https://doi.org/10.17221/314/2017-AGRICECON

Sectoral growth linkages of agricultural sector: Implications for food security in Pakistan

Hafiz Asim[1]*, *Muhammad Akbar*[2]

[1]*Department of Economics and Business Administration, University of Education, Lower Mall Campus, Lahore, Pakistan*

[2]*Department of Mathematics and Statistics, International Islamic University, Islamabad, Pakistan*

**Corresponding author: asim.hafeez@ue.edu.pk*

Citation: Asim H., Akbar M. (2019): Sectoral growth linkages of agricultural sector: Implications for food security in Pakistan. Agricultural Economics – Czech, 65: 278–288.

Abstract: Does the growth in non-agricultural sectors spill over to the agricultural sector of an economy? There is limited evidence available on the issue for the developing world, especially for Pakistan which has undergone large structural changes since its independence. This study examined the impact of sectoral growth linkages on agricultural output of Pakistan for the period of 1960–2016. We have estimated an econometric model which incorporates inter-sectoral linkages of Pakistan economy using a Vector Error Correction Model (VECM). Our analysis revealed that the economy of Pakistan has shifted from an agricultural dominant economy to services-based economy during the past six decades. Results of VECM show that the industrial sector has a negative impact on the performance of agricultural output whereas services sector is influencing the output of agriculture sector positively in the long run. Short run results show that industrial sector is affecting the performance of agricultural output positively whereas services sector is influencing the output of agriculture sector negatively. Negative impacts of industry in the long run and services in the short run imply that agricultural sector should be given its due share in public investment and the role of middle man should be minimised at the time of sale of agricultural production in the markets.

Keywords: growth linkages; public investment; Pakistan; spillover; structural changes; vector error correction model (VECM)

Agricultural sector plays a crucial role in the socio-economic development and overall growth of many countries through its linkages with other sectors (Johnston 1970; Singariya 2016). Its role in food supply, safety, and environmental protection is important (Rehman et al. 2016). It is the primary source of employment and food security for most of rural population in Pakistan (Chandio et al. 2016). Future success of these contributions depends mainly on the impact of agricultural sector on the growth of other sectors of the economy and on how other sectors stimulate the growth of agricultural sector. It is because structural changes in the economies have large impact on the composition of sectoral output. Importance of different sectors in the overall output of an economy does not remain the same due to structural changes that take place over time in almost every country. Therefore, understanding the role of agricultural sector and its linkages to the rest of the sectors of the economy is important especially for food security of a country like Pakistan which has undergone large structural changes since its independence.

From an agriculturally dominant economy up to 1960s Pakistan economy has been converted into services-based economy, but agricultural sector still accounts for 25% of Pakistan's Gross Domestic Product (GDP) and employs 45% of our labour force. Figure 1 shows that the share of agricultural sector over time declined from 46% in 1960 to 25% in 2016. With the declining share of agriculture, the share of industrial sector has increased but this increase is not that much as compare to the decline in the share of primary sector. In 1960, the share of industrial sector was approximately 16% which has increased to 19% in 2016. With the changing contribution of agriculture and industrial sector to overall GDP, services sector did not remain

https://doi.org/10.17221/314/2017-AGRICECON

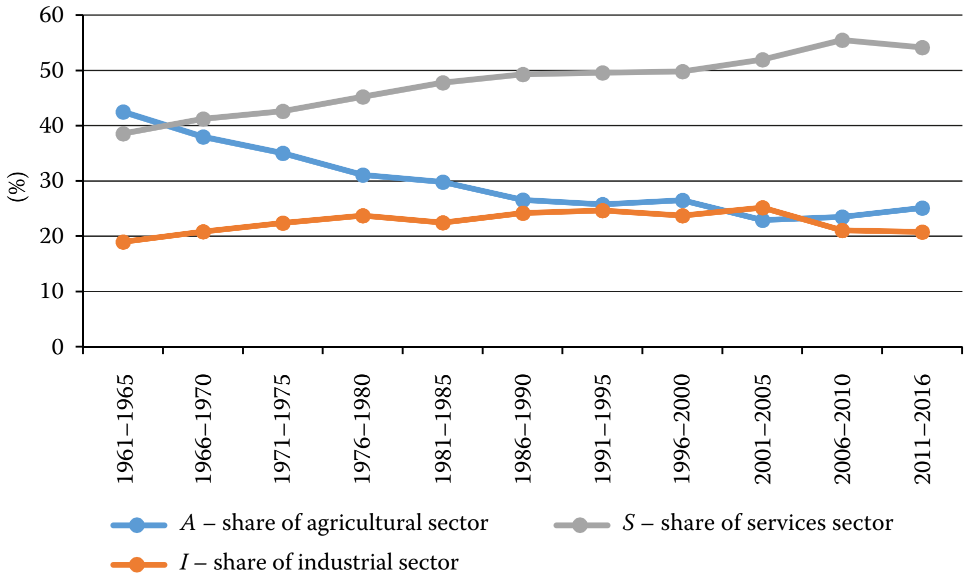

Figure 1. Sectoral share in GDP of Pakistan

Source: authors' calculation

behind. During the early 1960s, the share of services sector was 38% and it was the second major sector of the economy. But since late 60s it has grown very rapidly and has become the top contributor to the country's total output. Currently the share of this sector in our economy is more than 56% . The share of agricultural, industrial and services sectors in GDP changed from 46, 16 and 38% respectively in 1960 to 25, 19 and 56% respectively in 2016.

Simply, we can say that Pakistan has shifted from an agriculture-based economy to services-based economy. This structural change implies that the share of commodity producing sectors (i.e. agriculture and industry) has decreased over time while that of services (non-commodity producing sector) has increased sharply. This may be one of the reasons of hunger and food insecurity in Pakistan which is mainly the result of high inflation rates, particularly food inflation in the economy of Pakistan. Economies based on the highest share of services sector usually experience higher inflation rates than other economies (Joiya and Shahzad 2013).

The hypothesis of inter-linkages between different sectors of the economy is mainly based on dual economic model of Lewis (1954) and on the theory of unbalanced growth developed by Hirschman (1958). Lewis (1954) explains the role of agricultural and industrial sector in economic growth, and the inter-relationship between these two sectors. According to this model, agricultural sector is considered as the base for a developing country that generates capital for industrialisation, which is the second stage of economic development. The process that transforms an economy from rural agricultural-sector-based to the modern industrial-sector-based should be based on balanced growth of all economic activities in order to attain self-sustaining growth (Lewis 1954). Hirschman (1958), in his theory of unbalanced growth, argues that balanced growth cannot succeed in achieving high growth rates because developing countries face demand and capital constrains. He is of the view that the sectors having the highest linkages may stimulate growth of production, employment, and income more rapidly. He proposes that initial investment should be made in social overhead capital (SOC), which is self propelling and will cause an increase in investment in direct productive activities (DPA). Therefore, the idea of unbalanced growth is also contaminated with inter-sectoral linkages.

Hirschman (1958) explains linkages of a sector with other sectors of the economy through their direct and indirect intermediate purchases and sales. According to Thirlwall (1995) and Saikia (2011), the relationship between agricultural and industrial sector had been examined from different channels because of the interdependence between these two sectors of the economy. Firstly, agricultural sector supplies food to the industrial sector to absorb labour in industry. Secondly, it provides inputs such as tea, coffee, jute, and raw cotton used by the agriculture-based industries. Thirdly, industrial

https://doi.org/10.17221/314/2017-AGRICECON

sector also provides inputs, like pesticides, machinery, fertilisers to the agricultural sector. Fourthly, agricultural sector affects the output of manufacturing sector through consumer demand. Fifthly, agricultural sector generates savings that can be used for industrial investments as well as for other sectors of the economy. Lastly, fluctuations in the output of agriculture sector may affect the decisions of private investors through the impact of terms of trade (Rangarajan 1982). Some of these inter-sectoral relations have already been modelled by Feder (1982, 1986) and Dowrick and Gemmell (1991).

Some of the channels emphasise the supply-side linkages for meeting their needs of inputs, while the stress of others is on demand-side linkages that arise from the inter-dependence of sectors for meeting their demand for final consumption. Furthermore, based on the direction of interdependence between the sectors, the linkages may also be divided into two types. First one is the backward linkage which identifies the dependence of a sector upon other sectors for its input supplies, and the second one is forward linkage that determines how the output of a sector is distributed to the remaining economy. Unlike the two-way interdependencies between the agricultural and industrial sectors, linkages between agricultural and services sectors are one-way only and are mainly backward linkages, whereas industry has both forward and backward linkages with services sector and the levels of linkages are much higher than in case of the agricultural sector. Furthermore, services sector has much stronger backward linkages than forward linkages with both agricultural and industrial sectors (Singh 2007). Inter-linkages of these sectors affect the output of agricultural sector. Major portion of agricultural output is composed of food items, and hence these inter-sectoral linkages may also play a key role in determining the food supply in the long run.

Once these inter-linkages have been identified, the information can be used to determine the effects of different policy measures adopted by the country. For instance, the presence of a long-run equilibrium between different sectors of the economy could have affected certain policy outcomes. For example, agricultural and industrial sectors might have developed a negative relationship in the short-run, while the long-run relationship is positive. It means that the short-run impact of industrial sector growth on agriculture sector will be negative; however, the long-run effect on agricultural sector will be positive. Therefore, understanding both short- and long-run inter-linkages and their implications could be helpful in explaining certain policy outcomes and also in classifying the optimal policy for the country (Gemmel et al. 2000).

Hence the objective of this study is to investigate the dynamics of short run and long run impacts of inter-sectoral linkages on agricultural output and to derive possible implications for food security in Pakistan. This study will help the policy makers to design appropriate policies with respect to the linkages between different sectors of the economy and their impact on food supply.

MATERIAL AND METHODS

Model specification

In order to analyse the linkages between the growing sectors of Pakistani economy, this study adopted the Feder (1982) two sector model, extended to three sectors by Gemmell et al. (2000). Services sector has been ignored in many of the past studies, and sectoral linkages that involve services sector have been documented mostly in separate literature, such as Gemmell (1982) and Bhagwati (1984). The advantage of this model is that it explores linkages between sectoral outputs in both short and long run even in the absence of input data. Gemmell specifies production functions for the three sectors as follows:

$$A = f\left(K_a, L_a, I, S\right) \quad (1)$$

$$I = f\left(K_i, L_i, A, S\right) \quad (2)$$

$$S = f\left(K_s, L_s, I, A\right) \quad (3)$$

where A – agricultural output, I – industrial output, S – services sector output, and K_a – capital in agriculture, L_a – labour in agriculture, K_i – capital in industry, L_i – labour in industry, K_s – capital in services sector, L_s – labour in services sector.

By assuming that the production functions in Equations (1–3) are linear functions of the relevant explanatory variables, we may write these functions as:

$$A = \phi_a + \alpha_a L_a + \beta_a K_a + \gamma_a^i I + \gamma_a^s S \quad (4)$$

$$I = \phi_i + \alpha_i L_i + \beta_i K_i + \gamma_i^a A + \gamma_i^s S \quad (5)$$

$$S = \phi_s + \alpha_s L_s + \beta_s K_s + \gamma_s^i I + \gamma_s^a A \quad (6)$$

https://doi.org/10.17221/314/2017-AGRICECON

where φ represents the intercept and a, i and s represent agricultural, industrial, and services sectors respectively. Marginal products are denoted by α and β signs, while the externality effects by γ signs that allow for two-way possible spill-overs. It follows the Feder (1982) and Feder (1986) assumption that marginal productivity differences between sectors are:

$$\frac{\alpha_t}{\alpha_a} = \frac{\beta_t}{\beta_a} = 1 + \delta_t,\ \delta_t > 0;\ t = i, s \quad (7)$$

The coefficient δ_t denotes the measure of efficiency of the resource use in sector t as compared to agriculture.

Adding Equations (4–5) and (6) yields the total output (Y) as follows: (Let $\phi = \phi_a + \phi_i + \phi_s$).

$$Y = \phi + \alpha_a L_a + \beta_a K_a + \gamma_a^i I + \gamma_a^s S + \alpha_i L_i + \beta_i K_i + \gamma_i^a A + \gamma_i^s S + \alpha_s L_s + \beta_s K_s + \gamma_s^a A + \gamma_s^i I$$

$$Y = \phi + \alpha_a L_a + \beta_a K_a + \gamma_a^i I + \gamma_a^s S + \left(\frac{1+\delta_i}{1+\delta_i}\right)\alpha_i L_i + \left(\frac{1+\delta_i}{1+\delta_i}\right)\beta_i K_i + \gamma_i^a A + \gamma_i^s S + \left(\frac{1+\delta_s}{1+\delta_s}\right)\alpha_s L_s + \left(\frac{1+\delta_s}{1+\delta_s}\right)\beta_s K_s + \gamma_s^a A + \gamma_s^i I$$

$$Y = \phi + \alpha_a L_a + \beta_a K_a + \gamma_a^i I + \gamma_a^s S + \frac{\alpha_i}{1+\delta_i} L_i + \frac{\delta_i}{1+\delta_i}\alpha_i L_i + \frac{\beta_i}{1+\delta_i} K_i + \frac{\delta_i}{1+\delta_i}\beta_i K_i + \gamma_i^a A + \gamma_i^s S + \frac{\alpha_s}{1+\delta_s} L_s + \frac{\delta_s}{1+\delta_s}\alpha_s L_s + \frac{\beta_s}{1+\delta_s} K_s + \frac{\delta_s}{1+\delta_s}\beta_s K_s + \gamma_s^a A + \gamma_s^i I$$

Since $\frac{\alpha_i}{1+\delta_i} = \alpha_a$, $\frac{\beta_i}{1+\delta_i} = \beta_a$, $\frac{\alpha_s}{1+\delta_s} = \alpha_a$ and $\frac{\beta_s}{1+\delta_s} = \beta_a$

$$Y = \phi + \alpha_a L_a + \beta_a K_a + \gamma_a^i I + \gamma_a^s S + \alpha_a L_i + \frac{\delta_i}{1+\delta_i}\alpha_i L_i + \beta_a K_i + \frac{\delta_i}{1+\delta_i}\beta_i K_i + \gamma_i^a A + \gamma_i^s S + \alpha_a L_s + \frac{\delta_s}{1+\delta_s}\alpha_s L_s + \beta_a K_s + \frac{\delta_s}{1+\delta_s}\beta_s K_s + \gamma_s^a A + \gamma_s^i I$$

Collecting the like terms and taking out the common factor where possible:

$$Y = \phi + \alpha_a (L_a + L_i + L_s) + \beta_a (K_a + K_i + K_s) + \frac{\delta_i}{1+\delta_i}(\alpha_i L_i + \beta_i K_i) + \frac{\delta_s}{1+\delta_s}(\alpha_s L_s + \beta_s K_s) + \gamma_a^i I + \gamma_a^s S + \gamma_i^a A + \gamma_i^s S + \gamma_s^a A + \gamma_s^i I$$

Let $L = L_a + L_i + L_s$, $K = K_a + K_i + K_s$ and noting from Equations (5–6):

$$Y = \phi + \alpha_a L + \beta_a K + \frac{\delta_i}{1+\delta_i}\left(I - \phi_i - \gamma_i^a A - \gamma_i^s S\right) + \frac{\delta_s}{1+\delta_s}\left(S - \phi_s - \gamma_s^a A - \gamma_s^i I\right) + \gamma_a^i I + \gamma_a^s S + \gamma_i^a A + \gamma_i^s S + \gamma_s^a A + \gamma_s^i I$$

Opening the parenthesis:

$$Y = \phi - \frac{\delta_i}{1+\delta_i}\phi_i - \frac{\delta_s}{1+\delta_s}\phi_s + \alpha_a L + \beta_a K + \frac{\delta_i}{1+\delta_i} I - \frac{\delta_i}{1+\delta_i}\gamma_i^a A - \frac{\delta_i}{1+\delta_i}\gamma_i^s S + \frac{\delta_s}{1+\delta_s} S - \frac{\delta_s}{1+\delta_s}\gamma_s^a A - \frac{\delta_s}{1+\delta_s}\gamma_s^i I + \gamma_a^i I + \gamma_a^s S + \gamma_i^a A + \gamma_i^s S + \gamma_s^a A + \gamma_s^i I$$

Let $\phi - \frac{\delta_i}{1+\delta_i}\phi_i - \frac{\delta_s}{1+\delta_s}\phi_s = \phi'$

https://doi.org/10.17221/314/2017-AGRICECON

$$A + I + S = \varphi' + \alpha_a L + \beta_a K + \frac{\delta_i}{1+\delta_i} I - \frac{\delta_i}{1+\delta_i}\gamma_i^a A - \frac{\delta_i}{1+\delta_i}\gamma_i^s S + \frac{\delta_s}{1+\delta_s} S - \frac{\delta_s}{1+\delta_s}\gamma_s^a A - \frac{\delta_s}{1+\delta_s}\gamma_s^i I +$$
$$+ \gamma_a^i I + \gamma_a^s S + \gamma_i^a A + \gamma_i^s S + \gamma_s^a A + \gamma_s^i I \quad (\text{as } Y = A + I + S)$$

Taking the terms of agricultural sector on the left side and of other sectors on the right side and then simplifying:

$$A = \left[1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}\right]^{-1}\varphi' + \left[1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}\right]^{-1}(\alpha_a L + \beta_a K) + \left[\frac{\gamma_a^i - \frac{1}{1+\delta_i} + \frac{\gamma_s^i}{1+\delta_s}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}}\right] I + \left[\frac{\gamma_a^s - \frac{1}{1+\delta_s} + \frac{\gamma_i^s}{1+\delta_i}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}}\right] S$$

To eliminate the factor inputs from the above model, we adopt the Feder (1982) and Feder (1986) assumption that marginal productivity of labour and capital in agricultural sector is proportional to the average productivity in economy as a whole, so that:

$$\alpha_a = \alpha\left(\frac{Y}{L}\right) \text{ and } \beta_a = \beta\left(\frac{Y}{K}\right)$$

And as we know that $Y = A + I + S$; after some manipulations it yields:

$$\left[1 - \left\{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}\right\}^{-1}(\alpha+\beta)\right] A = \left[1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}\right]^{-1}\varphi' + \left[1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}\right]^{-1}(\alpha+\beta) I +$$
$$+ \left[\frac{\gamma_a^i - \frac{1}{1+\delta_i} + \frac{\gamma_s^i}{1+\delta_s}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}}\right] I + \left[1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}\right]^{-1}(\alpha+\beta) S + \left[\frac{\gamma_a^s - \frac{1}{1+\delta_s} + \frac{\gamma_i^s}{1+\delta_i}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}}\right] S$$

$$\left[\frac{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s} - (\alpha+\beta)}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}}\right] A = \frac{\varphi'}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}} + \left[\frac{(\alpha+\beta) + \gamma_a^i - \frac{1}{1+\delta_i} + \frac{\gamma_s^i}{1+\delta_s}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}}\right] I +$$
$$+ \left[\frac{(\alpha+\beta) + \gamma_a^s - \frac{1}{1+\delta_s} + \frac{\gamma_i^s}{1+\delta_i}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s}}\right] S$$

$$A = \left[\frac{\varphi'}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s} - (\alpha+\beta)}\right] + \left[\frac{(\alpha+\beta) + \gamma_a^i - \frac{1}{1+\delta_i} + \frac{\gamma_s^i}{1+\delta_s}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s} - (\alpha+\beta)}\right] I + \left[\frac{(\alpha+\beta) + \gamma_a^s - \frac{1}{1+\delta_s} + \frac{\gamma_i^s}{1+\delta_i}}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s} - (\alpha+\beta)}\right] S$$

$$\text{Let } \frac{\varphi'}{1 - \frac{\gamma_i^a}{1+\delta_i} - \frac{\gamma_s^a}{1+\delta_s} - (\alpha+\beta)} = \varphi''$$

https://doi.org/10.17221/314/2017-AGRICECON

$$A = \varphi'' + \left[\frac{(\alpha+\beta) + \gamma_a^i + \frac{\gamma_s^i}{1+\delta_s} - \frac{1}{1+\delta_i}}{1-(\alpha+\beta) - \frac{\gamma_s^a}{1+\delta_s} - \frac{\gamma_i^a}{1+\delta_i}} \right] I + \left[\frac{(\alpha+\beta) + \gamma_a^s - \frac{1}{1+\delta_s} + \frac{\gamma_i^s}{1+\delta_i}}{1-(\alpha+\beta) - \frac{\gamma_s^a}{1+\delta_s} - \frac{\gamma_i^a}{1+\delta_i}} \right] S$$

After some simplification, the following results are yielded:

$$A = \varphi'' + \left[\frac{(1+\delta_i)\left\{\alpha+\beta+\gamma_a^i + \frac{\gamma_s^i}{1+\delta_s}\right\} - 1}{(1+\delta_i)\left\{1-(\alpha+\beta) - \frac{\gamma_s^a}{1+\delta_s}\right\} - \gamma_i^a} \right] I + \left[\frac{(1+\delta_i)\left\{\alpha+\beta+\gamma_a^s - \frac{1}{1+\delta_s}\right\} + \gamma_i^s}{(1+\delta_i)\left\{1-(\alpha+\beta) - \frac{\gamma_s^a}{1+\delta_s}\right\} - \gamma_i^a} \right] S \quad (8)$$

Letting $\beta_0 = \varphi''$, $\beta_1 = \left[\frac{(1+\delta_i)\left\{\alpha+\beta+\gamma_a^i + \frac{\gamma_s^i}{1+\delta_s}\right\} - 1}{(1+\delta_i)\left\{1-(\alpha+\beta) - \frac{\gamma_s^a}{1+\delta_s}\right\} - \gamma_i^a} \right]$, $\beta_2 = \left[\frac{(1+\delta_i)\left\{\alpha+\beta+\gamma_a^s - \frac{1}{1+\delta_s}\right\} + \gamma_i^s}{(1+\delta_i)\left\{1-(\alpha+\beta) - \frac{\gamma_s^a}{1+\delta_s}\right\} - \gamma_i^a} \right]$

Therefore, the Equation (8) can be simplified as follows:

$$A = \beta_0 + \beta_1 I + \beta_2 S \quad (9)$$

This shows that $A = f(I, S)$. Here, β_0 represents intercept, β_1 measures the effect of any expansion in industrial sector on the output of agricultural sector, whereas β_2 denotes the effect on the output of agricultural sector that results from any expansion in services sector, and these sectoral effects may be negative or positive.

DATA AND METHODOLOGY

In order to analyse the impact of sectoral growth on agricultural output by using Equation (9), we have employed annual time-series data on the sectoral output (agricultural, industrial, and services sectors) for Pakistan economy with constant base of year 2005 in Pakistani Rupee for the period of 1960 to 2016. Data has been taken from the dataset of the World Bank (World Bank 2016).

Testing the stationarity of the data is the first step in time-series analysis. Estimation technique is decided on the basis of stationarity of the data, because most of time-series are non-stationary; therefore, traditional Ordinary Least Squares (OLS) method cannot be applied for such series as it gives spurious results in that situation. Therefore, all variables are tested for stationarity by Augmented Dickey-Fuller (ADF) test developed from Dickey and Fuller (1979) and Phillips-Peron test developed by Phillips and Peron (1988), before estimating a model.

The null hypothesis which we have to test is that the variable under consideration is non-stationary, i.e. it contains unit root, while according to its alternative hypothesis the variable is stationary:

$$H_0: \beta_1 = 1 \quad (10)$$

$$H_1: \beta_1 < 1 \quad (11)$$

The usual t-statistic along with the tabulated values of MacKinnon (1991) are used to reject or accept the above null hypothesis.

After testing the stationarity, the next step is to determine the number of co-integrating vectors. There is a variety of methods available to test for co-integration between variables. Engel-Granger approach, Johansen co-integration technique and Autoregressive Distributed Lag (ARDL) approach to co-integration are the most famous among these available methods. Engel-Granger approach is useful for the models with two variables only. In case of models with more than two variables, Johansen approach and ARDL approach to co-integration are used. In this study, we have employed Johansen procedure to test co-integration developed by Johansen and Juselius (1992) because our model contains more than two variables and order of integration among the variables is one. To employ Johansen procedure to test co-integration, trace test statistics and maximum Eigen value test statistics are applied:

https://doi.org/10.17221/314/2017-AGRICECON

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{n}\ln(1-\hat{\lambda}_i) \qquad (12)$$

$$\lambda_{max}(r, r+1) = -T\ln\left(1-\hat{\lambda}_{i+1}\right) \qquad (13)$$

where T denotes the number of usable observations and $\hat{\lambda}_i$ are estimated values of characteristic roots that can be obtained from the estimated matrix (π). Equation (12) tests the null hypothesis that there are at most r different co-integrating vectors whereas the Equation (13) tests the hypothesis of r co-integrating vectors against an alternative hypothesis of $r + 1$ co-integrating vectors. These calculated statistics will be compared to the critical values to reject or accept the null hypothesis.

After establishing the long run relationship among the variables, the next step is to estimate Engle and Granger (1987) vector error correction model (VECM). The purpose of VECM is to estimate the long run coefficients along with short run dynamics. The general model of VECM may be described as follows:

$$\Delta Y_t = \sum_{i=1}^{p-1}\tau_i\Delta Y_{t-i} + \Pi Y_{t-1} + \mu D_i + \varepsilon_t \qquad (14)$$

The following hypothesis is tested for the existence of co-integration:

$$H_1(r): \Pi = \alpha\beta' \qquad (15)$$

The detection of VECM implies the presence of a long run stable relationship between dependent and independent variables. It also provides us with the long run adjustment coefficient along with short run estimates. Moreover, based on the long run adjustment coefficient, weekly exogenous variables can be identified. Weekly exogenous variables are tested after the number of co-integrating vectors is determined. "A variable Z is weekly exogenous if it is only a function of lagged variables, and the parameters of the equation generating Z are independent of the parameters generating the other variables in the system (Asteriou and Hall 2007)." If a variable is weekly exogenous, its equation can be dropped from the endogenous part of the system. Before testing for week exogeneity, diagnostic tests are applied to test the validity of model. These include Breusch-Godfrey serial correlation LM (Lagrange multiplier) test, Jarque-Bera test for normality of residuals, and Autoregressive conditional heteroskedasticity (ARCH heteroskedasticity) test.

RESULTS AND DISCUSSION

Table 1 contains the results of ADF and Philips-Perron tests in order to detect the order of integration of the respective variables. It can be shown that we are unable to reject the null hypothesis of unit root at level for agricultural output (A), industrial output (I) and services sector output (S), i.e. all of the variables are non-stationary at level. However, all series become stationary after taking first difference as indicated by the respective p-values. Hence, order of integration is one. So, the next step is to determine the number of co-integrating vectors by Johansen co-integration test.

Based on the results given in Table 2, both trace test statistics and maximum Eigen value test statistics reject the null hypothesis (H_0) of zero co-integrating vectors, but on the other hand, the alternative hypothesis (H_1) of one co-integrating vector is not rejected. It means that there is one co-integrating vector between the three sectors of Pakistan economy. We can now proceed to estimate VECM. However, before approaching VECM, diagnostic tests were applied to check the validity of the model. Since the results of all diagnostic tests given in Table 3 confirm the validity of our model as we are unable to reject the

Table 1. Results of Augmented Dickey Fuller and Philips-Perron tests

Variables	Level				First difference				$I(d)$
	ADF		Philips-Perron		ADF		Philips-Perron		
	test-statistic	p-value	test-statistic	p-value	test-statistic	p-value	test-statistic	p-value	
Ln (A)	−2.4420	0.3549	−2.4420	0.3549	−9.2404	0.0000	−9.8007	0.0000	I(1)
Ln (I)	−2.3842	0.3835	−2.3704	0.3905	−6.1978	0.0000	−6.1488	0.0000	I(1)
Ln (S)	−1.5077	0.8129	−0.9900	0.9370	−6.2985	0.0000	−6.3312	0.0000	I(1)

$I(d)$ – integrated of order "d"; ADF – Augmented Dickey Fuller; ln (A) – natural log of agricultural output; ln (I) – natural log of industrial output; ln (S) – natural log of services sector output

Source: authors' calculation

https://doi.org/10.17221/314/2017-AGRICECON

Table 2. Summary of Johansen co-integration test

Eigen value	Trace test				Maximum Eigen values			
	hypothesised		trace	critical value at 0.05	hypothesised		maximum Eigen	critical value at 0.05
	H_0	H_1			H_0	H_1		
0.3381	$r = 0$	$r > 0$	31.9921*	29.7970	$r = 0$	$r > 0$	22.2832*	21.1316
0.1176	$r \leq 1$	$r > 1$	9.7089	15.4947	$r \leq 1$	$r > 1$	6.7548	14.2646
0.0532	$r \leq 2$	$r > 2$	2.9542	3.8415	$r \leq 2$	$r > 2$	2.9542	3.8415

*the rejection of null hypothesis of no co-integration at 5% level of significance; r –number of cointegrating equations

Source: authors' calculation

null hypothesis of no serial correlation, error terms are normal and no ARCH, hence the resulting model is called VECM and its results are given in Table 4.

The long run adjustment factor for the agriculture output is significant, negative as well as less than one, and it shows that there is stable long run relationship between agricultural output, industrial output, and services sector output of Pakistan economy. Its value is –0.0605 which shows that the speed of adjustment towards equilibrium is 6.05% per year because we have used annual data. The negative sign and the value of this long run adjustment factor between zero and one is the indication of a long run stable relationship.

The effect of the lag value of agricultural output is found to be negative in the dynamics of short run because the higher output of last year may reduce the fertility of land and hence causes the output of agriculture in current year to fall, as 85% of farmers own less than 2.5 ha of land in Pakistan and are usually unable to afford or use significant amount of fertilisers to maintain the fertility of their land for the next year production. Agricultural output is found to be positively related to the industrial sector growth in the short run. As industrial output grows, the demand for inputs from the primary sector also increases, encouraging agricultural activities to grow, too.

Table 3. Results of diagnostic tests

Breusch-Godfrey serial correlation LM test (H_0: no serial correlation)	
F-statistic	0.2466
Probability $F(2, 48)$	0.7825*
Jarque-Bera normality test (H_0: error terms are normal)	
Jarque-Bera statistic	1.1751
Probability	0.5557*
Heteroscedasticity test: ARCH (H_0: no ARCH)	
F-statistic	0.5963
Probability $F(1, 46)$	0.4435*

*shows the failure to reject null hypothesis; LM test – Lagrange multiplier test; ARCH – autoregressive conditional heteroskedasticity test

Source: authors' calculation

The negative impact of services-led growth in the economy is due to the fact that economies with high share of services sector experience high rate of inflation which reduces the savings of agricultural sector and hence investment. The low level of investment in this sector may reduce the level of capital stock and result in negative relationship between services sector and agricultural sector. Moreover, the prices of agricultural inputs increase due to inflation caused by services-led growth which also affects agricultural output negatively. Another reason may be the role of middlemen at the time of sale of agricultural products in the markets, which can be a constraint for small farmers preventing them from accessing the markets. These effects not only reduce the income of small farmers, but also deteriorate the food security of urban consumers.

Long run relationship between agricultural and industrial sectors came out as negative for our economy. It means that as industrial sector output grows, the average growth of the agricultural sector will diminish in long run, as all other factors that may have an effect on the agricultural sector are kept constant. Literature shows that industrial sector may have a negative or positive impact on the health of agriculture. There are many factors which may have contributed to this negative impact of industrial sector on agricultural growth of Pakistan. The following discussion will provide some possible explanations for this negative impact of industry.

One possible explanation is that the agriculture sector has been treated unfairly by the government

https://doi.org/10.17221/314/2017-AGRICECON

Table 4. Summary of vector error correction model

Dependent variable	Long run coefficients		Short run coefficients	
	ln (*A*)	*t*-statistic*	D (ln (*A*))	*t*-statistic*
Intercept	0.3611	–	0.0485	4.2794
ECT	−0.0605	−2.0988	–	–
Ln (*I*(− 1))	−2.6883	3.5150	–	–
Ln (*S*(− 1))	3.5485	−4.1784	–	–
D (ln (*A*(− 1)))	–	–	−0.2214	−1.7070
D (ln (*I*(− 1)))	–	–	0.2306	1.9065
D (ln (*S*(− 1)))	–	–	−0.3669	−1.9521

*indicates that the estimated coefficients are significant; ln (*A*) – natural log of agricultural output; D (ln (*A*)) – first difference of natural log of agricultural output; ECT – error correction term; ln (*I*(− 1)) – first lag of natural log of industrial output; ln (*S*(− 1)) – first lag of natural log of services' output; D (ln (*A*(− 1))) – first difference of first lag of natural log of agricultural output; D (ln (*I*(− 1))) – first difference of first lag of natural log of industrial output; D (ln (*S*(− 1))) – first difference of first lag of natural log of services' output

Source: authors' calculation

policies in terms of low investments by the government and high prices of inputs. Moreover, most of the time our industrial sector has been promoted at the expense of agricultural sector. Many policies which have been implemented to encourage the industrial sector at the expense of agriculture also did not give the intended results (Hassan 1998). Hussain (1999) shows that the resources were transferred from agricultural sector to industrial sector in Pakistan and prices of manufactured goods remained high as compared to agricultural commodities. This type of actions may have adversely affected the output of agricultural sector. However, it cannot be ruled out that while both of these sectors benefit each other, industrial sector has gained more from the traditional agricultural sector in Pakistan. We thus need to develop agriculture more, as Yoa (1996) suggested that agricultural sector growth and rural sector development should be the main concern of the policy makers because such growth helps the industrial sector to grow even faster.

The conventional economic growth theory also supports this long run negative impact of industrial output on the output of agricultural sector. According to this theory, with economic growth the significance of agricultural sector decreases because resources, such as land, labour, and capital, are transferred to the more productive and efficient industrial sector. Therefore, this negative sign on the industrial sector is not a surprising one.

Long run impact of services sector on agricultural sector can be positive or negative depending on the stage of development. Services sector stimulates agricultural and industrial sector growth in the early stages of economic development; hence, a positive relationship can be expected. On the other hand, the more mature and developed economies transfer their resources, for example land, labour, and capital, to services sector because of higher income elasticities in this sector than in case of agricultural and industrial products. This results in a negative relationship between agricultural and service sectors.

Results show that service sector positively affect the agricultural sector in the long run, because agricultural activities usually take place in less developed areas and small improvements in infrastructure may remove large obstacles in terms of access to the markets. Better access to markets provided with the growth of services sector provides incentive to farmers to produce more, and it also helps to distribute this agricultural output across the country. Moreover, the growth in services output results in better infrastructure and other facilities, reducing the transportation costs and thus encouraging agricultural activities. The results indicate that agricultural sector in Pakistan has indeed benefitted from the faster growth of services sector. Improvements in infrastructure, finance, marketing, and other facilities may have developed a positive backward linkage to agricultural sector. The direction of sign confirms the progressing stage of Pakistan economy. Thus, services sector plays a significant and positive role for agricultural sector of Pakistan economy.

https://doi.org/10.17221/314/2017-AGRICECON

The positive impact of services sector may also be explained in another way. Faster growth in services sector increases aggregate demand and hence encourages agricultural sector. As services sector provides storage, ports, transportation, marketing, health, education, telecommunication, financial and insurance services to the economy, in the long run it has a positive effect on the performance of agricultural sector which can boost the food availability in the country and make it food secure. Henneberry et al. (2000) also found the same relationship between GDP of agricultural and transport sectors for Pakistan economy.

The contradiction between short run and long run signs associated to the industrial sector output is explained by the government policies discussed above that result in the inverse relationship between these two sectors in the long run. If government promotes the agricultural sector, the growth of this sector will also enhance the industrial activities and hence a positive relationship will result, as Yoa (1996) suggested that agricultural sector growth and rural sector development should be the main concern of the policy makers because such growth also helps the industrial sector to grow faster.

CONCLUSION AND POLICY IMPLICATIONS

This study examines the inter-sectoral linkages of agricultural sector and its policy implications for food security in Pakistan. Time-series analysis was carried out to study the impact of sectoral output on agricultural production. For this purpose, Johansen approach to co- integration and VECM were used.

Results of VECM show that there is a stable relationship between agricultural, industrial, and services sector output. Industrial sector has a negative effect on the performance of agricultural sector output in the long run due to rapid urbanisation and harmful environmental effects of industrialisation. On the other hand, services sector is influencing the output of agricultural sector in the long run positively because growth in services output results in better infrastructure and other facilities, reduces the transportation costs, and encourages agricultural activities. Short run results show that industrial sector is positively affecting the performance of agricultural output because growth in industrial output enhances the demand for inputs from the primary sector and hence it encourages agricultural activities to grow, too. On the other hand, services sector is influencing the output of agricultural sector in the short run negatively due to inflationary pressure. Inflation not only reduces the income of small farmers, but it also deteriorates the food security of the country.

Based on the results presented in this study, it can be concluded that we are still lagging behind many nations of the world. Even after more than six decades, agricultural sector in Pakistan has not reached to its potential level. The underlying reason is the biased policies of the government. Most of the time, excessive protection of industrial sector by the government resulted in inefficient allocation of resources in the industrial sector. Fiscal policy steps of the government show that policy-makers have been ignoring agricultural sector while industrial and services sectors are promoted. This type of exercise has adversely affected the agricultural output and hence food security in the long run. Therefore, policy makers are advised to revise their policy for promoting industrial sector at the expense of agricultural sector.

REFERENCES

Asteriou D., Hall S.G. (2007): Applied Econometrics: A Modern Approach Using Eviews and Microfit. Revised edition. Palgrave Macmillan, Hampshire.

Bhagwati J.N. (1984): Splintering and disembodiment of services and developing nations. The World Economy, 7: 133–143.

Chandio A.A., Jiang Y., Magsi H., Rehman A., Koondhar M.A. (2016): Agricultural formal credit distribution and agricultural GDP in Pakistan: A granger causality approach. Transylvanian Review, 11: 3180–3191.

Dickey D.A., W.A. Fuller (1979): Distribution of the estimators for autoregressive time series with a unit-root. Journal of the American Statistical Association, 74: 427–431.

Dowrick S.J., Gemmell N. (1991): Industrialization, catching-up and economic growth: A comparative study across the world's capitalist economies. Economic Journal, 101: 263–275.

Engle R.F., Granger C.W.J. (1987): Co-integration, and error correction: Representation, estimation and testing. Econometrica, 55: 251–76.

Feder G. (1982): On exports and economic growth. Journal of Development Economics, 12: 59–73.

Feder G. (1986): Growth in semi-industrial countries: A statistical analysis. In: Chenery H.B., Robinson S., Syrquin M.: Industrialization and Growth. Oxford University Press, New York.

Gemmell N. (1982): Economic development and structural change: The role of the service sector. Journal of Development Economics, 19: 37–66.

https://doi.org/10.17221/314/2017-AGRICECON

Gemmell N., Lloyd T.A., Mathew M. (2000): Agricultural growth and inter-sectoral linkages in a developing economy. Journal of Agricultural Economics, 51: 353–370.

Hassan P. (1998): Pakistan's Economy at the Crossroads: Past Policies and Present Imperatives. Oxford University Press, Karachi: 79–80.

Henneberry S.R., Khan M.E., Piewthongngam K. (2000): An analysis of industrial-agricultural interactions: a case study in Pakistan. Agricultural Economics, 22: 17–27.

Hirschman A.O. (1958): The Strategy of Economic Development. Yale University Press, New Haven: 41–97.

Hussain I. (1999): Pakistan the Economy of an Elitist State. Oxford University Press, Karachi: 123–149.

Johansen S., Juselius K. (1992): Some structural hypotheses in a multivariate cointegration analysis of the PPP and the UIP for the U.K. Journal of Econometrics, 53: 211–44.

Johnston B.F. (1970): Agriculture and structural transformation in developing countries: A survey of research. Journal of Economic Literature, 8: 369–404.

Joiya S.A., Shahzad A.A. (2013): Determinants of high food prices The Case of Pakistan. Pakistan Economic and Social Review, 51: 93–107.

Lewis W.A. (1954): Economic development with unlimited supplies of labour. The Manchester School, 28: 139–191.

MacKinnon J.G. (1991): Critical values for co-integration tests. In: Engle R.F., Granger C.W.J. (eds): Long-Run Economic Relationships. Oxford University Press, Oxford: 267–276.

Phillips P.C., Perron P. (1988): Testing for a unit root in time series regression. Biometrika, 75: 335–346.

Rangarajan C. (1982): Agricultural Growth and Industrial Performance in India. International Food Policy Research Institute, Washington, D.C.

Rehman A., Jingdong L., Iqbal M.S., Hussain I. (2016): A study on agricultural development in China and its comparison with India and Pakistan. Transylvanian Review, 6: 603–610.

Saikia D. (2011): Analyzing inter-sectoral linkages in India. African Journal of Agricultural Research, 6: 6766–6775.

Singh N. (2007): Services-led industrialization in India: Assessment and lessons. In: Industrial Development for the 21st Century: Sustainable Development Perspectives. Department of Economic and Social Affairs, United Nations, New York.

Singariya M.R., Naval S.C. (2016): An empirical study of inter-sectoral linkages and economic growth in India. American Journal of Rural Development, 4: 78–84.

Thirlwall A.P. (1995): The terms of trade, debt and development: with particular reference to Africa. African Development Review, 7: 1–34.

World Bank (2016): World Development Indicators. World Bank, Washington, DC.

Yoa S. (1996): Sectoral cointegration, structural break and agriculture's role in the Chinese economy in 1952–92: a VAR approach. Applied Economics, 28: 1269–1279.

Received October 29, 2017
Accepted November 20, 2018
Published online June 10, 2019