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An Examination of the Relationship Between Agricultural Value Added and Agricultural Supports with Panel Simultaneous Equation Systems

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ARTICLE INFO	ABSTRACT
	Agricultural support is a crucial way to overcome the difficulties of long agricultural production process, lack of capital and low productivity. Moreover, the fact that increasing the supply is not possible in a short while makes agricultural support more important. Different agricultural structures of countries imply different agricultural support values. This paper examines the simultaneous relations between agricultural support and agricultural value added in the six developing countries with the highest agricultural production value. Simultaneous equation systems are estimated by Two-Stage Least Squares method using annual data for the 2002-2018 period. The findings suggest that there is a simultaneous positive and statistically significant relationship between agricultural value added and agricultural supports.

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Introduction

Agriculture is a source of inspiration for social, cultural, moral and artistic structures of nations. The conceptions of economy such as cost, price, productivity and profit were formed with agricultural development (Ciutacu et al., 2015: 170). Since agricultural sector takes part in the heart of economic activities, the agricultural policies make a huge contribution to economic development (Akyol, 2018: 226). For instance, the rapid industrialization of developed countries initially depended on their agricultural accumulation. On the other hand, it can be said that agricultural and industrial sectors are supporting each other over time. Thanks to improvements in industrial sector and technology, agricultural sector gives opportunity for building global economic power and so it rises in importance depending on the increase in the competitive environment and change in market conditions (Erdinç and Aydınbaş, 2021: 215-217).

As known, agricultural supply is price-inelastic in the short-run. Accordingly, in case of any sudden change in the supply of agricultural products, the volatility of prices of these products significantly increases. This leads to undesirable results in industrial sector as well as decreasing

agricultural export and income of the producers (Yılmaz and Çobanoğlu, 2017: 146). To avoid these negative impacts or to achieve supply-demand equilibrium, agricultural sector is supported by all countries. Agricultural supports are expected to be effective in many issues such as productivity, technical infrastructure, agricultural sustainability, production and consumption (Doğan et al., 2018: 946). Taking into account all of these, determining the relationship between agricultural supports and agricultural value added becomes critical especially for developing countries. Importance of agricultural supports and agricultural value added are emphasized by Rizov et al. (2013), Rupasingha (2009), Ciaian and Swinnen (2009), and Clark et al. (2021). There are different findings in the literature about the relationship between agricultural supports and agricultural value-added. Some of the authors (e.g., Garrone et al., 2019; Rizov et al., 2013; Hennessy, 1998) suggest that there is parallel relationship between these variables. That is, agricultural supports will encourage agricultural value-added. On the other hand, a group of authors (e.g., Minviel and Latruffe, 2017; Yanlin et al., 2020; Siudek and Zawojska, 2012) argue that agricultural supports have a

negative effect on agricultural value-added. Unfortunately, there is lack of enough study in the literature on whether agricultural value-added has any effect on the agricultural supports. Considering all of these, this study aims at determining the simultaneous relationship between agricultural supports and agricultural value-added since it becomes more essential for the economic development of the countries. Moreover, determining this relationship can contribute to help decision-makers in designing appropriate agricultural policies.

The analysis consists of China, Russia, Brazil, Turkey, Indonesia, Mexico, which are developing countries with the highest agricultural production value. The relationship between agricultural supports and agricultural value-added in these six countries is estimated by panel simultaneous equation systems, covering the period between 2002 and 2018 which is restricted based on the availability of data. The rest of the paper is organized as follows.

The first section, the theoretical framework, defines the concepts of agricultural support and agricultural value added and introduces the econometric literature on this issue. In the second section, data set and empirical model are introduced. Third section mentions methodology and fourth section explains empirical findings of the econometric analysis. Finally, the last section evaluates empirical results and puts forward some policy implications and suggestions.

Theoretical Framework

Agriculture value added is a set of agricultural practices that provide farmers with an opportunity to comply with consumer preferences for agricultural products with form, space, time, identity, and quality characteristics, which are not provided in conventionally-produced agricultural products (Lu and Dudensing, 2015: 4). Agriculture value-added, which can be identified as the differentiation of agricultural products, adds economic value to agricultural products (Wright and Annes, 2016: 552). Ceylan and Ozkan (2013), Erdinç and Aydınbaş (2021) and Yavuzaslan and Soyyiğit (2019) examine the determinants of agricultural value-added for different group of countries. The common finding of Ceylan and Ozkan (2013) and Erdinç and Aydınbaş (2021) is that GDP per capita growth increases agricultural value-added and similarly Yavuzaslan and Soyyiğit (2019) argues that economic development is an important determinant of agricultural value-added. On a basis of reciprocity, thanks to value-added and differentiated agricultural products, consumer interest is grown up and thus this offers new opportunities for increase in production, development of agricultural sector and economic growth (Clark et al., 2021). Moreover, development of value-added agricultural sector contributes to income growth in rural areas, employment increase and poverty reduction. Since agricultural sector is a labor-intensive sector, raising value-added agricultural production provides employment increase. Accordingly, supporting and subsidizing value-added agricultural commodities can reduce unemployment (Rupasingha, 2009: 512). In this way, agricultural sector is the most supported sector in many developed countries. The positive impact of the agricultural sector on domestic income increase, employment creation, foreign trade and supplying raw materials to industry sector makes agricultural supports and agricultural value-added more important and therefore support policies are carried out in the agricultural sector to provide productivity and sustainability (Yüceer et al., 2020: 37). The countries supporting the agricultural sector in various ways have high agricultural output level. In these economies, approximately one third of total value-added emerges from the agricultural sector (Uslu and Apaydın, 2021: 478).

The agricultural supports and incentives are used for seed improvement, agricultural spraying, fertilization, marketing and production process improvement and thus increase the productivity, that is, value-added (Akyol, 2018: 229). In other words, main target of agricultural supports is increasing the agricultural value-added and thus increasing the income and welfare of the producers, increasing welfare of the consumers thanks to cheap food supply, rural development, foreign exchange saving and price stability (Semerci, 2019: 181). Structural transformation in the developed countries happens through increasing the agricultural value-added (Yavuzaslan and Soyyiğit, 2019: 410). In the least developed and developing countries, the fact that agricultural sector is the basis of capital accumulation is one of the motivations of agricultural supports (Acar and Bulut, 2010:2). Moreover, global food price volatility leads to food security concerns in developing countries and in this sense, increasing the food supply and meeting the food demand in the long run are of vital importance. To achieve these, enhancing modern technology in agricultural sector becomes necessary (Rizov et al., 2013: 538).

The positive effect of agricultural supports on productivity is closely related to innovation and agricultural technologies (Akyol, 2018: 229). Since the agricultural support provides direct or indirect funds transfer to agricultural enterprises, it raises the productivity of these enterprises (Ciaian and Swinnen, 2009: 1137). Using these financial supports in the restructuring or modernization of agricultural enterprises, investments in modern technologies increase the production capacity of agricultural enterprises and their technical efficiency (Zhu and Lansink, 2010: 546). Furthermore, this type of supports enables farmers and firms maintain agricultural land in good condition by cultivating the agricultural land with poor natural agricultural endowments and have cost-decreasing and productivity-increasing effect (Garrone, 2019: 805). Garrone et al. (2019), Koç et al. (2019), and Mamatzakis and Staikouras (2020) examine the effect of the agricultural supports or subsidies on the agricultural value-added while Akyol (2018) discusses the relationship between them in a bidirectional way. Akyol (2018) argues that agricultural supports and agricultural value-added affect each other in a positive way for a group of emerging countries including Turkey. Garrone et al. (2019) and Koç et al. (2019) indicate that agricultural subsidies have a positive effect on productivity. According to the study of Mamatzakis and Staikouras (2020), the shocks in direct subsidy payments provide a low level of agricultural value-added.

According to the theory which argues that agricultural supports affect the agricultural value-added in a negative way, agricultural supports can lead to a change in the enterprises' attitude against risk and hence decrease their performance. In this case, the technical productivity tends

to decrease. For instance, since farmers have higher income thanks to agricultural financial support, they do not need to develop a new production strategy. That is, farmers earn more income without effort thanks to financial supports and they use their preferences for leisure instead of developing production strategies, thus causing the decreasing in farming activities (Minviel and Latruffe, 2017:213; Zhu et al., 2011: 631; Zhu and Lansink, 2010: 546). Unlike the authors arguing that the effect of the agricultural supports on the agricultural value-added is positive, Uslu and Apaydın (2021) suggest that agricultural supports do not affect agricultural productivity when recalculated in terms of purchasing power parity in Turkey.

Data and Econometric Model

This study aims to examine the simultaneous relationship between agricultural supports and agricultural value added in 6 developing countries with the highest agricultural production value. The panel consists of China, Russia, Brazil, Indonesia, Mexico and Turkey. The analysis, in which the two-stage least squares (2SLS) method is applied, covers the period of 2002-2018. The sample period is restricted based on the availability of data. The annual data of the variables are gathered from the World Bank and OECD databases. All variables are expressed in real terms and enter the equations in logarithms.

$LAVA$ is the agricultural value added measured by the ratio of agriculture, forestry, and fishing value added to GDP, and $LSUPPORT$ is the agricultural producer support. Agricultural land ($LLAND$), employment in agriculture ($LEMP$), agricultural raw materials imports ($LIMP$) and, GDP per capita in constant dollar price ($LGDPPC$) are exogenous variables of the models. The simultaneous equation systems based on Akyol (2018, 2020), Erdinç and Aydınbaş (2021), Liu et al. (2020), Hayaloğlu (2018) can be expressed as follows:

$$LAVA_{it} = \alpha_0 + \alpha_1 LSUPPORT_{it} + \alpha_2 LLAND_{it} + \alpha_3 LEMP_{it} + \varepsilon_{it}$$

$$LSUPPORT_{it} = \beta_0 + \beta_1 LAVA_{it} + \beta_2 LIMP_{it} + \beta_3 LGDPPC_{it} + \vartheta_1$$

In the above equations i and t denotes the cross-section units and time period, respectively. According to the current literature agricultural supports and agricultural value added simultaneously affect each other. The relationship between the two equations cannot be considered independent of each other and is handled by the system. These are called endogenous variables.

Agricultural supports are expected to have a positive effect on agricultural value added as they encourage the development of the agricultural sector and have reducing effects on production costs. It is also accepted that agricultural land size and agricultural employment are important explanatory variables of agricultural output and agricultural value added.

The governments provide agricultural support to imported inputs (such as imported fertilizers, seeds, pesticides) in order to maintain agricultural production and protect its producers. It is also expected that $LGDPPC$ will have a positive impact on $LSUPPORT$ as countries with high per capita income will allocate more funds to promote agricultural production. Table 1 provides information about the abbreviations, data sources, and definitions of the variables utilized in this study.

The descriptive statistics of the raw data used in this study are presented in Table 2 below. As can be seen from the table, while the mean value of AVA among the endogenous variables is 7.213, the highest value is 16.31 and the lowest value is 2.926. The mean values for the exogenous variables of the first model, $LAND$ and EMP, are 38.70 and 22.24, respectively. For $SUPPORT$ with an average of 14.48, the minimum is 1.15 and the maximum is 30.89. The mean values for the exogenous variables of the second model, IMP and $GDPPC$ are 2.265 and 7264, respectively. The skewness test statistics indicate that series are positively skewed except $LAND$. Kurtosis statistics of all series except $SUPPORT$ are less than three and these series are highly platykurtic relative to the normal distribution.

Descriptive statistics on the original form of the variables indicated that there was a scale difference, and thus the regression models were established in log-log form.

Table 1. Definitions and Abbreviations of the Variables

Abbreviation	Variable	Data Source
LAVA	Agriculture, forestry, and fishing value added (% of GDP)	World Bank, WDI
LSUPPORT	Agricultural producer support (% of gross farm receipts)	OECD
LLAND	Agricultural land (% of land area)	World Bank, WDI
LEMP	Employment in agriculture (% of total employment)	World Bank, WDI
LIMP	Agricultural raw materials imports (% of merchandise imports)	World Bank, WDI
LGDPPC	GDP per capita (constant 2015 US$)	World Bank, WDI

Table 2. Descriptive Statistics of the Variables

Abbreviation	Mean	Median	Minimum	Maximum	Std. Deviation	Skewness	Kurtosis
LAVA	7.213	5.907	2.926	16.31	3.926	0.667	2.093
SUPPORT	14.48	13.25	1.15	30.89	8.013	0.158	3.007
LAND	38.70	41.14	13.15	56.13	16.03	-0.326	1.581
EMP	22.24	17.78	5.88	50.01	12.43	0.591	2.100
IMP	2.265	2.001	0.787	5.804	1.217	0.555	2.273
GDPPC	7264.5	8416	1968.3	12006	2671.2	0.699	2.262

Table 3. Coefficient Matrix

	Endogenous coefficient matrix		Exogenous coefficient matrix			
	LAVA	LSUPPORT	LEMP	LLAND	LIMP	LGDPPC
LAVA	-1		0.5	0.5	0	0
LSUPPORT	0.5	-1	0	0	0.5	0.5

Methodology

Sometimes one equation is not enough to explain the economic relations. For this reason, relations are tried to be explained by the system established with more than one equation. Simultaneous Equations Models (SEM) is a statistical method that models the simultaneity in the presence of a bidirectional relationship between variables. A set of regression equations is estimated to consider the simultaneity between the dependent and independent variables (Baltagi, 2011: 257).

Estimating simultaneous equations with ordinary least squares (OLS) has been criticized for giving biased and inconsistent results (Hill et al., 2017: 532). The most important problem encountered in simultaneous equations is endogeneity as the OLS violate the assumption of noncorrelation between the regressors and the error terms. In order to avoid this problem, some estimation methods with instrumental variables are used (Lee et al., 2016: 944). 2SLS is the most common method for a SEM, developed independently by Theil (1953) and Basmann (1957).

This method is called two-stage least squares because Ordinary Least Squares (OLS) is applied twice. In the first step, each equation in the system of simultaneous equations is converted to reduced form and OLS is used for estimation. A reduced form equation is a representation with an endogenous variable on the left-hand side and the error term and the exogenous variables on the right-hand side. In the second stage, instead of endogenous variables in a structural form, the predicted value from OLS is used as an instrumental variable (Hill et al., 2017: 534; Stock and Watson, 2008: 423-424). The reduced form equations in this study can be expressed as follows:

$$LAVA = \pi_{11} + \pi_{21}LEMP + \pi_{31}LLAND + \pi_{41}LIMP + \pi_{51}LGDPPC + \vartheta_1$$

$$LSUPPORT = \pi_{12} + \pi_{22}LEMP + \pi_{32}LLAND + \pi_{42}LIMP + \pi_{52}LGDPPC + \vartheta_2$$

Coefficient estimates of variables cannot be made directly in simultaneous equation systems. Before the estimation, it should be determined whether the parameters are predictable or not. This is controlled by the order condition in practice. If there is no way to estimate the parameters, this equation is under-identified. If the structural parameters can be estimated, the equation is either exactly-identified or overidentified. 2SLS can be used for the estimation of the exactly-identified or overidentified equations (Greene, 2003: 394).

Necessary condition for identification of structural equation is that the number of exogenous variables excluded from equation are greater than or equal to the number of right-hand side included endogenous variables (Baltagi, 2011: 260-261). The rule for order identification is that in a system of M equations at least (M–1) variables must be omitted from each equation in order for it to be

identified (Hill et al., 2018: 539-540). In the first equation LIMP and LGDPPC are not included, and LLAND and LEMP are absent in the 2nd equation. Thus, the necessary $(M – 1) = 1$ variable is omitted. It is concluded that each equation in the system is identified and can be estimated by two-stage least squares.

The order condition is necessary for identification but it is not sufficient. A necessary and sufficient condition for identification is rank condition (Greene, 2003: 392). An equation in a model with M endogenous variables can be determined if and only there is at least one non-zero determinant (M-1)(M-1) can be constructed from the coefficients of the variables excluded from that particular equation but included in the other equations of the model (Gujarati and Porter, 2008: 701; Wooldridge, 2010: 248).

The checkreg3 command in the STATA software allows to verify the whether the rank condition is satisfied for each of the N equations in the system. The system to be estimated in this study consists of 2 equations. There are 2 endogenous variables $(LAVA, LSUPPORT)$ and 4 exogenous variables $(LEMP, LLAND, LGDPPC, LIMP)$. The checkreg3 command for STATA, is conducted to verify whether the system of equations is appropriately identified. The findings confirm that the equations used in this study are properly identified. The results are presented in Table 3.

The existence of simultaneity in equation systems is investigated with the Hausman test. The Hausman simultaneity test investigates the existence of a relationship between the variables and the error term. According to the Hausman test, if the variables are related to the error term in a simultaneous equation system, there will be a simultaneity problem. If the Hausman test gives a result that there is no simultaneity, there will be no need to use the 2SLS (Wooldridge, 2012: 481).

Results and Discussions

Simultaneous equation systems were established by determining the endogenous and exogenous variables and the existence of individual (country) effects in the models was tested with F test. The F test results in Table 4 and Table 5 indicated that there was individual effect in the first and second models.

The estimation method differs depending on whether the individual effects are correlated with the independent variables. In the case of correlation, the Fixed Effects (FE) estimator will be more consistent, while in the absence of correlation, the Random Effects (RE) estimation result will be more efficient (Cameron and Trivedi, 2005; Baltagi, 2005). The first and second models were estimated by FE and RE methods for cases with and without simultaneity. Hausman test is used to choose between different estimates.

First of all, the equation in which LAVA is the dependent variable was estimated by FE and RE methods with and without simultaneity. Two-stage OLS method was used for FE and RE estimations, considering simultaneity, and the findings were reported under the FE-2SLS and RE-2SLS (Column 1-3), respectively. The Hausman test of the FE-2SLS and FE estimations (Column 1-2) made under the assumption that the individual effects are correlated with the independent variables yielded results for the selection of the FE estimator. The Hausman test findings for the RE-2SLS and RE estimations (Column 3-4) made under the assumption that the individual effects are uncorrelated with the independent variables lead to the RE-2SLS estimator. Finally, the Hausman test for selection between the FE and RE-2SLS estimators (Column 5-6) showed that the two-stage random effects estimator (RE-2SLS) gave more efficient results.

The R-square of the random effects instrument variable regression estimation (RE-2SLS) is 80%, and the Wald statistic is 87.07, which has a p-value of less than 0.001. The estimation results show that the coefficient of agricultural support has a significant and positive sign. Since agricultural producers' supports encourage the development of the agricultural sector and have reducing effects on production costs, it is expected to have a positive impact on agricultural value-added. This finding was also supported by Akyol (2018), Garrone et al. (2019), Koç et al. (2019) and Mamatzakis and Staikouras (2020) in the literature. Agricultural employment, which is the exogenous variable of the first equation, takes a positive and significant coefficient. Accordingly, the increase in agricultural employment in the countries included in the panel increases the agricultural value-added. However, the other exogenous variable agricultural land width does not have statistical significance.

After estimating the first equation, similar steps were repeated for the second equation where *LSUPPORT* was the dependent variable. Findings of different estimators are shown in Table 5. The Hausman test pointed to FE-2SLS among the FE and FE-2SLS (Column 1-2), which were made with the assumption that the individual effects were correlated with the independent variables. In the selection between RE and RE-2SLS (Column 3-4), it was determined that RE was more suitable.

The instrument variable regression estimation of the fixed and random effects for the second model are given in the 5th and 6th columns in Table 5. The Hausman test results for the two estimators showed that the FE-2SLS estimator was more consistent. The R-square of the model is 12%, and the Wald statistic is 2156, which has p-value of less than 0.001. The coefficient estimates indicate that agricultural value added have a statistically significant effect on the agricultural support given to producers. It is determined that the exogenous variable of the second model, *LGDPPC*, has significant effects on agricultural support at 99% significance level. Although the effect of the imports of agricultural raw materials on *LSUPPORT* has a positive sign, it is not statistically significant.

According to the results of simultaneous equation systems estimated by the two-stage least squares method, it has been determined that there are simultaneous positive and statistically significant relationships between agricultural value added and agricultural supports. Based on the coefficient estimation, it can be said that a 1% increase in the share of agricultural producer supports in gross farm receipts increases the agricultural value added by 0.181%, while a 1% increase in agricultural value-added leads to an increase of 4.69% in agricultural supports share in the farm receipts.

Table 4. Coefficient Estimates of First Equation

Variable	FE-2SLS (1)	FE (2)	RE-2SLS (3)	RE (4)	FE (5)	RE-2SLS (6)
LSUPPORT	0.093	-0.057***	0.181**	-0.032	-0.057***	0.181**
LEMP	0.638***	0.677***	0.668***	0.648***	0.677***	0.668***
LLAND	0.825*	1.500***	-0.149	0.058	1.500***	-0.149
Constant	-3.202*	-5.334***	-0.059	-0.202	-5.334***	-0.059
R-sq.	0.40	0.64	0.80	0.76	0.64	0.80
F stat.	28285***	55.62***	87.07***	148.94***	55.62***	87.07 (0.00)
F test	26.65***	50.80***			50.80***	
Hausman	4.13 (0.24)		8.00 (0.04)		4.05 (0.25)	

Note: Probability values are in parentheses; ***, ** and * indicate denote the significance at 0.01, 0.05, and 0.10 level, respectively; RE: random effect, FE: fixed effect, FE-2SLS: fixed effects instrument variable regression, RE-2SLS: random effects instrument variable regression.

Table 5. Coefficient Estimates of Second Equation

Variable	FE-2SLS (1)	FE (2)	RE-2SLS (3)	RE (4)	FE-2SLS (5)	RE (6)
LAVA	4.698***	0.675	2.515*	0.429	4.698***	0.429
LIMP	0.593	0.978***	0.328	0.880***	0.593	0.880***
LGDPPC	3.098***	1.170***	1.991**	1.026***	3.098***	1.026***
Constant	-33.73***	-9.675***	-19.83**	-7.897**	-33.73***	-7.897**
R-sq.	0.12	0.17	0.14	0.19	0.12	0.19
F / Wald stat.	2156***	6.16***	16.88***	18.27***	2156***	18.27***
F test	15.21***	20.72***			15.21***	
Hausman	9.97 (0.01)		2.06 (0.55)		10.79 (0.01)	

Note: Probability values are in parentheses; ***, ** and * indicate denote the significance at 0.01, 0.05, and 0.10 level, respectively; RE: random effect, FE: fixed effect, FE-2SLS: fixed effects instrument variable regression, RE-2SLS: random effects instrument variable regression.

Conclusion

Determining the relationship between agricultural value added and agricultural support is crucial for the countries to provide economic development. Accordingly, the main purpose of this study is to examine the simultaneous relationship between agricultural value added and agricultural support to producers in 6 developing countries with the highest agricultural production value. For the 2002-2018 period, the two-stage OLS method was applied using data obtained from the World Bank and OECD. In the econometric analysis, firstly, endogenous and exogenous variables were determined and then the presence of individual (country) effects in the simultaneous equations was tested. The results of the instrument variable RE model, in which agricultural value added is the dependent variable, show that agricultural supports have positive effects on agricultural value added at the 5% significance level. Similarly, it is determined that the effect of agricultural value-added on agricultural supports is statistically significant and positive.

Considering the findings that agricultural supports increase agricultural value-added, it can be said that increasing agricultural supports have positive effects on the economy. Accordingly, it is recommended to increase the share of the support given to innovative projects and to follow the usage process of the supports closely because agricultural supports increase the value-added through technological developments and innovation. In addition, based on the results of the econometric analysis showing that agricultural value-added also positively affects agricultural supports, it can be said that priority should be given to the production of products with high added value since it is an incentive element for agricultural supports.

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