Agricultural producer support and production relation: Panel data evidence from selected countries on agricultural wheat crop

SELIM TÜZÜNTÜRK*, FILIZ GIRAY**, VOLKAN GÜRSEL***

DOI: 10.30682/nm2504e
JEL codes: C23, H71, Q18

Abstract

The study's main purpose is to analyze the effect of wheat producer support on wheat production using panel data methods. The primary independent variable of interest is wheat producer support, and the secondary variables of interest are wheat harvested area, previous period price of wheat, and previous period production of wheat. Panel data include 352 observations from selected 16 countries between 2000 and 2022. All the data are annual and retrieved from the OECD official website. The main finding of this study is that wheat producer support has a positive effect on wheat production. This finding reveals that agricultural support increases agricultural production for wheat crops. The findings indicate that countries should give importance to producer support policies in agriculture and develop new support policies. The secondary findings of this study show that wheat harvested area, previous period price of wheat, and previous period production of wheat have a positive effect on wheat production. The study has significant consequences for the Mediterranean countries, which have a considerable share of world wheat imports during and after the analysis period.

Keywords: *Agricultural policy, Producer support, Subsidies, Wheat production, Panel data analysis.*

1. Introduction

Food systems embrace the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption, and disposal (loss or waste) of food products from agriculture (including livestock), forestry, fisheries, and food industries (Von Braun *et al.*, 2021). Many factors affect the food system in a country. These include market fluctuations, changes in agricultural policies at the national and international level, use of technology, trade conditions, and biophysical properties (such as the presence of water resources, soil quality, carrying capacity, pests, and diseases) (Kurukulasuriya & Rosenthal, 2013). Dimitri and Rogus (2014) stated that the behavioral factors that reflect individuals' food choices could be another factor that can be added to the above factors. However, main-

* Bursa Uludağ University, Faculty of Economics and Administrative Sciences, Department of Econometrics, Bursa, Türkiye.
** Bursa Uludağ University, Faculty of Economics and Administrative Sciences, Department of Finance, Bursa, Türkiye.
*** Bursa Uludağ University, Faculty of Economics and Administrative Sciences, Department of Economics, Bursa, Türkiye.
Corresponding author: selimtuzunturk@uludag.edu.tr

ly in the 2000s, climate change has been added to these factors. Climate change and its consequences are the phenomena that all countries face. Agriculture is the food system's primary sector. It is most affected by climate change due to its production structure (Trentinaglia *et al.*, 2023). This situation has led to the formation of literature on the effects of climate change on agriculture (Gregory *et al.*, 2005; Reddy *et al.*, 2013; Wheeler & Von Braun, 2013; Saranga *et al.*, 2024). On the other hand, human nutrition is closely related to grain consumption: wheat, corn, and rice are the three main pillars of human nutrition (Soto-Gomez & Perez-Rodriguez, 2022). Wheat, corn, and rice, which are cereals that provide a significant portion of human nutrition, are among humanity's most important food sources and will continue to be staple foods with the estimated increase in the global population (Aktaş Çimen, 2025). Commodity supplies such as wheat, corn, and rice are important to many countries. They are essential to meet the needs of people living in countries where these commodities are not produced or produced in sufficient quantities. Ensuring the population's food security is one of the primary challenges of the agricultural sector (Harbouze *et al.*, 2024). The issue of access to and availability of food on a global basis is known as food security (Lacirihnola *et al.*, 2015). On the other hand, agricultural production risk affects food availability (Chavas *et al.*, 2022). Food insufficiency has serious consequences. For example, food insufficiency in African societies causes illness and even death. Therefore, ensuring food safety is essential. In summary, this study focuses on agriculture, the priority sector of food systems, and agricultural policies, among the factors affecting food systems, especially agricultural support policies.

Agricultural support policies are an essential mechanism that countries' governments can use to develop the agricultural sector and ensure its sustainability and food security. Agricultural policies affect productivity growth and environmental performance (Lankoski & Thiem, 2020). The development and growth of the agricultural sector will significantly contribute to the country's economy by increasing production, providing employment opportunities, and providing foreign exchange inflows to the country through the growth of export-oriented foreign trade. Agriculture is a sector that has a vital role in economic development. Agriculture provides inputs (or raw materials) to sectors such as industry and services. It is of primary importance for the growth of other sectors of the economy. The agricultural sector provides employment. The agricultural sector helps reduce poverty and raise incomes for the people who live in rural areas and work mainly in farming. This importance increases significantly in countries where the income source of a significant part of the population is agriculture. The agricultural sector also provides a source of foreign currency for the country's economy by exporting agricultural products. In this context, Johnston and Mellor (1961) summarized the contributions of agricultural growth and productivity to economic development in five points: (i) Providing increased food supplies, (ii) enlarged agricultural exports, (iii) transfers of workforce to nonagricultural sectors, (iv) contributions to capital formation and, (v) increased rural net cash income as a stimulus to industrialization. Today, for many countries, agriculture needs to grow to sustain economic growth in the long term.

The agriculture sector is also of social importance. People are fed by the agricultural products that are produced. Ensuring adequate food supply is essential to all societies. With the rapid increase in agricultural trade worldwide, the dependence on international trade to meet food needs has increased (Porkka *et al.*, 2013). This situation causes the fluctuations in international agricultural markets to spread more rapidly to domestic markets. The increase in volatility in agricultural markets makes low-income countries especially vulnerable regarding food security. (FAO, 2010; Ceballos *et al.*, 2017; Bekkers *et al.*, 2017; Gutiérrez-Moya *et al.*, 2021). For most developing countries, food security depends on agricultural product imports. MENA (Middle East and North Africa) countries highly depend on food imports (OECD – FAO, 2018). For example, while the cereal import dependency ratio for low-income economies was 25.9% in 2022, it was 57.5% in North African countries (FAO, 2024).

On the other hand, agriculture is more fragile as a sector with more risks and costs from natural conditions than other sectors. Besides, it includes more seasonal activities. Drought, floods, decrease in water resources, increasing uncertainty in climate, length of season, and increase in precipitation caused by global warming and precipitation increase in soil erosion led to a decrease in agricultural production and an increase in the prices of farm products, creating a food security problem.

Agriculture is a sector where the state intervenes due to its social importance. Agriculture support policies in many countries actively promote food production and reduce hunger and poverty (Zhang *et al.*, 2022). Although state intervention in many sectors has decreased due to the liberalization policies that started in the 1980s, state intervention in agriculture continues for the development of the agricultural industry in both developed and developing countries. In addition, the search for sufficient and safe agricultural production to meet the worldwide population growth keeps agricultural support policies on the agenda. The agricultural sector is a sector that requires support due to its structure and strategic importance.

Agricultural support policies influence production patterns, farming practices, and input use and thus can have significant environmental impacts (Lankoski & Thiem, 2020). Though agricultural supports differ in country practices regarding their types and scope, they are concepts integrated with the agricultural sector. Countries provide different levels of support, from public expenditures to farmers (Ruzsikova, 2019). Some countries subsidize their agricultural producers more significantly, and some countries provide less support from public resources. While the agricultural support in middle- and high-income countries and regions is relatively high, in low-income countries, the level of support is low or even negative (Zhang *et al.*, 2022). According to the classification made by the Organization for Economic Cooperation and Development (OECD), the state's agricultural supports comprise producer, general service, and consumer support. Among these stated supports, producer supports are the most critical (Baliño *et al.*, 2019; OECD, 2023). In this context, in the 1990s, when discussions on the reform of the international agricultural trade system began, the type of support that was taken as the basis for evaluating national support was producer support (Kirsten *et al.*, 2000). Since producers are the main determinants of agricultural activities among these supports, the field studies after that date observed that producer support was the focus point (e.g., Helm & Van Zyl, 1994; Kirsten *et al.*, 2000; Chintapalli & Tang, 2021; Koetse & Bouma, 2022). Therefore, it is essential to determine the effects of producer support on the development of agriculture.

In the context of the above explanations, the study's main purpose is to analyze the effect of wheat producer support on wheat production using panel data methods. Wheat was examined as an essential agricultural product in this study because it has importance for several reasons: (i) Wheat is one of the first domesticated plants in the world and is among the plant foods widely grown and consumed today, (ii) it provides one-fifth of the world's total calorie and protein supply, (iii) it is one of the most widely produced primary crops in the world, and (iv) twenty-five percent of worldwide wheat production is exported. With this rate, wheat is the most traded grain in the world (Erenstein *et al.*, 2022).

This study makes many contributions to the literature in terms of being a study that only deals with (i) an essential agricultural product such as wheat, (ii) analyzing wheat producer supports (producer single commodity transfers), (iii) using a panel data set consisting of a selected group of countries, (iv) its findings for a selected group of countries and, (v) its consequences for the Mediterranean countries. Besides these, due to the nature of panel data methods, the fact that they work with many observations considered cross-sectional and time dimensions has enabled the subject to be addressed from a different perspective with more information.

The rest of this study was organized as follows: The next section covers the theoretical framework of agricultural support policies. Section three was composed of the literature review. In section four, applications were given. The last section contains the conclusion.

2. Agricultural support policies

The agricultural sector is much more exposed to uncontrollable risk factors, such as natural conditions, than other sectors. These risk factors in the agricultural sector require governments to be more responsible for keeping farmers in the agricultural sector and ensuring adequate food supply (Vigani *et al.*, 2024). This situation leads to agriculture being one of the sectors where government intervention is required. State interventions, on the other hand, consist of agricultural support and regulations. Agricultural support, also the subject of this study, is the most critical intervention tool.

There are different opinions on agricultural support, primarily based on theoretical ideas and the development levels of the countries. In theory, the proponents of classical and neo-classical economics are opposed to state intervention in agriculture and other sectors due to the ideology of this movement. For example, economists with neo-classical thought have addressed the state's role in agriculture and stated that state intervention in agriculture in developed and developing countries leads to severe market distortions (Vyas, 2022). In comparison of the developed and developing economies, it is seen that there are different practices in agricultural support. In the case of advanced economies, it is observed that with economic growth, the gap between the incomes of farmers and urban workers widens as the demand for nonagricultural goods and services increases faster than the demand for agricultural products. In addition, farmers in developed countries face higher labor costs than producers in developing countries, and they need help to compete.

For this reason, the farmers' lobby's demand for various concessions and subsidies increases in developed countries. With a high income level, governments in these countries can meet the needs of farmers because the subsidies given to farmers include only a tiny part of the country's budget and can be easily covered. Farmers are better organized and able to express their demands better in these countries.

On the other hand, farmers are poor, uneducated, and unorganized in the case of developing countries. Therefore, they are unable to express their demands and protect their interests. As a result, while agriculture in developed countries earns 'rent' due to state interventions, it becomes difficult for agriculture to earn rent in developing countries. At this stage, governments tend to appease industrial workers and urban consumers at the expense of the agricultural sector. In other words, developing countries' governments tax the agriculture sector. Therefore, government interventions in developed and developing countries distort markets, leading to misallocation of resources and loss of productivity. This means government intervention is not good because markets function better without them. The above views have been criticized from various angles. These criticisms are explained on the following grounds:

- Especially in developing countries, there need to be more efficient markets to allocate resources appropriately. The initial conditions for the efficient functioning of markets, such as equal access to productive resources, ease of entry, and symmetry in information, need to be more present in developing countries. In other words, 'market failures' and 'market losses' are common in developing countries (Vyas, 2022).
- In addition, other justifications for government intervention are that uncontrolled market forces do not improve food security, pose some challenges and that governments are under political pressure to increase and stabilize farmers' income (Helm & Van Zyl, 1994).
- In both developed and developing countries, governments intervene in the agricultural sector to respond to political-economic pressures with support such as trade policies or price support for certain agricultural products to develop agriculture (CGIAR Research Program on Policies, Institutions, and Markets (PIM), 2021).
- The increase and diversification of numerous socio-economic and bio-physical factors affecting food systems and, thus, food security has increased the importance of government interventions in this sector. Adaptation to changing conditions and results for sustainable agriculture requires a connection with incentives (Piñeiro *et al.*, 2021).

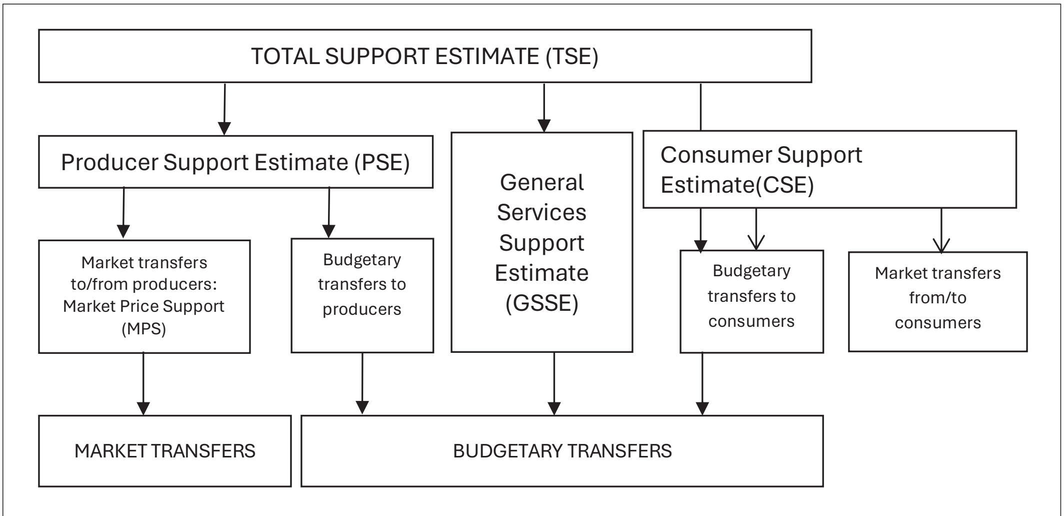
- On the one hand, the importance of agricultural products for individuals and the fragility of agricultural production due to many factors necessitate government support. Climate change is one of these factors. Climate change has increased the fragility of agriculture much more and made government support more necessary. Climate change imposes additional financial burdens on farmers, such as crop yields, the possibility of extreme natural events, and investments in new technologies compatible with climate change. Support is especially mandatory for producers to meet these costs (Kurukulasuriya & Rosenthal, 2013).

Within the framework of these debates, for much of the 1990s, discussions about reforming the international agribusiness system were dominated by issues related to domestic agricultural policy and, more specifically, levels of local support to farmers. Afterward, agricultural policies have maintained their importance in every period until today and still have an essential place.

As general government support, the support given to the agricultural sector shows diversity. On the other hand, researchers and international official organizations classify these supports according to various criteria. For example, Piñeiro *et al.* (2021) divided incentives into four groups. The first is market-based incentives. These economic incentives include changes in input and output prices, income transfers, or other cash or in-kind incentives provided to agricultural producers. The second is non-market incentives. Non-market incentives are a broad group of non-market-based mechanisms, such as technical assistance and technology transfers, to improve environmental sustainability. The third is regulatory measures, which are general rules or specific actions implemented by government agencies, private businesses, and organizations to improve environmental and economic outcomes. These supports include certifications given in the agricultural sector and environmental laws and standards. The fourth is cross-compliance incentives. They are payments made directly from the budget: subsidies, depending on farmers' compliance with fundamental environmental standards or keeping the land in good agricultural and ecological conditions (Piñeiro *et al.*, 2021). Another example is the classification of the OECD, which is one of the leading official organizations working on agricultural support within the scope of this framework. In the classification made by the OECD, the support provided by the state to agriculture is classified into three groups, as is seen in Figure 1.

These groups are (i) Producer Support, (ii)

Figure 1 - Structure of agricultural support indicators.



Source: OECD, 2023, p. 82.

General Services Support, and (iii) Consumer Support. Consumer support, similar to producer support, covers transfers from the market and budget to consumers of agricultural goods (OECD, 2023). General service support includes expenditures benefiting the agricultural sector rather than directly to individual producers. Producer supports cover all supports given to agricultural producers.

Producer supports are also divided into two. The first is market price support (MPS). MPS represents transfers from taxpayers and consumers to agricultural producers in the form of domestic market prices that are higher than international reference prices due to domestic and foreign trade policies. It involves implicit transfers from consumers to producers by creating a price gap between domestic market prices and border prices for specific agricultural commodities (Vos *et al.*, 2023). MPS will be positive if product prices are higher than reference prices. Conversely, negative MPS is formed. The second is transfers from the budget to producers. The source of these transfers is transfers from taxpayers. Budget transfers consist of direct payments and forego budget revenues. Tax concessions can be given as an example of foregone budget revenues. Farmers pay indirect taxes not only on the income they receive but also on their agricultural inputs. These subsidies, which include the various taxes farmers pay and the subsidies they receive, go beyond market prices. Because these supports also affect farmers' production decisions. This indicator is more complex than other supports. Some of the supports within this scope include indirect income transfer in the form of payments and tax concessions given directly to the producer. In the agricultural sector, producers and consumers look at prices and other factors such as subsidies, tax deductions, and exemptions. These factors change the expectations of producers and buyers (Baliño *et al.*, 2019).

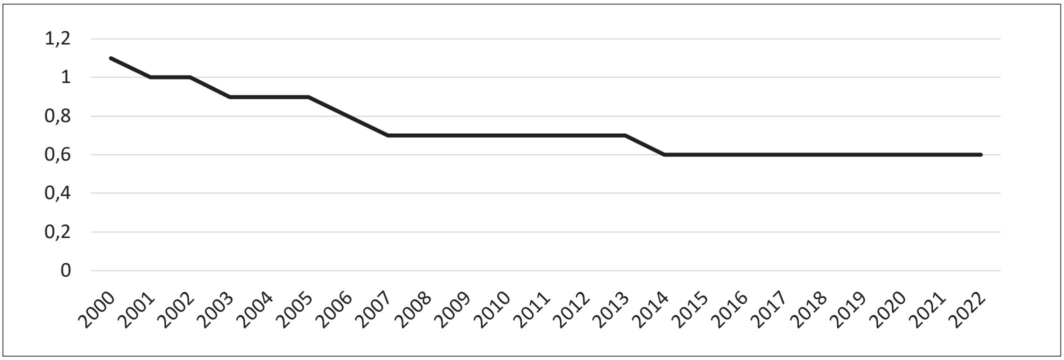
Producer decisions are the main determinants of agricultural production. Producer support is the most important type of support in all economies among these supports. Producer supports also consist of cost and minimum price supports. Cost subsidies to producers should be at a level that covers at least part of the planting costs incurred by farmers. Minimum price support occurs in real terms when the market price of crops is below the minimum price set by the government. Minimum price support may have different applications. The most common of these supports is when the government gives a difference to farmers if the current market price for the products is below the market price determined by the government in advance (Nan *et al.*, 2023). Among the producer supports, the supports that directly affect production decisions are the MPS provided by commercial measures and the supports provided to outputs (Laborde *et al.*, 2021).

Producer support varies from country to country. For example, a study covering 54 countries conducted by the OECD shows that the weight of support given to the producers varies from country to country. OECD reported that Australia had the lowest producer support among OECD countries in 2023 (OECD, 2023). Moreover, the distribution of agricultural support as an average for the 2020-2022 period shows that 74% of the total support was given to the producers individually, either directly from government budgets or indirectly through MPS. In this distribution, the share of general service support was 12.5%, and consumer support was 13.5% (OECD, 2023).

Baliño *et al.* (2019) note that when considering the types of support provided to producers, although MPS has decreased in most OECD countries, total agricultural support remains relatively high due to subsidies and other transfer payments. This situation increased nominal agricultural support in OECD countries in the 2000s (see Figure 2).

Following Figure 2, it is seen that the share of total agricultural subsidies in GDP has steadily declined from 2000 to 2007. Between 2007 and 2013, it generally continued in the same course. This share declined again in 2014. It continued in the same course in the following years. The decline in state support in the 2000s was due to the World Trade Organization's (WTO's) neo-liberal agricultural policy proposals, especially for developing countries. Similarly, in the Uruguay Round, the abolition of support mech-

Figure 2 - Evolution of total support to agriculture in OECD (% of GDP).



Source: OECD, 2023, p. 84.

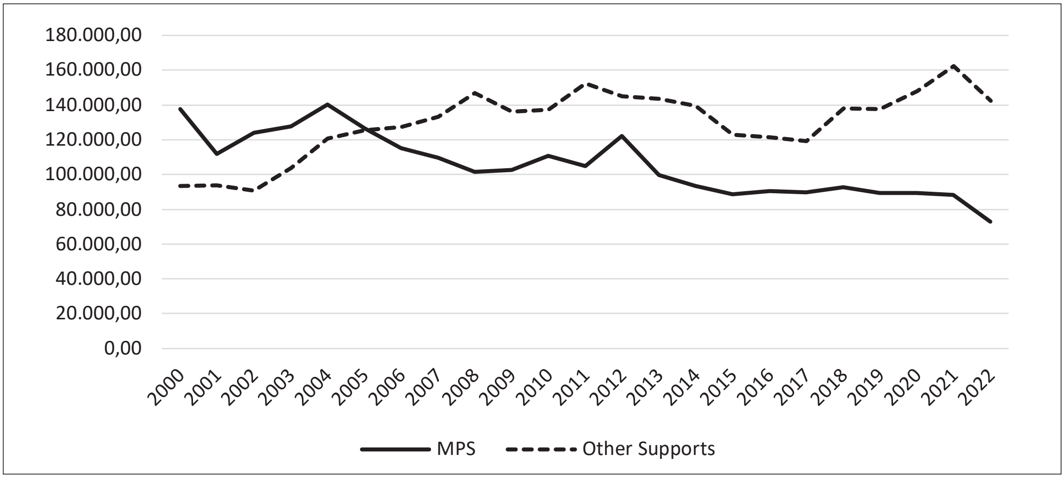
anisms that disrupt the free-market system was an issue on the agenda (OECD, 2001). However, the lack of fiscal incentives is considered in many countries as a significant obstacle to the agricultural regime change necessary for sustainable agriculture to solve the problem of food security. European Union (EU) countries such as the Netherlands are at the forefront of these countries (Vermunt *et al.*, 2020). Developing economies have tended to tax local agricultural sectors, while developed economies have subsidized their farmers. This trend began to change in the 1980s when developing economies ended most of the taxes on agriculture and subsidies that supported industry as part of their structural adjustment policies. In addition, although developed countries have taken border measures to protect agriculture, developing countries have reduced direct price support to reduce price distortion in international markets for the benefit of agriculture. (Baliño *et al.*, 2019). All these developments have created a situation that is against developing countries. Developing countries already have structural problems, such as unstable economies and incomplete infrastructure. Because in a large part of these countries, rural areas are often marginalized and lack essential services, rural development is a crucial aspect of overall development efforts. In addition, constraints such as lack of access to technology, inputs, and markets are often the dominant agricultural elements in these countries (Trentinaglia *et al.*, 2023).

Although developed countries have some commitments to free trade, they can get more priority for protecting their agriculture. For example, support for farmers accounted for one-third of farmers' incomes in the United States in 2000, half in the EU, and two-thirds in Japan (Kannan *et al.*, 2000). However, climate risks to food security are even more significant for poor populations and tropical regions. Wealthy populations and temperate zones not near restrictive thresholds for food availability, access, use, or stability are less at risk (Brown *et al.*, 2015). Another significant change in the 2000s is the change in state support types within themselves. In many OECD countries, MPS to producers has decreased, while direct support to producers has increased (see Figure 3).

In many OECD countries, market price support to producers has decreased, while direct support to producers has increased. In some countries, such as Australia, market price support was removed in 2000 (OECD, 2023). When the MPS given to producers in OECD countries is compared with other supports, it is seen that MPS were higher than other supports until 2005, but their support share decreased after this year (see Figure 3).

Although there have been decreases in MPS, the weight of these supports continues in some countries (Canada and Colombia). When EU and OECD countries are evaluated in general, it is seen that this type of support is decreasing. For example, in EU countries, MPS for producers declined from 46% in 2000-02 to 16% in 2020-22 (OECD, 2023). As with other supports, the

Figure 3 - Market price and other supports to agriculture in OECD (Millions of US Dollars).



Source: OECD official web site. https://data.oecd.org.

share of subsidy payments made directly from the budget and support in the form of tax concessions has increased. In the 2000s, the most crucial fiscal policy instrument for agriculture in EU countries was payments made directly from the budget (Sinabell *et al.*, 2009).

For incentive policies to be successful, some issues must be taken as a basis. First, when designing a policy, the number of incentives used should often be directly linked to the number of desired outcomes. For example, it would be a mistake to expect an economic incentive for a specific outcome, such as soil health, to achieve an additional result, such as increases in productivity. Secondly, prerequisites for implementation should be considered, including an understanding of the impact of the policy and the selection of appropriate institutions and mechanisms. Conditions include audit mechanisms to ensure implementation and a net knowledge of the sustainability of the incentive. Third, when assessing the effectiveness of incentives, one should consider the trade-off between economic and environmental consequences and, if possible, social ones. Incentives must be large enough to motivate a change in manufacturing practices (Piñeiro *et al.*, 2021). At the same time, state support has a cost in terms of the budget. This support should not be unsustainable. For example, a study conducted in India stated that the current level of subsidy is an untenable financial burden for the state (Sharma & Gulati, 2005).

3. Literature

There are theoretical and empirical studies on agricultural support policies in the related literature. One of the early studies conducted by Johnston and Mellor (1961) discussed the role of agriculture in economic development. Gulati (1989) measured the level and spread of input subsidies in Indian agriculture during the 1980s. The study covers four primary inputs of modern agriculture: fertilizers, irrigation, electricity, and credit. The study revealed that total input subsidies created approximately 17% of net added value for India, and irrigation supports constituted more than 70% of the total input support. Helm and Van Zly (1994) analyzed the support given to producers in the agricultural sector in South Africa with data for the period 1988/89 to 1993/94. Analysis results showed that agricultural support increased steadily. In addition, it was stated in the study that market price support is the most significant component of domestic support and contributed about 48% of total support during the last four years of the analysis. In another study by Helm and Van Zyl (1995), South Africa's agricultural support was compared with that of some selected countries in the developed world. Researchers stated that except for Australia and New Zealand, South Africa had a relatively low degree of support compared to the other selected developed countries. The OECD has published a cross-nationally comparable data set on agricultural support since 1986 and has made it available since 1998 (Park & Jensen, 2007). The availability of such data has paved the way for studies in this field. On the other hand, it has been observed that some academics, such as Kirsten *et al.* (2000), have published publications criticizing and updating the OECD's calculations.

The number of studies in this field has increased relatively in the post-2000 period. Recent studies addressing different aspects of the subject are as follows: Frandsen *et al.* (2003) studied the impact of eliminating or decoupling at the individual member-state level in the European Union and non-member regions of liberalizing domestic support in the EU. Researchers found that the existing domestic support payments in the EU are indeed coupled with production, affecting production decisions and distorting international trade with adverse effects on the export potential of developing countries. Koo and Kennedy (2006) analyzed the changes in the distribution of social welfare among consumers and producers in both exporting and importing countries resulting from reduced subsidies. Researchers stated that their theoretical analysis indicates that domestic and export subsidies distort the trade flows of agricultural goods from exporting countries to importing countries. Piñeiro *et al.* (2021) investigated much-needed evidence about the effects of different incentives on farmers' adoption of sustainable agricultural practices and the expected agricultural, economic, and environmental consequences of such interventions. The study's findings show that incentives that provide financial benefits are better adopted in the short term. Chintapalli and Tang (2021) examined the effects of credit-based MPS in stimulating production. Researchers found that high MPS cannot improve the farmer's income, and the net benefit of market price support may be harmful. Koetse and Bouma (2022) analyzed whether support packages consisting of public and private payments would effectively promote a regime change in agriculture and how payments could further increase this effect. In the Netherlands, a significant sample of farmers producing crops and dairy products was taken as a basis. According to the analysis results, the importance of offering policy packages consisting of mixed incentives was emphasized to encourage farmers to adopt environmentally inclusive agricultural practices. It is also stated that the combination of incentives is more effective than individual incentives alone. Sun *et al.* (2023) investigated incentives and conditions that can enable adopting climate-change-adaptive technologies in agriculture. To this aim, they developed an evolutionary game model to analyze the behavior of local governments and farmers to encourage them to use technologies compatible with climate change. According to the study's findings, incentives in the form of subsidies and cost-sharing to be given to farmers increased the use of these technologies. Nan *et al.* (2023) evaluated the impact of three different strategies, namely cost subsidy, minimum price subsidy, and term contracts, on farmers, consumers, and society. In this search, alternative tools were examined, considering the burden of state support on the budget. The study's findings are that cost subsidies provide superior advantages for farmers and society when there is minimal uncertainty about harvest yield. When this is not the case, farmers benefit more from prospective contracts rather than relying on government subsidies. These results suggest that policymakers must design subsidy policies tailored to specific agricultural contexts to ensure optimal benefits for all stakeholders. Trentinaglia *et al.* (2023) conducted an empirical study of 115 developing countries covering 2010-2020. The results show that international aid to agriculture, especially climate change adaptation aid, positively affects agricultural productivity growth. Researchers also found that countries with higher climate preparedness benefited the most from aid. In contrast, countries that were highly vulnerable and heavily dependent on the agricultural sector benefited equally less from the aid received. Mgomezului *et al.* (2024) evaluated the efficiency of input subsidy programs given to farmers for the Malawi economy. The SWOT analysis showed that most smallholder farmers are unproductive despite the government's efforts to increase yields through subsidies. Following the finding that large farmers are more productive, the study reviewed models to increase agricultural production. Vigani *et al.* (2024) showed that higher intensity of common agricultural policy subsidies reduces spending on the risk management toolkit, which means that the income stability capacity of direct payments can be an alternative to risk management and can be a substitute between policies for EU countries.

On the other hand, recent studies that address the issue in the context of the relationship between agricultural support and production are as follows: Aktaş *et al.* (2015) analyzed twelve countries (US, EU, Australia, Brazil, China, South Africa, Israel, Canada, Mexico, Russia, Chili and Türkiye) panel data using annual data from 1995 to 2010 from the OECD database. Researchers concluded that price and input support increased agricultural output. Işık and Bilgin (2016) examined the relation between total agricultural production and market price and other supports for Türkiye using annual data for 1986-2015. Researchers found that the given supports positively influenced agricultural production. Vozarova and Kotulic (2016) studied the dependence of agricultural production and subsidies in Slovakia. The research results showed that annual gross agricultural production and the volume of subsidies strongly correlate with Slovak agriculture. Yıldız (2017) analyzed the effects of agricultural support on an agricultural production level for Türkiye using data from 2006-2016. The research results showed a long-term relationship between agricultural support payments made from the central government budget and agricultural production level. Zampa and Bojnec (2017) studied the relationships between subsidies and financial performance in Slovenia. Researchers reported that subsidies have a positive impact on financial indicators. Akyol (2018) analyzed the relationship between agricultural incentives and agricultural value-added between 2000 and 2016 in five developing countries (Türkiye, South Africa, Mexico, China, and Brazil). In this analysis using the panel data, researchers found that increased agricultural incentives positively affected the agricultural value added. Koç *et al.* (2019) studied the effects of government support and credits on Turkish agriculture. Researchers found the positive effect of agricultural credits on agricultural value added. On the other hand, researchers reported that they found a negative effect of government support on agricultural value added. Baştan and Songül (2019) investigated the impact of agricultural support on the value of agricultural production for six products (wheat, maize, cotton, rice, beef, veal, milk, and poultry) on OECD and selected countries using annual data for 2006-2017. Researchers concluded that support positively affects agricultural production value but is ineffective regarding animal production. Igberi *et al.* (2020) investigated the relationship between agricultural output and government spending on agriculture in Nigeria between 1987 and 2015. Researchers found a positive and significant long-run relationship between these variables. Önder and Şahin (2020) studied the relationship between agricultural production and subsidy policies in Türkiye from 2000 to 2020. They concluded that the subsidy policies had a positive effect on agricultural production. Canbay (2021) studied the effect of agricultural support on crop production in Türkiye between 1995 and 2018 with the obtained data from the OECD. Researcher reported that agricultural support in Türkiye positively affects short- and long-term crop production. Sağdıç and Çakmak (2021) studied the relationship between agricultural subsidy payments and agricultural production in Türkiye for the quarterly data between 2006 and 2019. Study results showed that agricultural subsidy payments have a long-term effect on the level of agricultural production in Türkiye. Agyemang *et al.* (2022) studied the effect of increased agricultural input subsidies on agricultural productivity in Ghana. Researchers found that agricultural productivity increases as farmers' level of agricultural input subsidy increases. Oğul (2022) examined the relationship between agricultural subsidies and agricultural production in Türkiye with quarterly data between 2006 and 2021. Researcher concluded that agricultural subsidies increase agricultural production in the long term. Bulut and Bayraktar (2023) investigated the effect of deficiency payment and land-based direct support given to eleven crop products in Türkiye on the production amount for 2002-2019 with the panel data method. Researchers determined that the supports subject to the research positively affected production. Yang *et al.* (2023) investigated the impact of agricultural subsidies on grain production in China. Research findings showed that agricultural subsidies in major grain-producing regions have significantly increased rural household grain yield. Özşahin *et al.* (2023) analyzed the data of six developing countries (China, Russia, Brazil, Indonesia, Mexico, and Türkiye) obtained from the World Bank and OECD from 2002-2018 by panel data method. Researchers found a positive statistically significant relationship between agricultural support and agricultural value added. Liu *et al.* (2024) studied the effects of agricultural subsidies on the technical efficiency of agricultural production technology and factor input for China. Research findings indicated that agricultural subsidies have substantial impacts and increase the technical efficiency of the production process.

4. Application

The method is briefly explained in this section. Afterward, the econometric model and data are described. The last section includes the estimation results.

4.1. *Method*

Time series, cross-section, and panel data are the types of data that are generally used for empirical analysis (Gujarati, 2003). In the time series data, the observation values of a variable are measured by its change over time. In cross-sectional data, observation values of a variable are measured from different cross-sectional units (e.g., countries, cities, or firms) in the same period. Panel data involves a cross-sectional N and a time series T dimensions (Hsiao, 2003). Panel data are repeated observations on the same cross-section (Cameron & Trivedi, 2005). A panel data set offers a certain number of advantages over traditional pure cross-section or pure time series data sets (Matyas & Sevestre, 1996): (i) Because of the number of observations *NT* is more than time series and cross-section data, more reliable estimates are produced, and more sophisticated models are tested with less restrictive assumptions, (ii) because of the structure of panel data in two dimensions, independent variables are less likely to be highly correlated and panel data sets alleviate the multicollinearity problem, (iii) panel data sets make it possible to identify and measure effects that are not detectable in pure cross-section or pure time series data and, (iv) the use of panel data may eliminate or reduce estimation bias. The panel data observations can be denoted on the variables X and Y as X_{it} and Y_{it} where the first subscript i refers to the individual being observed and the second subscript t refers to the date at which observed (Stock & Watson, 2007). The data set is called a balanced data set when the same periods are available for all cross-section units, and in other cases, it is called an unbalanced panel data set (Wooldridge, 2002).

The most restrictive model is called a pooled model that specifies constant coefficients (Cameron & Trivedi, 2005):

$$y_{it} = \alpha + x'_{it}\beta + u_{it} \quad i = 1, \ldots, N, \quad t = 1, \ldots, T. \tag{1}$$

Here, Y_{it} is a scalar dependent variable, is a kx1 vector of independent variables, and u_{it} is a scalar error term. A variant of the pooled model is the fixed effects (FE) model that permits intercepts to vary across cross sections while slope parameters do not is as follows:

$$y_{it} = \alpha_i + x'_{it}\beta + u_{it} \quad i = 1, \ldots, N, \quad t = 1, \ldots, T. \tag{2}$$

Here, α_i are random variables potentially correlated with the independent variables that capture unobserved heterogeneity across cross-sections. The significance of the cross-section effects is tested against a pooled model with the redundant fixed effects test. The null hypothesis is that cross-section effects are insignificant, which implies that the pooled model is the appropriate specification. The alternative hypothesis states that cross-section effects are significant, which implies the FE model with cross-section effects is the appropriate specification. On the other hand, the significance of the period effects can also be tested similarly. In this case, α_t are random variables potentially correlated with the independent variables that capture unobserved heterogeneity across periods.

The other variant of this model, called the random effects (RE) model, assumes that the unobservable cross-sectional effects (α_i) are random variables distributed independently of the X independent variables (Cameron & Trivedi, 2005, p. 700). That is, they have no covariance ($Cov(\alpha_i, X) = 0$). If there is covariance between them ($Cov(\alpha_i, X) \neq 0$), then the basic assumption is violated for the RE model, and it cannot be used. The Hausman test is applied to test this issue. The null hypothesis is $Cov(\alpha_i, X) = 0$, implying that the RE model is appropriate. The alternative hypothesis is $Cov(\alpha_i, X) \neq 0$, implying that the FE model is appropriate.

4.2. *Econometric model and data*

The study's primary purpose is to analyze the effect of wheat producer support (*WPS*) on wheat production (*WP*) using panel data methods. So, WP_{it} is the dependent variable, which is wheat production in the current period, and WPS_{it} is the primary independent variable of interest, which is wheat producer support in the current period. Secondary variables of interest that may have an impact on the dependent variable in this relationship are as follows: Wheat harvested area in the current period (WHA_{it}), previous period price of wheat (WPR_{it-1}), and previous period production of wheat (WP_{it-1}). In line with the Nerlove (1956) supply response model, previous period production quantity and price were included in the model as explanatory variables as it was also used in several studies (e.g., Albayrak 1998; Özkan *et al.*, 2011; Haile *et al.*, 2016). The functional relationship put forward for this purpose in the closed form is as follows:

$$WP_{it} = f(WPS_{it}, WHA_{it}, WPR_{it-1}, WP_{it-1}) \quad (3)$$

This functional relation can be expressed in the open form as the following pooled model form of the panel data model:

$$WP_{it} = c + \beta_1 WPS_{it} + \beta_2 WHA_{it} + \beta_3 WPR_{it-1} + \beta_4 WP_{it-1} + u_{it} \quad (4)$$

Here, the subscript "i" indicates the countries (16 countries), and the subscript "t" indicates the period (2000-2022). All variables were measured annually and retrieved from the OECD official website in June 2024. Each one of the variables has 352 observations. The data set included the following countries: Argentina, Brazil, Canada, India, Israel, Japan, Kazakhstan, Mexico, Norway, Russian Federation, Switzerland, Türkiye, Ukraine, USA, South Africa and China. While selecting the countries in this data set, the selection was made by determining the countries whose data on the variables to be used in the analysis were available. The panel data set allowed panel data regression inferences to be made using all the numerical information. All estimations were made in the Eviews program.

Wheat production dependent variable was measured in thousands of tons, and wheat producer support independent variable was measured in millions of US dollars. Producer single commodity transfers were used as a wheat producer's support indicator. The OECD defines producer single commodity transfers as the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm gate level. The producer's single commodity transfers refer to the total support given to manufacturers. In other words, the producer's single commodity transfers consist of market price support, product-based budget, and other transfers. The secondary independent variables of interest were measured as follows: The wheat harvested area was measured in thousand hectares, the previous period price of wheat was measured as US dollars per ton, and the previous period production of wheat in thousands of tons. The economic expectations are as follows:

- As wheat producer support increases, wheat production is expected to increase. Therefore, the economic expectation regarding the coefficient of the WPS_{it} variable is positive ($\beta_1 > 0$).
- As the wheat harvested area increases,

wheat production is expected to increase. Therefore, the economic expectation regarding the coefficient of the WHA_{it} variable is positive ($\beta_2 > 0$).

- As the price of wheat in the previous period increases, wheat production is expected to increase. Therefore, the economic expectation regarding the coefficient of the WPR_{it-1} variable is positive ($\beta_3 > 0$).
- As the previous period of wheat production increases, wheat production is expected to increase. Therefore, the economic expectation regarding the coefficient of the WP_{it-1} variable is positive ($\beta_4 > 0$).

4.3. *Estimation results*

The following steps were applied in the analysis, and summarized results were achieved:

- Step 1: The pooled model, FE model with cross-section effects, and FE model with period effects were estimated separately.
- Step 2: Cross-section and period effects were tested separately against a pooled model with redundant fixed effects tests. The FE model with cross-section effects was found to have appropriate model specifications.
- Step 3: The FE model was tested against the RE model by using the Hausman test, and it was found that the basic assumption that $Cov\ (\alpha_i, X) = 0$ is violated for the RE model. Then, the FE model found an appropriate model specification. Moreover, Breusch-Pagan and Honda Lagrange Multiplier (LM) tests were also used to test random effects.
- Step 4: The EGLS method (cross-section SUR) was applied to obtain more reliable estimates for the FE model.
- Step 5: The normality of residuals was tested with the Jarque-Bera test. Cross-sectional dependence of residuals was tested with Breusch-Pagan LM and Pesaran CD tests. Residuals were found to be normally dis-

Table 1- Pooled, one-way fixed effects with cross-section and period effects estimations.

Models / *Coefficients*	*Model 1*	*Model 2*	*Model 3*
	Pooled OLS	*One-way fixed effects with cross-section effects*	*One-way fixed effects with period effects*
Constant	-2294.548 (0.0015)	-14131.27 (0.0000)	-2307.258 (0.0040)
Independents			
WPS_{it}	0.249897 (0.0056)	0.266961 (0.0045)	0.241194 (0.0088)
WHA_{it}	0.420406 (0.0000)	2.537085 (0.0000)	0.406927 (0.0000)
WPR_{it-1}	6.511865 (0.0036)	14.42092 (0.0006)	6.593556 (0.0097)
WP_{it-1}	0.895755 (0.0000)	0.554427 (0.0000)	0.900166 (0.0000)
Statistics			
R^2	0.983056	0.988281	0.984242
$\bar{R}^2$	0.982861	0.987611	0.983033
F	5033.020 (0.0000)	1473.637 (0.0000)	814.4613 (0.0000)
RMSE	4534.515	3771.019	4372.963
SSR	7.24E+09	5.01E+09	6.73E+09
Akaike	19.70523	19.42171	19.75200
Schwarz	19.76011	19.64124	20.03738
Hannan-Quinn	19.72707	19.50907	19.86556
DW	2.546771	1.984865	2.530932

Note: In parenthesis, p-values are given.

tributed, and no cross-sectional dependencies were found.

The pooled model, one-way fixed effects with cross-section model, and one-way fixed effects with period effects model were initially estimated. The estimations are given in Table 1 above:

In these models, all coefficients are statistically significant at the 5 percent significance level (p-value < α=0.05). Also, in each of these models, the p-values of F statistics show that the models are statistically significant (p-value < α=0.05). When the coefficients of determination (R^2) are examined, it is seen that the model with the highest explanatory power is Model 2. When the RMSE, SSR, Akaike, Schwarz, and Hannan-Quinn criteria are examined, with the smallest criteria values, Model 2 appears to be the most appropriate. Although Model 2 is a proper model to evaluate the above statistics, a formal test must be performed to decide whether the cross-section effects and period effects are essential. The redundant fixed effects test results for both cross-section and period effects are given in Table 2

The p-value for the period effects shows that the period effects are insignificant (p-value ≥ α=0.05). However, the p-value for the cross-section effects shows that the cross-section effects are significant (p-value < α=0.05), which means that the FE model with cross-section effects is a better model specification than the pooled model. Therefore, Model 2 appears to be the appropriate model at this stage. However, whether the effects are fixed or random should be determined. For this purpose, the estimation results are given in Table 3.

In these models, all coefficients are statistically significant at the 5 percent significance

Table 2 - Redundant fixed effects test statistics.

Statistics / *Effect Tests*	*F- Statistics*	*Chi-square Statistics*
Cross-section Effects	9.869699 (0.0000)	129.798550 (0.0000)
Period Effects	1.168192 (0.2772)	25.539249 (0.2246)

Note: In parenthesis, p-values are given.

Table 3 - One-way fixed effects and random effects with cross-section estimations.

Models / *Coefficients*	*Model 2*	*Model 4*
	One-way fixed effects with cross-section effects	*One-way random effects with cross-section effects*
Constant	-14131.27 (0.0000)	-2294.548 (0.0002)
Independents		
WPS_{it}	0.266961 (0.0045)	0.249897 (0.0011)
WHA_{it}	2.537085 (0.0000)	0.420406 (0.0000)
WPR_{it-1}	14.42092 (0.0006)	6.511865 (0.0006)
WP_{it-1}	0.554427 (0.0000)	0.895755 (0.0000)
Statistics		
R^2	0.988281	0.983056
$\bar{R}^2$	0.987611	0.982861
F	1473.637 (0.0000)	5033.020 (0.0000)
RMSE	3771.019	4534.515
SSR	5.01E+09	7.24E+09
DW	1.984865	2.546771

Note: In parenthesis, p-values are given.

Table 4 - Hausman test results.

Test \ Statistic	*Chi-square Statistic*
Cross section random	140.899819 (0.0000)

Note: In parenthesis, p-values are given.

Table 5 - Lagrange Multiplier (LM) tests for random effects.

Test \ Dimension	*Cross-section*	*Time*
Breusch-Pagan	1.251492 (0.2633)	0.161360 (0.6879)
Honda	1.18701 (0.1316)	0.401696 (0.3440)

Note: In parenthesis, p-values are given.

level (p-value < α=0.05). Also, in each of these models, the p-values of F statistics show that the models are statistically significant (p-value < α=0.05). When the coefficients of determination (R^2) are examined, it is seen that the model with the highest explanatory power is Model 2. When the RMSE and SSR criteria are examined, all statistics show that the model with the smallest value is Model 2. According to these criteria, the most appropriate model is Model 2. Although Model 2 is a proper model to evaluate the above statistics, a formal test must be performed to decide whether the fixed or random effects are essential. The Hausman test result for this evaluation is given in Table 4.

The p-value for the Chi-square statistic shows that the null hypothesis is rejected (p-value < α=0.05). This means a covariance exists between unobservable cross-sectional effects (α_i) and the X independent variables ($Cov(\alpha_i, X) \neq 0$). So, the FE model is the appropriate model specification.

Breusch-Pagan LM test and Honda LM test results are given in Table 5.

These results showed that the null hypothesis is not rejected for all cases above p-value ≥ α=0.05). This means that there are no random effects.

The EGLS method (cross-section SUR) was applied to obtain more reliable estimates for this model. The estimation results are given in Table 6.

Table 6 - One-way fixed effects estimation with cross-section SUR.

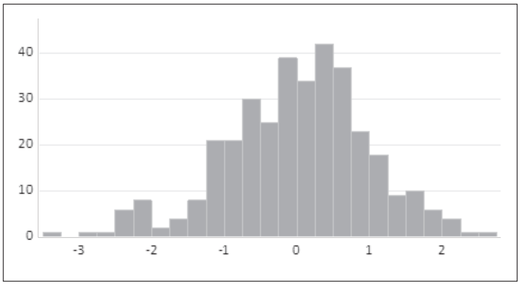
Coefficients \ Model	*Model 5*
	One-way fixed effects with cross-section effects SUR
Constant	-14252.87 (0.0000)
Independents	
WPS_{it}	0.285657 (0.0000)
WHA_{it}	2.603259 (0.0000)
WPR_{it-1}	13.54233 (0.0000)
WP_{it-1}	0.544437 (0.0000)
Statistics	
R^2	0.995485
$\bar{R}^2$	0.995226
F	3852.393 (0.0000)
RMSE	0.988676
SSR	344.0730
DW	2.025793

Note: In parenthesis, p-values are given.

All the coefficients are statistically significant at the 5 percent significance level in Model 5 (p-value < α=0.05). Also, the p-values of F statistics show that the model is statistically significant (p-value < α=0.05). The coefficient of determination (R^2) shows that independent variables collectively explain approximately ninety-nine percent of the total variation of wheat production. Durbin-Watson (DW) statistic equal to 2.02 shows no first-order serial correlation. In the end, Model 5 is acceptable. Moreover, the normality and cross-sectional dependence of residuals for Model 5 were also tested.

The histogram of the residuals is similar to the normal distribution shape, which is bell-curved (See Figure 4). The formal normality test for the residuals, the Jarque-Bera test, was performed, and the statistics were found to be 7.377 with a probability of 0.024. The null hypothesis that the residuals are normally distributed is not rejected at a 1 percent significance level (p-value ≥ α=0.01).

Figure 4 - Histogram of residuals.



Note: The vertical axis represents frequencies, the horizontal axis represents residuals.

Table 7 - Residual cross-section dependence test.

Test	*Statistic*
Breusch-Pagan LM	5.906081 (1.0000)
Pesaran CD	0.115304 (0.9082)

Note: In parenthesis, p-values are given.

Breusch-Pagan LM test and Pesaran CD test results are shown in Table 7.

The null hypothesis is not rejected, meaning there is no cross-sectional correlation dependency between residuals.

5. Conclusion

The study's main purpose is to analyze the effect of wheat producer support on wheat production using panel data methods. Due to the peculiar properties of panel data, it covers both cross-sectional and time dimensions. The main finding of this study is that wheat producer support has a positive effect on wheat production. This finding reveals that the higher agricultural support, the more the commodities produced (Park & Jensen, 2007). Agricultural subsidies aim to increase total production capacity and preserve national food security (Liu *et al.*, 2024). So, this finding also reveals that agricultural support, in line with its purpose, makes wheat production advantageous for producers and encourages producers to increase wheat production.

The secondary findings of this study show that wheat harvested area, previous period price of wheat, and previous period production of wheat have a positive effect on wheat production. The finding of a positive impact of the harvested area variable reveals that production will increase as the harvested area increases. In this context, the Heckscher-Ohlin theory of international trade, which includes views on the advantage of harvested area, predicts that countries with abundant land relative to labor will have a comparative advantage in agricultural production (Park & Jensen, 2007). Moreover, Cong (2022) suggested in a study related to land rights that improving the stability of land rights would generally be beneficial to increasing farmers' agricultural production efficiency as a policy recommendation. The finding of a positive effect of the previous period price variable indicates that the cobweb theorem is valid in wheat production. According to the cobweb theorem, current period production is a function of the past period price for products that take time to produce and require at least one period to change production after the production plan is made (Poitras, 2023). The finding of a positive effect of the previous period production variable indicates producer inertia caused by crop rotation costs that may arise due to the adaptation of product-specific land and other inputs to a different product (Haile *et al.*, 2016). However, it takes more than a year for wheat producers to fully adjust their production decisions according to external shocks (Albayrak, 1998).

The findings above indicate that countries should give importance to producer support policies in agriculture and develop new support policies. Policymakers should take these considerations into account when planning future wheat production. Because the agricultural support policy ensures food security and increases farmers' income, agricultural-related public expenditure improves total factor productivity and agricultural output (Zhang *et al.*, 2022). In this context, it is undeniable that agriculture, as mentioned in the previous sections, has many economic and social benefits and that agricultural support should be given importance and planned well. Studies on wheat show that countries less dependent on imports are less affected by volatility in international markets (Guo & Tanaka, 2019; Luo & Tanaka, 2021; Gutiérrez-Moya *et al.*, 2021). Therefore, increasing food self-sufficiency through agricultural support policies will improve food security by stabilizing local prices.

The main finding of this study (increasing agricultural support increases agricultural production) has indirect consequences for Mediterranean countries. Namely, increasing production enables foreign trade by enabling countries that meet their needs to sell their surplus products abroad. Thus, the wheat demands of importing countries are met. Therefore, these wheat productions are essential for the imports of Mediterranean countries.

According to our calculations using data from the official OECD website, the total wheat production of the relevant countries in the analyzed period (2000-2022) constitutes approximately 62% of the world's wheat production. On the other hand, according to our calculations using the data on the Food and Agriculture Organization (FAO) official website, the average share of the countries located on the Mediterranean coast in world wheat imports for the period 2000-2022 (average value of 23 years) is 28%. These important wheat-importing Mediterranean countries are Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Montenegro, Morocco, Palestine, Slovenia, Spain, Syrian Arab Republic, Tunisia, Türkiye.

According to our rankings using data from FAO statistics, in the world wheat import rankings in 2023, Egypt ranks second with approximately 3.77 billion dollars (5.1% of total wheat imports), Turkey ranks fourth with approximately 3.75 billion dollars (4.7% of total wheat imports), Italy ranks fifth with approximately 3.1 billion dollars (4.2% of total wheat imports), Spain ranks sixth with approximately 2.8 billion dollars (3.8% of total wheat imports), Algeria ranks tenth with approximately 2.1 billion dollars (2.8% of total wheat imports), and Morocco ranks eleventh with approximately 1.91 billion dollars (2.5% of total wheat imports). These 6 Mediterranean countries, among the world's 11 largest wheat importers, realized roughly 24 percent of world wheat imports in 2023. This rate is approximately one-fourth of world wheat imports and contains a significant amount.

When the literature is examined, it is seen that most studies focus on individual countries in reviewing the relationship between production and support. For instance, Vozarova and Kotulic (2016) studied Slovakia, Zampa, and Bonejic (2017) studied Slovenia, Igberi *et al.* (2020) studied Nigeria, Canbay (2021) studied Türkiye, Agyemang *et al.* (2022) studied Ghana, and Yang *et al.* (2023) studied China. However, although there are studies on country groups such as Aktaş *et al.* (2015), Akyol (2018), Baştan and Songül (2019), and Özşahin *et al.* (2023) in the literature, they seem to be few. In addition, this study differs from the mentioned country group studies in terms of the countries, periods, and variables used. Besides, the findings are consistent with similar studies in the literature (Aktaş *et al.*, 2015; Akyol, 2018; Baştan & Songül, 2019; Özşahin *et al.*, 2023) analyzing the relationship between agricultural support and production for country groups.

This study has some limitations. First, only one cereal crop (wheat) was used in the study. Other cereal crops, such as rice and corn, which are important sources of nutrients, can be considered for future studies. Secondly, in the study, 16 countries were analyzed collectively using panel data analysis methods using panel data including both cross-sectional and time dimensions. In future studies, other techniques, such as time series analysis, can be considered to investigate the functional relationships mentioned. Thus, analyzing countries individually and making inferences on a country basis will be possible. Third, the study is limited to 16 countries' panel data since the data was obtained within the existing countries' framework. In the future, if data for other countries are measured and made public by the OECD, analyses including those countries will be possible. Thus, it will be possible to make inferences about other country groups with panel data analysis as in this study. Fourth, this study used wheat production as the dependent variable and producer single commodity transfers as the primary independent variable. Other variables may be considered for future studies. For instance, the yield variable can be used as the dependent variable. While other types of support can be used, variables such as fertilizer, irrigation, and capital indexes can also be considered. Moreover, temperature change can also be used as the secondary independent variable.

References

Agyemang S.A., Ratinger T., Bavorova M., 2022. The impact of agricultural input subsidy on productivity: The case of Ghana. *The European Journal of Development Research*, 34: 1460-1485. DOI: 10.1057/s41287-021-00430-z.

Aktaş E., Altıok M., Songur M., 2015. Effects on agricultural production in different countries comparative analysis of agricultural support policies. *Anadolu University Journal of Social Sciences*, 15(4): 55-74.

Aktaş Çimen Z., 2025. Global competition in wheat and meslin, maize and rice products: Türkiye's competitiveness. *Black Sea Journal of Agriculture*, 8(2): 270-285. DOI: 10.47115/bsagriculture.1630840.

Akyol M., 2018. Examining the relationship between agricultural incentives and agricultural added value: Panel simulated equations system analysis for new industrialized countries. *The Journal of International Scientific Researches*, 3(3): 226-236. DOI: 10.23834/isrjournal.456791.

Albayrak N., 1998. Wheat supply response: Some evidence on aggregation issues. *Development Policy Review*, 16(3): 241-263. DOI: 10.1111/1467-7679.00063.

Baliño S., Laborde Debucquet D., Murphy S., Parent M., Smaller C., Traoré F., 2019. Agricultural bias in focus. *International institute for sustainable development research report*. Winnipeg: IISD.

Baştan E.M., Songül H., 2019. Effectiveness of agricultural supports across OECD and selected countries under the WTO spell. *International Journal of Food and Agricultural Economics*, 7(4): 303-311. DOI: 10.22004/AG.ECON.296759.

Bekkers E., Brockmeier M., Francois J., Yang F., 2017. Local food prices and international price transmission. *World Development*, 96: 216-230. DOI: 10.1016/j.worlddev.2017.03.008.

Brown M.E., Antle J.M., Backlund P., Carr E.R., Easterling W.E., Walsh M.K., Ammann C., Attavanich W., Barrett C.B., Bellemare M.F., Dancheck V., Funk C., Grace K., Ingram J.S.I., Jiang H., Maletta H., Mata T., Murray A., Ngugi M., Ojima D., O'Neill B., Tebaldi C., 2015. Climate change, global food security, and the US food system. *US global change research program research report*. Washington: USDA. DOI: 10.7930/J0862DC7.

Bulut E., Bayraktar Y., 2023. Do agricultural supports affect production? A panel ARDL analysis of Turkey. *Journal of Agricultural Sciences*, 29(1): 249-261. DOI: 10.15832/ankutbd.988246.

Cameron A.C., Trivedi P.K., 2005. *Microeconometrics Methods and Applications*. Cambridge: Cambridge University Press.

Canbay Ş., 2021. Does agricultural support policy affect crop production in Turkey?. *Bartın University Journal of Faculty of Economics and Administrative Sciences*, 12(23): 130-140.

Ceballos F., Hernandez M.A., Minot N., Robles M., 2017. Grain price and volatility transmission from international to domestic markets in developing countries. *World Development*, 94: 305-320. DOI: 10.1016/j.worlddev.2017.01.015.

CGIAR Research Program on Policies, Institutions, and Markets, 2021. *Ag-Incentives: A global database monitoring agricultural incentives and distortions to inform better policies*. International food policy research institute research report. Washington: IFPRI. DOI: 10.2499/p15738coll2.134967.

Chavas J.-P., Rivieccio G., Di Falco S., De Luca G., Capitano F., 2022. Agricultural diversification, productivity, and food security across time and space. *Agricultural Economics*, 53(S1): 41-58. DOI: 10.1111/agec.12742.

Chintapalli P., Tang C.S., 2021. The value and cost of crop minimum support price: Farmer and consumer welfare and implementation cost. *Management Science*, 67(11): 6839-6861. DOI: 10.2139/ssrn.3681588.

Cong S., 2022. The impact of agricultural land rights policy on the pure technical efficiency of farmers' agricultural production: Evidence from the largest wheat planting environment in China. *Journal of Environmental and Public Health*, 1: 1-14. DOI: 10.1155/2022/3487014.

Dimitri C., Rogus S., 2014. Food choices, food security, and food policy. *Journal of International Affairs*, 67(2): 19-31.

Erenstein O., Jaleta M., Mottaleb K.A., Sonder K., Donovan J., Braun H.J., 2022. Global trends in wheat production, consumption, and trade. In: Reynolds M.P., Braun H.J. (eds.), *Wheat Improvement*, pp. 47-66. Cham: Springer. DOI: 10.1007/978-3-030-90673-3_4.

FAO, 2010. *Price Volatility in Agricultural Markets, Economic and Social Perspectives Policy Brief.*

FAO, 2024. *A suite of Food Security Indicators*.

Frandsen E.S., Gersfelt B., Jensen G.H., 2003. The impacts of redesigning European agricultural support. *Review of Urban and Regional Development Studies*, 15(2): 106-131. DOI: 10.1111/1467-940x.00068.

Gregory P.J., Ingram J.S.I., Brklacich M., 2005. Climate change and food security. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360(1463): 2139-2148. DOI: 10.1098/rstb.2005.1745.

Gujarati D.N., 2003. *Basic Econometrics*. New York: McGraw-Hill.

Gulati A., 1989. Input subsidies in Indian agriculture: A statewide analysis. *Economic and Political Weekly*, 24(25): A57-A65.

Guo J., Tanaka T., 2019. Determinants of international price volatility transmissions: The role of self-sufficiency rates in wheat-importing countries. *Palgrave Communications*, 5: 124. DOI: 10.1057/s41599-019-0338-2.

Gutiérrez-Moya E., Adenso-Díaz B., Lozano S., 2021. Analysis and vulnerability of the international wheat trade network. *Food Security*, 13: 113-128. DOI: 10.1007/s12571-020-01117-9.

Haile M.G., Kalkuhl M., Von Braun J., 2016. Worldwide acreage and yield response to international price change and volatility: A dynamic panel data analysis for wheat, rice, corn, and soybeans, *American Journal of Agricultural Economics*, 98(1): 172-190. DOI: 10.1093/ajae/aav013.

Harbouze R., Elame F., Mohamed T.L., 2024. Analysis of the Moroccan agri-food system through national accounting 2015 social accounting matrix: The role of the wheat sector in the agri-food complex. *New Medit*, 23(3): 79-90. DOI: 10.30682/nm2403f.

Helm W., Van Zyl J., 1994. Domestic agricultural support in South Africa from 1988/89 to 1993/94: a calculation. *Agrekon, Agricultural Economics Research, Policy and Practice in Southern Africa*, 33(4): 213-219. DOI: 10.1080/03031853.1994.9524786.

Helm W., Van Zyl J., 1995. Does South African agriculture receive too much support? – A comparison. *Agrekon, Agricultural Economics Research, Policy and Practice in Southern Africa*, 34(2): 43-49. DOI: 10.1080/03031853.1995.9524292.

Hsiao C., 2003. *Analysis of Panel Data*. Cambridge: Cambridge University Press.

Igberi C.O., Taylor T.K., Omoke P.C., Ahamba K.O., Urom C.O., 2020. Do agricultural support policies work in Nigeria? Evidence from an ARDL model. *Journal of Economic Cooperation and Development*, 41(3): 15-44.

Işık H.B., Bilgin O., 2016. The effects of agricultural support policies on agricultural production: The case of Turkey. In: *RSEP International Conferences on Social Issues and Economic Studies, 2nd Multidisciplinary Conference, Madrid, Spain, 2-4 November, 2016*, pp. 111-119.

Johnston B.F., Mellor J.W., 1961. The role of agriculture in economic development. *American Economic Review*, 51(4): 566-593.

Kannan K.P., Dev S.M., Sharma A.N., 2000. Concerns on food security. *Economic and Political Weekly*, 35(45): 3919-3922.

Kirsten J.F., Tregurtha N., Gouse M., Tswai J., 2000. Producer support estimate (PSE) for South African agriculture for 1996, 1997, 1998. *Agrekon, Agricultural Economics Research, Policy and Practice in Southern Africa*, 39(4): 708-717. DOI: 10.1080/03031853.2000.9523686.

Koç A.A., Yu T.E., Kıymaz T., Sharma B.P., 2019. Effects of government supports and credits on Turkish agriculture. *Journal of Agribusiness in Developing Economies*, 9(4): 391-401. DOI: 10.1108/JADEE-11-2018-0164.

Koetse M.J., Bouma J.A., 2022. Incentivizing a regime change in Dutch agriculture. *Environmental Innovation and Societal Transitions*, 44: 265-282. DOI: 10.1016/j.eist.2022.08.001.

Koo W.W., Kennedy P.L., 2006. The impact of agricultural subsidies on global welfare. *American Journal of Agricultural Economics*, 88(5): 1219-1226. DOI: 10.1111/J.1467-8276.2006.00936. X.

Kurukulasuriya P.H., Rosenthal S.J., 2013. *Climate change and agriculture: A review of impacts and adaptations*. World Bank environment department technical papers.

Laborde D., Mamun A., Martin W., Piñeiro V., Vos R., 2021. Agricultural subsidies and global greenhouse gas emissions, *Nature Communications*, 12: 1-9. DOI: 10.1038/s41467-021-22703-1.

Lacirignola C., Adinolfi F., Capitanio F., 2015. Food security in the Mediterranean countries, *New Medit*, 14(4): 2-10.

Lankoski J., Thiem A., 2020. Linkages between agricultural policies, productivity and environmental sustainability. *Ecological Economics*, 178. DOI: 10.1016/j.ecolecon.2020.106809.

Liu F., Sahzad M.A., Feng Z., Wang L., He J., 2024. An analysis of the effect of agriculture subsidies on technical efficiency: Evidence from rapeseed production in China. *Heliyon*, 10(13). DOI: 10.1016/j.heliyon.2024.e33819.

Luo P., Tanaka T., 2021. Food import dependency and national food security: a price transmission analysis for the wheat sector. *Foods*, 10(8). DOI: 10.3390/foods10081715.

Mátyás L., Sevestre P., 1996. *The Econometrics of Panel Data*. Dordrecht: Kluwer Academic Publishers.

Mgomezulu W.R., Chitete M.M.N., Maonga B.B., Dzanja J., Mulekano P., Qutieshat A., 2024. Agricultural subsidies in a political economy: Can collective action make smallholder agriculture contribute to development?. *Research in Globalization*, 8: 1-10. DOI: 10.1016/j.resglo.2024.100212.

Nan Q., Sun M., Nie J., Yang R., Wan L., 2023. The Efficacy of a forward market for the agricultural sector in mitigating climate risk: A potential alternative to agricultural subsidies?. *Finance Research Letters*, 55: 1-6. DOI: 10.1016/j.frl.2023.103999.

Narain D., 2020. *Transforming Indian Agriculture: A policy framework to guide US-India partnership*. Atlantic council research report.

Nerlove M., 1956. Estimates of the elasticities of supply of selected agricultural commodities. *Journal of Farm Economics*, 38(2): 496-509. DOI: 10.2307/1234389.

OECD, 2001. *The Uruguay Round Agreement on Agriculture: An Evaluation of Its Implementation in OECD Countries*. Paris: OECD Publishing. DOI: 10.1787/9789264192188-en.

OECD, 2023. *Agricultural Policy Monitoring and Evaluation 2023: Adapting Agriculture to Climate Change*. Paris: OECD Publishing. DOI: 10.1787/b14de474-en.

OECD/FAO, 2018. *OECD-FAO Agricultural Outlook 2018-2027*. Paris: OECD Publishing.

Oğul B., 2022. Tarımsal destekler ve tarımsal üretim ilişkisi: Türkiye ekonomisi üzerine ampirik bulgular. *Tarım Ekonomisi Araştırmaları Dergisi*, 8(1): 44-56.

Önder K., Şahin M., 2020. *Destekleme politikalarının tarımsal* üretim üzerine *etkisi*. 13th International Congress on Social Studies with Recent Researches, İstanbul.

Özkan B., Kızılay H., Ceylan R.F., 2011. Supply response for wheat in Turkey: A vector error correction approach. *New Medit*, 10(3): 34-38.

Özsahin S., Akbal E., Koç Ş., 2023. An examination of the relationship between agricultural value added and agricultural supports with panel simultaneous equation systems. *Turkish Journal of Agriculture Food Science and Technology*, 11(8): 1317-1323. DOI: 10.24925/turjaf.v11i8.1317-1323.5926.

Park J.H., Jensen N., 2007. Electoral competition and agricultural support in OECD countries. *American Journal of Political Science*, 51(2): 314-329.

Piñeiro V., Arias J., Elverdin P., Ibáñez A.M., Morales Opazo C., Prager S., Torero M., 2021. *Achieving sustainable agricultural practices: from incentives to adoption and outcomes*. International food policy research institute research report. Washington: CGIAR. DOI: 10.2499/9780896294042.

Poitras G., 2023. Cobweb theory, market stability, and price expectations. *Journal of the History of Economic Thought*, 45(1): 137-161. DOI: 10.1017/S1053837222000116.

Porkka M., Kummu M., Siebert S., Varis O., 2013. From Food Insufficiency towards Trade Dependency: A Historical Analysis of Global Food Availability. *PLoS ONE*, 8(12): e82714.

Reddy C.S., Dutta K., Jha C.S., 2013. Analyzing the gross and net deforestation rates in India. *Current Science*, 105(11): 1492-1500.

Ruzsikova K.G., 2019. Differences in agricultural support between countries - The OECD measurement. *Acta Regionalia et Environmentalica*, 16(1): 10-14. DOI: 10.2478/aree-2019-0003.

Sağdıç E.N., Çakmak E., 2021. The causality relationship between agricultural subsidy payments and agricultural production: The case of Turkey. *Journal of the Human and Social Science Researches*, 10(2): 1858-1880.

Saranga H., Roy S., Chowdhury S., 2024. Charting a sustainable future: transformative policies for India's energy, agriculture, and transport sectors. *IIMB Management Review*, 36: 21-38. DOI: 10.1016/j.iimb.2024.02.005.

Sharma P., Gulati A., 2005. Can the budget boost agricultural performance?. *Economic and Political Weekly*, 40(21): 2136-2141.

Sinabell F., Schmid E., Hofreither M.F., 2009. The distribution of direct payments of the common agricultural policy. *The Jahrbuch Der* Österreichischen *Gesellschaft Für Agrarökonomie*, 18(1): 111-119.

Soto-Gomez D., Perez-Rodriguez P., 2022. Sustainable agriculture through perennial grains: Wheat, rice, maize, and other species. A review. *Agriculture, Ecosystems and Environment*, 325. DOI: 10.1016/j.agee.2021.107747.

Stock J.H., Watson M., 2007. *Introduction to Econometrics*. Boston: Addison Wesley.

Sun Y., Yu R., Cheng T.C.E., 2023. Incentives for promoting climate change adaptation technologies in agriculture: An evolutionary game approach. *Environmental Science and Pollution Research*, 30: 97025-97039. DOI: 10.1007/s11356-023-28896-w.

Trentinaglia M.T., Baldi L., Peri M., 2023. Supporting agriculture in developing countries: New insights on the impact of official development assistance using a climate perspective. *Agricultural and Food Economics*, 11(39): 1-23. DOI: 10.1186/s40100-023-00282-7.

Vigani M., Khafagy A., Berry R., 2024. Public spending for agricultural risk management: Land use, regional welfare and intra-subsidy substitution. *Food Policy*, 123. DOI: 10.1016/j.foodpol.2024.102603.

Vermunt D.A., Negro S.O., Van Laerhoven F.S.J., Verweij P.A., Hekkert M.P., 2020. Sustainability transitions in the agri-food sector: How ecology affects transition dynamics. *Environmental Innovation and Societal Transitions*, 36: 236-249. DOI: 10.1016/j.eist.2020.06.003.

Von Braun J., Afsana K., Fresco L.O., Hassan M., Torero M., 2021. *Food systems definition, concept and application for the UN food systems summit*. United Nations Food Systems Summit 2021.

Vos R., Martin W., Resnick D., 2021. The political economy of reforming agricultural support policies. In: Resnick D., Swinnen J. (eds.), *The Political Economy of Food System Transformation*. Oxford: Oxford University Press, pp. 54-79. DOI: 10.1093/oso/9780198882121.003.0003.

Vozarova I.K., Kotulic R., 2016. Quantification of the effect of subsidies on the production performance of the Slovak agriculture. *Procedia Economics and Finance*, 39: 298-304.

Vyas V.S., 2022. The Changing role of government in Indian agriculture. *Journal of Social and Economic Development*, 24(1): 209-227. DOI: 10.1007/s40847-022-00207-y.

Wheeler T., Braun J.V., 2013. Climate change impacts on global food security. *Science*, 341(6145). DOI: 10.1126/science.1239402.

Wooldridge J.M., 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge: Massachusetts Institute of Technology Press.

Yang T., Chandio A.A., Zhang A., Liu Y., 2023. Do farm subsidies effectively increase grain production? Evidence from major grain-producing regions of China. *Foods*, 12(7): 1435. DOI: 10.3390/foods12071435.

Yıldız F., 2017. The effect of agricultural support payments made from the central government budget on agricultural production in Turkey: The period of 2006-2016. *Sayıştay Dergisi*, 104: 45-63.

Zampa S., Bojnec S., 2017. The impact of subsidies on production innovation and sustainable growth. *Management and Production Engineering Review*, 8(4): 54-63. DOI: 10.1515/mper-2017-0036.

Zhang Y., Meng T., Lan X., Fan S., Chen K.Z., Si W., 2022. Evolution of agricultural support policies. In: Fan S., Chan K.Z., Zhu J., Si W. (eds.), *Reforming Agricultural Support Policy for Transforming Agrifood Systems*, China and Global Food Policy Report 2022.