

# Evaluating Innovation and Institutions for Tech-Trade: A Global Assessment in the Quest for Sustainable Economic Prosperity

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## Abstract

*Sustainable economic prosperity lies in the production of technological products that use the latest technology and do not depend upon natural, non-renewable sources. Trade of such goods boosts the economy and diversifies its existing trade pattern. This study analyses various variables that contribute to high-tech exports. All countries of the world that have more than one per cent share of high-tech exports to manufactured products are taken from 2008 to 2021. A robust statistical method called Feasible Generalized Least Squares (FGLS-hetero) is used to deal with heteroscedasticity. To minimize the impact of outliers, quantile regression, and bootstrap quantile regression techniques are also used. The main purpose of using multiple regression techniques is to assess whether the sign and significance of the coefficient will change by change in estimation techniques. The findings reveal that innovation, access to information, strong institutions, and partnerships between universities and industries all play a significant role in boosting high-tech exports in all estimation techniques. Financial development has a significant direct impact on high-tech export in the case of simple linear regression and FGLS (hetero) but an insignificant positive impact in the case of quantile regression and bootstrap quantile regression.*

**Keywords:** High-Tech Export, Financial Development, University-Industry Collaboration.

## Introduction

In today's globalized world, the pursuit of sustained economic prosperity remains a primary aim for societies across the globe. Economic growth enhances living standards by providing opportunities for development, innovation, and prosperity. But how to achieve this economic growth, made economists struggle to find the way throughout centuries. They have proposed various theories for economic growth, such as classical growth theory, neoclassical growth theory, endogenous growth theory, new growth theory, the Schumpeterian model, structuralist growth theory, dependency theory, and institutional theory (Goodwin et al., 2022; Taylor & Woodford, 1999; Mankiw, 1998). Interestingly, technology is seen as a key driver of economic growth in almost all the mentioned theories.

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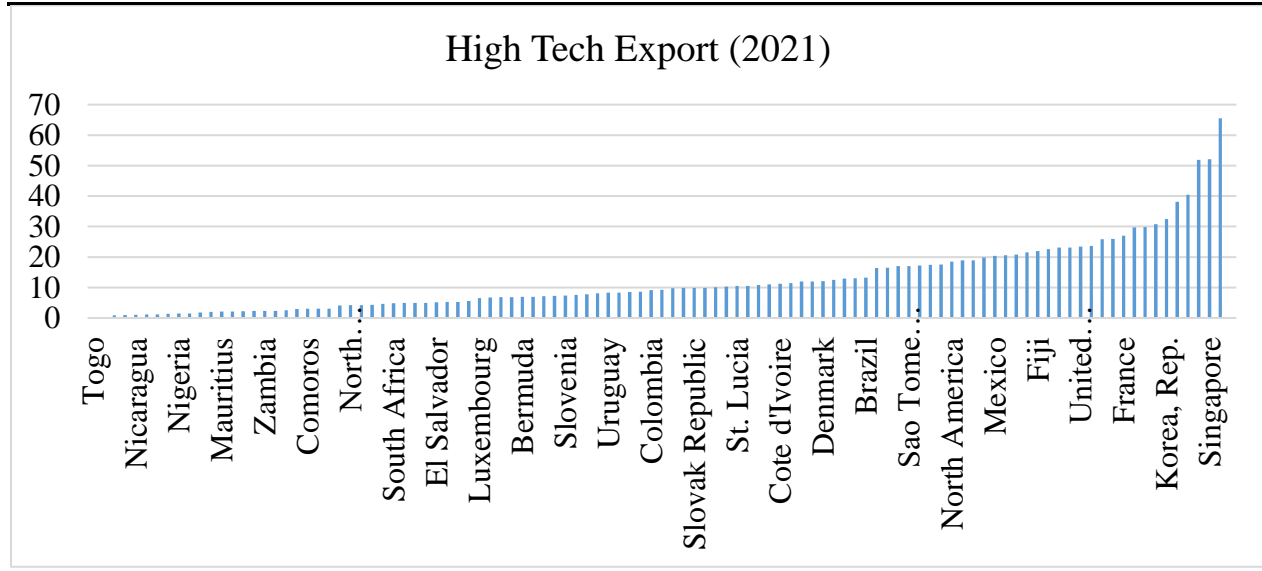
Technology can be used as an input resource for economic growth. Still, a lot of studies and theories have explored that, so this study has chosen it as an output factor and investigated certain explanatory variables that can enhance it. Moreover, this study has combined trade with technology for economic growth.

Economic growth can be achieved through various factors such as increase in quantity (Shabeer et al., 2021b) and or quality of resources (Martín-Retortillo & Pinilla, 2022), savings and investment (Lira & Kaleb, 2015), capital accumulation (Dugger, 1984), human capital (Gulcemal, 2020; Haseeb et al., 2020; Ogbeifun & Shobande, 2021; Sen, 1997), technological progress (Meral, 2019), intellectual capital (Schneider et al., 2009), education and knowledge spillovers (Döring & Schnellenbach, 2006), innovation (Shabeer & Rasul, 2024a), institutions (Swank, 2001), entrepreneurship (Acs et al., 2013), industrial policy (Aiginger & Rodrik, 2020), infrastructure (Ajakaiye & Ncube, 2010) and international trade (Roe, 2007). Among these, international trade emerges as a major determinant of economic growth (Singh, 2010). International trade offers a pathway to economic growth, but it also depends on the sectors to have leverage in benefits. The agriculture sector often faces diminishing returns and limited incentives for trade activities (Martín-Retortillo & Pinilla, 2022). There arises a pressing need to shift focus toward high-technology sectors, which hold greater potential for sustained economic growth because of their premium price and elastic supply (Kaur & Mehta, 2019).

This study focuses on high-tech trade and its determinants. Specifically, it seeks to explore the factors that influence high-tech trade dynamics, with a particular emphasis on innovation, information dissemination, institutional frameworks, university-industry collaboration, and financial development. This research aims to provide valuable insights about high-tech trade and its determinants for policymakers, businesses, and stakeholders striving to navigate the complexities of the global economy and foster sustainable economic prosperity.

This study offers nuanced perspectives and empirical evidence to inform evidence-based policy decisions and strategic initiatives aimed at promoting high-tech trade and driving economic growth.

**Figure 1: High-tech export as a percentage of manufactured products**



High-tech trading involves goods that are heavily focused on research and development. The World Bank has identified nine specific categories of high-tech exports, including aerospace, scientific instruments, computers and office machines, pharmaceuticals, electronics and telecommunications, electrical machinery, chemicals, non-electrical machinery, and armaments. Developed nations have higher high-tech export-to-manufacturing export rates, as shown in Figure 1.

This study aims to offer recommendations to the government for increasing high-tech exports. It does so by examining how innovation, access to information, and the strength of institutions influence the level of high-tech exports.

The following questions are investigated.

1. Can innovation lead to the creation of high-tech products for export?
2. Does information sharing play a meaningful role in exporting high-tech products?
3. Is there proof that better institutions enhance the export of high-tech goods?
4. How does financial development affect the export of high-tech products?
5. Does the collaboration between universities and industries influence the export of high-tech goods?

There is a lot of research on trade in general, but there's a notable gap when it comes to high-tech exports. This study has chosen high-tech exports as the dependent factor and has employed a comprehensive approach for the selection of independent variables. While many studies typically rely on a single proxy and link it to broader concepts such as using R&D to represent innovation, or internet usage to represent knowledge we've taken a different approach. This study has gathered data from various sources to create indices for institutions and financial development. These indices were constructed using principal component analysis in SPSS, allowing us to incorporate a wide range of proxies for each variable.

Most of the studies use more than one estimation technique to find the results of their research and ignore the fact that the results may change significantly if we use other techniques, and hence, the results may not be consistent. This study has used four different techniques to assess whether the impact of explanatory variables changes with change in the estimator. By testing a lot of variables and skipping those which were not significant and or have a different sign, in different estimations. The authors found some variables, which were significant in all estimations such as innovation, information, and institutions.

## Literature Review

### High-Tech Trade and Innovations

Srholec (2007) emphasizes that innovation and electronic product manufacturing drive the increase in high-tech exports from developing countries, fueled by the propensity to import such goods. Sara et al. (2012) found that innovative capacity significantly boosts high-tech exports in rapidly growing economies. Sandu and Ciocanel (2014) confirm a positive causal relationship between innovation and high-tech exports in the EU from 2006 to 2010. Bayraktutan and Bıdırdı (2018) concluded from a 16-year study (1996-2012) that patenting positively impacts medium and high-tech exports in both developed and developing nations. They found no short-term causality from patents to exports. Meral (2019) identifies patenting and R&D expenditure as key determinants of high-tech exports in Turkey, advocating for government financial incentives. Rahman et al. (2020) highlight a positive relationship between R&D, innovation, high-tech exports, and economic growth across 51 countries from 2001 to 2015, with long-term effects observed in high-income

countries. Other scholars who have worked on innovation and technology are (Shabeer & Rasul, 2024b; Wang et al., 2023; Huang et al., 2023; Arshed et al., 2022; Gul et al., 2022).

### **High-tech Trade and Information**

Information such as the internet, television sets, and cell phones contribute to the enhancement of high-tech exports (Shabeer et al., 2021a; Bougheas et al., 2000; Norton, 1992). Madden and Savage (2000) demonstrated a positive relationship between telecommunications infrastructure and economic growth across 43 nations. Wood (2001) observed a positive association between the number of telephones per 1000 workers and export performance in 36 African and Middle Eastern countries, with a coefficient of 0.24. Marandino and Wunnava (2017) highlighted the transformative potential of information, communication, and technology on export structures. (Tchamyoun et al., 2019) advocated for advancement in ICT, suggesting it would foster high-tech exports based on an ICT index encompassing internet accessibility, technology investment, R&D expenditure, broadband penetration, telephone infrastructure, cellular subscriptions, and internet usage. James (2016) found a direct relation between mobile, telephone, and internet penetration rates with high-tech exports.

### **Institutions and High-tech Exports**

Institutions play a crucial role in high-tech trade. Allen and Aldred (2011) found a positive relationship between institutions and trade. Institutions significantly influence the export potential of high-tech industries. Allen (2017) confirmed that the quality of institutions can affect the relationship between trade and growth, especially in economies where the export sector is a high-innovation sector. Chaudhry (2011) concluded that countries with strong institutions tend to gain more from trade in terms of growth, while countries with weak institutions face challenges in maximizing the benefits of trade. Institutions and innovation play significant roles in high-tech trade (Shabeer & Rasul, 2024b).

Tebaldi (2011) discovered that institutions alone don't directly influence high-tech exports. However, they could have an indirect effect by influencing other factors like human capital and the influx of foreign direct investments. Schneider et al. (2009) discussed how combinations of institutional conditions, such as lax employment protection and extensive university training, can support high-tech firms' export performance.

### **Financial Development and High-tech Exports**

Gaur et al. (2020) discussed the role of financial market development in promoting high-tech exports. They concluded that access to finance helps to increase high-tech exports. Financial development is positively associated with high-tech exports. Le et al. (2023) found that financial development affects technological progress and R&D spillovers in developing countries and promotes high-tech trade.

Kushwah et al. (2022) noted the dynamics of financial development and trade. They found interrelationships among financial development, trade, innovation, and economic growth in developed and developing societies. Shabeer (2022) concluded that financial development and information sharing are positively correlated with trade.

## Methodology

### Study Design

To examine the hypothesis, data on high-tech exports from all countries is obtained from the World Bank's World Development Indicators (WDI). Subsequently, countries whose high-tech exports to manufactured products were less than 1 per cent are excluded, and the remaining 110 countries (appendix 1) are studied from 2008 to 2021. Data on high-tech exports is exclusively accessible for the specified timeframe. Thus, it is a panel data study that can reduce multicollinearity (Boozer, 1997), fully explore the impact of cross-sections along time variations, and reduce biases (Barhoumi, 2006).

This is a panel data analysis, which can diminish multicollinearity (Boozer, 1997), thoroughly investigate the effects of variations across different periods and regions, and minimize biases (Barhoumi, 2006).

### Variables Description

The equation below illustrates the association between the dependent variable and independent variables.

$$HTE = \alpha + \beta_1 IN + \beta_2 INF + \beta_3 INS + \beta_4 UIC + \beta_5 FD + \mu$$

**Table 1: List of variables**

Variables	Symbol	Definition	Source
High Tech Export	HTE	Percentage of high-tech exports relative to manufactured goods	WDI, the World Bank
Innovation	IN	12 <sup>th</sup> pillar of the global competitiveness index	World economic forum
Information	INF	Informational globalization index	<a href="https://kof.ethz.ch/">https://kof.ethz.ch/</a>
Institutions	INS	Index of 6 governance by authors	WGI, the World Bank
University-Industry Collaboration	UIC	UIC in research. Index range 1-7, Seven best	<a href="http://reports.weforum.org">http://reports.weforum.org</a>
Financial Development	FD	Index from 12 variables by authors	WDI, the World Bank

High-tech exports encompass products with a significant focus on research and development. The World Bank has outlined diverse categories of high-tech exports, as discussed in the introduction of this study. Kof informational index includes television access, press freedom, internet access, bandwidth, patents, and R&D intensity.

The 12<sup>th</sup> pillar (innovation) of the global competitiveness index (GCI) is used to study the impact of innovation on high-tech exports. In the 12<sup>th</sup> pillar, innovation includes only technological innovations that are not subject to diminishing returns as old technology is replaced with superior new technology. The 12<sup>th</sup> pillar includes R&D expenditure, the number of scientific institutions, the collaboration of research institutes and industry, and intellectual property rights protection.

### Construction of Index

The institution index is made by authors from the following six variables: control of corruption, political stability, government effectiveness, absence of violence, voice & accountability, and rule

of law. The Bartlett test is significant and KMO adequacy is 0.905 which is appropriate for analysis. Kaufmann et al. (2011) have used such an institution index.

The financial development index is based on the depth, efficiency, access, and stability of financial institutions. A total of 12 variables are used for this purpose, including account ownership, ATMs, no of branches, borrows, depositors, the reserve to asset ratio, broad money, bank capital to the asset, domestic credit to the private sector, interest rate spread, real interest rate, and market capitalization. The principal component analysis is made in SPSS. KMO adequacy is 0.682 and Bartlett's test is significant which shows that this index is appropriate for analysis.

### Estimation Techniques

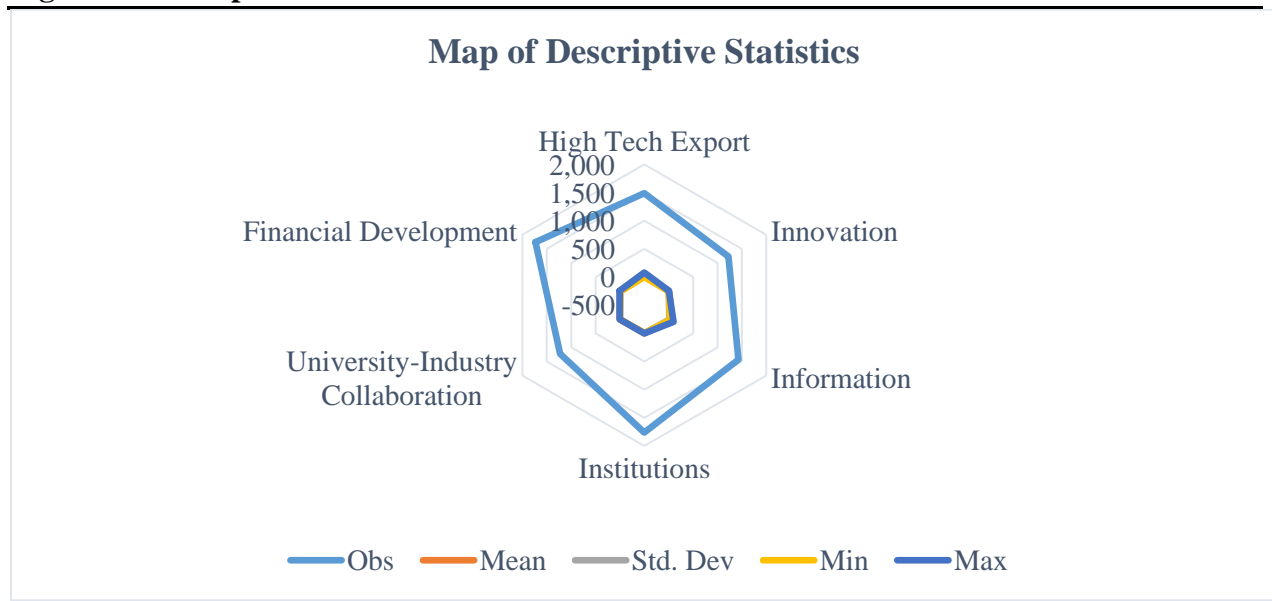
This study has used four estimation techniques: simple linear regression, quantile regression, bootstrap quantile regression, and feasible generalized least square FGLS (hetero) to assess the impact of explanatory variables on the dependent variable. Simple regression assumes that the cross-sections are homogeneous, quantile regression is used to robust outlier, and FGLS (hetero) is used to tackle cross-section heteroscedasticity (Shabeer et al., 2021a)

Using multiple techniques of regression also ensures the claim whether explanatory variables have a consistent impact, or the impact will change by change in estimators.

### Descriptive Statistics

Descriptive statistics provide insight into the characteristics of the data. It includes the number of observations, mean, standard deviation, minimum and maximum values.as presented in figure 2.

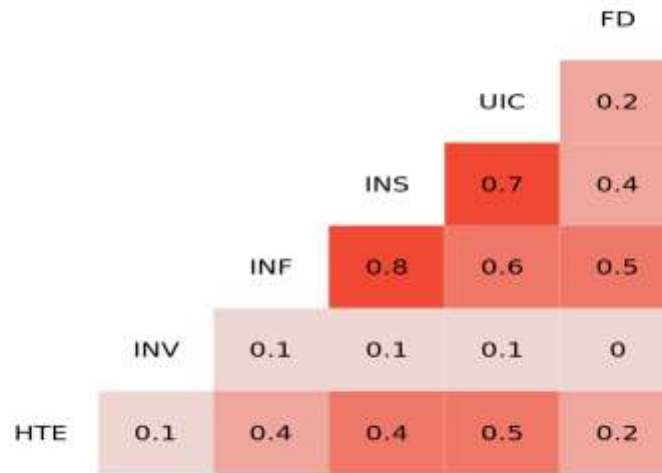
**Figure 2: Descriptive statistics**



### Correlation Overview

The correlation matrix illustrates the connections between variables, indicating whether they have a positive or negative relationship. Values range from 0 to 1, where 0 signifies no correlation and 1 represents a perfect correlation. Values closer to 1 indicate a strong correlation, while those closer to 0 suggest a weaker correlation. Figure 3 displays the correlations among the variables examined in this study.



**Figure 3: Correlation matrix**

### Variance Inflation Factor

When independent variables exhibit strong correlations with each other, it can lead to multicollinearity issues. However, table 2 reveals that multicollinearity is not a concern in this study, as all variables have a Variance Inflation Factor (VIF) of less than 10.

**Table 2: VIF**

	Innovation	Information	Institution	UIC	FD
Innovation	-				
Information	1.004	-			
Institution	1.003	2.333	-		
University-Industry Collaboration	1.004	1.461	2.061	-	
Financial Development	1.002	1.297	1.132	1.043	-

### Results and Discussion

This study has conducted four estimation techniques to know whether by changing the techniques, the results of the study will change or not. Moreover, FGLS is used to robust the heteroscedasticity, and quantile regression incorporates the outlier in the study. Table 3 shows the results.

**Table 3: FGLS results**

	Regression		Quantile Reg		Bootstrap QReg		FGLS (hetero)	
	Coef.	P>t	Coef.	P>t	Coef.	P>t	Coef.	P>t
Innovation	0.494	0.023	0.274	0.105	0.274	0.051	0.238	0.013
Information	0.064	0.067	0.087	0.001	0.087	0.000	0.081	0.000
Institutions	1.733	0.001	2.148	0.000	2.148	0.000	2.698	0.000
UIC	2.985	0.000	2.568	0.000	2.568	0.000	2.219	0.000
Financial Dev	1.169	0.000	0.246	0.305	.2461	0.234	.469	0.002
_Cons	-6.539	0.029	-8.129	0.000	-8.129	0.000	-5.272	0.001

Innovation shows that it has a significant and positive impact on technology export in the case of simple regression, bootstrap regression, and FGLS estimates. Its coefficient is 0.494 in the case of simple regression, 0.27 in the case of bootstrap regression, and 0.238 in the case of the FGLS estimator. Increasing innovation leads to an increase in high-tech exports. This is because innovation directly empowers producers to develop new technological goods that meet international market demand. Many technological items, like computers, scientific instruments, and electrical machinery, serve as capital goods used in producing other items, thereby aiding economic growth. High-income levels and health awareness contribute to increased demand for aerospace and pharmaceutical products. Researchers such as Srholec (2007), Sara et al. (2012), Sandu and Ciocanel (2014), Bayraktutan and Bırdırdı (2018), and Meral (2019) have also found the direct impact of innovation and high-tech export.

The influence of information on high-tech exports is positive and significant in all estimation techniques in the study. One unit increase in Kof informational globalization leads to an increase in high-tech export by 0.06 % in the case of simple regression, 0.087 in the case of quantile regression and bootstrap regression. In contrast, such an increase in FGLS is 0.081 per cent, significantly. Norton (1992), Madden and Savage (2000), Bougheas et al. (2000), Wood (2001), Marandino and Wunnava (2017), and Tchamyou et al. (2019) have shown such a relationship.

Institutions play a crucial role in managing various aspects within their domain, such as addressing corruption, ensuring accountability, and maintaining political stability. They cultivate an environment conducive to business growth and development. This study confirms that institutions have a significant and positive influence on high-tech exports in the case of all four estimation techniques used in this study. One unit increase in institution index increases high-tech export by 1.73% in case of regression, 2.14% in case of quantile regression and bootstrap quantile regression, and 2.689% in case of FGLS regression. Coefficients vary, but the level of significance and sign are the same. Scholars who have worked on the institution and high-tech exports are Allen and Aldred (2011), Allen (2017), Chaudhry (2011) and Tebaldi (2011).

Enhancing the quality of institutions enhances the business environment, resulting in a rise in high-tech exports—measures such as curbing corruption and ensuring accountability help lower business expenses. Political stability provides entrepreneurs with a consistent economic framework. It enables them to make informed long-term growth and sales decisions.

University-industry collaboration (UIC) is a goal outlined by the United Nations in the Sustainable Development Goals (SDGs), and this study has included it as a variable to explain high-tech exports. The findings indicate a positive and significant impact of UIC on high-tech exports in all four estimation techniques. Simple regression shows that the impact of UIC on high-tech export is 2.988%, quantile regression and bootstrap regression show the impact is 2.568 per cent whereas FGLS (hetero) shows the impact is 2.219%. The positive impact stems from the fact that as collaboration intensifies, industries gain increased opportunities to implement universities' ideas and research. This, in turn, facilitates the development of new technological products, ultimately boosting high-tech exports.

Financial development has a positive and significant impact in the case of simple regression and FGLS (hetero) but an insignificant positive impact in the case of quantile regression and bootstrap quantile regression. One unit increase in financial development increases high-tech export by 1.169% in the case of simple regression significantly, and in the case of FGLS hetero, such increase is 0.469 per cent.

The results of quantile regression and bootstrap quantile regression indicate that a unit increase in financial development leads to an increase in high-tech exports by 0.24 per cent. A financial index



is a composite of many financial variables (as discussed in section 3), and increases in variables like domestic credit to private firms, efficiency, and market capitalization of financial institutions enable tech export firms to get finance from banks and expand their production and marketing activities that lead to increase in technological export.

### **Conclusion and Policy Implications**

This study investigated the impact of innovation, institutions, information, university-industry collaboration, and financial development on high-tech trade. Results confirm that innovation has a significant direct impact on high-technology trade. In the case of simple regression, bootstrap regression, and FGLS regression, the values of coefficients vary. Information has a significant and positive impact on high technology export in all four estimation techniques used in this study. Institution index (governance indicators) positively influences high technology export significantly in case of regression, quantile regression, bootstrap regression, and FGLS (hetero).

The results indicate that university-industry collaboration increases high-tech export significantly in all four estimation techniques, and the values of coefficients show that it is a major factor for high-tech export. Financial development, although it has a positive sign for high-tech export, its coefficient is significant in two estimations (simple regression and FGLS) and insignificant in the case of quantile and bootstrap quantile regressions.

In line with the hypothesis, financial development estimations show that it has a positive impact on high-tech exports in the case of all four estimation techniques used in this study. Its coefficient is significant in the case of simple linear regression and FGLS (hetero) but insignificant in the case of quantile regression and bootstrap quantile regression.

The study demonstrates that the level of significance and coefficient sign does not change with a change in estimation technique for innovation, information, and institutions. Still, the significance level is different in the case of university-industry collaboration and financial development. However, there are at least two estimation techniques in which they have a significant impact. The sign of coefficients has not changed for all explanatory variables in all estimation techniques.

To enhance high-tech exports, it is imperative to foster innovation. Entrepreneurial efforts, as highlighted by Schumpeter (1942), play a pivotal role in driving innovation. They can achieve this by augmenting research and development (R&D) expenditure and offering tax credits to firms investing in R&D. Innovation directly correlates with increased production of high-tech products that are exportable.

To boost information accessibility, regions should expand access to television, phones, and the Internet and increase internet bandwidth. Information dissemination should not be restricted, with governments and societies safeguarding press freedom. Institutions also significantly contribute to high-tech product exports; thus, efforts to curb corruption and promote accountability are essential. Political stability ensures consistent economic policies while upholding the rule of law prevents exploitation, thereby enhancing productivity and export potential.

There is a need for further improvement in university-industry collaboration (UIC). This study demonstrates that the coefficient of UIC is higher than the other variables of this study, which indicates its importance for high-tech exports. Financial development can be enhanced by improving the depth, access, efficiency, and stability of financial systems. In this regard, account ownership, ATMs, no bank branches, and depositors should be increased. Central banks should facilitate the commercial banks to increase the number of borrowers who invest in high-tech businesses. Higher domestic credit to the private sector should also be increased to boost economic activities in a country, which would lead to an increase high high-tech exports.

This study provides comprehensive coverage across all countries and years, contingent upon data availability. However, it's important to note that results may vary for individual countries or specific groups (such as the EU). For countries with high-tech export data available before 2008, a longer period of analysis may be warranted. Additionally, numerous factors influence high-tech exports, and there's potential for incorporating additional variables or employing new estimation techniques.

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