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THE IMPACT OF TECHNOLOGICAL ADVANCEMENT ON THE INDUSTRIAL SECTOR PRODUCTIVITY: SOLOW MODEL APPROACH

SHATHA YOUSEF ABDEL KHALEQ

Al-Zaytoonah University of Jordan. Email: shatha@zuj.edu.jo

RUBA NIMER ABU SHIHAB

Al-Balqa Applied University. Corresponding Author Email: rubaabushhab@bau.edu.jom

AHMAD YOUSEF KALBOUNEH

Al-Balqa Applied University. Email: Ahmad.Kalbounh @bau.edu.jom

Abstract

This paper aims to analyze the impact of human capital on the Jordanian industrial sector productivity. For the objectives of analysis, the researcher will use time series data for the Jordanian industrial sector. Accordingly the researcher will analyze two kinds of mathematical and econometrics functions. The mathematical model for measuring the total productivity will be used through CobbDouglas Function, and then the previously accounted productivity will be used and replaced in the econometrics model used in the estimation. This study depends on Solow Model. The study had shown that the variables of human capital and inflation had achieved a statistical significance of less than 1%, as the increase in the number of employees with basic education by 10% led to a rise in total productivity growth with 0.07, this was in line with the economic theory which assumed that there was a direct relationship between human capital and total productivity in the industrial sector. In addition, the estimation results had shown that there was a direct relationship between the financial development index and total productivity in the industrial sector, as the high level of the financial sector contributed to providing credit facilities to the industrial sector with an increase in the total productivity in this sector.

Keywords: Productivity, Solow Model, Industrial Sector, Technological Advancement, Jordan

1. INTRODUCTION

The great evolution in technology and knowledge in the world had a significant role in the transformation from the traditional economy to the knowledge-based economy, in which the human capital forms the major component, as the human capital has become one of the most important assets for the organization which can influence its competitiveness and generally the economic competitiveness. By tracking the modern economic literature, we can notice the interests of the countries generally and organizations particularly in their well-trained and competent human capital to possess not only the competitive advantage (in the local market firstly, and the global market lastly) but also preserve it in the age of rapid evolution in the knowledge field.

Human capital is one of the most important themes which attract the attention of decision-makers who manage different organizations, especially amidst the quality shift towards a knowledge-based economy, where the human element has become one of the most important

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components of production in modern economies. The origin of the term "Human Capital" dates back to the economist Schultz in 1961, who was the first to create this term. He proved that the return on investment through training and education was greater than investment in physical assets. We should also note that the investment in human capital was first developed as an idea by Adam Smith in his book, "The Wealth of Nations", through which he demonstrated the differences in labour and the variance in return based on differences in training and education levels (Baron and Armstrong, 2007).

Human capital has become the basis for the advancement of societies, provided that this capital possesses the needed qualifications with a high level of culture, education and training. The interest was focused on human resources after the experiences confirmed that the first motive for the success or failure of the organizations was the good administration of human resources. This resource wasn't lower in value than the physical capital, but rather it is viewed as one of the most important themes to be discussed in the developed societies, where spending has increased more than ever on this resource believing that it is the highest and the most significant type of investment. Jordan seeks to be transformed into a knowledge-based economy. Accordingly, this study highlights the importance of human capital, especially in business contexts through studying the effect of human capital on the productivity of the Jordanian industrial sector.

The question which comes to our minds is: Why was the total factor productivity selected as an objective?

It is clear that organizational productivity affects the competitiveness within the country and consequently the competitiveness of the country at the international level. Therefore, this study examines the relationship between human capital and total factors productivity in the Jordanian industrial sector which plays an important role in the economy and provides the organizational decision-makers with the necessary indicators for decision making to increase competitiveness. The 1960s decade in the last century witnessed a great expansion in the industrialization movement in varied developing countries to achieve economic autonomy after their political autonomy and get rid of dependence on foreign countries through developing their national resources to improve the living standards of their peoples. The significant role of the industry in economic and social development has become obvious for many economists and politicians in the developing world. This leads to a call for the industrial sector to receive priority attention to become a leading sector as it is the basic driver of the growth and the core of the economic development process. The reports indicated that the size of the Jordanian industrial sector and its role in the economic development was very low before 1948 because there was less attention to this sector as a result of the small size of the local market, lack of economic studies and geological survey, low standard of living, unavailability of the necessary funding for investment, and lack of the electrical energy,... Etc. The interest in this sector had begun only in the early 1950s. Positive circumstances had emerged for the development of the sector including the migration of some trained competencies and experiences from the West Bank to the Jordan River and the flow of some capitals as a result of the issuance of the Investment Promotion Law in 1955. The total industrial production reached 7.2 million dinars in 1954 and

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increased to 11.6 million dinars in 1959. In addition, the number of employees increased to 23068 employees in 6887 manufacturing organizations (Al-Dabbas, 2010). The growth and expansion of the Jordanian industrial sector continued as a result of the concern of the government from one side and the concern of the private sector from another side. The total industrial production was about (16.678) million dinars in 2017, the total added value was (7.582) million dinars and the number of industrial organizations and services was about (95) thousand organizations with about 160 thousand employees (Department of Statistics, various issues). The industrial sector, which involves the extractive industries, electricity, and manufacturing industry, was one of the most important economic sectors as it was the major criterion and the critical indicator for the growth of countries. In addition, it was the stimulator of growth and the core of the economic development process as it was the main motivator of the increased growth in national income and the main axis of the economic development process through its contribution to the productive structure development in the national economy (United Nation, 1955). Accordingly, this study highlights the effect of human capital on the productivity of the Jordanian Industrial Sector.

2. STUDY LITERATURE

The 21st century has witnessed critical changes including knowledge and information revolution in different economic and administrative areas which has led to the transformation from the economy based traditional production elements such as (labour, capital, land, and organization) to the knowledge economy based on innovation, research and development, information and communication technology, and well-trained and competent workforces known as human capital. Human capital is the main basis in the knowledge economy framework because of its significant role in achieving the competitive advantage of the organization and the total economy through increasing the economic development rates. Thus, the economists considered this theme through their theories concerning economic development. The neoclassical theory in the productivity of production elements was one of the most important theories in this area. The model used in this study was the Solow Model which was one of the most important models of the neoclassical theory related to economic development in which the total production relied on capital, labour, and technology. Technology, in these models, was a variable that was determined outside the economic model. One of the most notable findings of the research based on the neoclassical theory was that the high levels of economic growth weren't necessarily due to a growth in the physical capital stock, on the contrary, technological change is the basic stimulator of production development and the main driver for raising the standard of living for the society members (Sredojevic et al, 2016). The follower of the different studies that addressed economic development can conclude that the majority of these studies tried to respond to an important question related to economic development: how can we use the available elements of production to achieve a long-term sustainable expansion in the average per capita of the gross domestic product, as the efficiency of effective elements of production contributes significantly to maximizing the economic development (Sredojevic, 2016). The neoclassical economists were the first to respond to the previous question; as researchers found out that technological changes were the basic

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stimulators of economic development, on the other hand, they failed to show how these technological changes can be demonstrated. We have previously shown that this study relied on Solow Model for economic development, which was one of the most important models of the neoclassical theory. Solow Model, which assumed the constancy of the returns to scale, didn't directly deal with total product and physical capital in explaining the economic development. Alternatively, it dealt with the average per capita of the product and physical capital as economic signals (Romer, 2012).

This model was one of the most famous models of the neo-classical school, which was developed by Solow and Swan in 1956.

This model depended on Cobb-Douglas Production Function with the constancy of the returns to scale (Romer, 2012).

$$Y_t = F(K_t, A_t L_t)$$

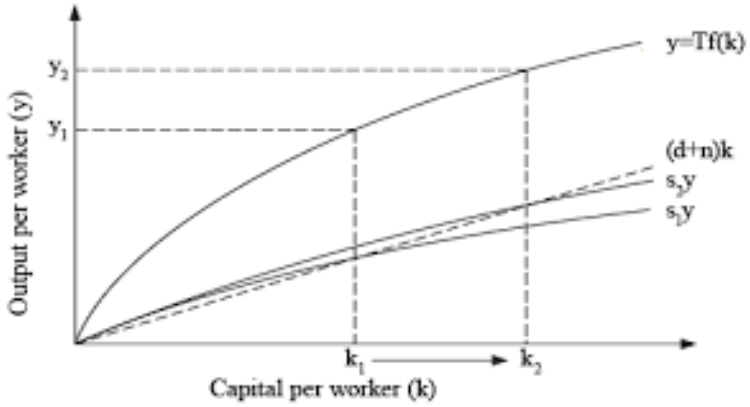
Y represents the total product, K represents the physical capital stock, L represents the labour, A represents the technology, and t represents the time.

With the definition of k= (K/AL) and y= (Y/AL) and the hypothesis that)α(represents the production flexibility to the capital, (n) represents the labour growth, (g) represents the technological evolution, (d) represents the capital amortization rate, (s) represents the saving rate. Accordingly, the basic Solow model can be written as follows:

$$dk/dt = \dot{k} = s\,k^{a} - (n+g+d)\,k$$

As dk/dt or k represents the rate of individual capital growth.

Figure No 1: Solow Model in growth (Romer, 2012)



The balanced development path in Solow Model suggested that k approached the stable status of the individual capital and k* represented the stable status because if the economy achieved this grade of capital, it rested on it. In addition, k will grow at the rate (n+g). According to the hypothesis of the constancy of returns to scale, K will grow at the rate (n+g). As included in Solow Model, y will grow at the rate g. Regardless of the starting point, the economy will eventually move towards a steady-state and then the only factor that determines the stable level

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of individual production is g. According to Solow, technological progress is the main stimulator of economic growth (Romer, 2012).

For the Solow residuals, they refer to the procedures related to the growth calculations in the Solow model. The growth calculations refer to the use of the non-standard production function model to analyze the components of growth. By applying the growth calculations to the Solow model, we find out that:

$$Y= F (K, AL) = \mathbf{K^{\propto} AL^{(1-\propto)}}$$

When we take the natural logarithm of both sides, we find out that:

$$Ln(y) =\alpha Ln (k)+(1-\alpha) Ln (A) +(1-\alpha) Ln(L)$$

By subtracting Ln (L) from both sides:

$$Ln(Y)-Ln (L) =\alpha (Ln K-LnL) +R$$

Or

$$Ln(Y/L) =\alpha Ln (K/L) +R$$

Where R or (1- α) Ln(A) refers to Solow residuals that reflect all sources of economic growth except L.K, where Solow refers to A as knowledge, efficient labour, or what is called labour productivity.

Al Harazin et al, (2016) sought to identify the reality of the transformational industry in Palestine and determine the most important factors affecting labour productivity and wages in this sector during the period 1994-2012 through the use of modern statistical and measurement methods. The results showed that there was a positive relationship between average productivity and each of the worker's average share of investment in the manufacturing industry, and the average worker's share of compensation in that sector. It was found out that there was a negative relationship between the average productivity and credit facility balances granted to the transformational industries. The statistical results indicated that there was a positive relationship between average productivity and workers' compensations in the Palestinian manufacturing industry sector and a negative relationship between workers' compensations in that industry and inflation. There was a positive relationship between the labour component and the compensation of workers in the manufacturing industry. Time variable in addition to political and economic instability variable had clear impacts on both labour productivity and wages in the manufacturing industry.

Al-Bishtawi (2014) analyzed the impact of intellectual capital on improving the profitability of Jordanian pharmaceutical companies, where a sample of 11 pharmaceutical companies was selected using the stratified sampling method. The results revealed that intellectual capital had a significant and effective role in improving the profitability of Jordanian pharmaceutical companies. One of the most important recommendations of the study is the need to invest money in intellectual capital to obtain knowledge resources and to develop a plan and preserve intellectual capital through providing financial and moral stimulus programs, setting the

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appropriate atmosphere, and attracting expertise, skills, and competencies. Abdel Moneim (2009) researched the concept of intellectual capital and its impact on raising the efficiency of Jordanian industrial businesses through a case study of the ready-made garments company as a model for Jordanian industrial companies and as a leading company in the ready-made garments industry as a result of its acquisition of the franchise of an internationally known German brand. The case study represents the practical aspect of the research; it was conducted by direct interviews with a sample of the company's board members, owners, and the financial manager. The findings revealed that there was ambiguity in the concept and significance of intellectual capital in the Jordanian ready-made garments Company and confusion between this concept and intellectual property concept. In addition, there was a lack of clarity of the impact of this concept on the efficiency of the company and its market value, as well as an absence of perception of how to measure and disclose it in the financial statements. The study emphasized the importance of intellectual capital in influencing the efficiency and value of the researched company. It also indicated that its officials did not realize its superior economic significance about efficiency, value, growth and ways to benefit from it.

Kok (2007) tried to clarify the importance of intellectual capital for higher education at the University of South Africa. The researcher explained the importance of intellectual capital management owned by the university and presented a set of intellectual capital management models and methods for measuring intellectual capital in higher education institutions. The study confirmed the importance of intellectual capital management in educational institutions, and it provided a model for intellectual capital management at the University of South Africa. This model had positive effects on identifying the university's strengths and weaknesses and providing recommendations regarding how to overcome areas of weaknesses. This model can be applied to other universities to develop several aspects of the university because of the good results it achieved at the university.

Boyce (2007) indicated that pharmaceutical companies in the United States of America must have a competitive advantage and work to maintain it, and this required them to implement an effective strategy that can exploit all the capabilities available to the company to meet future changing conditions. The study was applied to a selected group of pharmaceutical companies. The study showed that these companies can achieve the required competitive advantage that enabled them to face changing conditions through an optimal exploitation of the capabilities of the organization. The organization's strategic plan should include paying enough attention to the development and preservation of intellectual capital because of its capabilities that the organization can rely on in the future. In addition, the intellectual capital can be used to determine the organization's future strategic position. According with (Alnidawi et al, 2016), Pharmaceutical Industry Companies Sector in Jordan is a sector with great participation in the Jordanian Economy and despite that it faces high challenges on the local, regional and international level resulting from continuous progress in pharmaceutical industry area, therefore, these companies find itself in necessity of continuous development in order to keep up with intense competition in this sector. Al-Hawajrah (2005) studied the relationship between investment risk management in knowledge capital dimensions (learning development - institutionalization of knowledge, knowledge integration, and knowledge employment) and the

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four competitive advantages (profitability - total sales growth - performance rates - innovation and creativity) and their relationships with the dependent variable (competitive advantage). The study relied on descriptive and field analysis. The study population consisted of all managers working in Jordanian insurance organizations in senior management. The study revealed that there was a strong relationship between the independent variable with its dimensions and the four competitive advantages. There was a strong impact of investment risk management in knowledge capital on achieving competitive advantages in Jordanian insurance organizations. This study is characterized as one of the few studies applied in the field of business administration in addition to its use of the standard quantitative method for analysis.

3. STUDY METHODOLOGY AND HYPOTHESES

This paper aims to study the impact of human capital on the total productivity of the factors in the Jordanian industrial sector. The descriptive, mathematical, and econometrics methods will be used in the analysis process.

We will use time-series data for the Jordanian industry sector from 1994 to 2018. Two types of mathematical and econometrics functions will be used. The mathematical model will be used to calculate the total productivity through the Cobb-Douglas function, and then the productivity that was previously calculated will be used and replaced in the econometrics model used in the estimation; this study will depend on Solow model.

The study is based on the following hypothesis:

There is no statistically significant effect of human capital on the total factor productivity in the Jordanian industrial sector.

4. STUDY MODEL AND VARIABLES

4.1 Measuring human capital in Jordan

The educational level, its primary and secondary levels, is one of the most important indicators used in measuring human capital. The figure below shows the evolution of the percentage of workers with basic education out of the total number of workers in various industrial sectors during the study period.

It is noted that the majority of employment in the manufacturing sector has a basic education level, with an average of 50%. (Department of Statistics, various issues).

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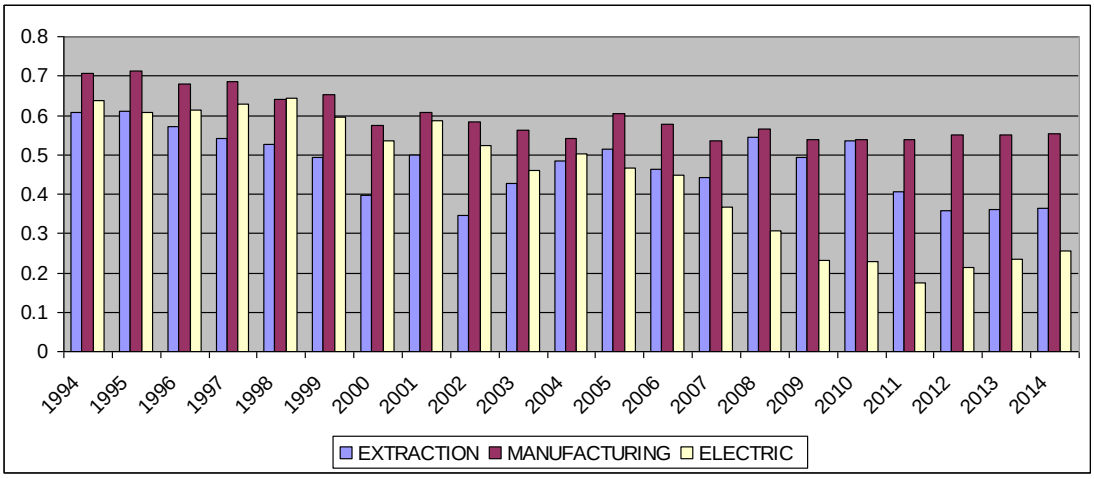
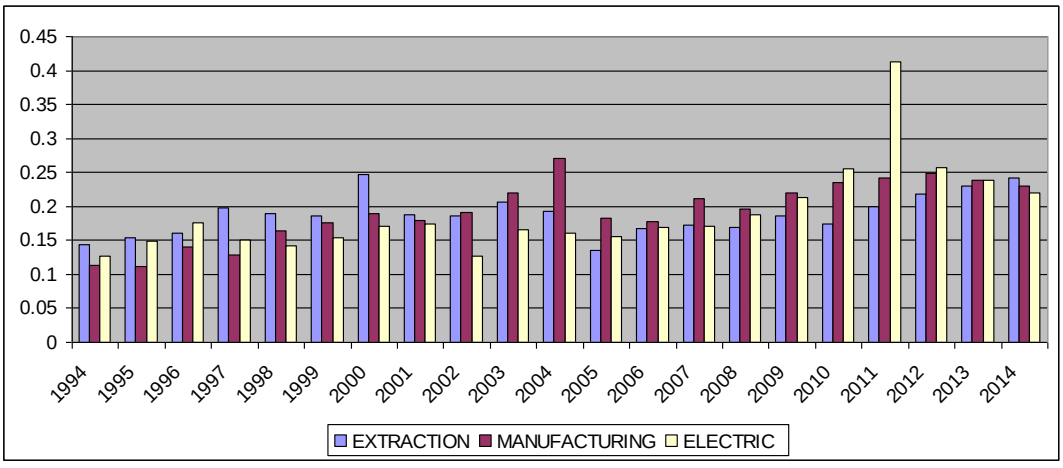
Figure No. (2) Percentage of workers with basic education in the industrial sector



On the other hand, the figure shows the evolution of the percentage of workers with secondary education out of the total number of workers in various industrial sectors during the study period; the electricity and water sector recorded the highest percentage of workers with secondary education, with an average of 18% of the number of workers in the sector (Department of Statistics, various issues).

Figure No. (3) Percentage of workers with secondary education in the industrial sector



4. 2 Mathematical model for measuring the total productivity of the industrial sector in Jordan

Cobb-Douglas function is one of the most widely used production functions in the application due to its ease of estimation. This function reflects the behaviour of the production process at the unit, sector or aggregate level, and depends in its analysis on only two factors: labour and capital according to the following formula:

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$$Y = AL^{\alpha}K^{\beta} \quad \ldots\ldots (1)$$

Where

Y: represents the value of production in the industrial sector.
L: represents the employment volume
K: represents the capital

To calculate the total productivity of the industrial sector, which means the quotient of the output divided by the value of the inputs, the following equation was used:

$$TFP = \frac{Y}{L^{\alpha}K^{\beta}} \quad \ldots\ldots (2)$$

The value of $\alpha = 0.36$ $\beta = 0.64$ was estimated based on (Hasan, 2017). The table below shows the descriptive statistics data for the productivity of the industrial sector in its three sections (extractive, manufacturing and electrical sections) during the study period. The extractive industries sector achieved the highest productivity compared to other sectors, while the productivity in the electricity sector recorded negative values.

Table No. (1) Descriptive Statistics Indicators of Industrial Sector Productivity during the Period 1994-2018

	Extraction	Manufacturing	Electric
Mean	804.2408	453.9001905	17.6688619
Standard Error	106.0381	31.45161178	68.92254906
Median	596.434	380.3515	136.1366
Standard Deviation	485.9277	144.1293917	315.8427982
Kurtosis	-0.24509	-1.439413476	0.946502717
Skewness	0.943474	0.589740538	-1.616317535
Range	1608.998	408.9564	1000.6615
Minimum	287.0151	296.3924	-678.448
Maximum	1896.013	705.3488	322.2135
Count	21	21	21

4.3 Econometrics Model and Variables

Several models were used in the studies that dealt with analyzing the relationship between human capital and total productivity. This study used a model of one dependent variable that represents the total productivity of the industrial sector in addition to a set of independent variables in the following formula:

$$TFP=B_0+B_1HC+B_2FD+B_3\ IN+\ E\ldots..(3)$$

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Where

TFP: Total Factor Productivity
HC: Human Capital which is measured by the basic and secondary educational levels.
FD: Financial Development Index which is measured by the return on assets ratio
IN: Inflation
E: Random Error
B_0: Constant Coefficient
B_1, B_2, B_3: slope parameters

As for the variables' data, they are in their real value estimated by Jordanian dinar at constant prices for the year 2010. The statistics have been excerpted from the Department of Statistics during the period 1994-2015. The standard approach used in the study depends on analyzing the relationship estimated across the time series 1994-2015 to include 21 observations for each variable in the model.

4.3.1 Stationary Time Series

ADF (1999) Levin, Lin & Chu (2002), Pesaran& Shin (2003), and Hadri . All of these tests, except Hadri's test, assume the presence of a unit root in the data, meaning that it is not static as a null hypothesis, in contrast to the alternative hypothesis that there is no unit root, meaning that the data is stationary.

Table No. (2) Results of the Stationary Test at level (I(0))

Variable (levels)	Method			
	LLC	IPS	ADF	Hadri
TFP	1.7 (0.95)	1.05 (0.85)	3.3(0.76)	1.9 (0.92)
FD	-2 (0.02)	-1.6 (0.05)	13.5 (0.03)	15 (0.02)
P	-1.2 (0.12)	-0.4 (0.33)	7.2(0.3)	5.5 (0.5)
SC	-2.5 (0.00)	-1.2 (0.12)	8.9 (0.18)	8.4(0.21)
IN	NA	NA	1.7 (0.99)	NA

Table No. (3) Results of the Stationary Test at the first difference (I (1))

Variable (differences)	Method			
	LLC	IPS	ADF	Hadri
ΔTFP	-3.3 (0.00)	-5.5 (0.00)	36.5(0.00)	64.1 (0.00)
Δ FD	-8.5 (0.00)	-8.3 (0.00)	56 (0.00)	108 (0.23)
ΔP	-9.4 (0.00)	-8.2 (0.00)	53.9 (0.00)	55.2 (0.16)
ΔSC	-8.9 (0.00)	-7.5 (0.00)	.500 (0.00)	60.7 (0.00)
ΔIN	NA	NA	(0.00)-4.22	NA

When applying the LLC test at the level for these data, it was found that most of the variables are static, as the calculated values for the test were greater than the tabular values at the level of significance of 5%. In other words, we reject the null hypothesis that the variables suffer from the non-stationary problem, except for the ratio of private investment to GDP variable, which became a stationary variable after taking the first difference. Other tests showed that

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most of the variables were not stationary at the level except for the financial development index, where the variables became stationary after taking the first difference.

4.3.2 Co-integration test

From the statistical perspective, the existence of a co-integration relationship among the variables means the existence of a long-term equilibrium relationship among these variables. Accordingly, this set of variables is co-integrated.

The co-integration test is conducted after making sure that all the variables are stationary and complementary. Therefore, the model equation can be used directly in the co-integration test, where the stability of the error limit will be tested using the above equation, and if it is stable and of zero degree integration, then it is possible to obtain integrated errors of zero degrees, and the variables included in the model are integrated. Therefore, the data can be used directly without the results of the estimation.

Table No. (4) Co-integration Test Results

Pedroni Residual Cointegration Test				
Alternative hypothesis: common AR coefs. (within-dimension)				
			Weighted	
	Statistic	**Prob**	**Statistic**	**Prob**
Panel v-Statistic	-1.3	0.90	-1.6	0.94
Panel rho-Statistic	0.3	0.6	0.73	0.76
Panel PP-Statistic	-1.6	0.05	-1.5	0.06
Panel ADF-Statistic	-1.23	0.11	-1.95	0.02
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	**Prob**		
Group rho-Statistic	1.09	0.86		
Group PP-Statistic	-1.7	0.05		
Group ADF-Statistic	-1.9	0.11		

Pedroni has suggested seven tests for co-integration including four tests for co-integration to longitudinal data that are based on the within-dimension and three tests for co-integration for medium data as a group between dimensions. All tests are based on the hypothesis that there is no co-integration in the group of variables. The alternative hypothesis is that there is co-integration for all variables. If the tests indicate the refusal of the null hypothesis at the proper significance level, it can be concluded that there is co-integration among variables (Pedroni, 1999). While performing these tests, it was found that there is a co-integration between variables in the equation according to PP and ADF tests, where the calculated value was greater than the tabular one, thus the null hypothesis which stated that there is no co-integration between the variables at the level of significance 5% was rejected at the internal and inter-dimensional levels.

4.3.3 The results of the econometrics estimation of the model

To test the hypotheses of the study, the coefficients of the econometrics model were estimated

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by using the generalized least squares (GLS) method, which gives more weight to observations taken from communities with less variance (variance of random error values) than observations that come from communities with greater variance to overcome cross-sectional variance problem resulting from different economic characteristics among countries and thus obtain best linear unbiased prediction (BLUE) (Gujarati, 2003).

Table No. (5) Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SC?	-8.954046	1.338699	-6.688620	0.0000
P?	0.701429	0.263439	2.662591	0.0101
FD?	3.548570	1.926876	1.841618	0.0708
IN	0.016108	0.003332	4.834503	0.0000
R-squared	0.483839	Mean dependent var		0.005458
Adjusted R-squared	0.456188	S.D. dependent var		0.518013
S.E. of regression	0.382001	Akaike info criterion		0.977556
Sum squared resid	8.171805	Schwarz criterion		1.117179
Log likelihood	-25.32667	Hannan-Quinn criter.		1.032170
Durbin-Watson stat	2.210758			

Estimation was carried out using various methods of econometrics estimation, and the best estimates were adopted. The explanatory power of the model represented by R squared (R^2) was 48%. In other words, the variables in the model explain 48% of the changes that occur in the rate of total productivity growth in the industrial sector during the study period, and the Durbin–Watson statistic showed that there is no autocorrelation between the variables.

The human capital and inflation variables have achieved statistical significance of less than 1%, as the increase in the proportion of employees with basic education by 10% leads to a rise in total productivity growth by 0.07. This is consistent with the economic theory which states that there is a direct relationship between human capital and total productivity in the industrial sector. In addition, the results of the estimation showed that there was a direct relationship between the financial development index and the total productivity in the industrial sector, where the high level of the financial sector contributes to the provision of credit facilities to the industrial sector, which leads to an increase in the total productivity of the industrial sector.

RESULTS AND RECOMMENDATIONS

The human capital and inflation variables have achieved statistical significance of less than 1%, as the increase in the proportion of employees with basic education by 10% leads to a rise in total productivity growth estimated by 0.07. This is consistent with the economic theory which assumes that there is a direct relationship between human capital and total productivity in the industrial sector. The results of the estimation also showed that there is a positive relationship between the financial development index and the total productivity in the industrial sector, where the high level of the financial sector contributes to the provision of credit facilities for the industrial sector, which leads to an increase in the total productivity in the industrial

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sector. Based on the results mentioned above, the researcher recommended the need for states to pay more attention to encouraging the investment in the industrial sector and the necessity to follow policies at the aggregate or partial levels through administrations in different institutions to train and enhance the competency of the employees.

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