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Inducing Saudi High-Tech Exports: Role of Public R&D and Foreign Technology

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ABSTRACT

This study investigates the separate role of public R&D and foreign technology channels, presented by FDI and high-tech imports, and their complementary roles in inducing high-tech exports. The ARDL approach is used to estimate the relationship in Saudi Arabia during the period (1992-2016). The findings confirm the superiority of public R&D over the considered foreign technology channels in the short run, while in the long run the role of R&D is only evident in the joint effect with FDI and high-tech imports to absorb the foreign technology transferred by these channels. The findings also confirm the significance of high-tech imports in the long run, individually or jointly with R&D, while FDI is only significant when it interacts with public R&D.

JEL Classification:*F1; F23; L63; O3*

Keywords: R&D, FDI, High-tech imports, High-tech exports, ARDL Approach, Saudi Arabia.

INTRODUCTION

High-tech exports are the fastest growing section of exports worldwide indicating that the speed of technological change and innovation is increasing. R&D related activities enable countries not only to develop indigenous technological capabilities to achieve technological change, but also to absorb, use and adapt foreign technologies that enter the country via FDI and high-tech imports.

While there is little doubt on the crucial role of R&D in technological change and high-tech exports, the role of foreign technology via FDI and high-tech imports, is ambiguous and less evident and depends among other things on the level of the countries' technological development. Although there is almost consensus among studies that indigenous R&D capabilities are indispensable to benefit from foreign technology, most studies have treated indigenous R&D, FDI and high-tech imports as separate independent variables. This study will apply interaction variables "cross terms" between indigenous R&D and foreign technology, FDI and high-tech imports respectively, to capture the joint effect of the predictors which can be greater or smaller than the sum of the individual effects.

Due to the unavailability of reliable data on R&D expenditures for long time periods for many developing countries, empirical studies have mainly relied on panel data analysis. Therefore, some countries are overrepresented in previous studies, while others are not represented at all. So far, very little attention has been paid to the factors inducing high-tech exports in predominantly oil-exporting developing countries such as Saudi Arabia. Saudi Arabia is the world's largest oil exporter and is aspiring to diversify its exports to reduce its dependency on oil exports, which are relatively sensitive to economic crises and to spur economic growth by exporting high-tech products which have the highest possible value added. Although R&D

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expenditures have increased by an average of 9.57% annually (General Authority for Statistics) during the period 1992-2016, and high-tech exports have increased by37.44% annually (World Bank) during the same period, research to date has not yet determined the role of indigenous R&D and foreign technology in Saudi high-tech exports empirically. This study critically examines the view that indigenous R&D is not sufficient to induce Saudi high-tech exports, and attempts to assess the significance of foreign technology by using interaction variables and adopting an ARDL approach to capture both short run and long run effects. The results of the study will provide new insights into how to promote high-tech exports in Saudi Arabia efficiently and possibly also in the group of oil-exporting developing countries that have been neglected in empirical studies so far.

The study has been organized in the following way. After the introduction in part one, the paper gives a brief overview of the recent literature of high-tech exports and its main determinants in part two. Part three lays out the methodology used for the study and part four gives the results. The study ends with a general conclusion and policy implications.

2- Literature Review:

The growing importance and fierce competition in high-tech exports worldwide has motivated a vast number of empirical studies trying to identify the most important factors inducing high-tech exports of countries, industries and firms. In a review on over 90% of the world's high-tech bilateral trade, high-tech exports have been highly concentrated in a small number of countries which differ noticeably in their stages of technological and economic development. The review has revealed that while developing "emerging" countries depend heavily on FDI and trade processing; developed "established" countries rely essentially on industrial infrastructure and R&D (Abedini 2013).

Thus, economic literature identifies two main factors inducing high-tech exports according to where they originate; first indigenous technological capabilities and second, foreign technological capabilities. Indigenous technological capabilities include patents and innovations and result from domestic R&D related activities, such as R&D expenditures and R&D personnel (Seyoum 2004; Suri & Banerji, 2016; Alagöz et al. 2016;Sandu&Ciocanel 2014; Sezer 2018). Foreign technological capabilities affect high-tech production and high-tech exports through channels of technology transfer, such as imports of high-tech capital and intermediate products or components (Srholec 2007; Alves 2010; Iqbal et al. 2015) and Foreign Direct Investment FDI (Seyoum 2005; Gökmen&Turen 2013). Technology transfer induces technological progress directly through the use of high quality capital goods and inputs and indirectly through technological knowledge spillovers (Mehraraet al. 2017). Other studies have considered both roles of indigenous and foreign technologies in enhancing high-tech exports (Alves, 2010; Mehraraet al. 2017; Abedini 2013). The following is a brief description of the most influential studies examining the determinants of high-tech export performance under different circumstances.

Considering the difficulties in quantifying the output of technological progress and innovations, R&D related activities are often used as a proxy for domestic technological capabilities, due to the availability of data. Advanced factors of production such as scientists and engineers working in R&D, the quality of math and science education, research collaboration and modern physical infrastructure play a crucial role in enhancing high-tech exports. In a study on 54 countries, which has used panel data regression analysis and has accounted for nearly 90% of high-tech exports during the period 1996 - 1998, these advanced factors of production have shown a positive impact, alongside with other factors such as FDI and domestic rivalry, on high-tech exports (Seyoum2004).

While studies agree in general on the importance of R&D in inducing high-tech exports, they recognize that inter-country differences in high-tech exports cannot be explained by R&D related activities or indigenous technological capabilities alone, especially for developing countries.

China's remarkable success in dominating high-tech exports has raised the question of whether this success is merely a result of processing trade and/or foreign invested firms or of indigenous innovative capabilities. The answers are ambiguous, as the unexpected results of some studies have revealed. One study, which has used panel data regression analysis to relate variations in export sophistication across 240 cities in China to processing trade, foreign investment and local human capital for the period from 1996 to 2004,has revealed that human capital and tax-favored high-tech zones are the main determinants of export sophistication, while foreign factors such as processing trade, foreign firm ownership are the main determinants of export unit value (Wang and Wei 2008). On contrary, a firm level analysis on high-tech firms in different Chinese provinces during 2005-2007 which has adopted a parametric, instrumental variable approach and a non-parametric matching method has reached a different conclusion. The analysis has found evidence that firms which are successful in high tech exports are foreign owned and do not rely on innovation related activities in China, and that innovation activities by domestic firms have a relatively weak positive impact on their export performance, because their high-tech products cannot compete in international markets (Fu et al. 2010). However, an evaluation of the statistical comparison of R&D expenditures and various technology indicators, such as high-tech exports and the share of high-tech exports to manufacturing exports of Brazil, China, Indonesia, India, Mexico, Russia, and Turkey (E7 countries) for the period 1996-2014 has shown that China stands out in all indicators, implying a possible positive relationship between R&D expenditures and high-tech exports for these countries (Alagöz et al. 2016).

As for India, a recent study about the role of R&D in promoting Indian pharmaceutical exports has differentiated between current and capital R&D expenditures to examine the causal relationship between investment in R&D and pharmaceutical exports of Indian firms for the period 2000-2013using a VAR model. The analysis has indicated that R&D capital expenditures alone do not induce pharmaceutical exports, but require current R&D expenditures to have a significant positive impact on pharmaceutical exports. However, this impact is short-lived implying the necessity to continuously invest in both capital and current R&D (Suri & Banerji, 2016). Applying several Tobit regression models which have included a three year time lag, another study on Italian high technology small and medium firms HTSMEs has examined the effect of innovation, measured by various R&D related activities, on the export intensity of these firms. The empirical results have revealed that R&D employees, external R&D when carried out by universities, and product innovation have a positive impact on high-tech export intensity; while R&D expenditures, external R&D in general, and process innovation have no positive effect on high-tech export intensity (D'Angelo 2010).

On the country level, panel data regression analysis has been frequently used to examine the relationship between R&D expenditures and high-tech exports for developed and developing countries. While a study covering the period 1996-2011 has identified mutual causality between R&D expenditures and high-tech exports for the G-8 countries (Kiliç et al. 2014), other studies have detected a positive causality from R&D expenditures to high-tech exports for Turkey and 12 EU countries during the period 1996-2015 (Özkan and Yilmaz 2016), for 24 OECD countries during 1996-

2015using Fixed Effects (FE) and Random Effects (RE) Models. (Topcu 2018); and for five different manufacturing sectors for seven newly industrialized countries during the period 1996-2013 (Çetin 2016).

Another important aspect of R&D is the differentiation between private and public R&D. A panel data model with country-specific effects has been applied to measure the effect of private and public R&D expenditures separately on high-tech exports for 26 EU countries from 2006 to 2010. The analysis has revealed that the impact of private R&D expenditures on high-tech exports is realized in the same year and is higher than the impact of public R&D expenditures, which has only realized after two years (Sandu & Ciocanel 2014).Whether this relationship applies for developing countries needs further investigation.

For the BRICT countries consisting of Brazil, Russia, India, China and Turkey a long run relationship between R&D expenditure, trade openness and high-tech exports for the period 2001-2011 has been detected adopting panel FMOLS and panel DOLS methods(Kizilkaya et al. 2016). Adding South Africa to the previous countries, known as BRICST countries, and taking a longer time period form 1996-2014 and applying panel causality tests and panel regression analysis, evidence for a long term relationship between R&D expenditures, the number of R&D researchers and high-tech product exports, running from both R&D expenditures and R&D researchers to high-tech exports has been detected (Sezer 2018).

Having discussed how R&D affects high-tech exports, the study turns now to analyzing the impact of foreign technology on high-tech exports. Many developing countries suffer from insufficient indigenous technological capabilities to compete in high-tech exports. Inward foreign direct investment and the import of intermediate technology intensive products are considered important channels of technology transfer. Although FDI has a rather ambiguous effect on high-tech exports, the Pearson's correlation coefficients between FDI and high-tech exports have been stronger than between FDI and exports in general for eleven European transition economies implying a possible causal relationship between FDI and high-tech exports (Mitic and Ivić 2016)

A comprehensive study on the link between FDI and high-tech exports covering the 1980s and the 1990s has used an identical set of explanatory variables for each year on the same cross-sectional regression model to evaluate whether the impact of the explanatory variables has changed over time. The results for 70 countries in the year 1985 and for 87 countries in the year 1998, provide evidence that the positive effect of FDI on high-tech exports has been grater in the 1990s than in the 1980s (Zhang 2007).

Another study on 55 developing and developed countries, which has adopted Factor analysis and multiple regressions, has found evidence that inward foreign investment has a heavier positive impact on high-tech exports than technological infrastructure, and that countries such as Malaysia and Singapore have benefited from multinationals as a major source to develop their indigenous technological know-how up to the ability to export high-tech products (Seyoum 2005). Although another study using a structural trade model in both static and dynamic versions, to capture both short and long run effects on developed countries during 1995–2008, has not found evidence for a significant effect of FDI on high-tech exports(Abedini 2013), yet another study using panel cointegration method and panel causality test on 15 EU countries for the period 1995-2010, has shown a positive impact of FDI on high-tech exports both in the short and in the long run (Gökmen and Turen 2013).

The interaction between human capital in the receiving country and FDI is considered a very important factor to improve export quality and volume. A study using a panel data regression analysis which has differentiated between developing host countries and less developed host countries shows that many LDCs have not reached a minimum level of human capital and therefore have not profited from technology transfer through US MNEs (Xu 2000). Other studies have found different reasons for the adverse impact of multinationals on high-tech exports. An analysis using an empirical Bayesian methodology to get estimates for each country separately on multinationals in the Organization of Islamic Countries (OIC's) has shown a negative impact on high-tech exports, which has been thought to reflect the non-export domestic market orientation of FDI in these countries (Iqbal et al. 2015). According to another study on 10 developing countries for the period 1996–2012,adopting a panel cointegration and causality analysis, the adverse effect of FDI on high-tech exports has been explained by the inadequate regulations to protect intellectual property rights in these countries which have made MNCs prefer labor-intensive industries to high-tech production. However, for most of the 16 developed countries in the same study a positive effect of FDI on high-tech exports has been confirmed (Bayraktutan et al. 2018).

A similar conclusion about the role of FDI for developing countries has been reached in an analysis for 20 Latin American countries and the Carib bean using a fixed effects panel data model. While R&D and advanced educated labor force have shown a significant role, both current and past FDI have no significant effect on high-tech exports (Moraes and Luna 2018).

The following section considers the role of high-tech imports, another important channel of technology transfer, on high-tech exports. Adopting an approach based on Bayesian Model Averaging (BMA) and Weighted-Average Least Square (WALS) technique, a Panel data analysis for 24 developing countries during the period 1996 to 2013 has revealed that while imports have a role in inducing high-tech exports; FDI seems not to have affected high-tech exports (Mehrara et al. 2017).

Some studies have remarked that that the role of imports should be interpreted with caution, as in many cases high-tech exports are to a large extent assembled imported high-tech components (Sandu &Ciocanel 2014). Because current trade statistics do not differentiate between assembled high-tech exports with low value added and indigenously manufactured products with high value added, China's high tech exports statistics might have been misleading because low value added assembled high-tech exports magnify their high-tech exports. Therefore, a value-added approach has been adopted to distinguish China's technology contribution from its contribution to assemble high-tech components. The results indicate that the value added of China's exports in iPhones and laptop PCs was only 3% (Xing 2014).

To better understand the mechanisms of how high-tech imports might affect high-tech exports, looking at high-tech imports of electronics components and that of electronics finished goods separately has been useful. In a cross-sectional regression analysis on 111 countries during the period 2001-2003 electronics exports and imports of electronics components have been highly correlated, while there has been no significant relation between electronics exports and electronics imports in terms of finished products. This analysis has also confirmed the importance of indigenous technological capabilities for electronics exports but has suggested that the imports of electronics components are considerably more important in explaining the differences among countries in electronics exports (Srholec 2007).

In contrast to regarding intermediate high-tech imports just as components of high-tech finished export goods, high-tech imports can induce innovation by domestic firms through technological spillovers. Imports from technologically advanced economies have found to reduce costs for R&D related activities for importing firms. Two-stage instrumental regressions on Chinese firms have shown that the positive effect of high-tech intermediate imports on innovation has been greater the more advanced the source of imported intermediate high-tech good is; and also the higher the absorptive capacity of the importing firms (Chen et al. 2017).

Studies determining the impacts of indigenous or foreign technological capabilities on high-tech exports have not explained the complementary conditions that make these impacts possible. Using cross terms enables the analysis to capture the impact of the independent variables that depend on other independent variables to exert their effect. In an interprovincial panel data analysis for three Chinese regions from 2000 to 2007, empirical results have shown that while high-tech imports alone have a negative impact on high-tech exports, high-tech imports in combination with R&D expenditure, human capital or intellectual property rights have a positive impact on high-tech exports for the overall sample and for at least one of the three regions (Wang et al. 2011). Furthermore, another study, applying an adapted trade-flows gravity model, has examined the effect of the interaction term of R&D expenditures and FDI on high-tech exports in 10 Asian countries in the years 2004, 2005, 2006 and 2009. The analysis has shown that while the coefficient for R&D alone is positive but not significant, both the coefficients for FDI and for the interaction term between R&D and FDI are positive and significant. This implies that FDI is indispensable for some countries to capitalize on their R&D related activities to enhance their high-tech exports (Ismail2013)

Taken together, the literature review suggests that there is an association between R&D and foreign technology on one side and high-tech exports on the other side. However, this association depends among other things to a large extent on the interaction between R&D, high-tech imports and FDI, and on the specific characteristics of the countries under investigation.

To date there has been little agreement on what factors are more important than others in inducing high-tech exports; and up to now, far too little attention has been paid to rich oil-exporting countries as a group or as individual countries. This study sets out for the first time to investigate not only the independent effects of R&D, high-tech imports and FDI on high-tech exports, but also their combined effects for Saudi Arabia, which has high ambitions to transform its export structure from predominantly low value added oil exports to high-tech exports with the highest added value possible. Using an ARDL model, the present study allows also differentiating between short run and long run effects of the independent variables.

The interest of this study lies in understanding how R&D might induce high-tech exports in Saudi Arabia; and in identifying the most favorable channels of foreign technological spillovers, such as FDI and high-tech imports, which in combination with the improvement of their indigenous technological capabilities might transform the structure of Saudi exports from predominantly low-end oil exports to technology-intensive exports with the highest added value possible.

3- Methodology:

3-1 Variables and DATA

In order to investigate the impact of internal public R&D and foreign technology on high-tech exports in Saudi Arabia for the period 1992-2016, three relationships are formulated in the following general functions:

$$T\_EX_t = f\,(RDG_t\,,\,FDIP_t\,,\,IM_t) \qquad (1)$$

$$T\_EX_t = f\,(RDG_t,\ RDG_t * FDIP_t) \qquad (2)$$

$$T\_EX_t = f\,(RDG_t,\ \ RDG_t * IM_t) \qquad (3)$$

Where:

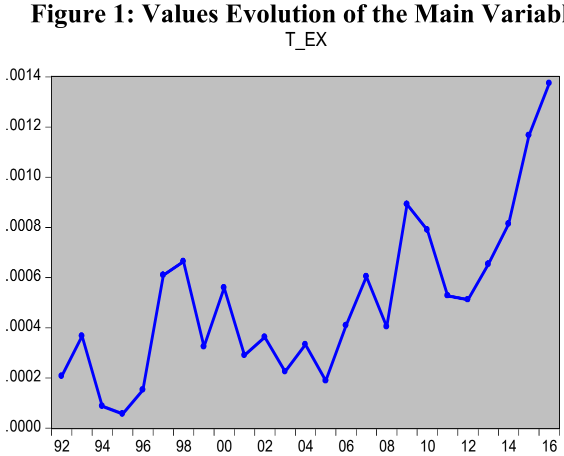
- **TEX:** High-tech exports as a percentage of gross national product (GDP)-(Source: World Bank, World Development Indicators)
- **RDG:** Government scientific expenditure as a

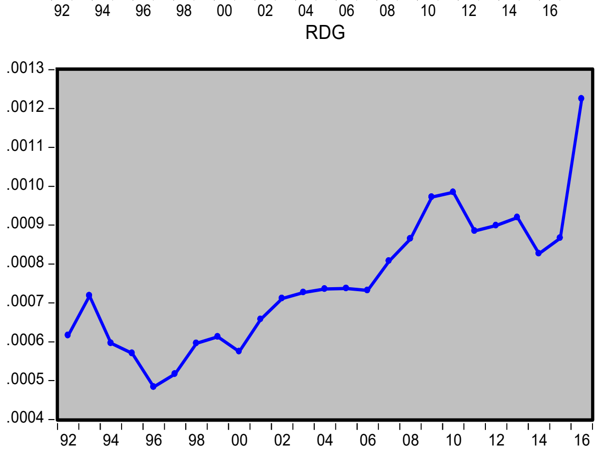
percentage of gross government expenditure- (Source: General Authority for Statistics, Saudi Arabia).

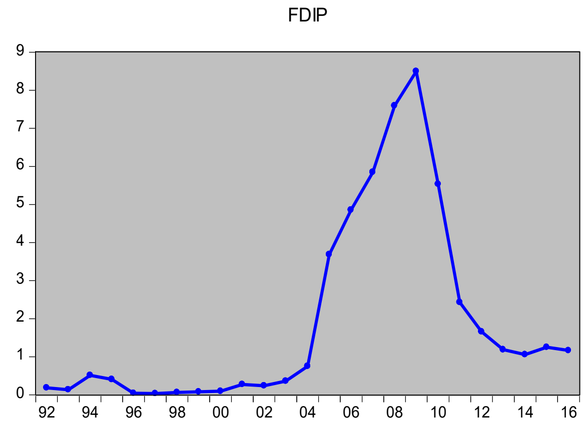
- **FDIP:** Net inflows of foreign direct investment as a percentage of GDP- (Source: UNCTAD).
- **IM:** High-tech imports as a percentage of GDP- (Source: Annual Statistics of Saudi Arabian Monetary Authority)
- **RDG*FDIP and RDG*IM:** Interaction terms indicate the complementary role of foreign technology, presented by FDI and high-tech imports, to the effect of R&D in enhancing the performance of Saudi high-tech exports.

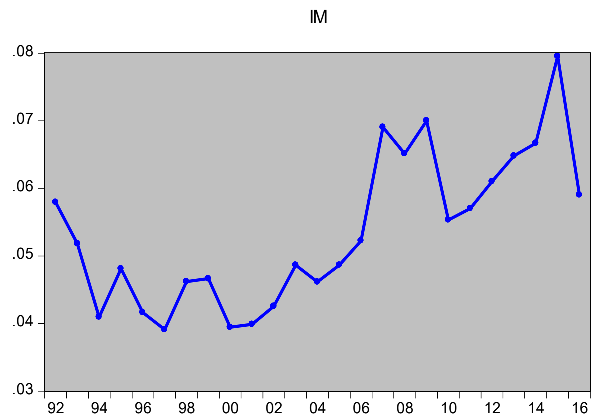
The following graphs give an overview of the development of variables' values during the given study period.

Figure 1: Values Evolution of the Main Variables









Source: *Authors' Calculations.*

The above graphs show the annual changes in the main variables of the study during the period from 1992 to 2016, namely public R&D (RDG graph), high-tech exports (T_EX graph), high-tech imports (IM graph) and FDI (FDIP graph). Both public R&D (RDG graph) and high-tech exports (T_EX graph) exhibit an increasing average trend of 9.57% and 37.44% annually respectively. It can be seen that both variables show a sharp increase in the end of the study period compared to the rather only slight increases in the beginning of the study period, which indicates the increasing attention given to both R&D activities and high-tech exports in recent years. According to a published report by UNESCO, in 2013 public R&D expenditures in Saudi Arabia were mainly allocated to fields of natural sciences (35.3%), engineering and technology (30.7%), humanities (12.5%), medical sciences (11.4%) and other fields (10.1%). On the other hand, high-tech exports are defined "according to SITC Rev.4 as the sum of the following products: Aerospace, Computers-office machines, Electronics-telecommunications, Pharmacy, Scientific instruments, Electrical machinery, Chemistry, Non-electrical machinery, Armament" (World Bank).With respect to high-tech imports (IM graph), although exhibiting an increasing trend in general, the most interesting aspect of the graph on high-tech imports (IM graph) is that its values far exceed those of high-tech exports (T_EX graph). A possible explanation for this might be the dependency of the Saudi economy in general and the Saudi technological capability in particular on imported high technology, which includes machinery, mechanical appliances, electrical equipment & parts thereof, optical, photographic, measuring, checking, precision, medical & surgical instruments & apparatus, clocks &watches, musical instruments, sound records &reproducers & parts thereof (Saudi Arabian Monetary Authority). Regarding foreign direct investment (FDIP graph) no comparable trend to the other variables can be detected, only an unexpected high rate of change around the year 2008. It is important to bear in mind that most FDI in Saudi Arabia is directed to the oil sector, and is therefore very likely to have been affected by the financial crisis in 2008 in agreement with the sensitive nature of international capital flows.

Before proceeding to examine the models in more detail, it is important to mention that the small size of the available dataset meant that it was not possible to include more independent variables in the models and therefore, the results should be interpreted with caution. In addition, assuming the possibility that indigenous R&D activities are enhanced by the interaction with foreign technology, the interaction term between R&D and FDI (as proposed by Ismail 2013) and the interaction term between R&D and high-tech imports (as suggested by Wang et al. 2011) have been included in the model.

3-2 The Models:

To determine the most suitable approach for estimating the short-run and long-run relationship among the variables, a unit root test is performed as shown in table (1). The results of the unit root test indicate that the variables' time series have a mixture of integration degrees in level I(0) and in first difference I(1). Thus, the Autoregressive Distributed Lag (ARDL) approach is more suitable than other approaches for examining the three relationships (Nkoro and Uko, 2016). Furthermore, ARDL is more efficient with small samples and gives the estimation for short run and long run relationships in one equation.

Table (1): Augmented Dickey Fuller Unit Root Test

Variables		Level			First Difference		
		Intercept	**Intercept and Trend**	**None**	**Intercept**	**Intercept and Trend**	**None**
T_EX	**t- Stat.**	**-0.8589 (0.7834)**	**-2.2450 (0.4455)**	**0.4547 (0.8050)**	**0.4547 (0.8050)**	**-5.74653 (0.0006)**	**-5.41505 (0.0000)**
	CV: 1%	-3.73785	-4.3943	-2.6649	-3.75295	-4.41635	-2.66936
	CV: 5%	-2.99188	-3.6122	-1.9557	-2.99806	-3.62203	-1.95640
	CV: 10%	-2.63554	-3.2431	-1.6088	-2.63875	-3.24859	-1.6085

Variables		Level			First Difference		
		Intercept	Intercept and Trend	None	Intercept	Intercept and Trend	None
RDG	**t- Stat.**	**0.280204 (0.9715)**	**-3.8181 (0.0360)**	**1.65629 (0.9721)**	**-2.849746 (0.0677)**	**-2.94939 (0.1704)**	**-2.49657 (0.0152)**
	CV: 1%	-3.769597	-4.467895	-2.674290	-3.769597	-4.532598	-2.674290
	CV: 5%	-3.004861	-3.644963	-1.957204	-3.004861	-3.673616	-1.957204
	CV: 10%	-2.642242	-3.261452	-1.608175	-2.642242	-3.277364	-1.608175
FDIP	**t- Stat.**	**-2.27759 (0.1869)**	**-2.3437 (0.3963)**	**-1.6692 (0.0891)**	**-2.537493 (0.1201)**	**-2.53346 (0.3106)**	**-2.59514 (0.0119)**
	CV: 1%	-3.752946	-4.416345	-2.669359	-3.752946	-4.416345	-2.669359
	CV: 5%	-2.998064	-3.622033	-1.956406	-2.998064	-3.622033	-1.956406
	CV: 10%	-2.638752	-3.248592	-1.608495	-2.638752	-3.248592	-1.608495
IM	**t- Stat.**	**-1.83197 (0.3569)**	**-3.5818 (0.0530)**	**-0.3319 (0.555)**	**-5.554825 (0.0002)**	**-5.40275 (0.0012)**	**-5.66705 (0.0000)**
	CV: 1%	-3.737853	-4.394309	-2.664853	-3.752946	-4.416345	-2.669359
	CV: 5%	-2.991878	-3.612199	-1.955681	-2.998064	-3.622033	-1.956406
	CV: 10%	-2.635542	-3.243079	-1.608793	-2.638752	-3.248592	-1.608495

Source: Authors' own calculation in Eviews.

- lag length are selected automatically by Eviews9 depending on Shwarz Info Criterion.
- CV is the critical values.
- Values between brackets are the probability of t- statistics.

According to ARDL approach the three mentioned relationships in short-run and long-run can be formulated in these three following models:

$$\Delta T\_EX_{t} = \alpha_{0} + \sum_{i=1}^{n} \beta_2 \, \Delta T\_EX_{t-i} + \sum_{i=1}^{m} \beta_2 \, \Delta RDG_{t-i} + \sum_{i=1}^{m} \beta_3 \Delta FDIP_{t-i} + \sum_{i=1}^{m} \beta_4 \Delta IM_{t-i} + \delta_1 T\_EX_{t-1} + \delta_2 RDG_{t-1} + \delta_3 FDIP_{t-1} \; \delta_4 IM_{t-1} + \mu_{1t} \quad (1)$$

$$\Delta T\_EX_{t} = \alpha_{0} + \sum_{i=1}^{n} \beta_1 \, \Delta T\_EX_{t-i} + \sum_{i=1}^{m} \beta_2 \, \Delta RDG_{t-i} + \sum_{i=1}^{m} \beta_3 \Delta RDG_{t-i} * FDIP_{t-i} + \delta_1 TEX_{t-1} + \delta_2 RDG_{t-1} + \delta_3 RDG_{t-1} * FDIP_{t-1} + \mu_{2t} \quad (2)$$

$$\Delta T\_EX_{t} = \alpha_{0} + \sum_{i=1}^{n} \beta_1 \, \Delta T\_EX_{t-i} + \sum_{i=1}^{m} \beta_2 \, \Delta RDG_{t-i} + \sum_{i=1}^{m} \beta_3 \Delta RDG_{t-i} * IM_{t-i} + \delta_1 T\_EX_{t-1} + \delta_2 RDG_{t-1} + \delta_3 RDG_{t-1} * IM_{t-i} + \mu_{3t} \quad (3)$$

Where α_0 is the constant of the equations, β_s are the short run coefficients, δ_s are the long run coefficients, and μ is the error term. The null hypothesis of the model states H0: no long-run relationships exist (where $\beta_s = 0$) while the alternative hypothesis is H1: long-run relationships exist (where $\beta_s \neq 0$).

4- The Results:

To examine these cointegration relationships, the bounds test approach will be implemented, whose critical values of the F-statistic were developed by Pesaran et al. (2001).

Table (2): The Results of Bounds Test

Model	Lag Length	F-statistic	I_0 Bound		I_1 Bound		The Null Hypothesis
			5%	10%	5%	10%	
(1) (RDG, FDIP, IM)	(1, 1, 1, 3)	4.134315	2.45	2.01	3.63	3.1	rejected
(2) (RDG, RDG*FDIP)	(2, 5, 5)	9.975575	2.72	2.17	3.83	3.19	rejected
(3) (RDG, RDG*IM)	(1, 4, 2)	4.836429	2.72	2.17	3.83	3.19	rejected

Source: Authors' own calculation in Eviews.

-The lag length was determined by using Akaike information criteria.

Rejecting the null hypothesis (no long run relationship exist) depends on the exceeding of the F-statistics value to the values of the lower bound I(0) and upper bound I(1) at 5%. Accordingly, the results of the bounds test confirm that there is a long run relationship for the three models.

Diagnostic Tests:

Diagnostic tests are a prerequisite to check the fitness of the ARDL estimates in the long run and the short run.First, Breusch-Godfrey LM Test for residuals serial correlation (the null hypothesis is no serial correlation) and Breusch-Pagan-Godfrey heteroscedasticity test to ensure the homoscedasticity of models' residuals (the null hypothesis is no heteroscedasticity) are performed. Then, Ramsey RESET test checks the linearity of the models, and determines whether the ARDL models are correctly specified (the null hypothesis is the model linearity), and Jarque-Bera tests the normality of residual distribution. For examining the stability of the models over time, the cumulative sum (CUSUM) and the cumulative sum of squared (CUSUMSQ) recursive residuals tests (Brown, Durbin & Evans, 1975) are performed. If the cumulative sum falls outside the area between the two 5% critical lines, instability would be found.

The results of the diagnostic tests show that the null hypotheses are accepted, as can be seen in table (3), confirming the fitness of ARDL estimates. According to F-statistic, the residuals do not suffer from serial correlation or heteroscedasticity, and the linearity is the suitable mathematical specification of the models. In addition, the Jarque-Bera value indicates that the residuals are normally distributed and figures (2, 3, and 4) show the stability of the models over time, as the cumulative sum falls inside the area between the two 5% critical lines.

Table (3): Diagnostic Tests

Models	Breusch-Godfrey Serial Correlation LM Test	Heteroscedasticity Test: Breusch-Pagan-Godfrey	The Linearity Test: Ramsey RESET		Normal distribution of residuals
	F-statistic	F-statistic	F-statistic	t-statistic	Jarque-Bera
(1) (RDG, FDIP, IM)	0.437897 (0.4535)	0.590051 (0.7827)	1.882958 (0.1951)	1.372209 (0.1951)	1.292408 (0.524031)
(2) (RDG, RDG*FDIP)	1.169845 (0.3981)	0.708676 (0.7202)	2.512873 (0.1738)	1.585204 (0.1738)	0752034 (0.686591)
(3) (RDG, RDG*IM)	2.479281 (0.1335)	0.681959 (0.7124)	0.296161 (0.5972)	0.544207 (0.5972)	0.854822 (0.652196)

Figure 2: Stability Tests of Model (1)

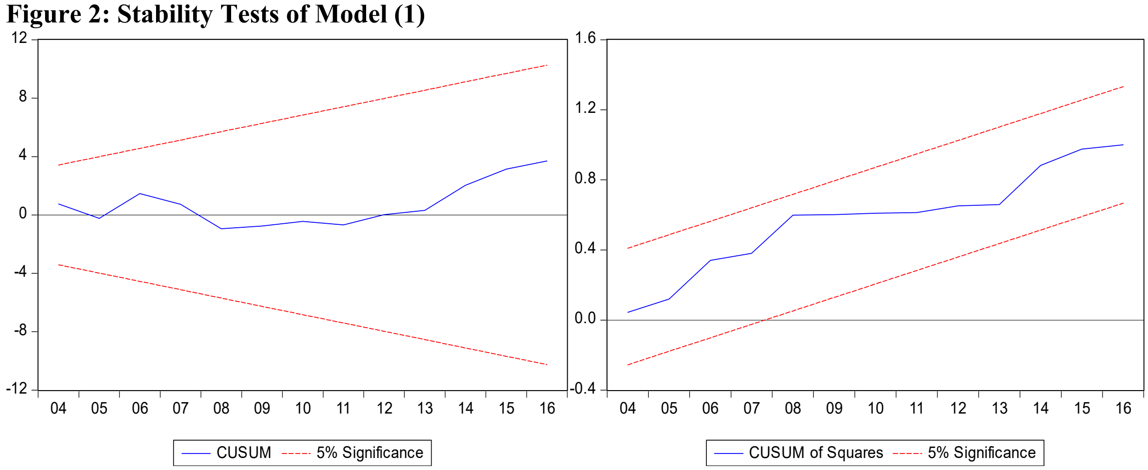


Figure 3: Stability Tests of Model (2)

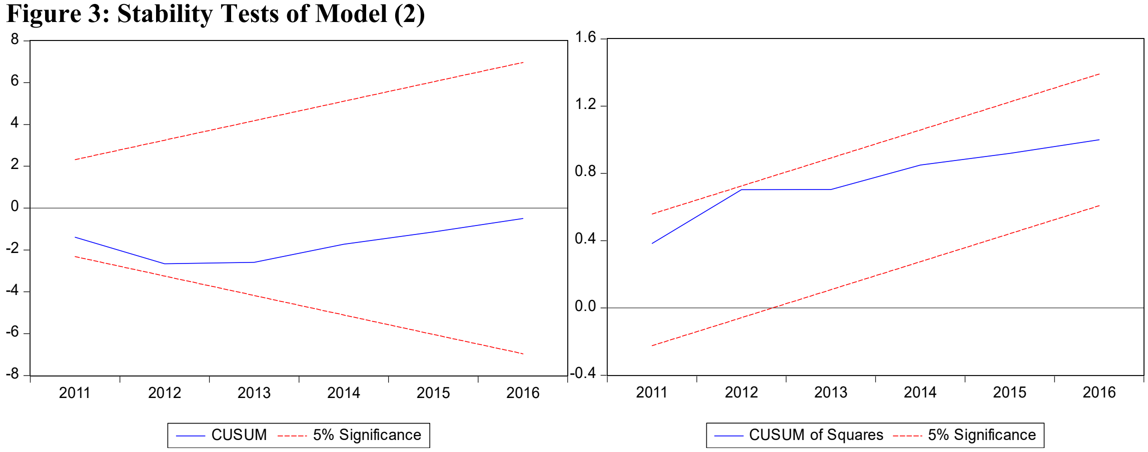
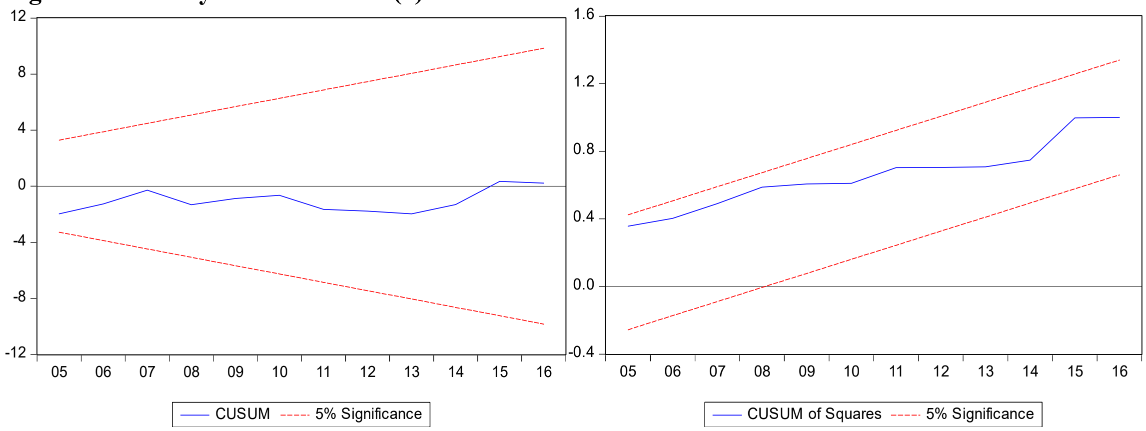


Figure 4: Stability Tests of Model (3)



Source: *Authors by Using Eviews.*

Table (4): Long Run Coefficients for The Dependent Variable T_EX

Models	RDG	FDIP	IM	RDG*FDIP	RDG*IM
(1) (RDG, FDIP, IM)	-1.143021 (0.1934)	-0.000022 (0.3452)	0.026281 (0.0472)	-	-
(2) (RDG, RDG*FDIP)	0.661708 (0.0008)	-	-	0.070490 (0.0480)	-
(3) (RDG, RDG*IM)	-0.216319 (0.5983)	-	-	-	18.195854 (0.0275)

Source: Authors' own calculation in Eviews.

According to the first model, high-tech exports in Saudi Arabia are only determined by the high-tech imports in the long run. This indicates the importance of this channel of foreign technology in determining the capability of Saudi Arabia in promoting its high-tech exports. While public expenditure on R&D, as an indicator of the indigenous technology, is not individually a determinant of this capability, it is only effective through interacting with high-tech imports. This is validated by the significance of the interaction term (RDG*IM), which confirms their complementary roles in inducing Saudi high-tech exports. On the other hand, foreign direct investment inflows (FDIP) to Saudi Arabia as a channel to transfer foreign technology, have no individual effect on high-tech exports, but when they complement with the indigenous technology indicator as presented by the interaction term (RDG*FDIP), they become significant.

The results of the short-run coefficients reveal the existence of short-run and long-run relationships between the dependent variable and the explanatory variables. The sign of CointEq(-1) lagged error correction term (ECT) is negative and significant at 5% level for the three models. The estimated coefficients of ECT are -0.800988, -0.894141, and -0.817666, respectively for model (1, 2, and 3). This illustrates a fast speed of adjustment to the equilibrium, where more than 80% of the disequilibrium is adjusted to the long-term equilibrium path within one year.

Table (5): Short Run Coefficients for The Dependent Variable T_EX

Model (1) (RDG, FDIP, IM)		**Model (2)** (RDG, RDG*FDIP)		**Model (3)** (RDG, RDG*IM)	
Variables	**Coefficients** (p. value)	**Variables**	**Coefficients** (p. value)	**Variables**	**Coefficients** (p. value)
D(RDG)	1.171508 (0.085)*	**D(T_EX(-1))**	-0.434057 (0.086)*	**D(RDG)**	1.328915 (0.087)*
D(FDIP)	-0.000113 (0.049)**	**D(RDG)**	2.213060 (0.015)**	**D(RDG(-1))**	-0.238594 (0.885)
D(IM)	0.011722 (0.087)*	**D(RDG(-1))**	-0.980547 (0.394)	**D(RDG(-2))**	1.002871 (0.360)
D(IM(-1))	-0.013372 (0.115)	**D(RDG(-2))**	0.163370 (0.885)	**D(RDG(-3))**	-1.464580 (0.058)*
D(IM(-2))	0.015155 (0.052)*	**D(RDG(-3))**	0.481222 (0.537)	**D(RDGIM)**	-0.685375 (0.930)
		D(RDG(-4))	-1.904645 (0.015)**	**D(RDGIM(-1))**	-11.505363 (0.291)
		D(RDGFDI)	-0.068439 (0.092)*		
		D(RDGFDI(-1))	-0.027070 (0.707)		
		D(RDGFDI(-2))	0.106258 (0.181)		
		D(RDGFDI(-3))	-0.034059 (0.626)		
		D(RDGFDI(-4))	-0.040414 (0.382)		
CointEq(-1)	-0.800988 (0.006)***	**CointEq(-1)**	-0.894141 (0.038)**	**CointEq(-1)**	-0.817666 (0.007)***

Source: Authors' own calculation in Eviews.
(*) Significant at 10%, (**) Significant at 5%, (***) Significant at 1%.

In the short-run, the indigenous technology, presented by public R&D, is more important in affecting high-tech exports, while foreign technology is less important or has a negative impact. Furthermore, there is no role of the interaction terms, which indicates that variables need more time to interact with each other to be effective in their relation with high-tech exports.

Conclusion and Policy Implications:

This study aims to investigate the role of public R&D and foreign technology channels, presented by FDI and high tech imports, in inducing Saudi high-tech exports. Their individual effects and their interaction effects have been examined by adopting three econometric models, estimated by using the ARDL approach, for data extending from 1992 to 2016.

The findings of this study have generally confirmed the crucial role of indigenous public R&D in inducing Saudi high-tech exports in the short run (in line with Sezer 2018), while foreign technology is less important, as it needs longer to be absorbed and modified to be influential in high-tech exports. This is confirmed in the long run, where the role of R&D is evident in the joint effect with FDI and high-tech imports to absorb the foreign technology transferred by these channels (Agree with Alves, 2010; Mehraraet al. 2017; Abedini 2013), while the individual effect disappears.

The significance of high-tech imports in affecting Saudi high-tech exports, whether individually or jointly with R&D in long run, reveals the extensive dependency of Saudi Arabia on this channel of foreign technology transfer (in line with Srholec 2007; Alves 2010; Iqbal et al. 2015). It may indicate that Saudi Arabia is efficiently involved in trade processing or high-tech re-exporting. On the other hand, FDI could not play the same role if its transferred technology is not being absorbed by indigenous technological capability (same results as Ismail2013).

Based upon the previous findings, this study recommends that policy makers support indigenous technological capabilities, as a promoter of high tech exports by its own in the short run and jointly in the long run, through increasing the amount allocated to public R&D and encouraging the private sector to involve in R&D activities. Until a certain level of indigenous R&D capabilities is reached, the dependency on foreign technology, especially high-tech imports, is vital. In the mean while Saudi Arabia should attract export oriented FDI and set up high-tech joint foreign ventures to absorb high technology and train domestic scientists to improve indigenous R&D capabilities.

In addition, further work needs to be done to establish the role of private R&D in enhancing high-tech exports. The previous results are subject to certain limitations. First, as mentioned earlier, the relatively small dataset did not allow for more possibly important explanatory variables to be included in the models. Second, the study would have been more useful if the models had not only included public R&D but also private R&D, especially as private R&D expenditures have been reported to have a stronger impact on high-tech exports than public R&D expenditures (Sandu & Ciocanel 2014). Unfortunately, data on private R&D expenditures was not available for Saudi Arabia. A larger dataset and data on private R&D expenditures would definitely help to establish a greater degree of accuracy on this topic. Notwithstanding the relatively limited sample, this study offers valuable insights into the role of public R&D and foreign technology in inducing high-tech exports in Saudi Arabia.

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حفز الصادرات السعودية ذات التقنية العالية: دور البحث والتطوير الحكومي والتقنية الأجنبية

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ملخص

تبحث هذه الدراسة في الدور المستقل والتكاملي لكل من الإنفاق الحكومي على البحث والتطوير وقنوات التقنية الأجنبية ،المتمثلة في الاستثمار الأجنبي المباشر والواردات ذات التقنية العالية، في تحفيز الصادرات ذات التقنية العالية، وتعتمد الدارسة على منهجا لانحدار الذاتي للمتباطئات الموزعة لتقدير العلاقة في المملكة العربية السعودية خلال المدة (1992–2016). وتؤكد النتائج تفوقا لدور المستقل للبحث والتطوير الحكومي على قنوات التقنية الأجنبية على المدى القصير. بينما على المدى الطويل، يبرز فقط الدور التكاملي للبحث والتطوير الحكومي في التأثير المشترك مع الاستثمار الأجنبي المباشر والواردات ذات التقنية العالية لاستيعاب التقنية الأجنبية المنقولة بواسطة هذه القنوات، وتؤكد النتائج على أهمية دور الواردات ذات التقنية العالية على المدى الطويل في حفز الصادرات ذات التقنية العالية، سواء أكان ذلك بشكل مستقل عن (أو متكامل مع) البحث والتطوير الحكومي. واقتصرت أهمية دور الاستثمار الأجنبي المباشر في حفز الصادرات عالية التقنية على الحالة التي يتكامل فيها البحث والتطوير الحكومي.

الكلمات الدالة: البحث والتطوير، الاستثمار الأجنبي المباشر، الواردات ذات التقنية العالية، الصادرات ذات التقنية العالية، منهج الانحدار الذاتي للمتباطئات الموزعة، المملكة العربية السعودية.

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