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Time Series Analysis of Causal Relationship among Sectoral Labor Productivity in Turkey

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ABSTRACT

In this paper, we investigate the causal relationship in terms of labor productivity among GDP and its constituent three main sectors, e.g. agricultural, industrial and services sectors, in Turkey for the period of 1988-2015. In the study we employed Granger causality/block exogeneity Wald test, Impulse Response and Variance Decomposition analysis. The results showed that both agriculture and industry have positive effects on the labor productivity in services sector, and industry has a positive effect on the labor productivity in agriculture sector, while industrial labor productivity is not affected by the others. The main aim of the paper is examine the question of whether agriculture could serve as an engine of growth. Accordingly, the results indicated that labor productivity in agriculture sector increased during the course of study, and contributed to the labor productivity in services sector, as well. To our knowledge, although this method has been applied in various areas, sectoral causality has not been studied for Turkey before.

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Introduction

Labor productivity is the key factor of economic growth for any economy in the world. Labor productivity is related to the quality of available labor resources and technologies used in the production of goods. Therefore, labor productivity has a direct influence over production process and costs, which then affect the competitiveness of the countries (Emsina, 2014).

Agriculture is an important constituent of GDP and also contains a big part of work force in the developing countries. Agriculture can be an important source of growth by supporting other sectors through the transfer of resources, and providing a market for non-agricultural goods and services. On the other hand, agriculture can also take advantage of the technological improvements in the industry and services that spill over to agriculture, which has direct influence over the productivity. However, as the countries become industrialized, agriculture’s relative importance in the economy starts to decrease. Labor force is driven out of agriculture to other alternative sectors. In Turkey, agriculture’s share in GDP decreased from 22.5% in 1968 to 8.9% in 2015, and its share in total employment decreased from 46.5% in 1988 to 20.5 in 2015 (TSI, 2016).

The aim of this paper is to investigate the interrelations among labor productivity levels in agriculture, industry and services sectors of Turkey. For this purpose, we examined the relationships and causality among the three main sectors and GDP using a vector autoregression (VAR) model for the period 1988-2015. By using a VAR model, all variables are considered to be potentially endogenous, and we observed the short and long run responses to shocks and causality among the sectoral productivity levels.

Rahman et al. (2011) examined the causal relationship among GDP, agricultural, industrial and service sector outputs for Bangladesh using the time series data from 1972 to 2008. They employed granger causality/block exogeneity Wald tests statistics in their study. They found a long run equilibrium relationship among these variables and bi-directional causality is observed between GDP and agriculture, industry and GDP, as well as between industry and service sectors. They also determined unidirectional granger causality from industrial sector to agricultural sector and GDP to service sector. Their results indicate that agricultural and industrial sectors are driving factors of the GDP in Bangladesh and the reverse is also true. On the other hand, service sector does not influence the GDP but GDP influences the growth of the service sector.

Adenomon and Oyejola (2013) investigated the impact of agriculture and industry on GDP in Nigeria for the period of 1960-2011, employing VAR and SVAR models. The results of VAR model indicated that agriculture contributed about 58% to GDP, while industry contributed about 32%. On the other hand, the results of SVAR model revealed that agriculture and industry contributed to the structural innovations of GDP in Nigeria, with more contribution resulting from agriculture sector. In conclusion, they recommended that special incentives should be given to agriculture sector and infrastructural facilities to boost the development, while new approaches should also be pursued for industry sector.

Siboleka et a. (2014) investigated whether or not there is a causal and long term relationship between agriculture and manufacturing sectors of Namibia over the period 1981-2012. They used unit root, correlation and granger causality tests and determined no causal relationship between agriculture and manufacturing in Namibia, and claimed that appropriate policy interventions are required to influence how the two sectors should benefit from each other in order to support potentials for both sustained employment opportunities and economic growth in Namibia.

Wang and McPhail (2014) examined the impacts of energy price shocks on US agricultural productivity growth and commodity prices' volatility using a Structural VAR model. They used annual data set of gasoline prices, agricultural total factor productivity, real GDP, agricultural exports and agricultural commodity price for the period of 1948-2011. As a result, they determined that energy price shock has a negative impact on productivity growth in the short run, and an energy shock and an agricultural productivity shock each account for about 10% US agricultural commodity price volatility, while the productivity sock contributes slightly higher.

Martino (2015) investigated labor productivity Dynamics for 1263 regional economies of the European Union for the period of 1991-2007. The author used the data of Gross Value Added and employment pertaining to 1263 regional economies of Belgium, Czech Republic, Denmark, Germany, Estonia, Greece, Spain, France, Ireland, Italy, Lithuania, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden and United Kingdom. The results revealed a clear process of unconditional convergence for financial and business-related market services, but not for manufacturing and aggregate productivity.

Kurt and Kurt (2015) examined the effect of innovative technologies upon labor productivity for the 5 BRICS countries (Brazil, Russia, India, China, South Africa) using VAR and granger causality tests. The data set covered the periods of 2000-2012. As a result, they determined a positive relationship between innovation and labor productivity. They concluded that innovation is an important factor in economic growth equations, and in addition to its improvement in efficiency and productivity of capital, innovative technologies also contribute greatly to the productivity of labor force.

Boghean and State (2015) analyzed the effects of foreign direct investments (FDI) on the economic development of countries in terms of labor productivity. They argues that FDI enables long term technological progress and economic growth through technological transfer, management and marketing proficiency. And the development of management skills will increase population's training level and its capacity to adapt to the technological developments, which results in the increase of labor productivity. From this respect, they analyzed EU countries using correlation method on data of 2000-2012 time periods retrieved from Eurostat website. In conclusion, they determined a strong connection between the volume of foreign direct investments and average labor productivity.

Polemis and Stengos (2015) investigated the impact of market structure on labor productivity and wages using a panel set of US manufacturing industries for the period of 1958-2007 with a smooth coefficient semiparametric model (SCSM). They determined a nonlinear relationship between market concentration and labor productivity and wages.

Gaspar et al. (2015) investigated the long run relationship and causality among agriculture, industry and service sectors of Portugal for the period of 1970-2006, estimating a trivariate VAR model in terms of both value added and productivity of the sectors. As a result, they determined that agriculture value added is both weakly and strongly exogenous and exerted no influence on the other two sectors, nor was it affected by them. In terms of labor productivity, bot industry and services have positive effects on agricultural productivity, while the agriculture has a stronger effect on the other two sectors.

Material and Methods

Annual data of GDP and constituent three main sectors for the period of 1988-2015 were used in the study. Accordingly, agriculture sector comprises agriculture and livestock production, forestry and fishing; industry comprises mining and quarrying, manufacturing, electricity, gas and water, construction, wholesale and retail trade; and services sector comprises services of hotels and restaurants, transportation and communication, financial institution, ownership of dwellings, business and personal services, imputed bank services, government services and private non-profit institutions.

The real GDP values were obtained from Turkish Statistical Institute (TSI, 2012) in two different constant series fixed on 1987 prices and 1998 prices. In order to combine these two time series, distinct inflators were utilized for each sector using the data pertaining to the period of 1998-2006 covered by both series. The inflators were obtained from the information given by TSI (TSI, 2012). As a result, we obtained a single series of GDP fixed at 1987 prices. In addition, sectoral employments were also obtained from TSI for each sector and used in the study. And, all the variables were transformed in natural logarithm. Then, sectoral labor productivity rates were calculated by dividing the obtained real sectoral production values by sectoral employment. As we used long term values in the study, we employed stability diagnostics tests CUSUM and CUSUM-square to check for possible structural breaks in the data. The results are given in the Figures below. As a result, although it is a known-fact that Turkey has undergone important structural changes in the last decades, no structural break is detected in the diagnostics tests, which can be explained by the nature of data, in that we are using productivity rates derived by the division of sectoral production and employment in the study.

Stationary property of the data series has to be checked in order to prevent biased conclusions in the study. For this purpose, Augmented Dickey-Fuller (ADF) unit root test was used to check stationarity (Yetiz, 2008; Rahman et al., 2011).

$$\Delta X_t = \mu + \alpha t + \delta X_{t-1} + \sum \delta i \Delta X_t - 1 + \varepsilon_t$$

$$\Delta X_t = X_t - X_{t-1}$$

X_t : dependent variable
μ : constant
t : trend
ε_t :stochastic error
H_0 :δ=0 (X_t is non-stationary)
H_a :$\delta \neq 0$ (X_t is stationary)

In the next step, Johansen Cointegration test was used to determine possible cointegration relationship among data. In this model, the cointegration relationship is shown as below, and if the error term is stationary I(0), two series is concluded cointegrated. Some previous studies that implemented Johansen Cointegration, Granger Causality and VAR model on GDP parameters are Adenomon M.O., Oyejola B.,A., (2013); Dritsakis N., Varelas E., Adamopoulos A., (2006); Uddin M., (2015); Los E, Gardebroek C, (2015); Gaspar, J., Gilson, P., Simoes, M. C. N. (2015), and Rahman M., Rahman S., and Hai-Bing W (2011).

$$Y_t = \beta X_t + \varepsilon_t$$

H_0 :β=0 (series are not cointegrated)
H_a :$\beta \neq 0$ (series are cointegrated)

The rejection of null hypothesis H_0 indicates the cointegration of series, which means that the series take joint action in the long run. However, this test does not reveal the direction of the relationship. One method that can be used for this purpose is Granger causality test. In order to test for Granger causality, we will estimate a VAR model as follows, in which all variables are initially considered symmetrically and endogenously (Rahman et al., 2011; Gaspar et al., 2015).

$$Y_t = a_0 + a_1 Y_{t-1} + \cdots + a_p Y_{t-p} + b_1 X_{t-1} + \cdots + b_p X_{t-p} + \mu_t$$

$$X_t = c_0 + c_1 X_{t-1} + \cdots + c_p X_{t-p} + d_1 Y_{t-1} + \cdots + d_p Y_{t-p} + v_t$$

Here, testing H0: $b1 = b2 = ... = bp = 0$, against HA: 'Not H0', is a test that *X does not* Granger-cause *Y*. Similarly, testing H0: $d1 = d2 = ... = dp = 0$, against HA: 'Not H0', is a test that *Y does not* Granger-cause *X*. In each case, a *rejection* of the null implies there is Granger causality.

Results of Discussion

In order to analyze inter-sectoral linkages in terms of productivity, total and sectoral labor productivity rates were calculated through dividing sectoral gross products by sectoral employments. The results are then tested for stationarity. The summary statistics are given in the Table 1 and trend graphs are given in Figure 2.

From Table 1, the mean returns of labor productivity in total, agriculture, industry and service sectors are 6.17, 2.42, 7.04 and 8.71, respectively. The ranges of standard deviation of the same series change from 0.82 to 0.721. From Figure 1, it is seen that the series of total, industry and service sectors have increased faster than the series of agriculture in Turkey's case, and all the series seem to be not stationary. As a well-known rule, non-stationary data are unpredictable and cannot be modeled.

The results obtained by using non-stationary time series may be spurious in that they may indicate a relationship between two variables where one does not exist. In order to receive consistent, reliable results, the non-stationary data needs to be transformed into stationary data. (Arisoy, 2005) On the other hand, stationary time series tend to return its mean value and fluctuate around it with a constant range. And, a non-stationary variable becomes stationary after it is differenced, in which case the first order differencing mostly suffices. Stationarity of a variable depends on whether it has a unit root or not.

Table 1 The summary statistics of labor productivity in total, agriculture, industry and service sectors

Statistics	Total	Agriculture	Industry	Services
Mean	6.171867	2.417914	7.042966	8.710177
Median	5.529580	2.066513	6.644246	8.505323
Maximum	8.390057	3.877326	8.882783	10.16566
Minimum	4.197899	1.494347	4.995767	7.492302
Std. Dev.	1.528736	0.821114	1.377896	0.949419
Jarque-Bera	3.407867	3.414031	3.100155	2.899424
Observations	28	28	28	28

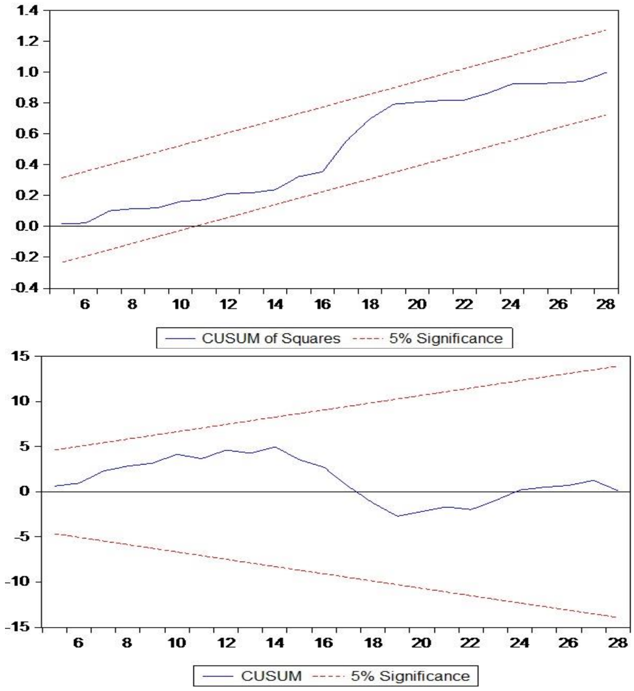

Figure 1 Results of structural diagnostics tests

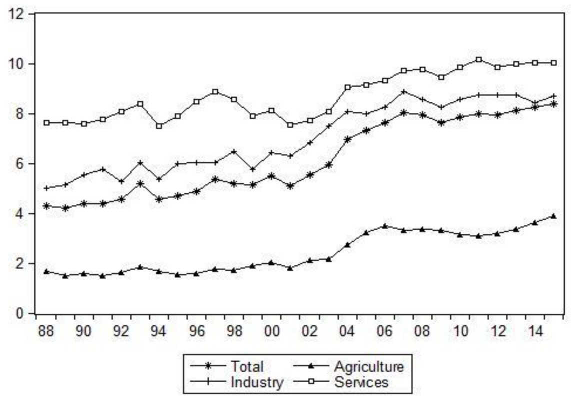

Figure 2 Trend values of labor productivity in total, agriculture, industry and service sectors

Table 2 Augmented Dickey-Fuller Test Results of Variables in Level and First Difference

Items	ADF t-statistics	prob.	Result
TOT	2.2469	0.9923	Non-stationary
AG	2.0456	0.9880	Non-stationary
IN	1.4595	0.9605	Non-stationary
SE	1.0548	0.9192	Non-stationary
DTOT	-4.3088	0.0001	stationary
DAG	-3.4116	0.0014	Stationary
DIN	-6.7367	0.0000	Stationary
DSE	-4.8268	0.0000	stationary

*D refers to the first difference.

In the Table 2, the results of unit root test obtained using Augmented Dickey-Fuller (ADF) are given for both level and first difference of the series (TOT:Labour productivity in Total, AG: Labour productivity in Agriculture, IN: Labour productivity in Industy and SE: Labour productivity in Services).

From Table 2, the null hypothesis that the series are non-stationary is not rejected at levels for all variables. However, after taking their first differences, the null hypothesis is rejected for all variables, in which case the series becomes stationary and variables are integrated at order one I(1).

After questioning the stationarity and the fitness of the series, the next step is to apply Johansen co-integration test, which requires the existence of sufficient number of time lags and the suitable model for the test. The optimum lag length is determined as 2 using LR, FPE, Akaike and Hannan-Quinn information criteria. Among the 5 possible cointegration models, the first test assuming no deterministic trend assumption (no intercept or trend in CE- or test VAR) is chosen according to Log Likelihood, Akaike Information Criteria and Schwarz Criteria. Then, the Johansen Co-Integration test is applied using model 1 and lag interval (1, 2). Test results are given in Table 4.

Trace statistics indicate that there is at least 1 co-integrating equation at 5% significance level. Therefore, the results of Johansen co-integration test show a long-running association among labor productivity series. The obtained cointegrating equation is given below.

In the next step, we applied Granger Causality Wald Test and the results are given in Table 6.

From Table 6**,** it is evident that DAG (agriculture), DIN (industry) and DSE (services) is granger cause to DTOT (total), which is an expected result. In the case of intersectoral labor productivity relationship, industry and agriculture are granger cause to services, while industry is not affected by any series, and the labor productivity in agriculture sector is only affected by that in industry. To explore the dynamic features of the series, Impulse Response Functions (IRFs) are computed. IRFs show the impact of a shock in an exogenous variable upon endogenous variable over a period of time (15 years in the present study).

From Figure 3 below, we found the evidences from the impulse response analysis on the convergent and divergent influence of the labor productivity in agricultural, industrial and services sector from one time shock on total productivity. Accordingly, total labor productivity responds to the change in its three main sectors. Labor productivity in services sector responds to the change in agriculture and industry, and this effect diminishes only after 10 years. Lastly, labor productivity in agriculture responds to the change in industry sector, and this effect diminishes after 7 years.

In the next step, we performed variance decomposition to understand the extent of effects. In this analysis, it would be more convenient to consider the 10^{th} period for services sector and 7^{th} period for agriculture since the shock effects subside in these periods for the relevant sectors (Evrimoglu and Condur, 2012). Accordingly, labor productivity in services sector is explained 40.37% by itself, 33.15% by agriculture, 14.56% by industry and 11.93% by services sectors. On the other hand, labor productivity in agriculture sector is explained 30.55 by total, 26.03% by itself, 22.47% by services, 20.94% by industry. These figures support the results of granger causality analysis.

Table 3 Fitness of data series for the analysis

Series	Mean	SD	Normality analysis		
			Ex. Kurtosis	Skewness	Normality test
Total	0.151	0.327	3.997	0.099	1.163
Agriculture	0.081	0.206	2.906	0.534	1.297
Industry	0.136	0.416	2.258	-0.411	1.380
Services	0.089	0.398	3.410	-0.538	1.496

The normality test reports the LM statistics from Jarque-Bera test and the p-values are 0.473, 0.501, 0.5226 and 0.558, respectively. Heteroscedasticity is analyzed with White test, accordingly, the f-statistics and p-value are 1.515 and 0.247. Autocorrelation test results donot pose any problem, either. The p-values are 0.579, 0.249, 0.403, 0.560, 0.670 and continues slightly increasing for 12 lags.

Table 4 Cointegration test results

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.563556	41.69938	40.17493	0.0348
At most 1	0.449700	21.80109	24.27596	0.0994
At most 2	0.196855	7.466087	12.32090	0.2811
At most 3	0.087773	2.204796	4.129906	0.1623

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) P-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.563556	19.89828	24.15921	0.1704
At most 1	0.449700	14.33501	17.79730	0.1540
At most 2	0.196855	5.261291	11.22480	0.4413
At most 3	0.087773	2.204796	4.129906	0.1623

Max-eigenvalue test indicates no cointegration at the 0.05 level, * denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) P-values

Table 5 Cointegration equation (Log likelihood 213.2686)

Normalized cointegrating coefficients (standard error in parentheses)			
Total	Agriculture	Industry	Services
1.000000	-0.805419 (0.07671)	-0.194423 (0.07767)	-0.565717 (0.10594)
Adjustment coefficients (standard error in parentheses)			
0.297073 (0.82198)	3.194593 (0.89164)	-0.790760 (1.19545)	0.892234 (0.80827)

Table 6 VAR Granger Causality/Block Exogeneity Wald Tests Analysis

Excluded	Chi-sq	df	Prob.
Dependent variable: DTOT			
DSE	7.781404	2	0.0204
DIN	32.98649	2	0.0000
DAG	21.69698	2	0.0000
All	38.61543	6	0.0000
Dependent variable: DSE			
DTOT	19.38473	2	0.0001
DIN	32.45268	2	0.0000
DAG	21.37973	2	0.0000
All	39.93576	6	0.0000
Dependent variable: DIN			
DTOT	3.639871	2	0.1620
DSE	0.858830	2	0.6509
DAG	3.099373	2	0.2123
All	6.685294	6	0.3509
Dependent variable: DAG			
DTOT	1.769479	2	0.4128
DSE	1.706758	2	0.4260
DIN	9.595457	2	0.0082
All	16.22278	6	0.0126

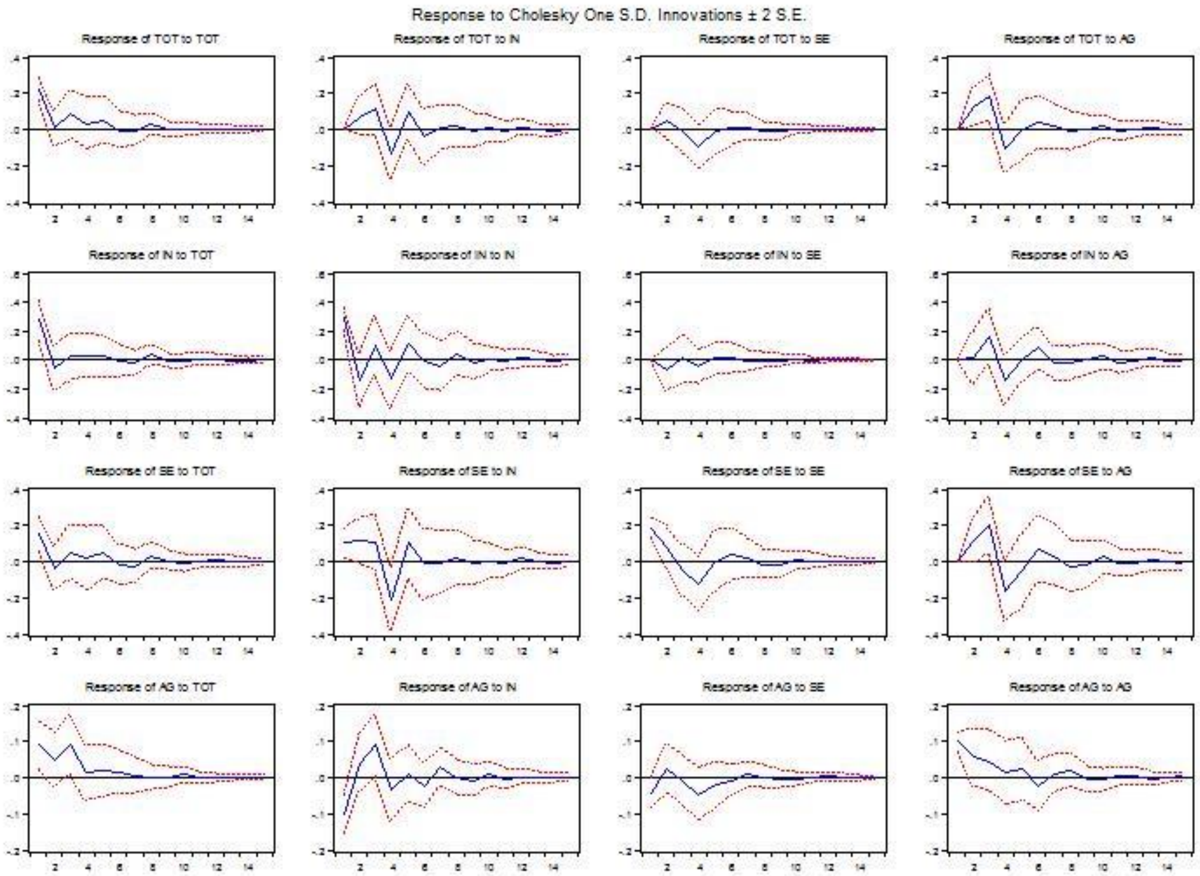

Figure 3 Impulse response analysis for different variables

Conclusion

This study investigated the causal relationship among labor productivity in total, agriculture, industry and services sectors in Turkey for the period of 1988-2015. A long run equilibrium relationship was found among these variables. And, to further examine the nature of the relationship, granger causality/block exogeneity Wald test was applied. The results indicate that both agriculture and industry have positive effects on the labor productivity in services sector, and industry has a positive effect on the labor productivity in agriculture sector, while industrial labor productivity is not affected by the others. From these findings, one can confirm the theoretical predictions that the industrialization allows agriculture to benefit from scale economy and increase its efficiency through improving financial services and providing high-tech inputs like machineries, seeds and easy communication and transport opportunities. In the study, labor productivity in services sector is affected by both industry and agriculture services, which can be explained by the transfer of surplus employment and even higher growth of this sector compared to the others. Probably the most important finding is that industry had positive effects on the labor productivity of other two sectors without itself being affected. The share of agriculture in GDP and employment is expected to decline as economic development advances. The surplus workforce in agriculture has shifted mainly to industry sector in Turkey, and industry has been successful to absorb incoming labors, so far. From this regard, necessary supports should be provided to improve the industrial productivity if it is to embrace further rural workforce. Or, rural population should be encouraged to stay in agricultural production.

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