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Determinants Of Agricultural Productivity: The Turkish Case Between 1962-2017

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Abstract

Agricultural productivity is especially important for developing countries. Taking into account the productivity gap between different sectors of the economy and the instability in food prices, the determinants of agricultural productivity in the long-run seems more important than ever. This study aims to find out the determinants of agricultural total factor productivity for the period 1962-2017 using human capital, fertilizer consumption, credits and land utilization as explanatory variables. Key findings suggest that human capital, fertilizer consumption and credits all have positive effects on agricultural productivity and among them the most effective has been the human capital.

1. Introduction

Agricultural development and increased productivity in the Turkish agricultural sector are -still- an important source for economic growth and stable economic function and Turkey is not an exception. Thus, maintaining a good level of productivity in the sector is of high importance. Considering the facts that the sector provides living for a non-negligible part of the population (for Turkey the rate is about 25% in 2018 according to the World Bank) and that it has strong bilateral ties with some important sub-sectors of industry, it seems logical to expect a better platform for both rural and urban development under higher productivity levels in agricultural production. Despite a sharp decrease in agricultural sector's share in GDP especially after late 1960s, the sector in Turkey still accounting for a higher part of GDP compared to developed countries.

As in many countries, one can argue that agricultural sector and industrial sector to be complements rather than being each other's rival. This means that a productivity increase in the agricultural sector may be counted as a future expected productivity increase in the manufacturing sector through forward linkages, by reducing input costs. Similarly, it seems reasonable to assume that a higher productivity in agricultural sector would increase farmers' income per capita, causing an expected increase in future demand for goods and services produced in industrial sector through backward linkages, again creating an

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opportunity for a productivity increase in industry. In the progress of development, the agricultural sector feeds other parts of economies with labor and raw materials and those parts also feed the agricultural sector by directly increasing productivity as Taymaz and Suicmez (2005) puts.

Agricultural productivity is especially important for Turkey in terms of the stability of food prices. Although there are other reasons that are seemingly much more relatable to the instability for food prices (such as energy costs for retail), there is no reason to think that increased productivity in the agricultural sector would harm the stability farther. Conversely, the idea of farmers with increased income levels due to higher productivity levels may possibly find ways to decrease the instability in food prices by actively searching for new markets for their products and adapting their production to demand. This is accepted as a fact regarding many studies such as World Bank (2007), Torstle (2008) and Dorward (2013).

Food prices are also important for poverty related calculations and sustainability of agricultural production. Increases seen in food prices push people under subsistence level thus creating discomfort in society and even causing social unrest. On the other hand trying to suppress food prices causes agricultural producers to exit market or utilize unethical-forbidden and/or non-environment-friendly methods to increase productivity, for example using banned/obsolete pesticides or overdosing the soil with fertilizers. At this point, arguably, increases in agricultural productivity via environment-friendly ways may help cope with the issue.

Despite the significant increase in agricultural total factor productivity (TFP) in Turkey especially after 2000s, the sector stands far behind regarding productivity growth compared to other countries in the region, including but not limited to Bulgaria, Croatia and Ukraine and as well as other emerging markets -again including but not limited to- Brazil, Chile and Mexico. According to the Economic Research Service of USDA, agricultural TFP index (2005=100) value for those countries and Turkey given in the table below.

Table 1: Country Comparison: Agricultural TFP Values in 2016

Country	Agricultural TFP Value in 2016 (2005=100)
Turkey	113
Bulgaria	141
Croatia	149
Ukraine	148
Brazil	135
Chile	124
Mexico	120

This brings out a necessity for a study to identify the determinants of agricultural productivity in Turkey to become able to suggest a macroeconomic policy path.

2. Literature

Increases in agricultural production via productivity increases are thought to be most beneficial to people that need them most. This may be accepted as a fact considering various studies from different parts of the world, one important piece being Deller et al. (2003).

As agriculture constitutes for less and less proportions of modern economies, it becomes easier to argue that one does not simply encounter as many and as standardized studies in agricultural productivity. Other reasons for that may be lack of micro-data, differences in data aggregation techniques, insufficient metadata until recent years and of course problems in measurement. Along with country-specific rural conditions and policies, it has become harder to conduct a comprehensive study, especially using country panels. Thus many of the studies in the field of agricultural productivity either focused on a country or conducted panel analysis using only available standardized data. A brief set of examples are given below in date order.

Hayami and Ruttan (1970) show that human capital explains about one-third of the total increase in labor productivity and that in order to increase the productivity policies increasing the investment in rural education and physical-biological-social sciences, emphasizing the importance of human capital. Ball et al. (1997) find that between the years 1948-1994 labor input in US agricultural sector decreased 2.73% and a slight, less than 1% increase in capital input occurred annually. Yet, the sector managed to grow about 2% at an annual rate which the researchers interpreted as a consequence of productivity growth. Gollin et al. (2013) draw attention to agricultural productivity gap and argue that despite corrected calculations considering sectoral differences in hours worked and human capital, a serious productivity gap remains between agricultural and non-agricultural workers. This points out to the importance of needed investigation regarding human capital in agricultural sector. Dernek (2006) summarizes the progress in agricultural development in Turkey and puts that in spite of significant production increases in specific types of agricultural produces the rate at which the sector increases its productivity is insufficient in comparison. Chen et al. (2008) put that the agricultural TFP growth in rural China between 1990-2003 was originated largely from technical progress yet it didn’t help decrease regional disparities. Imhoroglu et al. (2012) investigates agricultural productivity and its long-term effects on income per capita in Turkey. Using specified key variables of intermediate input ratio, agricultural employment, agricultural labor productivity and total labor productivity to create agricultural production function and considering a bi-sector economy they find that historically, lower increases in agricultural productivity caused a divergence in terms of income per capita between similar countries. The study emphasizes that if Turkish agricultural productivity were to increase as much as Spain’s in the past, both the agricultural employment level would have dropped farther and income per capita would have increased significantly more.

Ahmad and Heng (2012) studied Pakistani agricultural TFP and found that fertilizer was the most important source of productivity increase both in the long-run and in the short-run while human capital and credit also being significant, yet the area under crops being insignificant in both long-run and short-run. Gutierrez (2002) found that as measures of human capital increases in a society, agricultural labor productivity growth increases. This is in line with his evidence towards conditional convergence, which is cross-country agricultural productivity does not converge to a mutual level, instead productivity level in each country converges to related long-run level. Endale (2011) found that among other inputs, fertilizer consumption significantly increased agricultural productivity in Ethiopia between 1995-2004. Petrick (2004) puts that credit usage and motivations related with it helped farmers increase their productivity and showed that as the size of production decreases the rate at which agricultural credits provide extra productivity increases. In other words, credits to agricultural sector makes a greater positive effect on small-size firms. Taking into account the fact that most Turkish farmers are small in size, positive effects of credits on productivity should be expected. Yalcinkaya (2018) puts that credits to agricultural sector Granger caused increases in agricultural GDP between 2005-2015.

3. Data Source and Methodology

This study accepts agricultural TFP (AgTFP) as the key proxy to agricultural productivity measurement and focuses on four key independent variables of human capital index (HC), total usage of selected fertilizers (FERT), net credit to private sector (CREDIT) and agricultural land (LAND). The index data regarding AgTFP was gathered from USDA Dataset (2019). As Turkish agriculture is not focused on a limited variety of agricultural produces and it employs different types of soil-elevation-humidity combinations due to the country's geographical position, it seemed suitable to conduct such an analysis using only the inputs that are widespread throughout the whole sector. The consumption data for fertilizers were gathered from FAO Statistics database. Fertilizer selection was made regarding nutritional capacity and long-run harm criteria; thus phosphate and potash consumption was summed up for every observation. The fact that nitrous fertilizers are one of the major causes of soil degradation in the long-run (Velthof et al., 2011) due to excessive utilization (Pires et al., 2015) and causing depletion of soil nitrogen (Mulvaney et al., 2009), inclusion of more soil-friendly fertilizers seemed reasonable while being in line with global agricultural sustainability goals. The data on human capital was obtained from Penn World Table 9.1 as it is accepted as a standardized human capital measurement, despite its deficiencies. The lack of systematic special education towards rural population promoted the idea of using a general measurement of human capital rather than using a specific type of it directly measuring human capital accumulation in agricultural sector. Note that the proxy for the key input of high-tech capital is CREDIT due to the fact that not all types of agricultural production uses typical capital goods like tractors. Credit usage data was gathered from World Bank databank in local currency unit values in consequence of the large gap of observations in FAO Statistics database regarding credit to agricultural sector (only available between 2005-2017). Lastly, the data for agricultural land was gathered from FAO database as "land area equipped for irrigation", which helps make the effects of fertilizers clearer.

The study analyzes the period between 1962-2017 using annual data. The data for AgTFPgr in USDA dataset included the latest value for 2016. Thus the observation for the year 2017 was extrapolated as to fit aggregated welfare related TFP data from Penn World Table 9.1. Using logarithmic values for all the series, the following equation was constructed.

$$lnAgTFP = c + \beta_1 lnHC + \beta_2 lnFERT + \beta_3 lnLAND + \beta_4 lnCREDIT + \mathcal{E}_t$$

Unit root tests conducted on variables showed that the dependent variable (AgTFP) to be stationary at I(1) and independent variables to be a combination of I(0) and I(1). Phillips-Perron (1988) (for AgTFP, FERT, LAND and CREDIT) and Breakpoint ADF (1979, 1981) (for HC) unit root test results are given in the table below.

Table 2. Unit Root Test Results for Variables

Variable	Difference Level	Adj. t Value	Probability	Stationarity
AgTFP	I(0)	-2.536421	.3102	I(1)
	I(1)	-12.81273	.0000	
HC	I(0)	-6.581284	<.01	I(0)
FERT	I(0)	-2.756961	.2191	I(1)
	I(1)	-7.985009	.0000	
LAND	I(0)	.711618	.9996	I(1)
	I(1)	-6.102078	.0000	
CREDIT	I(0)	-1.639388	.7642	I(1)
	I(1)	-7.042025	.0000	

Assuming the sector in Turkey has not gone through any significant structural break, utilization of an autoregressive estimation technique seems suitable. Additionally, the dependent variable being I(1) makes the ARDL estimation more trustworthy (Pesaran and Shin, 1999 and Pesaran et al., 2001) and independent variables being a combination of I(0) and I(1) prevent using the VAR or VECM estimation. Lastly, ARDL estimation technique is useful even for analyses containing variables with the same order of stationarity (Duasa, 2007 and Adom et al. 2012). This makes using ARDL estimation technique justifiable. Final equations for long-run and short-run were generated as below.

$$\Delta AgTFP_t = a + \sum_{i=1}^{n} a_t \Delta AgTFP_{t-i} + \sum_{i=0}^{p} a_t \Delta HC_{t-i} + \sum_{i=0}^{q} a_t \Delta FERT_{t-i} + \sum_{i=0}^{s} a_t \Delta LAND_{t-i} + \sum_{i=0}^{r} a_t \Delta CREDIT_{t-i} + \delta_1 HC_{t-1} + \delta_2 FERT_{t-1} + \delta_3 LAND_{t-1} + \delta_4 CREDIT_{t-1} + \delta_5 AgTFP_{t-i} + \varepsilon_t$$

$$\Delta AgTFP_t = \theta_0 + \sum_{i=0}^{n} \theta_i \Delta AgTFP_{t-i} + \sum_{i=0}^{n} \theta_i \Delta HC_{t-i} + \sum_{i=0}^{n} \theta_i \Delta FERT_{t-i} + \sum_{i=0}^{n} \theta_i \Delta LAND_{t-i} + \sum_{i=0}^{n} \theta_i \Delta CREDIT_{t-i} + \theta_i ECT_{t-1} + e_t$$

Using maximum operable lag lengths for dependent variable and independent variables regarding Akaike Criteria, the optimal lags were automatically determined by the software Stata 15.1. Estimation results are given in the table below.

Table 3. Estimation Results for ARDL (1, 3, 3, 4, 1)

	Variable	Coefficient	t-value	P > |t|
	(ADJ)	.9887424	-7.56	.000
LR	HC	.4913044	3.55	.001
	FERT	.0748797	7.59	.000
	CREDIT	.1236311	4.06	.000
SR	HC(L2)	-2.514238	-2.21	.033
	FERT	-.0608845	-5.19	.000
	FERT(L1)	-.0488406	-4.33	.000
	FERT(L2)	-.0375682	-3.60	.001
	LAND(L3)	-.6366811	-2.69	.011
	CREDIT	-.1009128	-2.41	.021

The table includes significant values only.

The results revealed that the model's adjustment rate for Turkey to be 98% annually. The adjustment rate shows only a slightly less correction than full in unit period.

Diagnostic tests showed that the model was well-defined in terms of variable omission and had neither autocorrelation nor heteroskedasticity. Only a little deviation from normality condition was captured but considering the length of series the model was interpreted as usable. Test results are given in the table below.

Table 4. Diagnostics Test Results for ARDL Estimation

Test	**Value**	**Prob. > Chi Sq.**	**Prob. > F**
Durbin-Watson	2.089235	Ø	Ø
LM (ARCH)	.076	.7828	Ø
LM (Bresuch-Godfrey AC)	.654	.4185	Ø
Breusch-Pagan / Cook-Weisberg Heteroskedasticity	2.09	.1483	Ø
Ramsey RESET	.29	Ø	. 8331

The estimated coefficients of human capital, which is based on years of schooling and returns to education, are in opposite direction in the long-run and the short-run. As expected, long-run coefficient is positive meaning that a percentage increase in HC increases AgriTFP at the rate of .49%. On the contrary in the short-run a percentage increase in HC decreases AgriTFP by a much larger 2.51%. This may be due to the fact that in the short-run HC increases cause efficient labor, which to a large extent consists of young people, to be withdrawn from agricultural production.

The coefficients regarding fertilizer consumption are also in opposite direction in the long-run and the short-run. Again, as expected, long-run effects are positive but not as high. A percentage increase in aggregated fertilizer usage increases the AgriTFP only .07%. Considering the length of data and comparing the result with other studies that small effect seems reasonable. For example, a recent study by Rehman et al. (2019) found that for the time period 1978-2015, fertilizer usage increased agricultural productivity only at the rate of 1-3%. Another recent study by Patra et al. (2016) discovered that for the period 1989-2010, fertilizer usage was unable to explain the production increase at a significant level. On the other hand, fertilizer usage and its productive effects are well-documented in controlled studies. Here the reason the effect being so small is thought to be twofold: first, defects in fertilizer data due to problems in data collection and/or aggregation and second, the fact that the quality and utilization technique is much more important than the quantity of fertilizer consumed. The short-run coefficients are found to be all negative with a declining power as lags increase. Such results may stem from a couple of reasons. One of which should be the negative effects of chemical fertilizers combined with its misuse/abuse causing soil to become barren. This has been a remarkable issue especially in the last two decades in Turkey. Another notable factor should be the solubility of different fertilizers depending on their structure and of course the related irrigation technique.

The effect of land utilization is found to be negative in the short-run and insignificant in the -long-run. The result is consistent with the economic theory as other agricultural inputs per acre decreases a productivity decrease is expected. A percentage increase in land utilization in the short-run decreased agricultural productivity by .63 percent.

Lastly the effect of credit usage has also opposite directional effects in long-run and short-run. The magnitude of effect is slightly bigger in the long-run (.12%) than in the short-run (-.10%). This seems rational as in Turkey loans in agricultural sector are used substantially for agricultural land and facilities like warehouses. Capital accumulation and especially the increases in land ownership decreases agricultural inputs per acre while the effects of repayments translate into less input utilization, such as lower consumption of fertilizers, irrigation etc.

4. Discussion and Conclusion

The study, despite its weaknesses stemming from data and period, reveals that human capital has been the most effective source of agricultural productivity in the period of 1962-2017 and followed with the positive effects of credit and fertilizer consumption in the long-run.

Except for fertilizer consumption, all the variables introduced to the equation produced expected results both in the long-run and in the short-run. The reason for fertilizer consumption in the short-run causing negative productive effects in agriculture needs to be the subject of further research. But first, a trustworthy set of fertilizer consumption data will not be available unless a detailed metadata analysis revealing the fittest technique to aggregate fertilizer consumption data in such a way that both the quantity and quality characteristics of fertilizers are captured. It seems as a fact that there is substantial need for systematic and complex micro-data to understand and to be able to precisely evaluate the complete effects of agricultural inputs on agricultural productivity.

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