Period	GDP	R&D Expenditures (Percentage of GDP)	High-Tech Exports (Percentage of Exports)
1	0.000000	0.055459	0.144491
2	0.458703	0.056263	0.051940
3	0.068885	0.059848	0.083486
4	-0.099091	0.064772	0.190958
5	-0.151271	0.067261	0.245348
6	-0.202852	0.068658	0.284633
7	-0.238037	0.069609	0.321015
8	-0.256306	0.070175	0.351746
9	-0.265841	0.070488	0.378187
10	-0.269798	0.070664	0.401973

Table 5. Response of other variables to the shock from high-tech exports (percentage of exports)

Period	GDP	R&D Expenditures (Percentage of GDP)	High-Tech Exports (Percentage of Exports)
1	0.000000	0.000000	1.194035
2	0.304441	0.002490	1.106695
3	0.348876	0.002968	1.026466
4	0.329618	0.005377	0.997208
5	0.331951	0.008128	0.973649
6	0.325390	0.010903	0.950436
7	0.310142	0.013781	0.931913
8	0.292427	0.016691	0.916794
9	0.273266	0.019577	0.903996
10	0.253194	0.022416	0.893239

It was noteworthy that economic growth rates did not respond to the shock caused by variable High-Tech Exports (Percentage of Exports) in the 1st period, and the reactions in all subsequent periods were always positive. The reaction intensity was 0.304441 in the 2nd Period, 0.348876 in the 3rd Period, 0.329618 in the 4th Period, 0.331951 in the 5th Period, 0.325390 in the 6th Period, 0.310142 in the 7th Period, 0.292427 in the 8th Period, 0.273266 in the 9th Period, and 0.253194 in the 10th Period.

Variance Decomposition results were presented in the Table 6. According to the tables, 90.69348% changes in economic growth are explained by changes within the countries, while 5.655937% changes by changes in the variable "High Technology Exports" and 3.650579% by changes in the variable “Research and Development Expenditures”.

While 81.69413% changes in the variable “Research and Development Expenditures (Percentage of GDP)” are explained by changes in itself, 15.29733% by changes in economic growth and 3.008534% by changes originating from the variable “High Technology Exports”.

While 87.25557% changes in the variable “High Technology Exports” are explained by changes originating from it, 6.535871% by changes in the variable “R&D Expenditures” and 6.208559% by changes in economic growth rates.

Table 6. Variance decomposition test results

Variance decomposition of GDP				
Period	**S.E.**	**GDP**	**R&D Expenditures (Percentage of GDP)**	**High-Tech Exports (Percentage of Exports)**
1	3.301611	100.0000	0.000000	0.000000
2	3.615290	97.68106	1.609821	0.709119
3	3.701994	96.86567	1.569920	1.564411
4	3.761859	96.12750	1.589736	2.282761
5	3.796431	95.27441	1.719680	3.005907
6	3.820800	94.32736	1.979686	3.692958
7	3.842075	93.35454	2.341668	4.303787
8	3.861859	92.40860	2.758216	4.833182
9	3.880649	91.51679	3.200855	5.282355
10	3.898486	90.69348	3.650579	5.655937
Variance Decomposition of R&D Expenditures (Percentage of GDP)				
Period	S.E.	GDP	R&D Expenditures (Percentage of GDP)	High-Tech Exports (Percentage of Exports)
1	0.061503	18.68749	81.31251	0.000000
2	0.084720	12.95906	86.95459	0.086347
3	0.104004	9.050066	90.81119	0.138743
4	0.123902	8.398500	91.31540	0.286105
5	0.143274	9.133526	90.33066	0.535812
6	0.161946	10.45178	88.67556	0.872658
7	0.179885	11.86119	86.84462	1.294185
8	0.197069	13.16453	85.03977	1.795698
9	0.213546	14.31143	83.31884	2.369733
10	0.229393	15.29733	81.69413	3.008534
Variance Decomposition of High-Tech Exports (Percentage of Exports)				
Period	S.E.	GDP	R&D Expenditures (Percentage of GDP)	High-Tech Exports (Percentage of Exports)
1	1.238915	5.753539	1.360184	92.88628
2	1.707071	8.236566	0.809012	90.95442
3	1.993673	6.039590	0.768486	93.19192
4	2.239606	4.989666	1.335974	93.67436
5	2.459537	4.555398	2.102809	93.34179
6	2.661325	4.582389	2.939883	92.47773
7	2.850391	4.863178	3.831175	91.30565
8	3.029365	5.265402	4.740059	89.99454
9	3.200077	5.726422	5.644489	88.62909
10	3.363942	6.208559	6.535871	87.25557

4. Conclusion

This paper aimed to investigate the effect of R&D expenditures and high-tech exports in order to ensure sustainable economic growth. The research scope included Turkey and BRICS countries. VAR analysis was made for annual data from 2000 to 2021 using Econometrics Views (EViews). Panel VAR analysis method was used in this study, because VAR analysis had an advantage over other methods in revealing dynamic relationships over the years and accepting all variables as internal ones.

It is important to catch up with economic development in order to sustain long-term economic growth. This applies to not only developed countries, but also developing and underdeveloped countries. The development of

R&D activities effectively promoted long-term economic growth and socio-economic development. Analysis showed that the R&D investment expenditures in developed countries had a higher proportion in GDP than other countries.

Analysis results in this study determined that economic growth of a country had significant effects on R&D expenditures. In other words, with economic development, R&D expenditures increased within the country.

This study revealed and explained in detail the dynamic relationships in impulse-response analysis and all the variables in the analysis. The advantage of VAR analysis over other methods is that it explains the dynamic relationships between variables. Variance decomposition method was used to determine the percentage of changes in each variable explained by changes within itself or by changes of other variables.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

Aghion, P. & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica*, *60*(2), 323-351.

Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy*, *98*(5), S103-S125. https://doi.org/10.3386/w2588.

Baumol, W. J. (2002). The free-market innovation machine: analyzing the growth miracle of capitalism, Princeton. *N.J.: Princeton University Press*. https://doi.org/10.1515/9781400851638.

Bilbao-Osorio, B. & Rodríguez-Pose, A. (2004). From R&D to innovation and economic growth in the EU. *Growth Change*, *35*(4), 434-455. https://doi.org/10.1111/j.1468-2257.2004.00256.x.

Diao, X., Roe, T., & Yeldan, E. (1999). Strategic policies and growth: An applied model of R&D-driven endogenous growth. *J. Dev Econ.*, *60*(2), 343-380. https://doi.org/10.1016/S0304-3878(99)00044-9.

Fan, Q. L., Zeng, K., Dong, D. Z., & Peng, Y. (2009). Innovation for development and the role of government: A perspective from the east Asia and pacific region. *Washington, World Bank Group*.

Freire-Serén, M. J. (1999). Aggregate R&D expenditure and endogenous economic growth. UFAE and IAE Working Papers, WP436.99.

Griliches, Z. (1998). Introduction to R&D and productivity: The econometric evidence. R&D and Productivity: The Econometric Evidence, University of Chicago Press. pp. 1-14.

Grossman, G. M. & Helpman, E. (1994). Endogenous innovation in the theory of growth. *J. Econ Perspect.*, *8*(1), 23-44. https://doi.org/10.1257/jep.8.1.23.

Luh, Y. H. & Chang, S. K. (1997). Building the dynamic linkages between R & D and productivity growth. *J. Asian Econ.*, *8*(4), 525-545. https://doi.org/10.1016/S1049-0078(97)90029-4.

Palley, T. I. (2011). The rise and fall export-led growth. *Invest Econ.*, *71*(280), 141-161.

Samimi, A. J. & Alerasoul, S. M. (2009). R&D and economic growth: new evidence from some developing countries. *Australian Journal of Basic and Applied Sciences*, *3*(4), 3464- 3469.

Sylwester, K. (2001). R&D and Economic Growth. *Know Techn Pol.*, *13*(4), 71-84. https://doi.org/10.1007/BF02693991.

Wong, P. K., Ho, Y. P., & Autio, E. (2005). Entrepreneurship, innovation and economic growth: Evidence from GEM data. *Small Bus Econ.*, *24*, 335-350. https://doi.org/10.1007/s11187-005-2000-1.

Warne, A. (2004). Lecture Notes on Stuructural Vector Autoregression. http://texlips.hypermart.net/download/lecture_notes.pdf.