Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 25, Issue 1, 2025
PRINT ISSN 2284-7995, E-ISSN 2285-3952

TOMATO PRODUCTION AND PRICE IN THE EUROPEAN UNION

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Abstract

Tomato production within the European Union (EU-27) is a vital component of the agricultural sector, providing significant economic and nutritional value. This study examines the trends in tomato production and the impact of agricultural input prices across key EU countries: Italy, Spain, Portugal, Poland, Greece, the Netherlands, and France from 2015 to 2022. The research investigates the influence of climate change, fluctuations in input costs, and shifts in production conditions on tomato production levels. Climate change, characterized by increased frequency of extreme weather events such as high temperatures and prolonged droughts, poses a substantial challenge to tomato cultivation, affecting yield and quality. Rising costs of essential inputs—seeds, fertilizers, plant protection products, and fuel—further exacerbate production challenges. Specifically, fertilizer prices have surged significantly, particularly after 2020, due to global economic factors including trade wars and supply chain disruptions. The study employs data from the Eurostat database and various scientific sources to analyze production trends and price indices, using graphical and regression analyses to assess the impact of these factors. Results indicate a 9.2% decline in overall EU tomato production from 2015 to 2023, with notable reductions in Greece, the Netherlands, and Spain. Despite these declines, some countries, such as Italy and Portugal, have increased their production shares, reflecting a shift towards more efficient agricultural practices. Findings suggest that while higher tomato prices can incentivize increased production, rising input costs significantly impact profitability. The analysis underscores the importance of adopting sustainable agricultural practices and supportive policies to mitigate cost pressures and enhance production efficiency. Future strategies should focus on investing in innovative technologies and adaptive practices to ensure the resilience and sustainability of tomato production in the EU.

Key words*: *tomato producer's price, climate change, input prices

INTRODUCTION

Tomatoes have emerged as a crucial economic and nutritional resource within the agricultural sector of the European Union (EU). The production of tomatoes is significant across various European countries, particularly in Italy, Spain, Portugal, Poland, Greece, the Netherlands, and France. These nations are prominent players in EU tomato production, assuming a strategic role in both domestic consumption and export of the product [14, 28]. However, recent years have witnessed various challenges in the production processes, leading to significant changes that threaten the sustainability of tomato cultivation. In this context, it can be clearly stated that climate change, fluctuations in agricultural input prices, and shifting production conditions are among the principal factors affecting this sector.

Increasing temperature, drought, cold and salinity are important abiotic stresses that cause serious cellular damage in the most of plant species including tomate and other vegetabales and are considered as the results of global climate change [8]. This situation is one of the critical factors that significantly affect both agricultural production and tomato cultivation. Climate changes associated with global warming have led to more frequent and severe extreme weather events. This situation negatively affects agricultural production and causes yield and quality losses not only in tomatoes but also in many species. Extreme weather conditions such as high temperatures and prolonged droughts directly affect tomato growth, development and yield. For example, [6] determined the effects of meteorological

events such as temperature fluctuations, excessive rainfall and low humidity on tomato production and indicated the important effects of climate change. In addition, [41] stated that it is necessary to develop salt-tolerant tomato varieties to increase productivity and overcome socio-economic challenges, especially in saline environments. In this context, development of adaptation strategies to both climate change and abiotic stress conditions is necessary to increase sustainability and yield in tomato production. Therefore, the effects of climate change on tomato production need to be examined in detail, current production strategies need to be re-evaluated and new strategies need to be put forward to improve tomato production under these changing environmental conditions.

In addition to environmental factors, the costs of agricultural inputs such as seeds, fertilizers, plant protection products, fuel and herbicides used in tomato production are the most important factors determining the economic aspects of the production process. Recent years have seen substantial increases in the prices of these agricultural inputs, significantly raising production costs. Specifically, the rising prices of fertilizers and plant protection products have adversely affected the profitability of producers and complicated production processes. It is an accepted fact that changes in agricultural input prices directly affect production costs and, consequently, the profitability of producers. Therefore, it is essential to utilize resources efficiently. Indeed, resource use efficiency refers to the ability of a farm firm to obtain maximum output per unit of resources used in the production cycle [36]. Additionally, the European Commission provides crucial data on the relationship between input price indices and production [12]. This study analyzes the effects of input price indices on costs in detail, with price indices calculated using 2015 as a baseline and annual variations illustrated graphically.

EU agricultural policies also play a significant role in production. The European Commission's 2022 report offers a detailed evaluation of EU agricultural policies and production trends. This report encompasses regulations aimed at supporting agricultural production and ensuring sustainability in member contries [12]. Moreover, studies on agricultural input price indices and production trends contribute to understanding the effects of these policies [27].

The data used in this paper are sourced from the Eurostat database and various scientific publications. The period from 2015 to 2022 has been comprehensively examined, with production and price data analyzed in detail [13]. Graphical presentations of the data have helped in identifying annual changes and differences between countries. Regression analysis was used in this study to determine the trends in tomato production and the reasons for price increases. With these analyses aim to better reveal the effects of climate change and other economic factors on production. In addition, the current situation can be evaluated with the results of these analyses and future strategies can be determined. Similarly, the effects of agricultural input prices were determined not only for tomatoes but also for vegetable species such as lettuce and their effects on production costs were determined [33]. Furthermore, [39] reported that there has been a decrease in cereal production in the EU in recent years due to the negative effects of climate change. Additionally, it has been reported that not only changing climate conditions but also increasing production costs affect both the competitiveness of countries in plant production and the domestic and international trade of fresh vegetables [1, 2].

By examing the effects of climate change and economic factors on crop production including tomato, the current situation can be better understood. A better understanding of these factors can help developed more effective strategies for future agricultural production. Additionally, the study has the potential that can provide important suggestions for sustainable tomato production with improving new agricultural policies by better understanding the difficulties faced by producers. Therefore, this study was conducted to present a comprehensive

analysis of tomato production and agricultural input prices in EU member states.

MATERIALS AND METHODS

The paper is based on extensive data collected from various publications, including scientific articles and reports from the European Commission. The Eurostat database was utilized to gather statistical data. The primary indicators studied include:

1- Tomato production at the EU level from 2015 to 2022, specifically in the main tomato-producing countries: Italy, Spain, Portugal, Poland, Greece, the Netherlands, and France. Graphical illustrations were created to highlight the differences in production between countries over the years. The tomato prices considered in this study are expressed in price indices, calculated relative to the price level in 2015, which serves as a fixed baseline.

2- The analysis covers:

- Producer prices
- Farm input prices, including seeds, NPK fertilizers, products for plant protection against diseases, pests, and herbicides, as well as fuel.

Regression analysis was conducted to identify trends in tomato production within the EU. The study also discusses the impact of climate change, particularly extreme meteorological events, to explain the decline in tomato production in the EU and its main producing countries. Additionally, the study explores the reasons behind the recent price increases.

Finally, the study attempts to reveal the effect of various factors influencing tomato production within the European Union-27 through regression analysis. The functional form of the estimated model is as follows:

$$PRD = f\ (TP, PIS, PINPK, PIF, PIH)$$

PRD:Tomato Production (EU-27)
TP:Tomato Price
PIS:Price indices of Seed
PINPK: Price indices of NPK
PIF: Price indices of Fuels
PIH: Price indices of Herbicides

RESULTS AND DISCUSSIONS

Climate change is one of the most significant threats to crop production and natural biodiversity in the 21st century [3, 9, 10]. In addition to climate change, high input costs, price increases in inputs and abiotic stress factors negatively affect vegetable production. The impact of the COVID-19 pandemic, which continued from 2020 to 2022, can also be added to these factors. In particular, according to the available findings in this work, a 9.2% decrease in production was determined in the nine-year period in tomato production in the European Union. While a decrease was detected in production, no decrease was detected in tomato production areas. Therefore, this decrease in tomato production can be attributed to climate change and abiotic stress factors rather than high input costs and increasing prices.

While the tomato production of EU-27 was determined as 17,628,000 tons in 2015, it was determined that it decreased to 16,014,000 tons in 2023. In addition, the change in tomato production over the years is also supported by the trend equation ($Y= -16.2\ x^2 + 65{,}368\ x - 65{,}720{,}597$) in Figure 1. It is clearly seen that there is a decreasing trend over time both in Figure 1 and in the given equation.

Italy, Spain, Portugal, Poland, Greece, the Netherlands and France are the leading tomato producing countries in the EU and the changes in tomato production quantities of these contries are presented in Figure 2. Among these countries, the highest decrease in tomato production between 2015 and 2023 was determined in Greece with 30.5%, followed by the Netherlands and Spain with decreases of 18.4% and 17.9%, respectively. Among these major tomato-producing countries in the European Union, only Portugal and Poland did not see a decline in production. All other countries experienced varying degrees of reductions in tomato production.

The extreme weather events experienced in Italy, France, and Spain in 2022, exacerbated by intense heat waves, have adversely affected agricultural production [39]. It is

clear that European countries, particularly those in the Mediterranean region, have been significantly impacted by negative climatic events occurring globally in recent years. As a result, studies and statistical data indicate a decline in agricultural productivity and production [14, 39]. In the EU, prolonged droughts combined with reduced rainfall and vegetation stress have led to a decrease in agricultural output [16, 18]. Similarly, reductions in the production of maize and wheat have also been determined [39].

These declines highlight the multifaceted challenges faced by the agricultural sector, including climate change, economic pressures, and shifts in agricultural practices. Climatic extremes occurring at different times during the crop cycle can significantly reduce productivity beyond typical yield losses [5]. In South Florida, rising temperatures have decreased tomato fruit numbers and yield due to lower pollen viability and fruit set, and continued warming may further impact productivity [4]. The increasing frequency and intensity of extreme weather events may elevate the risks of simultaneous crop failures, including tomatoes, both regionally and globally [30, 35, 40].

Along with climate change, economic factors and rising costs of inputs such as seeds, fertilizers, and plant protection products can reduce profit margins and complicate production. The [25] further corroborate this by noting that input price volatility presents a major risk to agricultural profitability.

However, the resilience observed in Portugal and Poland, where production levels remained stable, suggests that effective adaptation strategies are in place. In the context of climate change, alterations in the concentrations of gases such as CO_2 and O_3, changes in temperature and precipitation, long-term water shortages, unsuitable soil conditions, drought, and desertification, as well as outbreaks of plant diseases and pests, are expected to significantly impact plant growth and increase both biotic and abiotic stress factors [7]. Tomato production has been affected by various biotic and abiotic constraints. Abiotic stresses are frequently interconnected; individually or in combination, they cause alterations at various biological levels that harm plant growth and productivity, ultimately leading to reduced yields [7, 8]. Climate-smart practices, such as enhanced irrigation and drought-resistant crops, can help mitigate the adverse effects of climate change. Additionally, supportive government policies are essential for farmers to adopt sustainable practices and technologies [26].

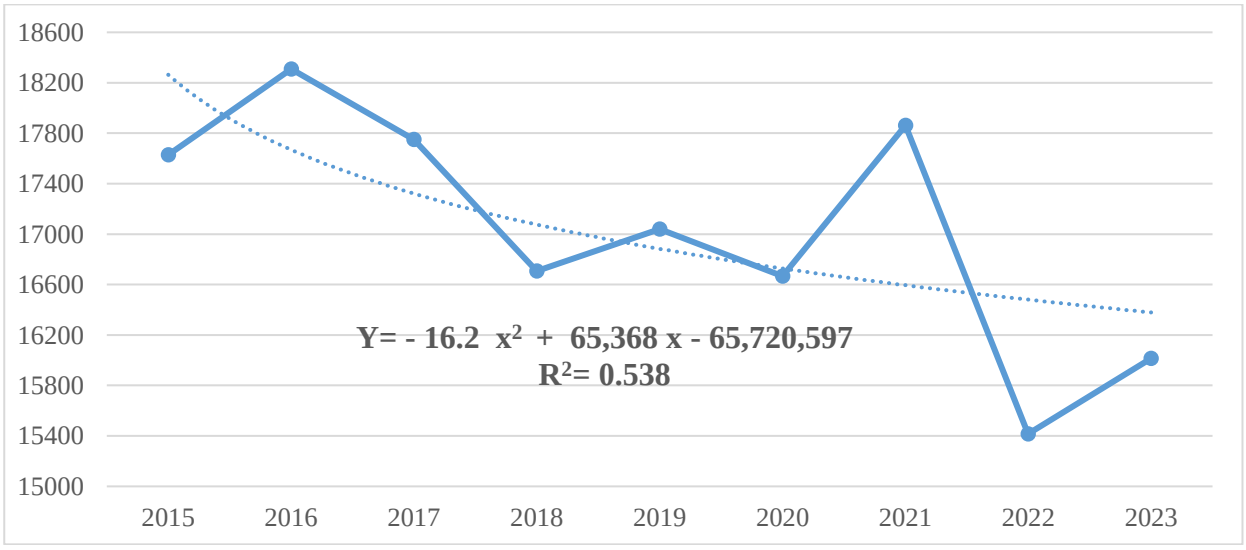

Fig. 1. Dynamics of tomato production in the EU, 2015-2022 (Thousand tonnes)
Source: Own design and calculations based on the data from [13].

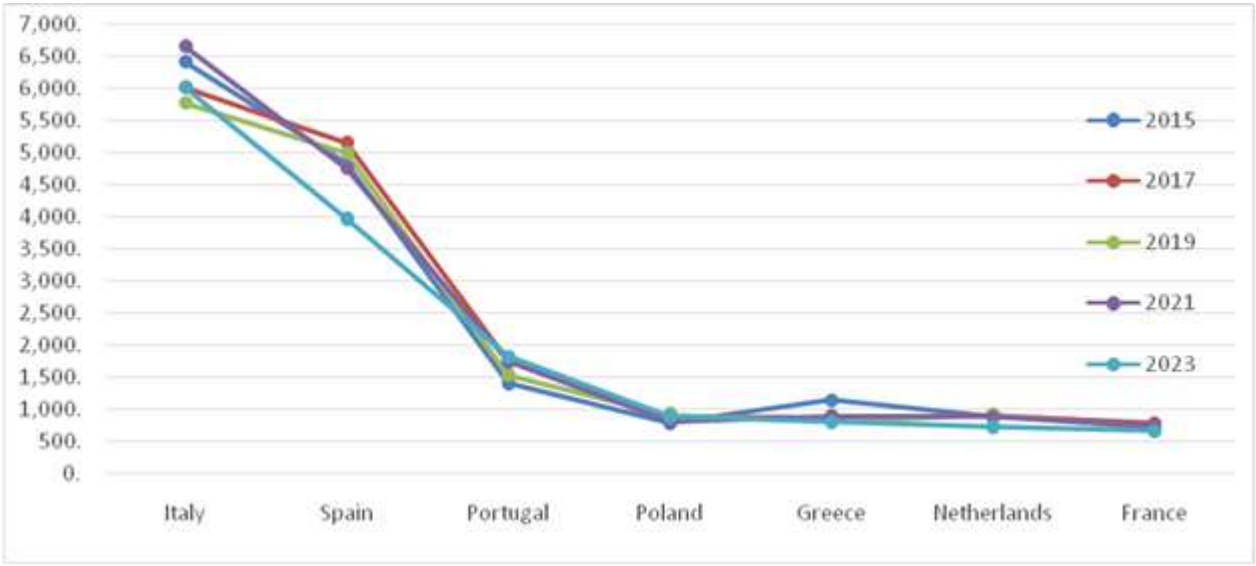

Fig. 2. Dynamics of tomato output in the EU main producing countries, 2015-2022 (Thousand tonnes)
Source: Own design based on the data from [17].

An analysis of the changes in production shares from 2015 to 2023 reveals that Italy, which held the largest share of tomato production in 2015 at 36%, experienced an increase in its share to 38% of total production by 2023. Similarly, Portugal's share of total tomato production rose from 8% to 11%. While the Netherlands, France, and Poland maintained their shares of total production during the examined period, Spain's share decreased from 27% to 25% (Figure 3). Despite fluctuations in the production shares among these countries, the combined share of the leading tomato-producing countries within the EU-27 increased from 92% in 2015 to 93% in 2023.

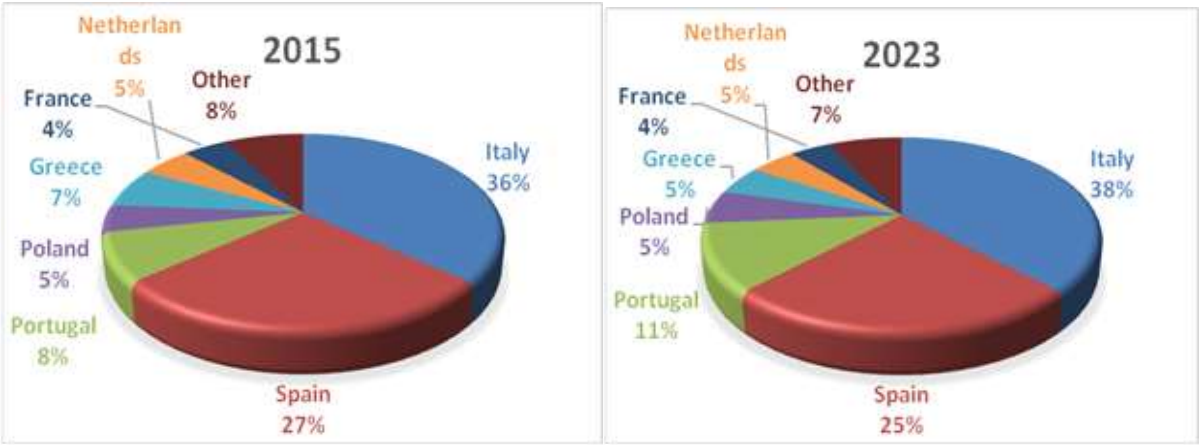

Fig. 3. The contribution of the major producing member states to the EU tomato production in 2023 versus 2015 (%)
Source: Own design and calculation based on the data from [19].

During the period from 2015 to 2022, the tomato price index was set to 100 based on the year 2015, and changes relative to this base year were analyzed. Across the European Union, there was a detected increase of 44.28% in 2022 compared to 2015. While producer prices vary between countries, the highest increase was recorded in Poland, with a rise of 71.65%. Conversely, the lowest increase occurred in the Netherlands, at 24.00% (Figure 4).

Certified seeds, essential fertilizers, pesticides for pest control, advanced agricultural machinery, and irrigation water, among other variable costs, account for a significant portion of agricultural production expenses. These variable costs, particularly in crop production, constitute the largest share of total

production costs and substantially impact the gross profit margin per hectare [34, 37, 38].

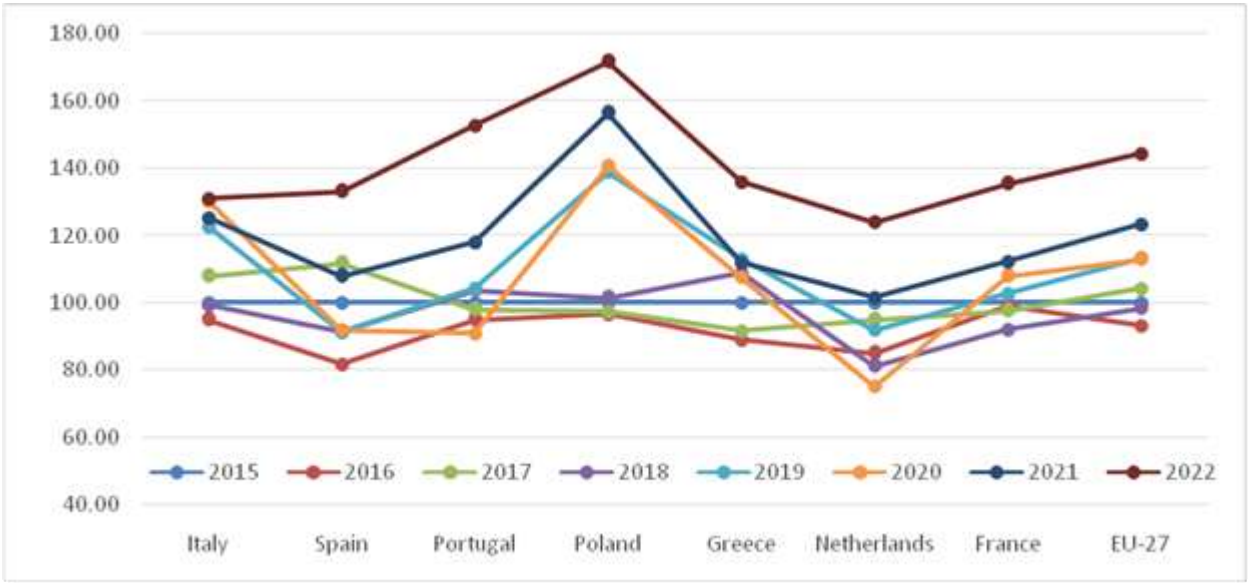

Fig. 4. Tomato price indices in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [20].

During the examined period within the European Union, the seed price index was found to have increased by 34.38%. In the leading tomato-producing countries within the EU, the highest increase in seed prices was recorded in Poland at 57.58%, followed by Italy at 44.60%. The lowest increase in seed prices within the EU was observed in France, at 8.37% (Figure 5).

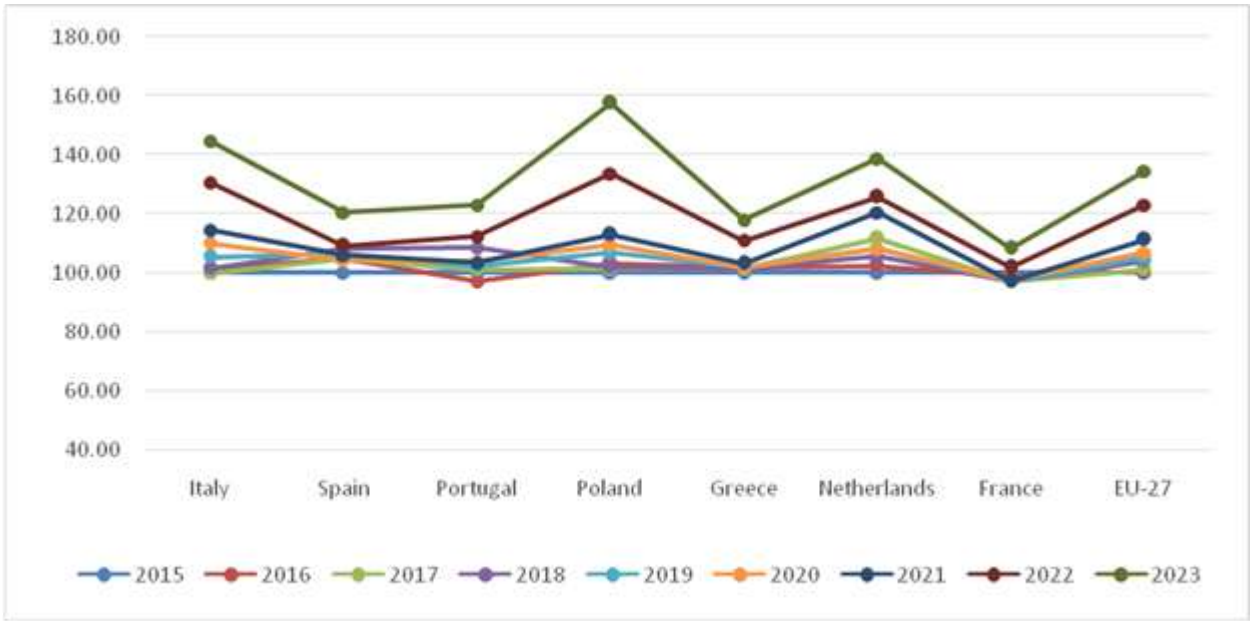

Fig. 5. Price indices of the means of agricultural production, Seeds input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [21].

Fertilizers are among the most critical inputs in agricultural production. Specifically, nitrogen and phosphorus fertilizers are fundamental plant nutrients widely used both in general agriculture and in vegetable production [31, 32, 33].Consequently, significant fluctuations in fertilizer prices can

lead to reduced fertilizer use, ultimately resulting in decreased production.

The basic fertilizer index within the EU-27 has shown a substantial increase, with a rise of 94.05% from 2015 to 2022. Notably, while the increase was relatively stable from 2015 to 2020, nearly all of this increase occurred in the last year of the period (Figure 6). Portugal exhibited the highest increase, with a rise of 141.17%, followed by Spain with an increase of 87.92%. The lowest increase in the basic fertilizer price index was observed in Greece, at 57.33%. It is noteworthy that while no significant increases were recorded in the leading tomato-producing countries between 2015 and 2020, there were substantial increases observed in the last two years.

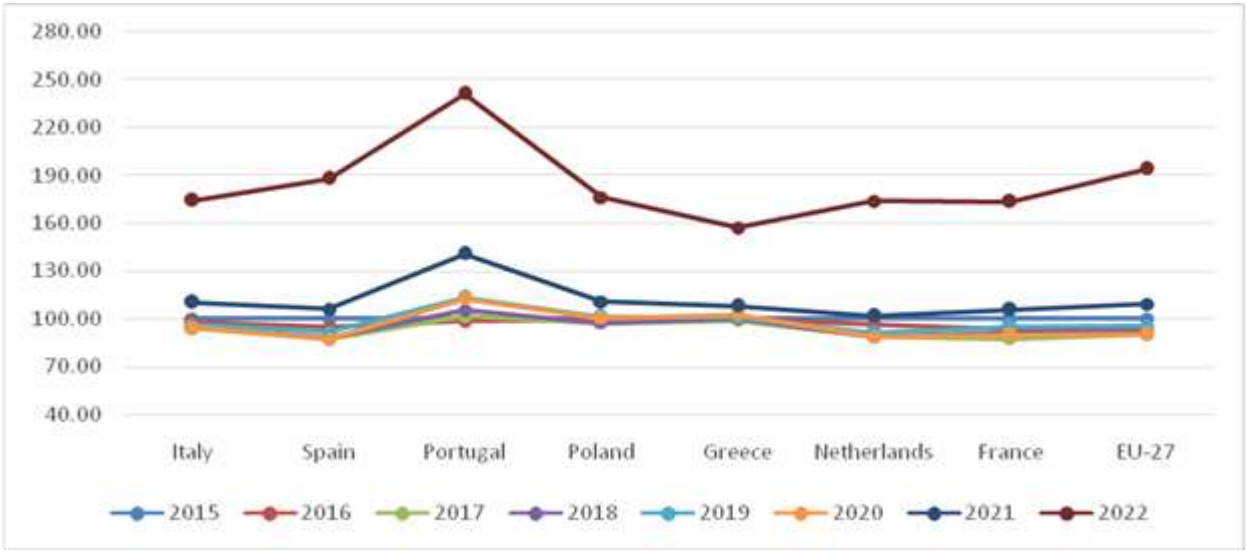

Fig. 6. Price indices of the means of agricultural production, NPK fertilizers input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [22].

An examination of the plant protection products price index reveals an increase of 14.46% from 2015 to 2022. Over the eight-year period analyzed, only France experienced a decrease of 4.02%. The countries with the highest increases in plant protection product prices were Portugal, with a rise of 56.23%, followed by Spain with 28.14%, and Italy with 24.90% (Figure 7).

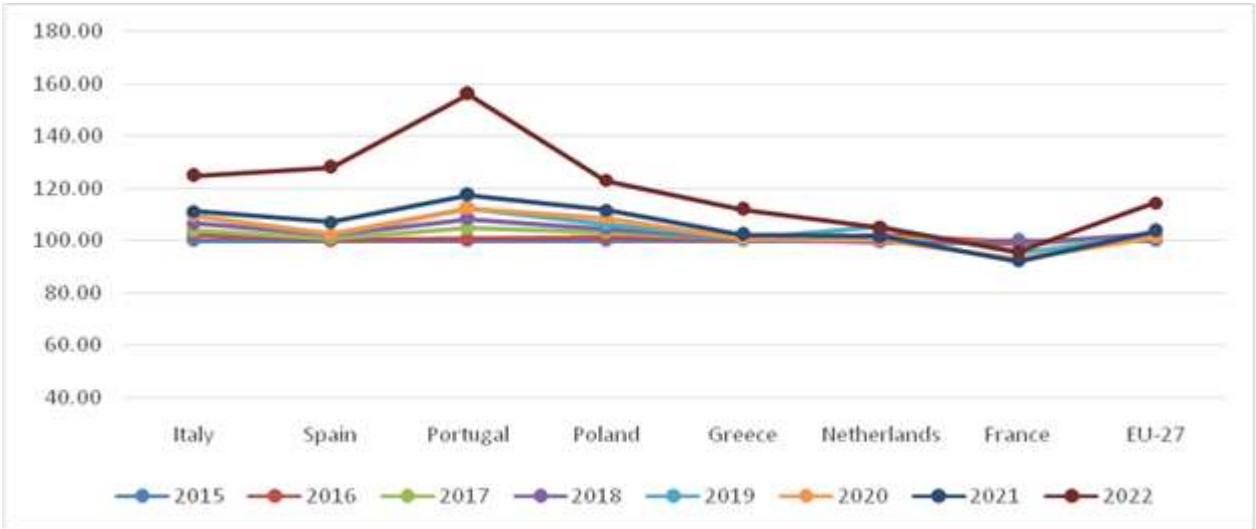

Fig. 7. Price indices of the means of agricultural production, Plant protection products input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [23].

In the EU-27 countries, the fuel price index for agricultural use was 100 in 2015, increased to 115.40 in 2021, and reached 166.13 in 2022, indicating a 66.13% rise from the base year (Figure 8). While there was no significant increase in fuel price indices among the leading tomato-producing countries from 2015 to 2021, an average increase of 45% was observed in 2022 compared to 2021. The most substantial increases in fuel prices were recorded in France (90.97%) and Spain (87.00%), whereas the least increases were noted in Poland (51.33%) and Greece (54.74%).

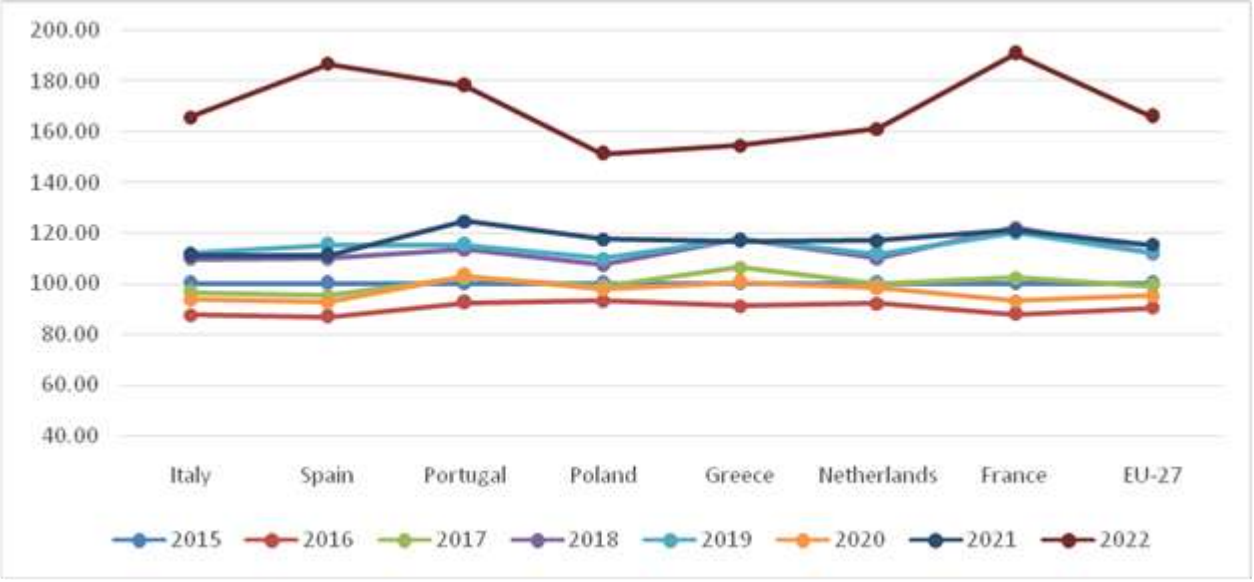

Fig. 8. Price indices of the means of agricultural production, Fuel input (2015 = 100) - annual data in the EU main producing countries, 2015-2022 (%), 2015=100
Source: Own design based on the data from [24].

Based on the analysis, the tomato production model for the EU-27 can be explained with a high R^2 value of 0.955 (Table 1). This high R^2 value suggests that the model captures the variability in tomato production effectively. The analysis reveals that an increase in tomato prices is associated with an increase in tomato production. However, there is an inverse relationship between tomato production and the price indices of key inputs such as seeds, fertilizers, and fuel. Despite the high R^2 value, statistically significant relationships between the dependent and independent variables were not identified.

Table 1. Estimation Results of the EU-27 Tomato Production Model*

	$R^2 = 0.955$			
	Coefficients	**Std.** deviation	t Stat	*P*-values
Constant	-48121.317	28885.689	-1.666	0.344
Tomato price	13.360	30.479	0.438	0.737
Price indices of seed	-334.686	116.242	-2.879	0.213
Price indices of fertilizers	-110.675	53.163	-2.082	0.285
Price indices of fuels	-58.569	29.508	-1.985	0.297

Source: Calculated by authors.

The production of tomatoes in the EU-27 is significantly influenced by both economic and environmental variables. The changes in production shares observed from 2015 to 2023 highlight the variations in agricultural practices among these countries. For instance, the increase in production shares in countries like Italy and Portugal indicates a transition towards modern agricultural techniques and more efficient production methods. This situation can be explained by the fact that countries like Portugal and Italy have enhanced their agricultural production

systems' adaptive capacities in response to both economic and climate change challenges. The relationship between rising tomato prices and increased production is consistent with well-established principles of agricultural economics. Higher prices provide farmers with the opportunity to generate greater income, thereby serving as an incentive to enhance production. However, increases in the prices of essential inputs such as seeds, fertilizers, and fuel are significant factors adversely affecting profitability in the agricultural sector. The limited advancements in optimizing the productivity of land, labor, energy, fertilizers, and other critical inputs in food production necessitate increased usage of these resources to meet growing demand, which is projected to result in elevated food prices [29].

The notable rise in fertilizer prices, particularly after 2020, can be attributed to global economic factors such as trade wars, supply chain disruptions, and increases in energy costs [26]. These factors have contributed to significant cost increases in input prices, even within developed agricultural markets like the EU-27. Regulatory policies and support programs play a critical role in alleviating these cost pressures. As highlighted by the [11, 15], promoting sustainable agricultural practices is crucial for managing input costs and enhancing overall production efficiency.

CONCLUSIONS

In conclusion, tomato production in EU-27 countries has not only been affected by environmental factors. Market dynamics such as seed, fertilizer and fuel have also affected tomato production. In addition, changes in production shares may have been affected by the agricultural policies and applied agricultural techniques of these countries. For example, the increase in production shares in countries such as Italy and Portugal or the decrease in Greece may be under the joint effect of these factors. Furthermore, the increasing costs of basic inputs such as seed and fuel, and the increase in fertilizer prices, which became especially evident after 2020, have been identified as critical factors that negatively affect production in the agricultural sector.

Tomato production in the EU-27 will continue to be affected by the process of adapting to market dynamics and environmental changes. Investing in new technologies and sustainable agricultural practices is critical to increase cost efficiency and productivity. In this context, policy makers and industry stakeholders should continue to develop supporting strategies and innovations for the sector.

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