Improving Tax Revenues in Iran's Provinces within the Framework of the Components of Knowledge-Based Economy

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ABSTRACT

A knowledge-based economy leads to a more efficient and dynamic national economy, contributing to the creation of more products, services, and innovation. Consequently, it brings about the outcomes of a stable economy, characterized by consistent and sustainable tax revenues. By focusing on innovation, advanced technologies, and specialized human capital, a knowledge-based economy plays a crucial role in improving the economic structure of the country. A knowledge-based economy is one in which the production, distribution, and application of knowledge are the main drivers of economic growth, wealth creation, wealth distribution, and job creation in all industrial sectors. The purpose of this research study is to investigate the impact of the knowledge-based economy on tax revenues in Iranian provinces. From the perspective of its purpose, this study is an applied study, and in terms of methodology, it is a panel data study, which has been conducted econometrically using the FMOLS panel data method. The findings indicated a positive and significant relationship between the components of the knowledge-based economy and tax revenues. As the components of the knowledge-based economy increase in Iranian provinces, tax revenues also rise. Furthermore, the model estimation, with the inclusion of auxiliary variables, showed that inflation rate, Gross Domestic Product (GDP), and government expenditures have a positive and significant impact on tax revenues, while the unemployment rate affects tax revenues negatively and significantly. Therefore, regional policymakers should prioritize enhancing human skills, expanding knowledge-based institutions, promoting innovative and creative centers, and developing technological infrastructure to increase tax revenues.

KEYWORDS

Information and Communication Technology, Innovation, Knowledge-Based Economy, Least Squares Method, Tax Revenues.

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Introduction

In today's world, national economies are undergoing profound and fundamental changes. The nature of production, trade, employment, and work will be vastly different in the coming decades. Previously, in the economy, natural resources were considered as the primary assets; however, in a knowledge-based economy, the production and utilization of knowledge play a major role in wealth creation, and the pace of change is extremely rapid. The new economy represents those aspects or sectors of an economy that are producing or employing new innovations and technologies to achieve long-term and sustainable growth (Sadeghi & Azarbaijani, 2006).

According to the definition provided by the Organisation for Economic Co-operation and Development (OECD), a knowledge-based economy is an economy that is shaped by the production, distribution, and application of knowledge and information. It is an economy in which investment in knowledge and knowledge-based industries receives special attention.

Many countries have concluded that a central strategy for achieving long-term and sustainable economic growth is to rely on the export of knowledge-based products and to embrace a knowledge-based economy. A knowledge-based economy is one where the creation and application of knowledge play a dominant role in wealth creation and drive economic growth and progress. Regarding tax revenue, it can be argued that taxation emerged simultaneously with the formation of the first human societies. A social economy, to fulfill its duties, resorts to tools referred to as institutions; one of these institutions is the government (Hadgoorpour, 2000).

Government revenue is broadly categorized into tax revenue and non-tax revenue. In many economies, tax revenue plays a far more significant role compared to other revenue sources, significantly mitigating the adverse economic effects compared to other revenue sources. Therefore, establishing a well-organized and systematic tax system creates a suitable environment for implementing various programs. These programs are usually planned within the framework of economic development plans, and economic goals must be predicted for their realization (Soltani & Porghafar Dastjerdi, 2013).

The tax system of each country plays a fundamental role in providing the financial resources for the government and the fair distribution of wealth. However, this system faces numerous obstacles and challenges that can reduce its efficiency. The most important obstacles are tax evasion, inefficiency in tax collection, complexity of tax laws, lack of transparency, and administrative corruption. The lack of effective government oversight leads to a decrease in tax revenues. Furthermore, inefficiency in tax collection, stemming from deficiencies in information systems and outdated technologies, can affect the overall performance of the tax system. The complexity of tax laws also causes confusion for taxpayers and increases compliance costs. In addition, administrative corruption and lack of transparency in the performance of tax officials reduce public trust in the tax system and lead to tax inefficiency (Khorshidi, 2024).

Therefore, examining the relationship between the knowledge-based economy and tax

revenues is of particular importance. Research in this area can help officials and policymakers develop and implement programs that lead to greater utilization of knowledge and increased tax revenues.

This research identifies and analyzes specific components that can influence provincial tax revenues, such as innovation, education, technology, and scientific collaborations. Specifically, attention to these components can offer novel strategies for improving tax revenues that have not been addressed in previous research and can explore international experiences regarding the relationship between knowledge-based economies and tax revenues. By doing so, successful models can be examined and adapted to Iranian conditions, an often-overlooked issue in previous studies. Furthermore, it will contribute to a deeper understanding of the relationship between the knowledge-based economy and tax revenues in Iranian provinces, leading to the development of effective tax policies, particularly at the provincial level.

Since most economic studies related to the knowledge sector have examined only one or a few aspects, this paper aims to investigate the relationship between the components of the knowledge-based economy and tax revenues in Iranian provinces. In this regard, statistical data will be used to measure the knowledge-based economy and tax revenues. The research question is whether the components of the knowledge-based economy lead to increased tax revenues in Iranian provinces. This study tests the hypothesis that the knowledge-based economy and its components have a significant effect on tax revenues.

Literature Review

The Concept and Evolution of the Knowledge-Based Economy

The term "knowledge-based economy" was first coined by the Organization for Economic Co-operation and Development (OECD) and defined as economies based on the production, distribution, and use of knowledge and information. The knowledge-based economy emerged from a newly developing economic structure resulting from a major transformation and revolution based on knowledge and innovation. It has entered the economic sphere as a primary factor in generating welfare and serving as the engine of economic growth in knowledge-based societies, driving development. The United Kingdom was the first country to embrace this concept, followed by countries such as Canada, Australia, South Korea, China, Lithuania, Romania, Finland, Armenia, Scotland, New Zealand, Thailand, and others, which independently or with the assistance of international organizations, declared their readiness to adopt this economic model (Shaghaghi Shahri & Alizadeh, 2016).

A knowledge-based economy is the economic satationarygement of human capital, encompassing the education of all individuals in a society at the macro level and the training of the workforce in organizations and economic enterprises, at the micro level (Ghorbani, 2015). In a knowledge-based economy, knowledge is the primary driver and catalyst for wealth creation, economic growth, and employment across all sectors. Based on this definition, a knowledge-based economy is not solely dependent on a few industries

relying on highly advanced technology; rather, all economic activities in this type of economy are, in some way, reliant on knowledge (Vahidi, 2002).

Dimensions of a Knowledge-Based Economy

To better understand a knowledge-based economy, it is necessary to identify broader knowledge dimensions that can meet the new knowledge needs of societies (Monavarian et al., 2007). Based on this, a knowledge-based economy is categorized into four main pillars, encompassing the development and effective application of knowledge. This section briefly examines the fundamental dimensions of a knowledge-based economy (Behboudi et al., 2015).

1. Trained and Specialized Workforce:

For the creation, acquisition, dissemination, and utilization of knowledge, a trained and specialized workforce is essential. Individuals with the necessary training can improve production factors and increase productivity, thereby promoting economic growth. Training can effectively identify the needs of organizations and the economy to perform their processes and adapt new technologies to domestic demands (Chen & Dahlman, 2004).

2. Innovation and Invention System:

Economic theories suggest that technological progress is a fundamental source of growth in productivity, and an efficient innovation system is key factor in technological development (Pilat & Lee, 2001).

A networked innovation framework refers to a set of institutions, regulations, and procedures that countries require to achieve the goals of acquiring, disseminating, and utilizing knowledge. Institutions within this innovation system include universities, public and private research centers, and policy-making bodies. These institutions engage in knowledge creation and development, its transfer, and policy measures through collaboration and interaction (Adams, 1990).

3. Appropriate Information and Communication Infrastructure:

The World Bank, as an international organization, defines information and communication technology (ICT) as a set of elements including hardware, software, networks, and media. These elements are used to categorize, store, process, transmit, and present information in text, audio, and visual formats via telephone, radio, television, and the Internet (World Bank, 2003). ICT, as the backbone of a knowledge-based economy, possesses many characteristics, including increased communication flow, reduced costs, decreased uncertainty in transactions due to rapid access to information, overcoming geographical limitations and increased competitiveness (Oliner & Sichel, 2000).

4. Institutional Regime and Economic Incentives:

The final pillar of a knowledge-based economy is the institutional structure and economic incentives operating on the basis of knowledge, innovation, and technology. In this economic system, price fluctuations are minimized, and global trade is free. Domestic

industries must compete in this system without the need for protective regulations, and this competition stimulates entrepreneurship in the domestic economy. Government spending and budgets are controlled, and the financial system is capable of allocating resources to sound investments (Chen & Dalman, 2004).

Key indicators include education, human capital skills, information infrastructure, innovation systems, and the economic and institutional regime. Sub-indicators include adult literacy rates, telephone lines per 1000 people, patent filings, tariff and non-tariff barriers, postgraduate enrollment rates, computers per 1000 people, technological papers per million, regulatory quality, higher rates of education enrollment, Internet use per 1000 people, the number of science and technology researchers, and the role of regulations (World Bank, 2003).

Tax Revenues

In macroeconomics, taxation is recognized as a crucial tool for government economic policy. Since the formation of the first human societies, taxes have served as a source of income for rulers. The economic system of any society includes institutions such as households, firms, and the government. The government needs revenue to implement collective governance and provide public services, and its largest source of revenue is taxation (Ghadiri et al., 2014).

With the expansion of government responsibilities in recent times and the pursuit of goals such as economic growth, employment, and equitable income distribution, economic issues and challenges have significantly increased. These changes have led to increased complexity in economic satationarygement and created a need for new strategies and policies for the government (Soltani & Porghafar Dastjerdi, 2013).

Under various economic conditions, taxes can be used as an effective tool to guide the economy in the desired direction. During inflation, increasing income taxes can reduce the individuals' disposable income, thus decreasing household consumption, lowering prices, and easing inflationary pressure. Conversely, during a recession, reducing income taxes can increase consumption and demand, leading to higher prices (Rashti, 2001).

The Impact of the Components of Knowledge-based Economy on Tax Revenues

To increase the share of the tax revenues in income sources, it is necessary to reform the revenue system and design a tax system suitable for improving and upgrading the institutions of the knowledge-based economy, new technologies, and advanced infrastructure. As a result, the possibility of tax evasion will be reduced, and on the other hand, with the improvement of the inputs of the knowledge-based economy, the executive costs of the tax system will be reduced. Furthermore, with the realization of a knowledge-based economy, economic activities and consequently tax bases will increase, because with the improvement and upgrading of the components of the knowledge-based economy, we will face innovations and an increase in knowledge-based products and services. As a result, the government tax revenues will increase (Shahabadi et al., 2022).

In the last two decades of the 20th century, economic theorists such as Roemer,

McLuhan, and Drucker predicted the emergence of a new economic era. In this era, knowledge is recognized as the primary source of wealth and is considered as the main factor in economic production. In the so-called knowledge age, the importance of knowledge in wealth creation and economy is very high. Knowledge, as a superior resource, plays a significant role in achieving the economic growth and progress (Azimi & Barkhordari, 2008).

The Impact of Inflation Rate, Government Expenditure, Gross Domestic Product, and Unemployment Rate on Tax Revenues

Inflation is one of the factors affecting taxes. As inflation increases, due to rising inflationary expectations, price transmission becomes easier, and the acceptance of taxes, as it leads to increased final consumer prices, results in increased tax revenues. With increased inflation in the economy, the prices of traded goods and services increase, and through this, the value-added tax received from the exchange of goods and services increases. Consequently, tax revenues also increase. To examine the effect of inflation on tax revenues, the effect of inflation on the final profit in economic activities must be considered to ultimately judge the effect of inflation on taxes. Therefore, the ultimate impact of inflation on the amount of tax revenue depends on the overall elasticity of tax revenue to inflation (Totonchi Maleki et al., 2020).

Based on the causal relationship between expenditure and taxes, the revenue response relative to the previous year is established. The government first spends and then decides how to finance these expenditures, if necessary, through increased taxes. This relationship suggests that the government budgets and forecasts its future tax liabilities based on the current government's borrowing. Therefore, an increase in government expenditure leads to an increase in taxes (Rezaei & Shahidi, 2015).

In national accounts, Gross Domestic Product (GDP) can be considered as a flow of income or output. This relationship shows the connection between tax revenue and Gross National Product (GNP). The composition of national production, including the agricultural, service, and industrial sectors' shares of the economy, can influence the level of tax revenue. Industry is recognized as the engine of economic growth and capital accumulation. With its dual characteristics of job creation and income generation throughout the economic cycle during the development process, the industrial sector leads to increasing per capita income. As the value added by the industrial sector increases, followed by increases in employment and per capita income, tax evasion decreases, and tax collection increases. Furthermore, the impact of taxation on agricultural sector is indirect; it occurs through the payment of taxes on consumed goods and services, leading to increased government tax revenue (Totonchi Maleki et al., 2020).

Generally, unemployment can negatively impact government tax revenues because individuals have lower incomes and therefore do not pay as much wage tax. Increased unemployment leads to a decrease in consumer spending, as unemployed individuals consume less, which can further reduce tax revenues. The tax system in the Iranian economy is not designed based on the full production capacity. Therefore, even with a

decrease in economic capacity, tax revenue may increase. This is due to the identification of new tax bases. Secondly, unemployment statistics in the Iranian economy are not accurate, and individuals employed in the service sector may be considered unemployed while having high incomes. Therefore, these inaccuracies in unemployment estimates are a major reason for the lack of a significant impact of unemployment on taxation (Alizadeh et al., 2023).

Research Background

Domestic Background

In a reseach study, Siahpoush (2023) concluded that human capital, through innovation, contributes to increased productivity, social participation and cohesion, entrepreneurship, and a belief in science and scientific insight, continuous and lifelong learning, and impacts good governance, leading to the realization of a knowledge-based economy in the country. Safardoost and colleagues (2022) conducted a research study and presented a model to examine the role of intellectual and social capital in the components of a knowledge-based economy in Iran. Their findings indicated that social and intellectual capital play a significant role in the knowledge-based economy, and that social capital can play a more effective role through the improvement and enhancement of intellectual capital. Ali-Nezhad and colleagues (2021) conducted a study and classified Iranian provinces based on regional knowledge-based economy indicators using the c-means and fuzzy k-means clustering algorithms. The findings showed a significant heterogeneity among the provinces in terms of knowledge-based economy; Tehran and Alborz were in a separate cluster and considered leading provinces, while more than half of the provinces were in the lowest cluster of the classification. Rahimi (2019) conducted a research study on measuring and prioritizing regional competitiveness in Iran based on the components of knowledge-based economy, finding that production, inventions, and the number of knowledge-based companies have a positive impact on regional competitiveness. An increase in ideas translated into production, inventions, knowledge-based companies, etc., leads to increased competitiveness. Ghaffary fard & Maleki Nasr (2021) investigated the impact of knowledge-based economy on the economic growth of Iranian provinces, demonstrating a significant, positive, and long-term impact of the composite knowledge-based economy index on economic growth. Raghfar (2018) researched the impact of knowledge economy components on entrepreneurship in selected countries. The results showed that in resource-based countries, the components of knowledge-based economy, except for information and communication technology, had a significant positive impact on entrepreneurship during the study period. In innovation-driven countries, all the components of knowledge-based economy had a significant positive effect on entrepreneurship. In another study, Kahraei (2018) examined the impact of knowledge-based economy companies and innovative startups in science and technology parks on regional economic growth in Iran. The results indicated a significant positive impact of the number of knowledge-based companies and their sales

on regional economic growth. Khodaverdi Zadeh et al. (2017) conducted a research study on the role of the knowledge-based economy in achieving the goals of the Resistance Economy, focusing on national production and employment as envisioned by the Supreme Leader. Their findings indicated that the indicators of knowledge-based economy have a positive impact on the country's Gross Domestic Product (GDP), a symbol of the Resistance Economy. Asnafi et al. (2015) investigated the role of university libraries in developing the knowledge-based economy within the branches of Islamic Azad University in Tehran. Their results showed that the components of knowledge creation, dissemination, and application were poorly implemented in these libraries. Therefore, university libraries play a minimal role in developing a knowledge-based economy. Mohaqeqi Kamal et al. (2013) estimated a composite social welfare index for Iran, evaluating economic welfare using several indicators. Their findings showed a decreasing trend in the index until the mid-point of the study period, followed by an increase. Based on this index, social welfare had both its best and worst performance during the study period. Dizaji et al. (2012) studied Iran's position in the knowledge-based economy among selected countries. Using Data Envelopment Analysis (DEA), they evaluated Iran's position against 40 other selected countries. Their results placed the United States first, China second, and Switzerland third. These countries, along with Norway, Singapore, Finland, and the United Kingdom, exhibited equal efficiency. Iran ranked as 29th with an efficiency score of 0.0946. Nazeman and Eslami-Far (2010) explored the relationship between knowledge-based economy and sustainable development. Their findings indicated a significant global correlation between economic development and the knowledge intensity of the economy. Another finding confirmed the overall validity of the Environmental Kuznets Curve (EKC) on a global scale.

Foreign Background

Saba and Monkam (2025), in a study on the role of Artificial Intelligence (AI) in enhancing tax revenue, institutional quality, and economic growth in selected BRICS-plus countries, concluded that there is a bidirectional causal relationship between tax revenue and AI, economic growth and institutional quality, as well as institutional quality and tax revenue. They emphasized that integrating AI into tax systems can promote both short- and long-term economic growth. However, they advised caution regarding the interaction between AI and institutional quality, which does not support economic growth, and highlighted the need for taking strong measures to mitigate potential negative effects of this interaction. Judijanto (2024), found that although there are initially promising signs, there is insufficient statistical evidence to confirm a significant effect of tax increase strategies on the tax revenue ratio within the studied sample. Similarly, the digital economy does not appear to have a significant impact on the tax revenue ratio. Furthermore, no significant moderating effect of the digital economy on the relationship between tax increase strategies and the tax revenue ratio was observed. Senawi et al. (2024) concluded that the process innovation mediates the relationship between both structural and relational performance of capital and property tax reassessment. This suggests that local

government policies indirectly influence reassessment through implementing new administrative and technological methods. Additionally, positive stakeholder relationships encourage staff to develop innovative ideas, enhancing reassessment outcomes. Ciucci (2024), in a study on the impact of education on tax evasion and the shadow economy, concluded that increasing the general level of higher education can reduce tax evasion and the size of the shadow economy, emphasizing a significant negative correlation between education and shadow economy. Elsayed (2023) found multiple benefits of using ontology in tax management, including cost reduction in tax advisory services, minimizing errors in tax calculations, and increasing tax revenues through enhanced transparency and accountability. The empirical analysis also confirmed a positive correlation between ontology-based knowledge management and improved accountability practices, as well as reduced tax risks.

Aparicio et al. (2023) identified seven thematic clusters of foundations of knowledge economics, knowledge economics satationarygement, knowledge-based work, knowledge production, knowledge-intensive environments, knowledge-based capitalism, and the reconceptualization of knowledge-driven economics, providing a general overview of this field. Ben Hassan (2024), in a study of Lebanon's competitive knowledge-based economy, concluded that the transition to a knowledge-based economy in Lebanon is influenced by two opposing factors: the education system and entrepreneurial culture on the one hand, and political instability on the other. In fact, the move towards a knowledge-based economy in Lebanon is supported by its highly skilled and multilingual human resources, a result of a reliable education system strengthened by a strong entrepreneurial spirit. However, several issues such as weak infrastructure, inefficient ICT and public institutions, and brain drain hinder the transition to a knowledge-based economy. Uyar et al. (2024) conducted an empirical analysis on a sample of 142 countries for the period 2006-2015 and found that the quality of general, mathematics, and satationarygement science education significantly reduces the tax evasion. Rim et al. (2019) examined the key indicators for determining the status of a knowledge-based economy and the statistical methods for its evaluation in their research. Polyakov et al. (2018) used the components of education, production technologies, science, information and communication technologies, and innovative businesses to assess the level of a knowledge-based economy during 2010-2014, aiming to cluster the selected countries using the k-means algorithm. Bakirci (2018) employed the components of a knowledge-based economy introduced by the World Bank and the innovation index to examine the status of the knowledge-based economy in Turkey. By introducing a new index, Delgado Marquez and Garcia Velasco (2017) clustered different European regions based on the weighted average of various knowledge-based economy indicators and the k-means algorithm. This composite index measures the access to specialized knowledge resources in a region, typically embedded in regional actors across Europe. Hsu et al. (2008) investigated the competitive policies for technological innovation in the knowledge-based economy era. The findings indicated a positive impact of competitive policies on

technological innovations. Tan and Hooy (2007), in their paper on the development of Southeast Asian countries towards a knowledge-based economy, used Data Envelopment Analysis to examine the performance of selected countries using both graphical and Data Envelopment Analysis methods. They assessed the knowledge gap and performance of the selected countries in their movement towards a knowledge-based economy.

Overall, while these studies offer substantial insights into the mechanisms underpinning KBE development and fiscal behavior, the ongoing challenges, such as political instability, inadequate infrastructure, and the need for tailored educational policies, demand further investigation and localized strategies to effectively leverage the potential of knowledge economies across diverse contexts.

This study, adopting a novel approach, examines the impact of the knowledge-based economy on tax revenues of Iranian provinces, presenting significant differences compared to the previous research. Through the use of a distinct methodology and multidimensional analysis, this research comprehensively investigates the effects of the knowledge-based economy at various provincial levels, facilitating the generalization of results to diverse geographical and economic locations. Furthermore, this study emphasizes specific components of the knowledge-based economy, such as innovation, information technology, and education. The practical findings of this study can assist policymakers in reforming and improving tax policies. Overall, by providing deeper and more practical analyses than the existing literature, this research offers added value to the field of the knowledge-based economy and its connection to tax revenues.

Methodology

This research is applied in terms of its objective and uses panel data in terms of its methodology. Panel data combines time-series and cross-sectional data, analyzing observations across several cross-sectional variables over a specific time period. This study identifies the impact of the components of knowledge-based economy on tax revenues in Iran's provinces using a composite index to achieve the desired results. The information, statistics, and data used in this research study, covering the years 2011-2019, were collected from the Statistical Center of Iran, statistical yearbooks, and the website of Ministry of Economy and Finance. The analysis employed the FMOLS (Fully Modified Ordinary Least Squares) panel econometric method, using the necessary tests in Eviews version 12.

The independent variables are the composite components of the knowledge-based economy, namely: the innovation system, information and communication technology (ICT), education, economic incentives, and the institutional regime. The dependent variable in this study is tax revenue in Iranian provinces. The control variables include Gross Domestic Product (GDP), government expenditure, unemployment rate, and inflation rate. These were incorporated into two models. The first model estimates the effect of the four components of the knowledge-based economy on tax revenue, while the second model estimates the effect of the composite components of the knowledge-based

economy (obtained using the Morris method) and the aforementioned control variables on tax revenue.

$$Yij = \left(\frac{Xij - XI\ min}{Ximax - Xi\ min}\right) * 100$$

In the first model, Iranian provincial tax revenues are influenced by the components of a knowledge-based economy including skilled and specialized workforce, innovation and invention systems, information and communication infrastructure, and the components of the economic incentives and institutional regime.

$$Tax\ Revenue = \alpha + \beta 1 Education + \beta 2 Innovation + \beta 3 Economic\ incentives + \beta 4 ICT + U$$

In the second model, Iranian provincial tax revenues are affected by inflation rate, Gross Domestic Product, government expenditure, unemployment rate, and a composite component of the knowledge-based economy.

$$Tax\ Revenue = \alpha + \beta 1 lGDP + \beta 2 lGCE + \beta 3 INF - \beta 4 NEM + \beta 5 lMOALIFA + U$$

Findings

This study has been examined using two models.

The First Model

In the first model, we examined the impact of the components of knowledge-based economy on tax revenues. Before model estimation, we conducted the Stationarity tests, followed by Hausman and Chow/Fisher tests.

The Stationarity Test

Given concerns about the stochastic processes and spurious regression of variables before estimation, the presence of unit roots in the variables is investigated. Therefore, before model estimation, to ensure that the results are not spurious and reliable, it is necessary to ensure the stationarity of the variables.

The stationarity test is primarily conducted to prevent spurious regressions. To avoid the spurious regression, the variables must be stationary. Otherwise, the differences of the variables, which are usually stationary, should be used.

Table 1.
The Stationarity Test of the First Model

Variable	Statistic	Prob	dynamic
Tax	8/66869	0.0000	Stationarity(2) I(1)
ICT	-6/94244	0.0000	Stationarity I(1)
Education	-30/5211	0.0000	Stationarity I(1)
Innovation	-5/66306	0.0000	Stationarity I(1)
E.incentives	-39/7658	0.0000	Stationarity I(1)

(Source: Researcher's Findings)

Chow's Test (F-Limer)

This test distinguishes between pooled OLS estimation and fixed effects estimation. If the

null hypothesis (H0) is confirmed in this test, it means the model should be estimated using pooled OLS regression; rejection of the null hypothesis indicates that a panel data approach is appropriate.

Table 2.
Chow's Test of the First Model

Effects Test	Statistic	D.f	Prob
Cross-section F	12/642780	30/180	0.0000
Cross-section Chi-Square	244/389585	30	0.0000

(Source: Researcher's Findings)

Given the table above, the test statistic is less than 5 percent. This indicates that the null hypothesis (H_0) is rejected, and the model estimation was performed using the fixed effects regression.

Hausman Test

The Hausman test can be used to distinguish between fixed-effects and random-effects models in panel data. Under the null hypothesis, the random-effects model is preferred due to the higher efficiency of its estimator. However, if the null hypothesis is rejected, the fixed-effects model is preferred.

Table 3.
Hausman Test of the First Model

Test Summary	Chi-S q. Statistic	C h-S q .d .f.	Prob
Cross-section random	58/869230	4	0.0000

(Source: Researcher's Findings)

Hausman test results indicated that the calculated statistic is smaller than the table statistic. Therefore, the null hypothesis (H_0) is rejected, and the model will be estimated using the fixed effects regression.

To estimate the relationship between tax revenues (dependent variable) and composite indicators of the knowledge-based economy (explanatory variables), the following model is presented. The results of this estimation for 31 provinces of the country during the years 2013-2019, using EViews software and the fully modified ordinary least squares (FMOLS) method, are presented in Table 4.

Table 4.
Summary of the First Model

Variables	Coefficient	Std. Error	t-Statistic	Prob
Inovation	0/033883	9/55E-15	3/55 E+12	0.0000
E.incentives	-0/005802	4/05E-15	-1/43E+12	0.0000
ICT	0/098611	3084 E-15	2/57 E+13	0.0000
Education	0/024426	9/34 E-15	2/20 E+14	0.0000
R2	0/99			

(Source: Researcher's Findings)

Based on the research results in Table 4, a one-unit increase in innovation leads to a 0.03-unit increase in tax revenues, as their relationship is positive and significant.

Incentives, however, have a negative and significant relationship with tax revenues; a one-unit increase in this variable results in a 0.00-unit decrease in tax revenues. The next variable, technology, has a positive and significant relationship with tax revenues, with a one-unit increase leading to a 0.09-unit increase in taxes. Finally, education also shows a positive and significant relationship with tax revenues; a one-unit increase in education and skilled labor results in a 0.02-unit increase in tax revenues.

The R-squared value in this model is 0.99, indicating that 99% of the variation in tax revenues across the country's provinces is explained by the variables in the model. This means the model has a high explanatory power.

The Second Model

In this model, in addition to the four components of a knowledge-based economy, other auxiliary indicators have been included, namely Gross Domestic Product, government expenditure, inflation rate, and unemployment rate. The impact of these variables on the dependent variable, tax revenue, was examined. As in the first model, stationarity tests, Chow test, and Hausman test were performed, which are discussed below.

Stationarity Test of the Second Model

Table 5.
Stationarity Test of the Second Model

Variable	Statistic	Prob	dynamic
Tax	-9/32788	0/0000	Stationarity I(1)
GDP	-18/7075	0/0000	Stationarity(2) I(1)
GCE	-36/1318	0/0000	Stationarity I(1)
INF	-9/88362	0/0000	Stationarity(2) I(1)
NEM	-13/0729	0/0000	Stationarity I(1)
MOALIFA	-32/9657	0/0000	Stationarity I(1)

(Source: Researcher's Findings)

Chow's Test of the Second Model

Table 6.
Chow's Test of the Second Model

Effects Test	Statistic	D.f	Prob
Cross-section F	6.261251	30/181	0.0000
Cross-section Chi-Square	154.473445	30	0.0000

(Source: Researcher's Findings)

Given a Chow test probability (prob) of less than 0.05, the null hypothesis (H0) is rejected, and a fixed-effects regression or panel data method is used.

Hausman Test of the Second Model

Table 7.
Hausman Test of the Second Model

Test Summary	Chi-S q. Statistic	C h-S q .d .f.	Prob
Cross-section random	14/731273	5	**0.0116**

(Source: Researcher's Findings)

The Hausman test results in Table 7 show that the calculated statistic is smaller than the critical value. This indicates that the null hypothesis (H_0) is rejected, and the model is estimated using the fixed effects regression.

Table 8.
Summary of the Second Model

Variable	Coefficient	Std.Error	t-Statistic	Prob
LGDP	0.576237	0.82176	7.012203	0.0000
LGCE	0.420994	0.029617	14.21447	0.0000
INF	0.014841	0.004519	3.283952	0.0012
NEM	-0.010627	0.004745	-2.239905	0.0264
LC.K B E	0.816013	0.134434	6.070002	0.0000
R2	0.67			

(Source: Researcher's Findings)

As shown in Table 8, a one percent change GDP leads to a 0.57 percent change in tax revenues; a one percent change in government spending leads to a 0.42 percent change in tax revenues; and a one percent change in inflation leads to a 0.014 percent change in tax revenues. The relationship between these variables and tax revenues is positive and significant.

Furthermore, a negative relationship exists between tax revenues and the unemployment rate. A one percent increase in the unemployment rate results in a 0.01 percent decrease in tax revenues. The combined components of the knowledge-based economy also have a positive relationship with tax revenues, such that a one percent change in this variable causes a 0.81 percent change in tax revenues.

The R-squared value in the above model is 0.67, indicating that the model has acceptable explanatory power.

Discussion and Conclusion

This study made an attempt to explain the effect of the combined indicators of a knowledge-based economy on tax revenues. Using the statistical data of twelve components of the knowledge-based economy, combined using the Morris method, and data of explanatory variables used in the model specified in this research during the years 2013-2019, a panel data approach with the Fully Modified Ordinary Least Squares (FMOLS) method was employed.

Based on the research results, a one-unit increase in innovation led to a 0.03-unit increase in tax revenues, as their relationship was positive and significant. Incentives, however, had a negative and significant relationship with tax revenues; a one-unit increase in this variable resulted in a 0.005-unit decrease in tax revenues. The next variable, technology, had a positive and significant relationship with tax revenues, with a one-unit increase leading to a 0.09-unit increase in taxes. Finally, education also showed a positive and significant relationship with tax revenues; a one-unit increase in education and skilled labor resulted in a 0.02-unit increase in tax revenues.

The R-squared value in this model was 0.99, indicating that 99% of the variation in tax

revenues across the country's provinces was explained by the variables in the model. This means the model has a high explanatory power.

By incorporating auxiliary variables such as the unemployment rate, inflation rate, GDP, and government expenditure, a positive and significant relationship between tax revenues and inflation rate, GDP, and government expenditure was established. A negative and significant relationship between tax revenues and the unemployment rate was also evident.

This aligns with Uyar et al. (2024), who also found that the quality of education correlated negatively with tax evasion, supporting the idea that improved education can enhance fiscal compliance. Moreover, the positive relationship between inflation, GDP, and government expenditure with tax revenues echoes Marcel et al., who highlighted the macroeconomic impacts of these factors in Indonesia, as well as Iriqat and Anabtawi (2016), who reported similar findings for Palestine. In contrast, the negative correlation between incentives and tax revenues in this research suggests that poorly designed tax incentives may lead to reduced revenues, a perspective that warrants further investigation. Furthermore, while the literature, including Ben Hassan (2023), emphasizes the dual influences of education and political stability in transitioning to a knowledge-based economy, this research contributes to the quantitative assessment of how specific knowledge economy components impact tax revenues, thereby enriching the body of knowledge and offering a nuanced understanding of how various factors converge to shape tax policy and economic outcomes. Overall, this study underscores the importance of investing in education and innovation while reconsidering tax incentive structures to optimize tax revenue generation within a knowledge-based economic framework.

Based on the vital role of the knowledge-based economy in advancing political and economic goals, governments have prioritized creating job opportunities and increasing tax revenues through the expansion of research institutes, research and technology centers, and the encouragement and support of innovation systems. They have designed the necessary mechanisms and frameworks to develop the infrastructure related to the pillars and components of the knowledge-based economy and created the necessary incentives. According to the research model's output, the following suggestions, considering the research topic, can be used to improve the knowledge-based economy by enhancing its four dimensions of economic and institutional regime, education, innovation, and information and communication technology (ICT).

1. Strengthening Education and Human Resources

To cultivate a skilled workforce essential for contributing to the knowledge-based economy, it is critical to enhance the quality of scientific education. This can be achieved by revising curricula to emphasize critical thinking, problem-solving, and creativity, thereby preparing students to meet the market demands effectively. Additionally, promoting lifelong learning initiatives through continuous education and vocational training programs that align with industry needs will enhance workforce adaptability and

productivity. Expanding STEM education and career pathways by increasing scholarships and mentorship opportunities in science, technology, engineering, and mathematics (STEM) disciplines will further build a pipeline of skilled talents.

2. Reforming the Innovation System

To develop a robust innovation ecosystem, policymakers should implement structural reforms to support Research and Development (R&D). This includes providing tangible incentives, such as grants and tax relief, for both public and private sector investments in R&D. It is also essential to revise the laws of intellectual property rights to strengthen the intellectual property framework, encouraging innovation and protecting the interests of inventors to enhance competitiveness. Furthermore, fostering public-private partnerships will create collaborative programs between universities and industry, facilitating the knowledge transfer and commercialization of research.

3. Enhancing Information and Communication Technology (ICT) Infrastructure

A comprehensive ICT infrastructure is vital for knowledge dissemination and economic growth. Recommendations include developing comprehensive e-governance systems that implement electronic tax registration and payment systems to streamline tax compliance, thereby improving efficiency, transparency, and taxpayer utilization. Investing in broadband connectivity, particularly in underserved rural areas, will ensure that all citizens and businesses can participate in the digital economy and benefit from industry innovation. Encouraging technology transfer from academic institutions by promoting universities as hubs for technology transfer and entrepreneurship, disseminating research outcomes through dedicated technology transfer offices and innovation incubators, is also critical.

4. Improving Economic and Institutional Frameworks

Creating a conducive environment for tax revenue growth requires focused efforts to establish a stable legal and regulatory environment. Clear, consistent, and enforceable regulations are necessary to safeguard businesses and promote fair competition. To combat corruption and build trust, robust measures should be implemented to reduce corruption and enhance governance, thus boosting investor confidence and ensuring an equitable economic environment. Policymakers should exercise prudence in the formulation of tax policies, carefully considering the potential effects of tax base expansion on economic activity. This includes conducting regular assessments of the tax system to identify inefficiencies and potential areas for growth that do not negatively impact the economy. Engaging stakeholders in tax policy discussions, including business leaders and economic experts, will ensure that the proposed tax measures foster growth without inadvertently triggering economic slowdowns.

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