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Agricultural Growth Accounting and Total Factor Productivity in Jordan:
Trends, Determinants, and Future Challenges

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ABSTRACT

This article develops new estimates of historical agricultural productivity growth in Jordan. It investigates how public policies such as agricultural research, investment in irrigation capital, and water pricing have contributed to agricultural productivity growth. The Food and Agriculture Organization (FAO) annual time series from 1961 to 2011 of all crops and livestock productions are the primary source for agricultural outputs and inputs used to construct the Törnqvist Index for the case of Jordan. The log-linear form of regression equation was used to examine the relationship between Total Factor Productivity (TFP) growth and different factors affecting TFP growth. The results showed that human capital has positive and direct significant impact on TFP implying that people with longer life expectancy has a significant impact on TFP growth. This article concludes that despite some recent improvement, agricultural productivity growth in Jordan continues to lag behind just about every other region of the world.

KEYWORDS

Agriculture, Growth, Jordan, TFP, Tornqvist Index

1. INTRODUCTION

Jordan has experienced spells of high growth, but the country has always faced the challenge of sustaining them. In the first half of the 1980s, Jordan's Gross Domestic Product (GDP) growth averaged 7.4 percent. Subsequently, as the regional economies entered into recession in the wake of a sharp fall in oil prices, the country's growth plummeted to -14 percent in 1988 and it took about 18 years for Jordan's GDP per capita to revert to its level of the late 1980s. Jordan posted an average 6.7 percent growth during 2000-2008, then the country's growth dropped sharply to 2-3 percent during the global financial crisis of 2009-2010. Jordan's resilience to exogenous shocks has remained extremely weak over the last 30 years.

The contribution of agriculture to the GDP in relative terms declined sharply from 40% in the 1950s to less than 4% in 2011 (Bahdousheh et al. 2010), while its contribution in absolute terms has increased from Jordan Dinar (JD) 32 million in 1964 to JD 560 million in 2010 (The Central Bank of Jordan, 2011). Despite the increase in absolute monetary terms, the contribution of agriculture to the national economic growth is very modest, reflected in the remarkable decline in the sector's share compared to other sectors.

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The importance of the agricultural sector stems from the fact that it is not only the major source of food items especially dairy products, fruits and vegetables, but is also one of the sources of hard currencies originated from exports. About 25% of the total poor in Jordan live in the rural areas depending mostly on agriculture (e.g., livestock keepers, small holder farm households, and landless former agriculturalists), and in spite of poor motivation of the rural youth, agriculture is an important employer of the rural communities. Additionally, cultural, social, and environmental considerations and mainly because of its strong forward and backward linkages with other sectors and activities, agriculture remains a very important sector that must be considered in the rural development and poverty reduction plans. The sector employed about 124,000 people (a total of 2.1% of the entire population or about 7.7% of the active labor-force of 1.771 million), and contributed to 17% of total national exports (equivalent to JD 795 million) in 2011 (MOA, 2012).

A major weakness of the sector is caused by the scarcity of irrigation water and overexploitation of groundwater; use of poorly treated brackish and sewage water, land fragmentation and reduction in the size of agricultural holdings; weak extensions services; poor transportation, packaging and processing; infrastructure; unfavorable price policies, and low investment in marketing infrastructure, post-harvest and quality enhancing facilities (e.g., grading, packing, storage). The claim that agriculture consumes 62% of the Jordanian scarce water resources leaving scant reserves for domestic and industrial use is unrealistic and is yet to be proven. However, the claim generally reflects the extent of poor water use practices in agriculture, and indicates the need for adopting alternative and modern agricultural practices and techniques.

The agricultural output growth is usually due to three types of factors: area growth, yield growth, and prices change. Area growth is related to an increase in the quantities of inputs use in addition to land. However, yield growth is generated by both inputs use growth and total factor productivity (TFP) growth. Then, TFP growth is the result of both technical change and the efficiencies deployed to lead to increased output. Growth patterns could be then defined as a trade-off between these two sources which determines TFP growth. Although all choices of growth patterns can achieve the substantive growth of TFP, the distributions between both sources should be coordinated.

There have been virtually no sector-level studies on agricultural productivity in this region or on the role of public policies in improving productivity growth. This article develops new estimates of historical productivity growth and water use in Jordan. It investigates how public policies such as agricultural research, investment in irrigation capital, water pricing, and others have contributed to agricultural productivity growth. The findings from this article will have important implications for agricultural development policy in the region.

The remainder of this article is divided into five sections. Section 2 provides a literature review on the empirical approaches used to measure the agricultural productivity in in Jordan and many other countries. Section 3 presents the methodologies used to measure TFP, and discusses the data used in Jordan to measure TFP growth. Section 4 presents results obtained from the analyses of outputs, inputs and TFP measurements, and then describes and summarizes the key findings of the TFP determinants. Finally, Section 5 presents the conclusions and policy implications.

2. BACKGROUND AND LITERATURE REVIEW

Agriculture productivity analyses performed to date show that most developing countries are experiencing relatively negative productivity growth with technical change being the main source of this regression. Kawagoe and Hayami (1985) showed agricultural productivity decrease in 22 Least Developed Countries (LDCs), but an increase in the 21 developed countries included in the sample. Kawagoe and Hayami (1985) found similar results for the same data set using an indirect production function approach that is similar to the indexing approach, except that input shares are estimated by using marginal productivities from an aggregate production function instead of prices. Lau and

Yotopoulos (1989) also found in their analysis declining agricultural productivity for LDCs in the 1970s but an increase in the 1960s, although they used different functional forms.

In later research, Qualset, McQuire, and Warburton (1995) state that California's rich agricultural productivity is founded on its biological diversity, both native and exotic. Native species contribute genetic resources and play a vital part in preserving land, air, and water quality. Qualset et al. (1995) assert that exotic species introduced from around the globe provide the raw genetic material for nearly all of California's agricultural commodities. Through generations of selective breeding, native and exotic biodiversity have been used to solve agricultural problems. Such biodiversity — termed "agrobiodiversity" — includes not only crops, livestock and their wild relatives, but the species that interact with and support them: pollinators, symbionts, competitors, pests, parasites, predators, and biological control agents. Qualset et al. (1995) suggest that long-term security and flexibility of California agricultural production requires conservation of both exotic genetic resources and native California habitats.

Trying to explain measured productivity decline in developing countries, Fulginiti and Perrin (1993, 1998) related poor productivity performance to economic policy. They found that those countries with heavy agriculture taxes had the most negative rates of productivity change. They suggested that price policies or other interferences with the agricultural sector might stifle potential productivity gains. Fulginiti and Perrin also suggested, as an alternative explanation, that the methods and data used in these studies may have inaccurately measured technical regression. Arnade (1998) estimated agricultural efficiency change indices, technical change indices and productivity indices using nonparametric Malmquist indices for 70 developed and developing countries during 1961 - 1993.

A total of 36 of the 47 developing countries included in this sample showed negative rates of technical change, whereas most of the developed country indices rose or followed mixed paths. In contrast, recent studies of agricultural productivity growth in developing countries have showed positive and rapid growth. Coelli and Rao (2003) examined the growth in agricultural productivity in 93 countries during 1980 - 2000. Their results showed an annual growth in total factor productivity growth of 2.1%, with efficiency change contributing by 0.9% per year and technical change providing the other 1.2%. There is little evidence of technological regression found in the earlier studies. Those results are explained as a consequence of the use of a different sample period and an expanded group of countries.

Nin et al. (2003) re-examined the nonparametric procedure for estimating the Malmquist productivity index. They argued that the technical regression observed is principally the consequence of biased technical change together with the definition of technology used to estimate the Malmquist Index. They eliminated this effect by applying a broader cumulative definition of technology than is normally used to estimate the Malmquist Index. Their results using this new approach reversed the previous findings and showed that most countries in their sample of 20 developing countries experienced positive productivity growth with technical change being the main source of this growth.

Al-Karablieh (2004) in his study of analysis of the TFP in Jordanian agriculture, analyzed the agricultural outputs of Jordan during 1983 - 1997 using the Tornqvist quantity index. In this study, data on output produced, input used, and their respective prices for the period were obtained from the Jordanian Department of Statistics (DOS) and were supplemented with several other sources. Output growth, during the period under study, principally came from the growth of fruits, vegetables, and poultry. Growth rates for all other crops and livestock were unbalanced due to few research and development efforts on those relative to fruit and vegetables. The average growth rate of TFP was 3.9% during 1983 - 1997.

During 1983 - 1987, the average growth rate of TFP was 6.1%, but dropped later to an average of growth rate of only 0.7% during 1993 - 1997. Although land remained static, labor, fertilizers, pesticides and water increased. The increase in output during the whole period was mainly 70% due to the technological change, whereas 30% was due to the increase in the inputs used. Much of the additional productivity is expected to come from cereals and livestock products; therefore, policy prescriptions should be allocated to direct research and development efforts towards efficient production of those along with fruit and vegetables. Given land is considered the most limiting factor and labor is the most elastic factor, the shift towards production of high value crops will increase aggregate output growth and at the same time employment.

Belloumiet et al. (2009) investigates the patterns of agricultural productivity growth in 16 Middle East and North Africa (MENA) countries during 1970 - 2000 using a nonparametric, output-based Malmquist index to examine whether author estimates confirm or invalidate the previous studies results indicating the decrease of agricultural productivity in developing countries. They showed that, on average, agricultural productivity growth increased at an annual rate of 1% during the whole period. Their estimations show that technical change is the main source for this growth. Those results weaken as a whole the findings of the other studies; however, they find a decrease in agricultural productivity mainly for developing countries suffering from political conflicts and wars. This article fills the void of hardly any agricultural studies on MENA countries collectively, especially on productivity trends.

Telleria et al. (2011) used the Malmquist Index to measure agricultural productivity. It is a powerful tool providing insights into whether or not a country is approaching what may be termed as "best practices" by using and disseminating existing technology (efficiency change), and/or by innovating technology (technical change). Using the Malmquist Index on a sample of 12 countries within West Asia and North Africa (WANA) indicated that between 1961 and 1997, Turkey, Tunisia, Syria, and Algeria (in that order) were the "most productive" countries.

3. CONCEPTUAL FRAMEWORK

3.1. Methodological Approach

Productivity is defined as the efficiency of a production system, and as such would be a ratio of units of output per unit of input to the system (James & Carles, 1996). It is also defined as the production value (or quantity) divided by the amount of factors consumed in the production process. Generally, productivity is the relationship between the quantity of output and the quantity of input used to generate that output. It is a ratio of output to input (Productivity = Output/Input). The output used for productivity calculation could be of different forms such as produced goods or provided services. Outputs may be expressed in physical (quantities) or financial (value) terms. Inputs are resources used to produce outputs. Most common forms of inputs are labor, capital, and intermediate inputs.

Productivity has an effect on organizations/economies/sectors growth. In fact, higher productivity results in performances enhancement (production increases) and higher profits (e.g., minimal factors costs, better selling prices, marketing capacities). Enhanced skills in transforming inputs to outputs play critical role in enhancing productivity and competitiveness. In fact, with the same amount of inputs, some farmers can produce more than others depending on their skills, knowledge level, and cognitive capacities.

The two most commonly used measures of productivity are single (partial) factor productivity (SFP) and total (multifactor) factor productivity (TFP). When multiple inputs of heterogeneous nature are used in the production process, aggregation of these inputs may require the use of price indices. This implies that productivity can be affected by both changes in relative prices of inputs and by the input use per unit of output (Kathuria et al. 2013). Precise definitions of partial and TFP will be presented in this article. However, the main focus will be on the TFP since it is the method we are using in the APWEC-MENA project to account for agricultural sector growth in Tunisia, Jordan, and Egypt.

There are basically two approaches to measure TFP growth: the frontier and non-frontier approaches. Each of these approaches is further divided into parametric and non-parametric techniques. Non-frontier approaches include growth accounting methods (or non-parametric index-based methods/ TFP index numbers) and econometric parametric approaches. Frontier approaches include the nonparametric Malmquist index methodology and the stochastic production frontier method; which is a parametric approach. A common feature of the TFP index number is that the empirical estimation of different TFP indexes is based on different weighting methods of inputs and outputs. In most empirical studies, the Divisia, Solow, and the Törnqvist Indexes are frequently used. Among index number methods, the Tornqvist-Theil Index, which is an approximation to the Divisia Index, was employed to construct the aggregate output index and aggregate input index.

In the literature on productivity measurement, the Törnqvist Index is the changing-weight index that has been most frequently examined and used. The Törnqvist Index, which was developed in the 1930s at the Bank of Finland (Törnqvist, 1936), makes use of logarithms for comparing two entities (e.g., two countries or two firms), or for comparing a variable pertaining to the same entity at two points in time. When used to compare inputs for two time periods within the context of productivity measurement, the Törnqvist Index employs an average of cost-share weights for the two periods being considered. The index number is computed after first determining a logarithmic change (or rate of proportional change). Explanation on theoretical properties and issues in measurement of the productivity through the Tornqvist Index can be found in Diewert (1978) and Coelli et al. (2005).

The Tornqvist output, input, and TFP index in logarithm for can be expressed as follows:

$$\text{Output index: } \mathrm{Ln}\left(\frac{Q_t}{Q_{t-1}}\right) = \frac{1}{2}\sum_j \left(R_{j,t} + R_{j,t-1}\right)\mathrm{Ln}\left(\frac{Q_{j,t}}{Q_{j,t-1}}\right) \tag{1}$$

$$\text{Input index: } \mathrm{Ln}\left(\frac{X_t}{X_{t-1}}\right) = \frac{1}{2}\sum_i \left(S_{i,t} + S_{i,t-1}\right)\mathrm{Ln}\left(\frac{X_{i,t}}{X_{i,t-1}}\right) \tag{2}$$

$$\text{TFP index: } \mathrm{Ln}\left(\frac{TFP_t}{TFP_{t-1}}\right) = \mathrm{Ln}\left(\frac{Q_t}{Q_{t-1}}\right) - \mathrm{Ln}\left(\frac{X_t}{X_{t-1}}\right) \tag{3}$$

Where;

Rj,t is the share of output (j) in total revenue in time (t),
Qj,t is the output (j) in time (t),
Si,t is the share of input (i) in total input cost, and
Xi,t is the input (i) in time (t),

3.2. Data Sources and Data Collection Procedure

The Food and Agriculture Organization (FAO)'s annual time series from 1961 to 2011 of all crops and livestock productions, land areas, labor, machinery, animal capital, and fertilizer consumption are the primary source for agricultural outputs and inputs used to construct the Törnqvist Index for the case of Jordan. The FAO data is complemented, when needed, with data from national statistical agencies, especially when such alternative data is more accurate or up to date. Data from FAO was continuously cross checked with the available (sometimes limited) data from national sources in order to be sure of its reliability. Moreover, the TFP determinant variables where primarily collected from national sources, while some of them were also collected from international databases, as it is for the UNDP-human development index.

3.3. Hypothesis for Estimation of the Missing Data

As mentioned above, inputs and outputs data was mostly gathered from online FAO database. However, we faced some missing observations and were therefore obliged to use different assumptions to complete them. Below is a description of the different estimation procedures of these variables:

Total Agricultural Output

This variable was available in both FAO and the DOS. However, we considered the FAO values in our output index calculation since most of our inputs variables were also from the FAO source. The calculation of the agricultural output value from the FAO dataset was based on available information about different agricultural commodities production (in metric tons) and prices (FAO have a dataset of historical agricultural commodities prices). Multiplying produced quantities of each commodity by its unit price provide the overall annual value of that commodity. By summing up crops commodities and livestock commodities, we obtain the annual crops output values and annual livestock values (see Figure 1). For the missing commodity prices observations, we were simply applying different constant inflation rates for different commodities based on their current prices.

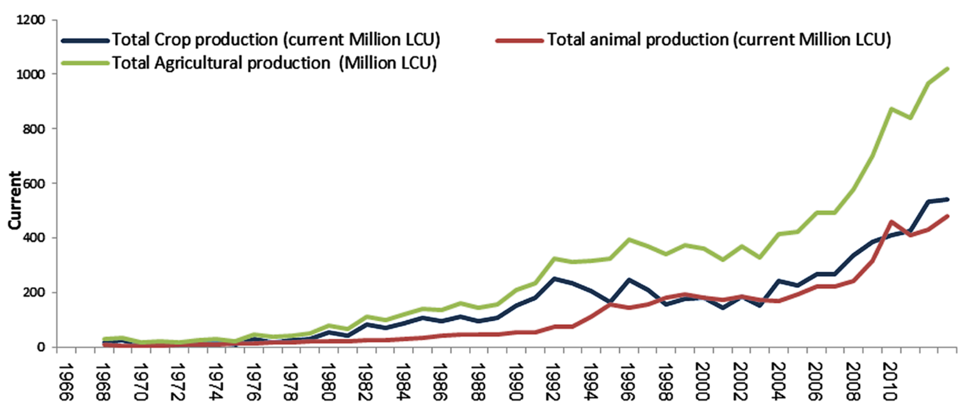
Total Agricultural Inputs

The FAO publishes data on cropland (rain-fed and irrigated), permanent pasture, labor employed in agriculture, animal stocks, the number of tractors in use, and inorganic fertilizer consumption. We supplement these data with better or more up-to-date data from national sources whenever available. For fertilizer consumption, the International Fertilizer Association has more up-to-date and more accurate statistics than does the FAO on fertilizer consumption by country, except for small countries.

Labor

this variable represents the annual volume of number (number of active persons) and value (in current JD) of the total labor mobilized in the agricultural sector. This variable was primarily collected from the DOS. The number of workers in the agricultural sector was not difficult to find as information, but the historical labor value was critical. We relayed on secondary data about daily wages in the agricultural sector to estimate this value. Secondary data about daily wages in the agricultural sector in Jordan were available from the DOS, but starting only from the 1990s. One observation of the wages in the 1960s was obtained from consulting experts, and then a constant inflation rate of this value was applied every five years until the 1990s.

Figure 1. Crops and Livestock Output Values in Jordan (in current JD / from 1966 to 2011) Source: Own elaboration (2014)



Seeds

Seed quantity was available in FAO datasets, but the FAO did not provide any seeds pricing data. Because cereals are the most important component of the overall seeds quantity, we decided to use an average price of cereals as proxy of the cereal seeds.

Machinery

This variable is reflected by the annual number and value of tractors in use. Other types of machineries were not used to account for this vector. The unit prices of tractors (in current local currency) were calculated based on the annual machinery import value drawn from the FAO database. From this annual unit value, an annual cost of machinery services was derived by amortizing the price of machine over 15 years and assuming a fixed marketing margin.

Pesticides

It was not possible to find any pesticides quantities. Instead, we used the number of cropped hectares treated by different types of pesticides as a proxy. This latest variable was available at the DOS. It was also difficult to find the annual total value of pesticides used in the agricultural sector of Jordan. This latter value was, however, estimated from the annual value of pesticides importations (available in the FAO database) corrected by a marketing margin of 85%. This marketing margin was identified from some primary data about average farms expenditure in treatment products. The margin is high mainly because private companies import active ingredients and transform them locally, thus producing important quantities of treatment productions.

Fertilizers

Aggregated fertilizers quantities were available from FAO data, the DOS, and the International Fertilizer Association (IFA). However, values from the IFA and FAO sources were highly similar so we decided to use the FAO data. The aggregated fertilizers value was, however, calculated based on average unitary price which was estimated through: 1) the international fertilizers price index (IFA: international fertilizer industry association); and 2) the average unitary price of 1963 (from FAO source).

Animal Feed

Animal feed quantities were also estimated from FAO sources, more precisely from the annual "commodity balance sheets". These annual sheets provide the quantity (in tons) of each agricultural commodity allocated for animal feed. By summing up through all of these commodities, we obtained the total quantity of feed consumed by the livestock activity. It was remarkable that cereals usually constitute more than 85% of the total annual animal feed. Therefore, an annual average cereal unitary price was used to calculate the feed value in Jordan. For the remainder of the feed share (other than cereals), half of the annual average cereal unitary price was used since we supposed that cereals are the most expensive among feed.

Capital Stock

was also calculated based on the FAO data for the period 1975 - 2007. In the calculation, we were considering the following components: "land development", "livestock fixed assets", "plant crops", and "structures for livestock". Each of these values was amortized based on the following rates, successively: 99 years, 10 years, 20 years, and 25 years. These depreciation rates are in line with the accounting system in the respective countries. The final capital stock formula is then: CS ($year_t$) =sum ((land development/99) + (Livestock fixed assets/10) +(plant crops/20)+(structure for livestock/25)). The capital stock values are reported in the FAO data as '2005 Constant USD'. We first changed the values to current US Dollars (based on US inflation rates) and then we applied the exchange rates to obtain the current JD values. The period 1960 - 1970 corresponds to the period of complicated political situation for Jordan with neighboring countries. This was our interpretation of the declining TFP indexes between 1966 and 1974.

Natural Resources

includes land, rangelands, and water used for irrigation. The annual land area was available in the FAO dataset while the value of natural resources was calculated by the residual imputation method. It is, in fact, considered as being the residual difference between the overall agricultural output and the sum of all inputs values.

3.4. Data Limitations and Missing Values

Some limitations of these calculations should be noted given the nature of the data on which they are based. The first limitation is that revenue and cost shares are held constant over time. Some of the data variables were not available for the whole period 1961 - 2012 in the FAO STATA. For input data there were a missing data fertilizer inputs during 1961 - 1993 and values of labor also during 1991 - 1993 were also missing, in addition to labor numbers, mechanization values were also missing during 1961 - 1973. Water values and quantities were also missing during 1961 - 1990; national statistics from the ministry of water and irrigation were used to fill the missing data from the FAO STATA. Seeds data were also missing for the period 1961 - 1990, so data also from the DOS were collected to fill the data gap.

However, an examination of the output data shows that for major commodity categories (e.g., cereal crops, oil crops, fruits and vegetables, meat, milk). On the input side, there has been more movement in cost shares among the major categories, but these changes occur gradually over decades. Thus, the likelihood of major biases in productivity measurement over a decade or two is not large, although this does remain a potential source of bias for longer-term comparisons. The principal advantage of these TFP growth estimates, however, is that the calculations have a standardized quality.

4. RESULTS AND DISCUSSION

The annual average growth rates in the total output index (TOI), total input index (TII) and total factor productivity index (TFPI) between 1966 and 2011 are shown in Figure 2 and Table 1. The results estimated for individual years appeared to vary widely because of fluctuations in the prices of inputs and outputs. The TFP index (Figure 2 and Table 1) shows an important fluctuation over the analysis period. This fluctuating trend is mainly due to the fluctuation of the Output index, which is explained by the variability of rain-fed agriculture in Jordan due to highly variable climate conditions.

Figure 2 and Table 1 show an increasing trend of the output, inputs, and TFP indexes in Jordan. However, these values should be further analyzed in order to investigate the components the TFP growth and attributes clear shares to the different growth sources.

Consequently, we conducted an econometric estimation of the relationship between TFP growth and different factors, including the most important factors that we consider crucial on the TFP determinants for the Jordanian case. In a stylized form, we used the following regression model (expected signs in parentheses):

$$TFP = f(HC, BTD, SRP, MC, RR, SIL, TO, INF, SM) \quad (4)$$

Where:

TFP = Total Factor Productivity in the Jordanian agricultural sector
HC (+) = Human Capital: Health status as measured by life expectance (Years)

Figure 2. Törnqvist Output, Inputs, and Total Factors Productivity Indexes, for the Jordanian Agricultural Sector (1966 - 2011) Source: Own elaboration (2014)

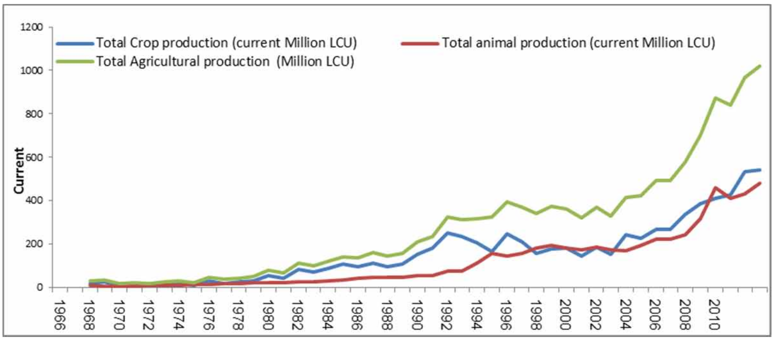


Table 1. Normalized (base 100 for 1966) Values of Output, Input and TFP Indexes

Years	Normalized Output Index	Normalized Input Index	Normalized TFP Index
1966	100	100.00	100
1970	135.23	52.48	38.81
1975	169.87	61.82	36.39
1980	185.79	110.59	59.52
1985	219.66	147.19	67.01
1990	250.02	202.86	81.14
Years	Normalized Output Index	Normalized Input Index	Normalized TFP Index
1995	301.69	275.04	91.17
2000	291.92	281.24	96.34
2005	420.05	341.24	81.24
2010	326.82	426.51	130.50
2011	323.60	443.75	137.13
2012	323.22	443.75	137.29

Source: Own elaboration (2014)

BTD (+) = Balanced territorial development Indicators: Rural GDP per capita (US$/Capita)
SRP (+) = Share of the rural population (in %)
MC (+) = Main crop (Tomatoes in Jordan): Share of total cropland harvested (in %)
RR (+) = Resources reallocation: Agricultural employment share (in %)
SIL (+) =Share of irrigated land/total agriculture land (in %)
TO (+) = Trade Openness: (Import +export)/total production (in %)
INF (+) = Infrastructure: Road density (km /km2 agricultural land) - 1000 Km
SM (+) = Sustainable management: Share of agriculture in water use (in %)

The log-linear form of equation (4) allows for estimating coefficients that can be directly interpreted as elasticities. In addition, as highlighted in the pioneering work by Jud and Hyman (1974), equation (4) contains a weak residual variance relative to other functional forms for the same data set and adjusts the data better than the linear specification for both forecasted parameter signs and statistical significance. The standard Ordinary Linear Squared (OLS) method, if applied to non-stationary data series, can produce spurious regression. That is, the OLS regression can give high R2, low Durbin-Watson (DW) statistics, and significant t-values of the estimated coefficients, suggesting a significant relationship between dependent and explanatory variables, when in fact they are completely unrelated.

Conventionally, the factors explaining TFP have been studied by expressing variables in logarithmic form. This is similar to the first differencing of variables in time series analysis. Provided the original series are integrated of order 1, as is normally the case, expressing the variables in logarithmic terms ensures a stationary data series and means that the OLS method can safely and directly be used (Hendry, 1995).

The log-linear form of regression equation as indicated above was used to examine the relationship between TFP growth and different factors that affect TFP growth. While investments in agricultural research provide an obvious mechanism for TFP growth through technical change, the other variables (economic policy, human capital, infrastructure, and the absence of armed conflict) help to establish an enabling environment for economic growth. These factors enable farmers to access new technologies and markets, increase returns to savings and investments, and provide incentives for farmers to reallocate resources to the most profitable enterprises.

The results showed in Table 2 that human capital has a positive and direct significant impact on the TFP which implies that people with longer life expectancy have a significant impact on TFP growth. The other determinant which showed to have positive and significant impact on TFP is the share of the main crop which is tomato crop in Jordan as tomatoes are among the most important vegetables grown in the country. There are two areas where tomatoes are grown. The total area planted with tomatoes was 8,115 hectares in 2000 and increased to 12,954 hectares in 2011 which reflected positively on TFP growth.

The independent variable of share of irrigated land/total agriculture land (in %) has showed positive and significant impact on TFP as indicated by the result of regression analysis. The total area used under irrigation in Jordan is estimated at 76,911.62 hectares in 2000 for fruit trees, filed crops, and vegetables; this area is estimated at 95,653.84 hectares in 2012 with a 24% increase that explains the direct and significant impact on TFP. The investment in irrigation capital and the modern and efficient use of irrigation systems that been used for the cultivation in the irrigated area has posted the productivity of the agricultural sector significantly.

The independent variable Infrastructure expressed in road density (km /km2 agricultural land) - 1000 Km found to have positive but no significant impact on TFP, thus implying that government investments in agricultural roads will post the overall productivity of the agricultural sector and allows more access for farmers for local market and new markets. The independent variables of Balanced territorial development Indicators: Rural GDP per capita (US$/Capita), the share of the rural population (in %), and sustainable management expressed in share of agriculture in water use (in %) found to have negative and significant impact on TFP as shown in the regression analysis in Table 2. However, the agricultural employment share and trade openness: (Import +export)/total production (in %) variables showed negative relationship and has no and significant impact on TFP.

5. CONCLUSION AND POLICY IMPLICATIONS

This article has summarized the data collection and calculation procedures for the estimation of TFP of the Jordanian agricultural sector for the period 1961 - 2011. Data was collected from different sources and some missing values were estimated and/or approximated through some proxy variables and assumptions. The list of assumptions was discussed above.

The agricultural output growth is usually due to three types of factors: area growth, yield growth, and prices change. Area growth is related to an increase in the quantities of inputs use in addition to land. However, yield growth is generated by both inputs use growth and TFP growth. Then, the

Table 2. TFP Determinants in the Jordanian Agricultural Sector (1967–2011)

	Dependent Variable LnTFPt		
Parameters	**Estimated coefficients**	**t-ratios**	**p-value**
Constant	-6.38	-1.79	0.08
LHCt (Human Capital)	3.08	5.08	0.00
LBTDt (Balanced territorial development Indicators)	-2.68	-1.46	0.15
LSRPt (Share of the rural population)	-0.53	-1.79	0.08
Parameters	Dependent Variable LnTFPt		
	Estimated coefficients	t-ratios	p-value
LMCt (Share of the main crop – tomatoes - of total cropland harvested)	5.68	1.43	0.23
LRRt (Resources reallocation: Agricultural employment share)	-0.77	-0.51	0.62
LSILt (Share of irrigated land/total agriculture land)	0.57	2.96	0.01
LTOt (Trade Openness)	-0.34	-1.15	0.26
LINFt (Infrastructure)	0.70	0.53	0.60
LSMt (Sustainable management)	-6.38	-1.79	0.08
T	45		
R2	0.44		
F-statistic	3.66 (p<0.003215)		
Log likelihood	13.54		

Source: Author's calculation based on coefficient estimates of the linear regression model.

TFP growth is the result of both technical change and better allocative efficiency of the used factors. Growth patterns could be then defined as a trade-off between these two sources which determines TFP growth. Although all choices of growth patterns can achieve the substantive growth of TFP, the distributions between both sources should be coordinated.

Despite some recent improvement, agricultural productivity growth in Jordan continues to lag behind just about every other region of the world. While there are important data challenges in measuring trends in agricultural productivity, most studies agree that agricultural TFP in Jordan was stagnant or declining in the 1960s and 1970s, but turned positive around the mid-1980s. A number of factors appear to have contributed to the renewal of agricultural productivity growth observed in recent decades. One driver is human capital that shown to have positive and direct significant impact on the TFP and the share of the main crop which is tomato crop in Jordan and the share of irrigated land/total agriculture land.

The Infrastructure expressed in road density (km /km2 agricultural land) - 1000 Km have positive but no significant impact on TFP, thus implying that government investments in agricultural roads will post the overall productivity of the agricultural sector and allows more access for farmers for local market and new markets. In addition to investing in agricultural research, strengthening the broader enabling environment for farmers to access technology, markets, and the necessary support services have helped raise agricultural productivity in Jordan. The main implication policy of this research is that estimating growth in TFP is difficult, but it is essential for assessing the country past and potential economic performance and the gains in TFP drive gains in income and growth.

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