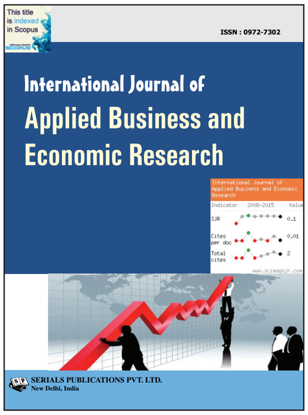

International Journal of Applied Business and Economic Research

ISSN : 0972-7302

available at http: www.serialsjournals.com

Volume 15 • Number 23 • 2017

The Impact of Technological Change on the Growth of Labor Productivity in the Jordanian Economy (1970-2016)

Abdel Baset Athamneh[1]

[1]*Dept. of Economics, Yarmouk University, Irbid, Jordan*

ABSTRACT

This study aimed at investigating the impact of technological change on the growth of labor productivity in the Jordanian economy during the period (1970-2016). It attempted to test the following hypothesis: "Technological change has a positive impact on labor productivity growth in the Jordanian Economy", through designing a macro econometric model for the supply side. The model included three behavioral equations; they were estimated using the Two-stage Least Squares method.

The results of this study showed that the average annual marginal product of labor during the period (1970-2016) came to 841.2 JDs. Results also found a significant impact of the technological change on increasing the marginal productivity of labor, where this impact fluctuated from year to another. The impact peaked in 2016 (232.2) and was least in 1976 (59.4), but the average annual impact was 92.7.

The study recommended setting such economic policies to pave the way for technology transfer to Jordan and reinforce its role in advancing the rates of total factor productivity and labor productivity growth in the Jordanian Economy so as to improve the levels of National Income and per capita income, therefore.

Keywords: Labor productivity, technological change, Jordanian labor market.

1. INTRODUCTION

Productivity is one of the most important sources of the economic growth, whereby enhancing motivations to improve productivity of different production factors leads to improve the overall productivity rates in economy. Humanity has ever since known the evolution of technology that man has used and continues until now, where technology was developed to increase productivity and income levels, and improve levels of welfare. For achieving that, man has built on a variety of developed means and methods in the production process (Drucker, 1976: 155-158). The concept of technology is attributed to the Greek word that refers to the art of extracting industrial raw materials from natural resources, to provide materials and goods that cover the basic human needs. (Salhani, 1981:27)

The word Technology has emerged in Germany for the first time in 1770 composed of two segments; (Techno) which means in Greek "the art" or "handicraft" and (Logy) which means "science" or "theory". Therefore the combination of the two segments means the art of making systematic knowledge in the arts of industry or applied science (Dlio, 2010: 20).

Technology is the set of available, accumulated and derived skills and expertise that are related to machinery, tools, methods, means and systems. Associated with production and services directed towards serving specific purposes of man and society, based on science in its progress, and depends on the productive base, which is associated with the comprehensive development for its growth and development (Al Obeid 1989: 19-20).

In the book of "The Wealth of Nations", Adam Smith (1776) has referred to the concept of technology by pointing out that the improvement of the production tools lies in the hands of "philosophers and those capable of making predictions", not "practical craftsmen", and explained that the growth of trade and specialization leads to a substantial increase in the amount of the scientific knowledge. While John S. Mill gave an increasing importance to the scientific and technological progress among other factors of production, in terms of its effectiveness in the production process and in achieving the economic growth (Abdulrahman, 1982: 49-52). Karl Marx (1867) pointed out that science and technology contribute to the supply of capital with an expansion force that is independent from the actual employed capital (Shanaah, 1997:82). Schumpeter stressed that technology is required to bring about development by raising the efficiency of labor and capital represented by the equipment, and in a way that increases the efficiency of production (Intensive growth) (Quraish, 1982:93). Therefore, technology is considered as the result of the development of human knowledge throughout the history, and has contributed to the acceleration of the transfer of knowledge over time from one generation to another, as well as between the countries and continents of the world, that has greatly helped in the discovery of many facts and in the collection and analysis of information and also contributed to the promotion of human cumulative knowledge.

The study of the impact of technology on human capital efficiency (represented by labor productivity) (Koch & McGrath, 1996) leads to a deeper understanding of the relation between these two important variables in terms of complementarity or substitution.

In spite of Jordan's rapid and considerable investment in the human capital, the expenditure on education exceeded 13.5%, out of the total expenditure in 2016 (Department of Statistics, 2017), labor productivity in Jordan remains low, especially for women (Bataineh and Athamneh, 2016:157). Therefore, it is important to study means for enhancing productivity in Jordan by taking advantage of the technological development in the Kingdom at all levels. The importance of this study is further boosted by its focuses on a vital subject in the Jordanian economy that measures the impact of technological change on increasing labor productivity over a relatively long period of time, using an appropriate statistical method to investigate the direct reciprocal and non-reciprocal effects of technology and labor productivity. This is the Simultaneous Equation Model. Therefore, this study aims to investigate the impact of technological change on the growth of labor productivity.

2. TECHNOLOGICAL CHANGE AND LABOR PRODUCTIVITY: THEORETICAL FRAMING

Cobb-Douglas production function is the most famous production function, which expresses an optimal mix of production factors. The general view of this function is drawn as follows:

$$Q_t = F(K_t, L_t) \tag{1}$$

where,

Q refers to the total production;

K refers to the capital stock in the economy; and

L refers to the number of employed.

It expresses the relation between the outputs of the production process and its inputs, taking the following form:

$$Q_t = AL_t^{\alpha}K_t^{\beta} \tag{2}$$

where,

A refers to a constant; α to the elasticity of production with respect to labor; and β to the elasticity of production with respect to capital.

This function is usually estimated by converting it into a linear logarithmic form, so that it becomes as follows:

$$\text{Log } Q_t = \log A + \alpha \log L_t + \beta \log K_t \tag{3}$$

It is noted that the technical efficiency of production includes producing the most possible outputs by lowest cost of production. This type of efficiency can be measured on a yearly basis through differentiating the production function with regards to the time, and then dividing the output on the original production function, resulting in:

$$GQ = GA + \alpha GL + \beta GK \tag{4}$$

where, GQ refers to the annual growth rate of production; GL to the annual growth rate in the work component; GK to the annual growth rate of capital; and GA to the annual growth rate in production efficiency.

$$GA = GQ - \alpha GL - \beta GK \tag{5}$$

As for the efficiency of using labor, it is expressed through the marginal product of this factor. This productivity can be measured through making a total differentiation of the production function in its general form, then dividing by Q and multiplying the first part of the right side with (L/L) and the second part of the same side by (K/K), resulting in:

$$GQ = \alpha MP_L + \beta MP_K \tag{6}$$

where, GQ refers to total output growth;

MP_L to the marginal production of labor; and

MP_K to the marginal production of capital.

We conclude from equations 4 & 6 that:

$$MP_L = \frac{GA}{\alpha} + GL + \frac{\beta}{\alpha}(GK - MP_K) \quad (7)$$

In theory, the marginal product of labor is positively correlated with the annual rate of growth in productive efficiency (technical change) and vice versa with the marginal productivity of capital . It also shows that the elasticity of production for labor determines the efficiency of labor (marginal product of labor) with technical change, so, increasing this elasticity reduces the marginal product of labor, because the production (when increasing the value of this elasticity) becomes more labor intensive, and according to the principle of diminishing marginal returns of productions that are used in the production process after a certain level of production.

Total productivity reflects the nature of the relationship between the level of the total output of goods and services and the total *s* of production within a specified period of time. (Baltagi and Griffin, 1988, 24)

$$TFP = \frac{Q}{AI} \quad (8)$$

where, Q refers to the total production;

TFP to the total *s* productivity; and

AI to the inputs (*s* of production).

Equation (8) can be written as a mathematical relationship between the total output volume (Q) and the total expenditure on the *s* of production (C).

$$TFP = \frac{Q}{C} \quad (9)$$

Thus, the total productivity is the inverse of average expenditure (average cost price). The average productivity, quality and cost of the product are important determinants of competitiveness, whether at the enterprise level or at the macroeconomic levels. Economists prefer the total productivity indicators rather than the partial indicators, because the partial productivity of the production s is vulnerable to the differing intensity of the production employment. Therefore, the greater the intensity of the production employment, the lower its productivity will get according to the law of diminishing marginal productivity.

The total factor productivity can be calculated by dividing the total production on the production inputs in the Cobb-Douglas function of production, so, the indicators of the levels of input can be given as approximate weights such as α_1 and β_1, so that the volume of production is given according to the following equation:

$$Q^* = \alpha_1 L + \beta_1 K \quad (10)$$

Therefore, the Total Productivity (TFP) is the division of actual total production (Q) on the estimated production volume (Q*):

$$TFP = \frac{Q}{Q^*} \quad (11)$$

So, the marginal production (MFP) level is provided in the following equation:

$$\text{MFP} = \frac{\Delta Q}{\Delta Q^*} \tag{12}$$

The non-embodied technological change is measured by introducing time (t) to the production function to become as follows:

$$Q_t = F(K_t, L_t, t) \tag{13}$$

Therefore, the time trend reflects the technological change (Tannura et. al., 2008), where biased technological progress is an indicator of labor when that progress leads to changes in the production function. So that it makes the marginal product of capital relatively high compared to the marginal product of labor, which calls on the producer to intensify the use of factor with the highest marginal product (capital). On the other hand, if the marginal product of capital is low compared to the marginal product of labor, the technological progress then can save the further expenses from capital. In this case, the producer should increase the use of labor.

The appropriate form of the Cobb-Douglas production function to estimate the impact of technological change on the production growth is: Solow (1957).

$$Q_t = AL_t^{\alpha} K_t^{\beta} e^{mt} \tag{14}$$

where, e refers to the natural logarithm (Nepari number);

t to time variable; and

m to the growth in production due to technological change.

Taking the natural logarithm of equation (14) gives:

$$\text{Ln } Q_t = \ln A + \alpha \ln L_t + \beta n\, K_t + mt \tag{15}$$

3. PREVIOUS STUDIES

The subject of technological change and its relation to productivity has been the subject of research and analysis of many studies, where the Solow Study (1957) is the most important study that analyzed the role of technological progress in economic growth, specifically industrial growth in the United States during the period 1909-1949, for his study has showed that about 85% of the growth achieved by production was attributed to technological progress. As for Schumpeter, he emphasized the role of innovators in generating economic growth as a source of economic progress, which in turn increases productivity and reduces production costs (Mansfield and Biharvich, 1986). Whereas In Intriligator Study (1965), the impact of technical change on productivity in the American industry was measured for the period (1929-1958), the results of this study indicated that the non-embodied technical change in the production s was 1.67% per year, and that the elasticity of production for labor was higher than the elasticity of production for capital.

The study of (Ayoub and Diab, 1991) on technical change and economic growth in Saudi Arabia, especially the cement industry, the results of the study showed that the elasticity of production for capital was estimated to be higher than the elasticity of production for labor, where the technical change coefficient was 0.059, indicating that the Saudi cement industry grew by 5.9% annually during the period of the study (1981-1987).

At the local level, the study of (Al-Malkawi, 1989) aimed to measure the productivity and technological change in Jordan Phosphate Mines Company for the period (1963-1986). The results of the study showed that the technical efficiency of the production was decreasing during the study period, and that the rate of growth of this efficiency was fluctuating. It was also found that the technological change was intensive for labor, with substitution between the production factors, where the replacement elasticity was 1.1 during the period (1973-1986).

In another study (Hamouri and Badri, 1995) about the impact of technological change development on the production of the industrial sector for the period (1969-1991), the study showed that there was no significant technological development in the Jordanian industry during the study period, as its effect on industrial growth was less than 1% per year. The study also found that the rate of participation of capital in the production process (65%) exceeded labor participation rate (35%). The study of (Al alwani, 1995) aimed at measuring the impact of technological change on the production of the Jordanian Petroleum Refinery Company for the period (1961-1991). The results of the study showed that the technological change has a positive impact on the output of the company amounted to 0.038 and that The Company achieved 11.3% growth in productivity during the study period, the contribution rate of technological growth was of 2.5% on average. It was also found that the technological change increased the company's production costs by 12%. While the study of (Shanaa, 1997) found that the average rate of growth for the technical efficiency of production in the Jordanian cement factories during the period (1968 - 1995) was 2.6%. Moreover, it was found that technical change was at the side of labor. Furthermore, the elasticity of substitution between labor and capital s was 0.972. The study concluded that the impact of the technical change was negative on the production costs and reached (–0.32).

The study of (Kanaan, 2005) aimed to examine the relationship between globalization and economic growth from the perspective of technological changes in East and South Asia, and to review the role of technology in the development strategies adopted over time in the countries of the world, concluding that the technological specialization determines the success of export, and that the accumulation of capital is important, but it needs to supplement the ability to learn and innovate in all fields. The study also showed that technological progress requires an active state, a set of good institutions, and the adoption of incentives and policies that enables the necessary resources to be utilized scientifically and objectively, in order to achieve advanced economic growth. The Study of (Mohammad, 2007) measures the effect of the Technological Development on the Iraqi industrial output during the period (1970-1990). The study found that the positive impact of technological development on Iraqi industrial output was very small (0.008). Whereas the average participation of the production *s* in the production process showed that the average participation of capital in production (0.16) was less than the average participation of labor (0.84). The effect of the technological Development on labor (5.21) found to be more than the effect on capital (0.19). The study of (Bakmi, 2009) aims to examine the impact of investment in technology on the economic growth, productivity of labor and capital, productivity of economic sectors at the sector level, savings and investment, and levels of incomes in the Saudi economy. The results showed that the gross national product, the marginal productivity of capital, the total productivity of the economic sectors, and the investment were higher, in the case of a technical change, than the basic case, which assumed that there was no technical change. The increase in the alternative compared to the basic case was by 17%, 36%, 36% and 11%, respectively.

Another study (WEI, 2010) measured the impact of technology transfer (represented by foreign direct investment and technology imports) on productivity in 28 regions in China during the period (2001-2008). The study showed that the imports of technology had a positive effect on productivity growth in these regions, unlike the impact of foreign direct investment which was negative.

In a study on technological progress, structural changes and productivity growth (Fagerberg, 2000), 39 countries and 24 industries were included. The results of the study showed that although structural change in the average did not lead to productivity growth, countries that have succeeded in increasing their presence in the more technologically advanced industry during this period experienced a higher productivity growth than other countries.

The study of (Carneh et. al., 2014) investigated the determinants of productivity change in the Iranian steam power plants during the period (2007-2012). The study found that the level of productivity has decreased substantially, and the effect of technological change on determining the level of productivity was greater than the change in efficiency. The study (Adu & Alagidede, 2016) aimed to investigate the incentive behind technology development to adapt to a changing world. The results of the study showed that technological change will be biased in favor of the sector that intensifies labor over time, especially when production inputs are replaceable. By reviewing the previous studies, we note that most of them focused on the partial application of the impact of the technological change on productivity, especially those related to the Jordanian economy, through the investigation of that impact in the case of specific application of some economic facilities. In addition, the focus of these studies is on estimating the annual rate of growth in productive efficiency. This study, however, used the time variable to reflect technological change at the macro-economic level in Jordan. It also used a methodology that was not used by any of the previous studies related to Jordan, which is the simultaneous equation model, in order to measure the impact of the technological change on the marginal productivity of labor by estimating the supply side in the Jordanian economy for a relatively long period (1970-2016) compared to the other studies.

4. THE DEVELOPMENT OF JORDAN'S ECONOMY

Jordan's economy has experienced significant development during the past four decades; increased production rates and employment, resulting in an increase in the GDP in the current prices from 310.1 million dinars in 1973, to 26637.4 million dinars in 2016, averaging an annual growth of 12% during the period of this study. There was an increase in employed between the previous two years, from 391.1 thousand workers to 1406.6 workers respectively, achieving an annual growth rate of 3.8% during the period of this study. Thus, the average product of labor has increased from 251.2 dinars to 1893.7 dinars respectively, achieving an annual growth rate of 7% during the period of this study.

The Jordanian economy is a service economy; service activities constitute 70.1% of the GDP. These activities employ 75% of the total employed labor force in the national economy for the same year. Therefore, production activities on contribute in about 29.9% of the GDP, and they employ 25% of the employed for the same year (Department of Statistics in 2016B).

The Jordanian society is described as young & youthful; the populations under the age of fifteen are 34.3% of the total populace, which explains Jordan's path towards investing in human capital. Thus, that was the center focus of the previous economic & social development plans, in addition to the strategies, initiatives, and current & future policies, especially in the sector of education & higher education. The numbers of the students in various stages of education are about 2 million students, which constitutes 30% of the total Jordanian populace (Department of Statistics, 2016 A).

Despite the geopolitical changes that surround Jordan, along with its limited natural resources, Jordan's economy has experience significant development during the past 5 decades, which has reflected on the level of the GDP, and economic growth rates. The GDP in constant fixed prices has increased from 3392.6 million dinars in 2005, to 9637.7 million dinars in 2015. Moreover, the per capita GDP in concurrent prices has increased during the past two previously mentioned years from 1630.8 dinars to 3652.6 dinars (Central Bank of Jordan, 2017).

In 2015, labor force was estimated to be about 1,607,630, and the number of employed to be 1,398,030. The general participation rate is 24.3%, with an unemployment rate of 13%. In the context of sectoral distribution of employed Jordanian, the agricultural sector, in 2015, has encompassed only 3.7% of the total employed workers, vis-à-vis the 21.8% for the industrial sector, 4.4% for construction, and 70.1% the service sector (Athamneh 2009, Department of Statistics, 2016 B).

Jordan has made reasonable achievements in human development; where the crude birth rate reached (0.23), and (0.061) for the crude death rate. The ratio of mortality for children under the age of 5 is 0.019, vis-à-vis 0.017 of infant's mortality. Life expectancy at birth reached 73.2 years old (72.5 for males, 74.0 for females) for the year 2015 (Department of Statistics, 2016 A).

Jordan has achieved high education rates; illiteracy among those over the age of 15 is only 6.4% (3.4% for males, 9.5% for females). The distribution of Jordanians over the age 15 in regards of educational level is as follows: pre high school (54.4%) high school (16.5%) diploma (7.5%) bachelors and higher (15.1%) (Department of Statistics, 2016 A)

The employment and unemployment survey (fourth round of 2016) by the Department of Statistics showed that the educational level of employed Jordanians of working age (15 or older) has increased. Those holding a bachelors degree or higher reached 26.8%, vis-à-vis 9.7% with a diploma, 10.8% with a high school degree, and 52.7% of pre high school degrees, inter alia those who are illiterate. Results from the same survey showed the educational level of unemployed Jordanians of working age are distributed as follows: Bachelors or higher (41.1%), diploma (8.8%), high school degree (6.7%), pre high school degree (43.1%). This indicates to the increase of the educational level of Jordanians of working age, be it employed or unemployed, in addition to indicating to Jordan's policy to invest in human development through promoting education, higher education, and increasing the number of entries in various educational programs in all of their level and majors. This has been confirmed since 8% of economically inactive Jordanians who are of working age holds a "Bachelor's degree or higher", vis-à-vis those with a diploma (6.4%), and those with a high school degree (19.2%) (Department of Statistics, 2016 A)

One of the important measurements to transfer technology is the volume of capital imports and how much they constitute of the total imports. In 2012, the value of capital imports reached 1730.4 million dinars, constituting 11.7% of the total of imports, and this ratio increased to 16.0% in 2016 (Central Bank of Jordan, 2017). Direct foreign investment is considered one of the channels to transfer technology to the host country; this type of investment decreased from 1291.3 million dinars in 2005, to 1178.7 million dinars in 2010, and then reached 1135.5 million in 2015. Direct foreign investment in Jordan peaked in 2006 reaching 2610.6 million dinars (Department of Statistics, 2016 A).

5. THE ECONOMETRIC MODEL

The econometric model consists of three behavioral equations and included of 8 variables, (3) of which are endogenous variables, and (5) are exogenous variables. They are as follow:

Table 1
Endogenous and exogenous variables of the econometric model

Endogenous variables		*Exogenous Variables*	
Y_t	Real GDP	I_t	Real investment volume
L_t	Number of employed in the economy	L_{t-1}	Number of employed in the economy in the previous year
K_t	Capital stock	K_{t-1}	Capital stock in the previous year
		W_t	Real wage level
		t	Time

The real values of variables are acquired through dividing them on the GDP deflator.

The equations that are going to be estimated can be elaborated as follow:

(i) Production Function

The economic theory indicates that production level (Y) is determined through two inputs; employment (L) and capital (K) (IMF, 1983) (Mckinnon, 1973):

$$Y_t = F(K_t, L_t) \tag{16}$$

Based on Cobb-Douglas production function, which is considered one of the most famous and commonly used by economists as an example of a homogenous production function, the function takes the following form:

$$Y_t = AL_t^{\alpha}K_t^{\beta} e^{mt} \tag{17}$$

To achieve the purposes of this study in measuring the effect of technological change on labor productivity, time (t) was added; where the time trend represents the technological change (Bäckman & Lansink, 2005:267).

In order to estimate the elasticity in the production function, it has been changed into an algorithmic form, making the function become as follow:

$$\ln Y_t = \ln A + \alpha_1 \ln L_t + \alpha_2 \ln K_t + mt + \varepsilon_t \tag{18}$$

where, Y_t refers to the real GDP at time t;

L_t to the number of employed in the Jordanian economy at time t;

K_t to the level of capital stock in the economy at time t;

t to time;

ε_t to the error term in the equation at time t; and

α_1, α_2, α_3 to the estimated elasticities for each of the inputs; labor, capital, and time respectively.

Where as (Log A), indicates the effect of other variables that aren't explanatory variables in the econometric model.

(ii) Labor Demand Function

The quantity demanded for labor (L_t) depends on the real income level in Jordan (Y_t), real wages level (W_t), and the level of labor demand in a previous period (L_{t-1}) (Addison and Siebert, 1979). The equation is as follows:

$$\ln L_t = \ln \beta_0 + \beta_1 \ln W_t + \beta_2 \ln L_{t-1} + \beta_3 \ln Y_t + \varepsilon_t \qquad (19)$$

where, L_t refers to the quantity demanded for labor measured by number of employed in the Jordanian economy at time t;

W_t to the real wage rate at time t;

L_{t-1} refers to the quantity demanded for labor in the previous year ($t-1$); and

Y_t refers to the real GDP at time t.

t to time;

ε_t to the error term in the equation at time t;

β_1, β_2, β_3 to the estimated elasticities for wages, labor demand in a previous period, and real income.

(iii) Capital Demand Function

The quantity demanded for capital depends on its level in a previous period (K_{t-1}) and the level of real investment (I_t). The equation is as follows:

$$\ln K_t = \ln \gamma_0 + \gamma_1 \ln K_{t-1} + \gamma_2 \ln I_t + \varepsilon_t \qquad (20)$$

where, K_t refers to the quantity demanded for capital at time t;

K_t to the quantity demanded for capital in the previous year ($t-1$);

I_t to the level of investment at time t;

ε_t to the error term in the equation at time t; and

γ_2, γ_1 to the estimated elasticity for capital level in the economy in a previous period, and the volume of real investment respectively.

Based on the previous literature review and the theoretical background of the econometric model; the study aims to test the following hypothesis:

"The technical development has a positive impact on the growth of labor productivity in the Jordanian economy during the period 1970-2016."

6. THE ESTIMATION RESULTS

The structural form of the model was estimated using the Two-stage Least Squares method, as estimation in this way yields more consistent and efficient results, especially in the over-identified equations. As errors in most systems of simultaneous equations are interrelated, this method can also put some conditions on the coefficients of some variables during the estimation process. The model found to be valid for the estimation process after confirming the order Identification and Rank condition. It was also found that the three equations are over identified. Therefore, it is appropriate to use the Two-stage Least Squares method in the model estimation process. The equation is over identified if the number of exogenous variables missing from its right side is greater than the number of the endogenous variables included in its left side (Gujarati, 1995). The data used in the estimation was tested and found to be Stationary from the first difference.

This study was based on secondary data published in specific sources, such as the Ministry of Labor, the Department of Statistics and the Central Bank of Jordan, through its economic publications, especially the monthly and annual reports. The Capital in the Jordanian economy was calculated using the ratio of capital to production (ICOR). This ratio is calculated by having the total of the net real gross capital formation during the study period divided by the difference in real GDP between the last year of the study and its first year, and This ratio is then multiplied by the gross domestic product for the first year, resulting in the estimated capital of the economy. By adding the net capital formation of the first year to its estimated capital, the estimated capital for the second year is produced, and the process continues by adding the net capital formation of any year to its estimated capital producing the estimated capital in the following year and so on (Hammad, 1986). The real values of the variables were calculated each year by dividing their nominal values by the GDP deflator.

The results of the estimation of the production function were in line with the economic theory. The results showed a positive effect on capital. The elasticity of production for capital was 0.82 and was statistically significant at 5%. The results of the estimation also showed that the elasticity of income for labor was 0.74 and was statistically significant at a significant level of 5%, meaning that the increase in labor employment by 1% will lead to real income increase by 0.74%. The results also indicated that the total of the production factor`s elasticities was more than one, i.e. the rates of total production increase will be greater than the increase rates of the employment of productions. Thus, the average cost would be increased as production levels increased.

As for the effect of technological change on the growth of real income (economic growth), it was positive and its estimated coefficient was 0.11 and had a statistical significance at a significant level of 1%. This indicates that 11% of the economic growth witnessed by the Jordanian economy during the period of this study was caused by technological change. While 89% of that growth is due to growth in labor and capital, in addition to other economic variables not covered by the estimated production function in this study (Appendix 1).

(Appendix 2) shows the estimated labor demand function in the Jordanian economy. The results of the estimation indicate that the demand for labor is positively determined by the level of previous demand. The results showed that the estimated coefficient was high (0.75) and was statistically significant at 1%, to indicate that the current demand for employment in the Jordanian economy is determined by 75% of the level of demand in the previous year.

The elasticity of labor for real wages was negative and averaged (–0.10) during the study period, and was consistent with the economic theory, so that a 1% real increase in wages would reduce the demand for labor by only 0.10% which is statistically insignificant. This indicate that wages are ineffective in determining labor demand levels due to significant imperfections in the Jordanian labor market that have weakened the role of demand for labor and labor supply in determining wage levels. Employment policy in Jordan, especially in the public sector (which employs about 40% of all workers in the national economy) is not subject to labor market interactions.

As for the capital function in the economy, the results of the estimation showed that capital with one lagged period played an important role in determining the current capital levels. The estimated coefficient of 1.01 was statistically significant at 1%.

The results showed that the estimating coefficient for the impact of investment in capital was low at 0.014, which indicates that the increase of investment by 1% will increase the accumulation of capital in the Jordanian economy by 0.014%. This coefficient was statistically significant at significant level 1% (Appendix 3).

7. THE IMPACT OF TECHNOLOGICAL CHANGE ON PRODUCTIVITY

To illustrate the impact of the technological change on labor productivity as an indicator of human efficiency in the economy, it should be noted that this impact starts with the effect of technological change on economic growth in the production function, while economic growth affects the marginal productivity of labor at labor demand function. Thus, the impact of technological change on labor productivity is indirect, through economic growth, which is initially affected by technological change and subsequently affects labor productivity.

By reviewing the results of the econometric model estimation for this study:

$$\text{Log } Y_t = 8.55 + 0.74 \log L_t + 0.82 \log K_t + 0.11t \tag{21}$$

$$\text{Log } L_t = 0.74 + 0.75 \log L_{t-1} + 0.17 \log Y_t - 0.1 \log W_t \tag{22}$$

$$\text{Log } K_t = -0.18 + 1.01 \log K_{t-1} + 0.014 \log I_t \tag{23}$$

The results showed that economic growth determine 17% of the demand for labor. The estimated coefficient of the real income variable in labor demand function was 0.17 and it has a statistical significant level of 5%. The increase of the economic growth rate by 1% will increase the demand for labor by 0.17%. Through the equations (21) and (22), the effect of technological change on labor productivity in the Jordanian economy can be calculated as follows:

$$\frac{d \log L_t}{d \log T} = \frac{d \log Y_t}{d \log T} \frac{d \log L_t}{d \log Y_t} \tag{24}$$

$$= (0.11)(0.17)$$

$$= 0.019$$

This emphasizes the modest role of the technological change in increasing demand for labor. The expansion of the use of technology in the national economy is supposed to reduce the production costs, increase the aggregate supply of the economy and consequently increase the employment of labor force. However, the results of the estimation indicated that technological change contributed to only about 2% of the demand for labor in the Jordanian economy.

To illustrate the impact of technological change on labor productivity, equation No (21) (the estimated production function) should be transformed using the inverse of the logarithms, so the function returns as it was in its original form:

$$Y_t = 2.146\ L_t^{0.74} K_t^{0.82} e^{0.11t} \qquad (25)$$

In order to find labor productivity, we make a partial differentiation for the last equation (Equation 25) for labor (L), resulting:

$$MP_L = \frac{\partial Y_t}{\partial L_t} \qquad (26)$$

$$MP_L = 1.588\ L^{-0.26} K^{0.82} e^{0.11t} \qquad (27)$$

The results showed that the estimated productivity of labor was the highest in 2013 (1801.1 JD) and the lowest was in 1976 (539.4 JD), while the average during the period (1970-2016) was 841.2 JD (Figure 1).

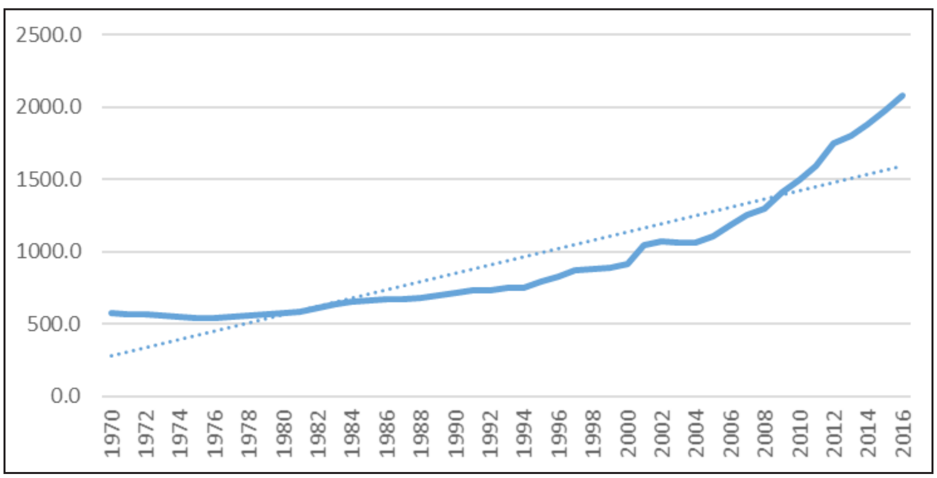

Figure 1: The estimate marginal product of labor (1970-2016)

The impact of the technological change on the estimated marginal productivity of labor (1970-2016) is the effect of time (*t*) on the MP_L. This can be achieved by performing a partial differential of equation (27) for time (*t*), resulting in:

$$\frac{\partial MPL_t}{\partial T} = 0.175\ L^{-0.26} K^{0.82} e^{0.11t} \qquad (28)$$

It was found that this impact was variable over time during the period of the study, and can be calculated by compensating the actual values of the three independent variables (*t*, K, and L) in equation 28. Figure 2 shows the impact of the technological change on the marginal productivity of labor during the period of the study.

The impact of the technological change on labor productivity in Jordan peaked in 2016 at 232.2 and the lowest impact was in 1976 at 59.4 while the average impact was 92.7 during the period of the study. Figure 2 shows clearly that the impact of the technological change on labor productivity in Jordan has been significantly increasing and correlated with the trend of increased marginal productivity of labor.

8. CONCLUSION

The findings of this study showed that technological change has a major role in increasing and enhancing the productivity of labor in the Jordanian economy. This impact occurred in a growing manner during the period (1970-2016), indicating that Jordan has benefited from the flow of the foreign economic resources which contributed to the transfer of technology into the kingdom, such as the flow of capital imports and foreign investments.

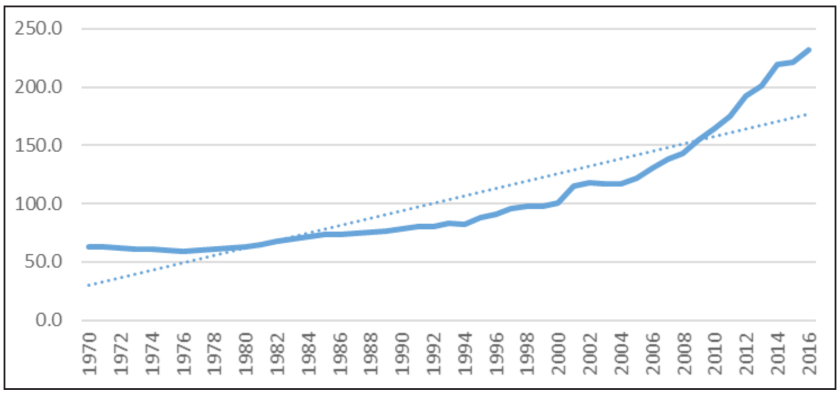

Figure 2: The impact of technological change on labour productivity (1970-2016)

At the local level, Jordan has for half a century or so adopted a national strategy for investment in the human capital, which has resulted in a significant drop in illiteracy rates, and a significant increase in enrollment rates in all levels of education. All this coincided with fundamental reforms in the structures of the educational systems, focusing on the importance of vocational training, technical education and the knowledge economy. Despite the limited expenditure on research and development in Jordan (like other developing countries), the mentioned s have led to an increase in gross output as well as per capita income in line with the increase in the productivity levels of the productions, foremost of which is labor.

Based on that, this study recommends the provision of economic means and policies that will transfer technology into the Kingdom and enhance its role in increasing the levels of total productivity and labor productivity in the Jordanian economy, which will increase the national income and per capita income, through the following:

1. The need to adopt a national policy to raise expenditure on research and development as the most important means of technology transfer, and linking this expenditure to tax incentive policies (tax exemptions).
2. Continue to provide various facilitations for direct foreign investments in the Kingdom as a way for technology transfer and localization in the host country, taking into considerations that the percentage of exemptions granted to these investments should be linked to the extent of their employment of the local labor (Jordanians).

3. Focusing on the importance of granting production inputs, especially capital imports (imports of capital goods) tax exemptions, since these imports are a prerequisite for the localization of technology.
4. To continue with the strategy of investing in the human capital, with the need to focus on the vocational training and technical education that Jordan needs to enhance the productivity rates in the national economy.
5. This study recommends conducting further studies that investigate the impact of technological change on the efficiency of the employment of human capital in Jordan, in all of the economic sectors.

References

Abdul Rahman, Ismail (1982). Economic Thought and Technological Change, Journal of Social Sciences, Kuwait, Issue (3).

Addison John and Stanley Sibert (1979). The Market for labor: An Analytical Treatment (California, Good Year Publishing Company).

Adu, George, and Paul Alagidede (2016). *Climate, Technological Change and Economic Growth*. No. 572.

Al-Hamouri, Qassim and Sabah Al-Badri (1996). The Impact of Technological Development on the Industrial Sector Production in Jordan, Yarmouk Research Journal, Human and Social Sciences, Vol. (12), Issue (1), pp 219-241.

Al-Malkawi, Ahmad (1989). Measuring Productivity and Technological Change in Jordan Phosphate Mines Company (1963-1986), Dirasat Journal, The University of Jordan, Volume 16, Issue. 1, pp. 26-61.

Al Obeid, Jacob (1989). Technological Development: Concept and Requirements, First Edition, International Publishing and Distribution House, Kuwait.

Al-Quraishi, Medhat (1981). Labor Productivity in the Mixed Industrial Sector, Journal of Economic and Administrative Research, Issue (2).

Alawani, Saad Abd (1995). The Effect of Technological Change on the Productivity of Jordan Petroleum Refinery Company, Unpublished Master Thesis, Department of Economics, Yarmouk University, Irbid, Jordan.

Athamneh, Abdel Basset and Bashir Zoubi (2009). The Relation between Investment and Employment in Jordan: An econometric Analysis (1973-2005), Dirasat Journal - Administrative Sciences, The University of Jordan, Volume 36, issue. 2, pp. 376-389.

Bäckman, S., & Lansink, A.O. (2005). Crop and soil specific N and P efficiency and productivity in Finland. Agricultural and Food Science, Vol. 14: 264-276.

Bakmi, Raja Bin Menahi (2009). The Impact of Technical Development on Economic Growth: The Case of the Kingdom of Saudi Arabia, Journal of Scientific Research, the Faculty of Commerce - Alexandria University, Volume 46, Issue 1, pp. 1-23.

Baltagi, B.H. and J.M. Griffin, (1988b). A general index of technical change, Journal of Political Economy 96, 20–41.

Bataineh, Bilal and Abdel Baset Athamneh (2016). Women's Productivity in the Jordanian Labor Market: An econometric Analysis (1970-2012), Jordanian Journal of Economic Sciences, vol. 3, Issue (2), pp. 157-177.

Central Bank of Jordan (2017). Monthly Statistical Bulletin (http://www.cbj.gov.jo/arabic/pages.php).

Department of Statistics (2016A). Jordan in figures 2015, Amman.

Department of Statistics (2016B). Jordan Statistical Yearbook 2015, Amman.

Department of Statistics (2017A). Employment and Unemployment Survey 2016: Fourth Round. (http://www.dos.gov.jo/dos_home_a/main/linked-html/Emp_unEmp.htm).

Department of Statistics (2017B). System of Economic and Social Indicator. (http://jorinfo.dos.gov.jo/View_ind/).

Dlio, Fadil (2010). New Technology for Media and Communications, Concept-Uses-Horizons, Dar Al-Thaqafa, Amman, Jordan.

Drucker, Peter (1976). "Technology, Management and Society", Translated by Dr. Salib Boutros, Egyptian General Book Organization, Cairo.

Eberly, J., Rebelo, S., & Vincent, N. (2012). What explains the lagged-investment effect?. Journal of Monetary Economics, 59(4), 370-380.

Fagerberg, J. (2000). Technological progress, structural change and productivity growth: a comparative study. Structural change and economic dynamics, 11(4), 393-411.

Gharneh, N.S., Nabavieh, A., Gholamiangonabadi, D., & Alimoradi, M. (2014). Productivity change and its determinants: Application of the Malmquist index with bootstrapping in Iranian steam power plants. *Utilities Policy*, *31*, 114-120.

Gujarati, Damodar (1995). Basic Econometrics, 3rd edition, McGraw Hill, Inc.

Hammad, Khalil (1986). "An Aggregate Production Function for Jordan", METU Studies in Development, Vol. 13, No. 3 & 4, pp. 287-298.

Intrilligator, M. (1965). Embodied Technical Change and productivity in the United States (1929-1958) Review of Economic and statistics, Vol. (47), pp. 65-70.

Kanaan, Abdul Ghafoor (2005). Technological Progress in the Context of Globalization and its Impact on Economic Growth in the Developing Countries, A study on the Asian Industries, Tanmiat Al-rafidain Journal, Vol. 27, pp. 59-80.

Khalil, Sami (1994). Macroeconomics Theory (Part II), Kuwait.

Koch, M.J., & McGrath, R.G. (1996). Improving labor productivity: Human resource management policies do matter. *Strategic management journal*, 335-354.

Mansfield Adonis, and Nariman behravesh (1986). "Economics". Jordan Bookstore (translated edition).

McKinnon, Ronald I., (1973). Money & Capital in Economic Develop nt, Washington, D.C., The Brookings Institution.

Mohammad, Saad Abd (2007). The Impact of Technological Development on the Output of the Iraqi Industrial Sector for the period 1970-1990, Al-taqani Journal, Volume (20), Issue. (2), pp. 1-10.

Quraysh, Mohammed Al-Rasheed (1982). Transfer of Technology in the Arab World: it's Concept, Forms and attitude: The Arab Future, Issue. (3)

Salhani, Izz Al-Din (1981). Notes on the Technological Transformation, Journal of the Arab Future, Center for Arab Unity Studies, Beirut, Issue (29).

Shanaah, Imad (1997). Technical Change and Economic Growth: A Study of the Situation of Jordanian Cement Industry: An Analytical and Econometric Study, Unpublished Master Thesis, Department of Economics, Yarmouk University.

Sheikha, Mustafa Rushdie (1985), Economics through Micro Analysis. Eldar Aljame`iah for Printing and Publishing. Beirut, First Edition.

Solow, R.M. (1957), Technical change and Aggregate production function, Review of Economics statistics, Vol. (39), pp. 312- 320.

Tannura, M., Irwin, S., & Good, D. (2008). Are Corn Trend Yields Increasing at a Faster Rate?. Marketing and Outlook Brief, 2.

Annexure

Annexure 1

(Log Y_t) Production function estimation results

Dependent variable: (Log Y): Logarithm of the real GDP			
(Independent Variables)	*(Estimated Coefficients)*	*(T-values)*	*(Significance level)*
Constant Term	8.55	2.57	0.05
(log K_t) Logarithm of capital stock	0.82	2.64	0.05
(log L_t) Logarithm of employed labor	0.74	2.34	0.05
Time (t)	0.11	5.95	0.01

$R^2 = 0.977$ Adj. $R^2 = 0.975$ F = 535.0 D.W = 0.19

Annexure 2

(Log L_t) Estimation results of labor demand function

Dependent variable: (Log L): Logarithm of the employed labor			
(Independent Variables)	*(Estimated Coefficients)*	*(T-values)*	*(Significance level)*
Constant Term	0.74	1.25	-----
In a previous year Logarithm of employed labor (log L_{t-1})	0.75	7.91	0.01
(log Y_t) Logarithm of the real GDP	0.17	2.46	0.05
Logarithm of the real wage rate (log W_t)	0.10-	1.06-	-----

$R^2 = 0.965$ Adj. $R^2 = 0.962$ F = 352.6 D.W = 1.57

Annexure 3

Estimation results of capital demand function (Log K_t)

Dependent variable: (Log K): Logarithm of the capital stock			
(Independent Variables)	*(Estimated Coefficients)*	*(T-values)*	*(Significance level)*
Constant Term	–0.18	–2.11	0.05
(log K_{t-1}) Logarithm of the real GDP	1.01	88.18	0.01
(log I_t) Logarithm of the real private investment	0.014	3.23	0.01

$R^2 = 0.999$ Adj. $R^2 = 0.998$ F = 2032.9 D.W = 0.491