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# Effect of Agricultural Research on Productivity and Rural Poverty: Evidence from Iran

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## ABSTRACT

**Most developing countries have achieved productivity growth in economic sectors like agriculture for more than 30 years. Universities and governmental research centers have tried to generate knowledge with direct social and economic effects during these decades. So, productivity and production growth can be attributed to technological changes made possible through investment in agricultural research. Also, investment in agricultural research can have high economic returns as well as helps to reduce poverty. Thus, this study investigated the impact of agricultural research investment on productivity growth and poverty reduction in Iran during 1971-2010. To this end, first, an agricultural productivity trend was estimated. Then, the effects of agricultural research expenditure on productivity growth and poverty reduction were evaluated using a system of simultaneous equations. Results indicate that agricultural productivity grew during this time and agricultural research expenditure had positive effect on agricultural productivity and helped reduce poverty. Nonetheless, barriers like low adoption rate of improved agricultural technologies, lack of awareness of potential research benefits, weak extension systems and poor infrastructural development limited the impact of agricultural research on poverty reduction. Therefore, improving the operation of extension services as well as credit and input supply systems are instruments with which to raise returns to agricultural research investments.**

**Keywords:** Extension services, Simultaneous equations, Total Factor Productivity, Research investments.

## INTRODUCTION

In the last three decades, agricultural productivity has been rising in both developed and developing countries (Rosegrant and Hazell, 2000). Agricultural productivity has several comprehensive effects on economic and agricultural growth, global food waste crisis, and improving agricultural production efficiency in different countries (Chen and Ravallion, 2007). Additionally, universities and public research centers have been attempting to produce knowledge that has direct social and economic effect (Alston, 2010). This situation is particularly strong in developing countries where policy makers have explicitly developed agreements with researchers from universities and public research centers, as well as business sector, to foster the emergence of new ideas that could result in innovations with commercial or social value (Rivera-Huerta *et al.*, 2011). Increases in productivity, production and real price that can be related to technological change are generated via investments in agricultural research and development promotion of public and nonpublic centers (Alston, 2010). Despite the fact that rapid urbanization is increasing the incidence of urban poverty in developing countries, researchers like Kuroda

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(1997), Suhariyanto *et al*. (2001), Nkamleu (2004), and Fulginiti *et al*. (2004) have shown that investment in agricultural research can yield favorable economic returns and contribute to significant reduction in rural poverty. This is related to the fact that agricultural research result in lower food price (Fan *et al.*, 2003).

The links between agricultural research and food price benefits for consumers have been quantified by using consumer surplus as a welfare measure. Over the past half century, hundreds of studies have been published to report measures of agricultural productivity, the effects of agricultural research on agricultural innovation and productivity patterns, and the result in social payoffs to investments in agricultural research.

While there is a large volume of theoretical literature on the role of agricultural research and technology in agricultural growth and poverty alleviation, there is limited empirical evidence establishing the links between agricultural research, productivity growth, and poverty in recent decades. Since it is important to concentrate on these years, some relevant studies is mentioned here. Alene and Coulibaly (2009) surveyed the impact of agricultural research on productivity and poverty in Sub-Saharan Africa (SSA). A polynomial distributed lag structure for agricultural research within a simultaneous system of equations frameworks were used to achieve these aims. Results indicated a strong link between research-led productivity growth and poverty in those countries. In fact, agricultural research was shown to reduce the number of poor by 2.3 million in the studied countries, equivalent to annual rate of 0.8%. Of course, potential impacts of agricultural research are far greater, but SSA faces several constraints outside the research system that hinder realization of potential research benefits. Also, the results show that doubling research investments in SSA would reduce poverty by 9% annually. Fan *et al.* (2003) developed a framework to measure the impact of agricultural research on urban poverty. When investments in agricultural sector increase, it can provide lower food prices by increasing food production, and lower food prices benefit the urban poor because they often spend more than 60% of their income on food. Application of the framework to China shows that these food price effects are large and that the benefits for the urban poor have been about as large as the benefits for the rural poor. Rivera-Huerta *et al.* (2011) emphasized that the impact of interactions between academic researchers and the business sector on research productivity has been less analyzed and they tried to analyze how agricultural fields are affected by the nature of academy-farmers interactions. It was done through two dimensions: the breadth of linkages and their intensity, measured by the duration, in two different modalities (R and D activities and consultancy). Original micro data were selected through a survey of researchers working in universities and public research centers. Results showed that there was a positive relationship between interaction with farmers and productivity growth. Barnes (2002) integrates some non-market components including costs of two specific externalities of agricultural production, namely, fertilizer and pesticide pollution into the Total Factor Productivity (TFP) index. Then, the adjusted index, i.e. 'social *TFP*' is measured against UK public research and development expenditures. The results indicated that the expenditures had positive impact on productivity index, but their rates of return were reduced by using the 'social' as opposed to the traditional TFP index. Therefore, they suggested to add environmental aspects to future researches. Thirtle *et al.* (2003) examined the effect of research expenditure on productivity growth in three agricultural, industrial, and service sectors. Results indicated that researches led to technological change in agricultural sector, thereby generating sufficient productivity growth in this sector. But, in industrial and service sectors, there was no relationship between expenditure of researches and productivity growth. Alwang and Siegel (2003) presented a simple method to measure the impact of agricultural research on the poor. This method has the advantage that it presents the results in a manner consistent with commonly used measures of poverty. This consistency and focus should facilitate and enhance dialogue between policymakers and research managers when deciding on resource allocations and assessing impacts on poverty reduction. Bellon *et al.* (2005) explored new approaches for targeting agricultural research to benefit poor farmers. They used small area estimation methods and spatial analysis and generated high-resolution poverty maps and combined them with geo-referenced biophysical data relevant to maize-based agriculture in Mexico. They believed this integrated approach would help increase benefits from agricultural research to poor rural communities. Otsuka (2000) sought to identify appropriate technologies that agricultural research should generate for poverty reduction and surveyed the impact of agricultural research on poverty reduction. This research was based on a review of the experience of the Green Revolution in rice production in Asia and an assessment of the changing structure of income sources among rural households in the Philippines.

As the reviewed literatures show, agricultural research can have positive impacts on productivity growth and poverty reduction in both developed and developing countries, in empirical view point. Whereas there is little empirical research in this aspect in Iran, this study examined the impact of agricultural research on productivity growth and poverty reduction in Iran as the main goal. To achieve it, we aimed to consider the trend of productivity growth in agricultural sector and poverty and, then, estimate the impact of agricultural expenditures as agricultural research proxy based on regression model.

## MATERIALS AND METHODS

Agricultural research can generate technological changes in various fields that benefit the poor in different ways. First, it can raise the incomes or home consumption of poor farmers who adopt the resulting technological innovation. So, it reduces poverty directly. Secondly, when both the poor and non-poor farmers adopt new technologies, it can have positive effect on their real income through lower food prices for consumers and increased employment and wage effects in agriculture and other sectors of economic activity through production, consumption, and savings linkages with agriculture. Thus, these technical changes can help poverty reduction indirectly (De Janvry and Sadoulet, 2002). Besides, agricultural research is the main factor in raising agricultural production through technological changes. So, it can affect productivity growth directly (Alene and Coulibaly, 2009). As such, there is a significant pathway from agricultural research to agricultural productivity, per capita income, and rural poverty reduction. Thirtle *et al.* (2003) modeled such a pathway and it was used by Alene and Coulibaly (2009). Such a pathway was also used in this study. For this purpose, agricultural productivity was modeled as lagged agricultural research expenditures and production factors. Secondly, *GDP* per capita was modeled as a function of agricultural productivity, land per agricultural worker, government expenditures, gross fixed capital investment, and rural population as a percentage of total population. Agricultural land productivity and land-labor ratio, that explained agricultural labor productivity, are two important explanatory variables in *GDP* per capita. Finally, poverty was modeled. In the fallowing sections, these steps are explained in detail.

### Productivity Estimation

In economic literature, estimation of productivity is done based on three types of data including time series, undated, and panel data. When data are time series, estimation of productivity growth is based on absolute and relative styles. In relative style, the time series data from particular section or country is analyzed separately. Rate of productivity growth is estimated for each section and then compared with each other. But in the absolute style, which was firstly used by Tinbergen in 1942 and 1959, the adjusted Cobb-Douglas production function was used (Akbari and Ranjkesh, 2003). This method estimates ratio of production inputs to define how much of production growth is related to inputs growth and how much is via productivity growth. Achieving this, it should determine inputs elasticity. These elasticity are extracted from production function. So, it is necessary to determine appropriate form of production function firstly. For this purpose, restricted least square F-test was used. Using this test, three more common forms of production function, including Cobb-Douglass, Transcendental and Translog forms were considered and compared with each other. Three forms of production function were estimated for the collected date. Then, they were compared based on value of estimated *F*. At first, Cobb-Douglass and Transcendental forms were compared. On this situation, Cobb-Douglass form is restricted and polynomial is unrestricted. *F*-criteria was computed as follows:

$$F = \frac{(R_{ur}^2 - R_r^2)/M}{(1-R_{ur}^2)/(N-K)} \qquad (1)$$

Where, $R^2_{ur}$ and $R^2_r$ are correlation coefficients of unrestricted and restricted regressions, *N* is the number of observations, *K* is number of parameters in unrestricted regression, and *M* is the added variables in unrestricted model. Estimated *F* would compare with critical values on *F* table. If estimated *F* value is significant, the unrestricted model would be accepted. Otherwise, the restricted model is more appropriate. The selected model in this part would be compared with transcendental form to determine final production function. Estimated *F* in comparing Cobb-Douglass and Transcendental form was 0.17. Since the estimated value was smaller than the critical value, the restricted model, i.e. Cobb-Douglass form was selected. In the second step, the selected form was compared with the Translog form. The *F* estimated in this part was 1.34, which was smaller than the critical value. Therefore, Cobb-Douglass form was the most appropriate production function for data used in this paper. Logarithmic form of Cobb-Douglass production function with respect to production factors is as follows,

$$\ln y = \alpha_0 + \alpha_1 \ln f + \alpha_2 \ln l + \alpha_3 \ln m \qquad (2)$$

Where, *y* represents agricultural value of gross output per hectare, *f* is total fertilizer usage in hectare; l is total agricultural labor force per hectare, and m represents machinery per hectare, α0 represents *TFP*, and *α1, α2*, and *α3* are inputs elasticity. Then, productivity growth is estimated *via* Equation (3).

$$\omega_t = \frac{\partial lnQ}{\partial t} - \left\{\alpha_1 \frac{\partial lnf}{\partial t} + \alpha_2 \frac{\partial lnl}{\partial t} + \alpha_3 \frac{\partial lnm}{\partial t}\right\} \qquad (3)$$

Where, $\omega_t$ is the growth rate of *TFP* at time *t*. A *TFP* index is then defined, setting $TFP_0$= 1.00 in the base year *t*= 0, year, as $TFP_1 = TFP_0 \exp(\omega_1)$, $TFP_2 = TFP_1 \exp(\omega_2)$, $TFP_3 = TFP_2 \exp(\omega_2)$, and so on.

## Effect of Agricultural Expenditure on Productivity and Poverty

This step includes estimation of equations system simultaneously. In this system, provided by Alene and Coulibaly (2009), agricultural productivity as shown in Equation (4), is modeled in logarithmic form as a function of agricultural research expenditures and production factors.

$$\ln y = \alpha_0 + \alpha_1 knf + \alpha_2 \ln l + \alpha_3 \ln m + \alpha_{4j} \sum_{j=1}^{J} \ln R_{i,t-j} \qquad (4)$$

(4)

Where, *R* is agricultural research expenditures in hectare with its lags. The rest of variable are explained previously. It is a fact that agricultural research investments generate a flow of benefits during time. So, it is necessary to add lag of this variable to productivity equation (Alene and Coulibaly, 2009). In this regard, determination of appropriate lag structure is very important. Various procedures have been suggested for determining the appropriate lag length. But, adjusted $R^2$ criteria are more commonly used in identifying lag length in empirical works (Fan *et al*., 1999). Thus, in this paper, the adjusted $R^2$ criterion is used to identify lag length that maximized the $R^2$ for the agricultural productivity equation. Results indicated that a lag length of 3 years made the highest adjusted $R^2$.

Logarithmic form of *GDP* per capita is expressed in Equation (5

$$\ln(\mathrm{gdp}) = \beta_0 + \beta_1 \mathrm{lny} + \beta_2 \mathrm{lnl}b + \beta_3 \mathrm{lng} + \beta_4 \mathrm{lnfi} + \beta_5 \mathrm{lnrp} \quad (5)$$

Where, *y* is agricultural productivity, *b* is land per agricultural worker, *g* is government expenditures, *fi* is gross fixed capital investment, and *rp* is the rural population as a percentage of total population. Agricultural land productivity and land–labor ratio, which together explain labor productivity in agriculture, are important component of *GDP* per capita. Government expenditures and fixed capital investments provide economic infrastructure for increased economic activity that raise per capita incomes. Finally, poverty equation is expressed bellow.

$$lnp = \gamma_0 + \gamma_1 lnG + \gamma_2 lngdp + \gamma_3 lng + \gamma_4 lnfi + \gamma_5 lnpg \quad (6)$$

Where, *G* is Gini coefficient, which refers to income inequality, and pg represents population growth. Other variables are defined previously. It is the poverty equation that captures the eventual trickle-down effect of agricultural research on poverty by way of increased productivity and per capita income. Government expenditures and fixed capital investments are hypothesized to affect poverty not only through per capita *GDP* but also directly through targeted poverty-alleviation expenditures, such as relief efforts through food-for-work and other programs, as well as increased off-farm employment opportunities induced.

To investigate effect of agricultural research it is necessary to estimate the three Equations (4), (5), and (6) simultaneously. To determine effect of agricultural research on poverty, we should estimate cross elasticity (Alene and Coulibaly, 2009), as presented in Equation (7).

$$\frac{\partial lnp}{\partial lnR} = \frac{\partial lny}{\partial lnR} \times \frac{\partial lngdp}{\partial lny} \times \frac{\partial lnp}{\partial lngdp} \quad (7)$$

All ratios are elasticity which are outcome of estimate the simultaneous equations. To estimate equations system, it is necessary to determine endogenous variables. To do this, at first, each of the potentially endogenous independent variables was regressed on the available instruments and the truly exogenous variables in the model. These reduced form equations were estimated for each of the potentially endogenous variables using ordinary least squares, with the main instruments for the potentially endogenous variables being their lagged values. First, the predicted values of the residuals from the reduced form equations were included in the original equation, and Wu–Hausman (WH) *F* tests and Durbin–Wu–Hausman (DWH) $\chi^2$ tests were used to determine whether the variables were endogenous or not. If the coefficient on the predicted residuals was significantly different from zero, then the null hypothesis was rejected and the variable was considered as endogenous. When exogeneity was rejected, the relevance of the instruments was then tested based on the significance and explanatory power of the instruments in the reduced form equations. The validity of instruments for endogenous variables was finally tested by regressing the original equation's errors upon the truly exogenous variables and the instruments, and using Sargan's $\chi 2$ test under the null hypothesis that the instruments were valid. The test is based on the statistic that is equal to $NR^2$ where $N$ is the sample size and $R^2$ is the coefficient of determination, with degrees of freedom equal to the number of instruments.

## Data Collection

Data used in this study were collected from different sources. Total fertilizer, land and machinery were collected from Food and Agriculture Organization (FAO) database. Others were collected from World Bank, Central Bank, and Statistical Center of Iran during 1971-2010. Eviews 7 was used to estimate equations.

## RESULTS AND DISCUSSION

The first step in estimation of time series data is testing their stationary by unit root test. Adjusted Dicky-Fuller Test was used for this aim and the results are presented in Table 1.

As the results show, Rural population (rp), Fertilizer (f), Government expenditures (g), Machinery (m), Agricultural research expenditures(r) are static in level and the first difference of the rest of them is static. Averages of variables used in the analysis are presented in Table 2. Whereas trend of agricultural research expenditure are transitive, accounts are classified based on it. Agricultural research expenditure had little stead growth during 1971-1988. Then it increased rapidly during 1988-2002. It was variable after this time.

As shown in Table 2, average of fertilizer/hectare, labor/hectare, machinery/hectare, total agricultural production, and Gross Domestic Production (GDP) increased in all three periods, while average of land labor ratio, Government expenditures, Gini coefficient, and population growth decreased. To investigate effect of agricultural research on productivity, at firs, trend of productivity growth is considered. To achieve this aim, productivity growth was estimated by using Equations (1) and (3). Results are presented in Table 3.

The results indicated that agricultural productivity experienced a positive growth in 1971-2009. So, it is possible to survey effect of agricultural research on productivity and determine the share of agricultural research expenditure on growth of productivity by suggested equation systems. But, before estimating the system, endogenous test should be done for potential endogenous variables. These variables include fertilizer and labor in the productivity equation; government expenditures and fixed investment in the per capita *GDP* equation; and government expenditures, fixed investment, and income inequality in the poverty equation. The

**Table1.** Unit root test for time series variables.[a]

| Variable | *t*-Statistic | Critical value | Significant level | Lag length |
|---|---|---|---|---|
| rp | 3.77 | 3.63 | 0.007 | I(0) |
| f | 2.95 | 2.94 | 0.015 | I(0) |
| g | 3.58 | 2.94 | 0.011 | I(0) |
| gdp | 3.64 | 3.63 | 0.010 | I(1) |
| lb | 6.77 | 3.63 | <0.001 | I(1) |
| l | 6.77 | 3.63 | <0.001 | I(1) |
| m | 5.35 | 3.63 | <0.001 | I(0) |
| r | 5.32 | 3.63 | <0.001 | I(0) |
| pr | 2.96 | 2.94 | 0.016 | I(1) |
| G | 5.97 | 3.64 | <0.001 | I(1) |
| pv | 3.96 | 3.63 | 0.005 | I(1) |
| fi | 3.90 | 3.63 | 0.005 | I(1) |
| y | 6.18 | 3.64 | <0.001 | I(1) |

[a] Source: Research findings.

**Table 2.** Description of the variables used in the analysis by time period.

| Variables | Source | Mean | | |
|---|---|---|---|---|
| | | 1971-1988 | 1989-2002 | 2003-2010 |
| Total Agricultural output | FAO (2010) | 30896861 | 56373853 | 66246101 |
| Fertilizer/Hectare | FAO (2010) | 0.057 | 0.096 | 0.116 |
| Labor/Hectare | FAO (2010) | 0.4 | 0.428 | 0.455 |
| Machinery/Hectare | FAO (2010) | 0.009 | 0.019 | 0.059 |
| Agricultural expenditures/Hectare | Central Bank of Islamic Republic of Iran (2010) | 714.2357 | 7243.298 | 21370.78 |
| Gross Domestic Production (GDP) | Central Bank of Islamic Republic of Iran (2010) | 195934.7 | 277490.9 | 440392 |
| Land labor ratio | Central Bank of Islamic Republic of Iran (2010) | 2.505 | 2.364 | 2.2 |
| Government expenditures (Percent of GDP) | Central Bank of Islamic Republic of Iran (2010) | 20.9 | 14.04 | 11.7 |
| Fixed investment (Percent of GDP) | Central Bank of Islamic Republic of Iran (2010) | 36.88 | 28.87 | 36.64 |
| Rural population (Million) | Center of Iranian Data Base (2010) | 19.58 | 23.71 | 23.08 |
| Poverty index | Central Bank of Islamic Republic of Iran (2010) | 0.536 | 0.583 | 0.61 |
| Gini coefficient | Central Bank of Islamic Republic of Iran (2010) | 0.41 | 0.401 | 0.399 |
| Population growth | Center of Iranian Data Base (2010) | 0.033 | 0.019 | 0.012 |

**Table 3.** Productivity growth index in agricultural sector 1971-2010 in Iran (1996= 1).[a]

| Year | Productivity growth index | Year | Productivity growth index |
|---|---|---|---|
| 1971 | -0.44 | 1991 | 0.736 |
| 1972 | -0.28 | 1992 | 0.868 |
| 1973 | -0.22 | 1993 | 0.874 |
| 1974 | -0.19 | 1994 | 0.9 |
| 1975 | -0.09 | 1995 | 0.954 |
| 1976 | -0.04 | 1996 | 1 |
| 1977 | -0.04 | 1997 | 1.016 |
| 1978 | 0.034 | 1998 | 1.167 |
| 1979 | 0.097 | 1999 | 1.051 |
| 1980 | 0.131 | 2000 | 1.1 |
| 1981 | 0.128 | 2001 | 1.063 |
| 1982 | 0.214 | 2002 | 1.213 |
| 1983 | 0.261 | 2003 | 1.369 |
| 1984 | 0.336 | 2004 | 1.405 |
| 1985 | 0.43 | 2005 | 1.385 |
| 1986 | 0.502 | 2006 | 1.439 |
| 1987 | 0.521 | 2007 | 1.455 |
| 1988 | 0.496 | 2008 | 1.501 |
| 1989 | 0.537 | 2009 | 1.536 |
| 1990 | 0.674 | | |

[a] Source: Research findings.

results are presented in Table 4.

The results show that for both fertilizer and labor exogenous could not be rejected, therefore, fertilizer and labor are exogenous variables to the system. Agricultural research is assumed to be weakly exogenous as it is conducted by researchers at the national and international level. While government expenditures turned out to be exogenous, the hypotheses of exogeneity of fixed investment in both *GDP* per capita and poverty equations and income inequality in the poverty equation were rejected, but with the instruments being relevant and valid to solve the problem.

Three-stage least squares estimates method was used to estimate the system of simultaneous equations. The results are presented in Table 5. The model fit of the three equations is reasonably well; 89 percent of variation in productivity, 96 percent of *GDP* per capita and 93 percent of the variation in poverty incidence are explained by variables included in the equations. The estimate of agricultural

**Table 4.** Endogeneity test results for potentially endogenous variables.

| Equation | Variables | Instruments | Endogeneity WH-test | DWH-test |
|---|---|---|---|---|
| Poverty | Investment | *Fi(t-1)* | 0.945 | 0.968 |
| | | *Fi(t-2)* | | |
| | Government Expenditure | *g(t-1)* | 2.478 | 2.499 |
| | | *g(t-2)* | | |
| | Inequality | *G(t-1)* | 6.563*** | 6.536*** |
| | | *G(t-2)* | | |
| *GDP* | Investment | *Fi(t-1)* | 7.541*** | 7.505*** |
| | | *Fi(t-2)* | | |
| | Government Expenditure | *g(t-1)* | 1.148 | 1.149 |
| | | *g(t-2)* | | |
| Productivity | Labor | *L(t-1)* | 2.624 | 2.686 |
| | | *L(t-2)* | | |
| | Fertilizer | *F(t-1)* | 0.325 | 0.346 |
| | | *F(t-2)* | | |

*** Represent significance at the 0.01 probability level.

**Table 5.** Simultaneous equation system estimates of the impact of agricultural research in Iran.

| Equation | Variables | Coefficient | *t*-Value | Significant level |
|---|---|---|---|---|
| Productivity growth (4) | Constant ($\alpha_0$) | 1.02 | 4.17 | < 0.001 |
| | Agricultural research expenditures (R) | 0.284 | 14.3 | < 0.001 |
| | Fertilizer (F) | 0.09 | 1.02 | 0.31 |
| | Agricultural Labor force (L) | 0.98 | 0.32 | 0.003 |
| | Machinery (M) | 0.18 | 2.36 | 0.02 |
| | First lag of agricultural research expenditures R(-1) | 0.023 | 2.13 | 0.024 |
| | First lag of agricultural research expenditures R(-2) | 0.034 | 2.42 | 0.02 |
| | First lag of agricultural research expenditures R(-3) | 0.052 | 2.11 | 0.023 |
| | | | | $R^2$= 0.89 |
| GDP equation (5) | Constant ($\beta_0$) | 43.55 | 29.12 | < 0.001 |
| | Agricultural productivity (Y) | 0.66 | 8.32 | < 0.001 |
| | Land per agricultural labor (Lb) | 0.868 | 6.99 | < 0.001 |
| | Government expenditures (g) | -0.1 | -2.56 | 0.016 |
| | Gross fixed capital investment (Fi) | 0.265 | 7.64 | < 0.001 |
| | Rural population (Rp) | -2.27 | -13.78 | < 0.001 |
| | | | | $R^2$= 96 |
| Poverty (6) | Constant ($\gamma_0$) | 2.764 | 7.31 | < 0.001 |
| | Gini coefficient (G) | 0.4 | 2.63 | 0.015 |
| | Gross Domestic Production (GDP) | -0.23 | -11.93 | < 0.001 |
| | Government expenditures (g) | -0.04 | -2.25 | 0.027 |
| | Gross fixed capital investment (Fi) | 0.098 | 6.41 | < 0.001 |
| | Population growth (pg) | 0.08 | 9.42 | < 0.001 |
| | | | | $R^2$= 0.93 |

Source: research findings

productivity equation is supported by Thitle *et al*. (2003) and Alene and Coulibaly (2009). Over 3 years, agricultural research has positive and significant effect on agricultural productivity. The estimated total elasticity of productivity with respect to agricultural research is 0.39. It means that by doubling agricultural research expenditures per hectare of agricultural land, agricultural productivity would increase about 39 percent. Labor and machinery have also positive and significant impact on agricultural productivity. Considering this fact that agricultural activities are concentrating on labor force, labor elasticity is higher than machinery elasticity. In contrast, these results indicated that fertilizer had no significant effect on agricultural productivity. It is likely implying that usage of chemical fertilizer in the study period was higher than optimal content in Iran's agriculture, so, it's higher usage had no effect on production level.

The estimation of GDP per capita equation indicated that all variables have significant effect on gross domestic production (GDP). Therefore, one percent change in agricultural productivity, would raise *GDP* per capita by 0.66 percent. This confirms that agricultural sector is the main economic sector in Iran. Government expenditures had negative effect on both *GDP* per capita and poverty. This result is similar to Thirtle *et al* (2003) study. The share of rural population is negatively and significantly associated with GDP per capita. This result confirms this fact that rural population lie in the bottom deciles of income. Furthermore, land per capita, agricultural labor, and gross fixed capital investment had positive effect on *GDP* per capita.

The estimated poverty equation shows that Gini coefficient as income inequality index has positive and significant effect on poverty. *GDP* per capita and government expenditure had negative and significant effect on poverty. The negative effect of *GDP* per capita on poverty confirms that economic growth could help to poverty reduction. Notable point is that, according to World Bank report (2007), *GDP* growth in agricultural sector itself is several times more effective in raising income and poverty reduction than *GDP* growth originating outside the sector. On the other hand, agricultural research affects poverty indirectly through productivity growth and its effect on *GDP* per capita. Thus, agricultural research has contribution to poverty reduction in Iran. Government expenditures and gross fixed investments have positive and significant effect on poverty. It shows that poverty-alleviation programs and development of infrastructural operations in rural areas would have new opportunities for rural poor. Population growth has a positive and significant effect on poverty.

According to Equation (6), the estimated coefficients were used to derive the elasticity between agricultural research, productivity, *GDP* per capita and poverty. The results are presented in Table 5. Since agricultural research affects *GDP* per capita through its effect on productivity, the *GDP* per capita elasticity of agricultural research (0.12) is the product of the productivity elasticity of agricultural research (0.189) and the *GDP* per capita elasticity of productivity (0.66). This means that increased

**Table 6.** Elasticity between agricultural research, productivity, income and poverty.[a]

| Elasticity | Estimate |
|---|---|
| (1) Agricultural productivity—agricultural research | 0.284 |
| (2) *GDP* per capita—agricultural productivity | 0.66 |
| (3) Poverty—*GDP* per capita | -0.23 |
| (4) GDP per capita—agricultural research= (1)×(2) | 0.19 |
| (5) Poverty—agricultural productivity = (2) × (3) | -0.15 |
| (6) Poverty—agricultural research = (1) × (2)×(3) | -0.028 |

[a] Source: research finding.

agricultural research has about 19% of the impact of productivity increases on *GDP* per capita. Since agricultural productivity affects poverty through its effect on *GDP* per capita, the poverty elasticity of productivity (-0.15) is the product of the *GDP* per capita elasticity of productivity (0.66) and the poverty elasticity of *GDP* per capita (-0.23). This means that productivity increases have 66% of the impact of increased *GDP* per capita on poverty. As productivity is generated by agricultural research and affects poverty through its effect on *GDP* per capita, the poverty elasticity of agricultural research (-0.028) is the product of all three elasticity in Equation (6). This means that agricultural research has 12% of the impact of increased *GDP* per capita on poverty or 12% of the benefits of economic growth that trickle down to the poor would be attributed to agricultural research. Therefore, agricultural research has positive impact on average incomes, but negative effect on poverty.

## CONCLUSIONS

This study surveyed the impact of agricultural research in Iran over the period 1971–2010, using a simultaneous system of equations model that establishes relations between agricultural research, productivity, per capita income, and poverty. The results indicated that agricultural research contributes significantly to productivity growth in Iran. The results suggest that doubling agricultural research expenditures per hectare of agricultural land would lead to 28% increase in agricultural productivity, with the implied absolute effects being even larger. Agricultural research has also positive effect on *GDP* per capita. In fact, about 19% of the impact of productivity growth on per capita incomes is attributable to increased agricultural research. While income inequalities worsen poverty, growth of *GDP* per capita has a significant poverty-reducing effect where a 1% increase in *GDP* per capita reduces poverty by 0.23%. This confirms the view that income growth originating in agriculture is many times more effective in raising incomes of poor people than income growth originating outside the sector. The econometric evidence thus suggests that agricultural research not only increases average incomes but also reduces poverty in Iran. The aggregational impact indicates that agricultural research investments are simply inadequate to bring such productivity growth that is high enough to reduce poverty. Alene and Coulibaly (2009) state several reasons for this inadequacy. These include low adoption rate of improved agricultural technologies, unawareness of potential research benefits, weak extension systems, and poor infrastructural development. Therefore, improving the operation of extension services as well as the credit and input supply systems would help to achieve greater poverty reduction through agricultural research.

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## تأثیر تحقیقات بخش کشاورزی بر بهره‌وری و فقر روستایی: شواهدی از ایران

ع. اسمعیلی، و ح. صدیقی

## چکیده

اغلب کشورهای در حال توسعه، طی ۳۰ سال اخیر، در بخش‌های مختلف اقتصادی از جمله بخش کشاورزی رشد بهره‌وری را تجربه کرده‌اند. از سوی، دانشگاه‌ها و مراکز تحقیقات دولتی طی سه دهه اخیر تلاش کردند دانشی را ایجاد کنند که دارای اثرات اجتماعی و اقتصادی مستقیمی باشد. سرمایه-گذاری در تحقیقات بخش کشاورزی از طریق تغییر در تکنولوژی، می‌تواند در ارتقای بهره‌وری و تولید در این بخش مشارکت دارد. همچنین این احتمال وجود دارد که این نوع سرمایه‌گذاری به بازده قابل قبول اقتصادی منجر شود و به کاهش فقر کمک کند. مقاله حاضر به دنبال بررسی امکان و چگونگی تأثیر گذاری هزینه تحقیقات بخش کشاورزی بر رشد بهره‌وری و کاهش فقر در ایران در دوره زمانی ۱۳۸۹-۱۳۵۰ است. برای دستیابی به این هدف، در ابتدا روند رشد بهره‌وری در بخش کشاورزی تعیین شده است؛ سپس تأثیر هزینه تحقیقات بخش کشاورزی بر رشد بهره‌وری و کاهش فقر در قالب یک سیستم معادلات، بررسی شده‌است. نتایج بدست آمده نشان داد بهره‌وری بخش کشاورزی در دوره مورد بررسی در کشور ایران در این دوره تقریباً رشد داشته است و هزینه تحقیقات در بخش کشاورزی تأثیر مثبت و معنی دار بر بهره‌وری در بخش کشاورزی و تأثیر منفی بر فقر داشته است. با اینحال، موانعی نظیر نرخ پذیرش پایین تکنولوژی‌های ارتقاء دهنده بخش کشاورزی، ناآگاهی از منافع بالقوه تحقیق، ضعف سیستم‌های ترویجی و توسعه زیرساختی، از اثربخشی و قدرت تحقیقات در بخش کشاورزی در راستای کاهش فقر می‌کاهد. بنابراین، بهبود عملیات ترویجی، سیستم‌های عرضه و اعتبارات، ابزاری برای بهبود کارایی تحقیقات در بخش کشاورزی محسوب می‌شوند.