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The impact of some animal products on agricultural gross domestic product in Türkiye: A time series analysis

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ABSTRACT - The relationship between animal products and agricultural gross domestic product (AGDP) in Türkiye was investigated in this study. We used data of eight animal products (cow milk, sheep milk, beef, mutton, poultry meat, eggs, wool, and honey) from 1980 to 2020. After checking the stationarity of the series by the Augmented Dickey-Fuller (ADF) test, the Johansen cointegration test was used to establish the existence of a long-term relationship between animal products and AGDP, and the results were interpreted using The Fully Modified Ordinary Least Squares (FMOLS) analysis. According to the findings, honey, beef, poultry meat, mutton, eggs, and wool had a positive and significant relationship with AGDP in Türkiye, whereas sheep milk and cow milk and AGDP was not significant. The total effect of the examined animal products on AGDP was 0.61%. The results showed that wool was the most important contributor to AGDP among the products analyzed. Therefore, it is suggested that policymakers develop funding strategies to expand the production of these products.

Keywords: AGDP, animal products, FMOLS analysis, sustainability, Türkiye

1. Introduction

The livestock sector is an essential activity that contributes to the national economy by ensuring adequate and balanced nutrition for people, reducing rural poverty and increasing operating profit and labor productivity (Ergün and Bayram, 2021). Livestock is currently one of the fastest growing agricultural sub-sectors in developing countries (Thornton, 2010). This increase is due to the rapidly increasing demand for livestock products as a result of population growth, urbanization, and rising income, particularly in developing countries (Delgado, 2005). According to the Food and Agriculture Organization (FAO) data in 2020, animal products account for 30.8% ($1.27 trillion) of the global agricultural production value of $4.14 trillion dollars, and countries with the highest ratio of animal products in the value of agricultural products are Germany (61.2%), the Netherlands (52.9%), Mexico (46.8%), Russia (44.6%), and Vietnam (40.3%) (FAO, 2020).

The livestock sector is critical to the food supply security of all countries. The main components of this contribution are meat and milk, which are the major products of the livestock sector. Consumption of animal products also provides numerous health benefits to poor people all over the world. According to FAO data, animal protein accounts for roughly a quarter (26%) of the average total protein supply for the five countries with the lowest protein supply in the world (FAO, 2020). Livestock can also help meet fertilizer requirements in mixed crop systems, thereby subsidizing other farm costs and reducing waste (Mehrabi et al., 2020). On the other hand, besides all these positive effects, the livestock sector is estimated to be responsible for approximately 13% of global greenhouse gas emissions (Herrero et al., 2016).

The livestock sector has a significant role and potential in the Turkish economy and agricultural sector. According to 2020 data, the share of animal products in the agricultural production value in Türkiye is 34.4% with 18.7 million dollars, which is higher than the global average (FAO, 2020). Animal husbandry enterprises in Türkiye are generally small-scale family businesses, but with the projects implemented in recent years, there is a significant increase in the number of medium and large-scale enterprises. With the new legislation adopted in subsidy items and amounts, particularly since the mid-2000s, new practices in livestock support have come to the fore, and the share of livestock subsidies in total agricultural subsidies have increased (Demir and Yavuz, 2010). For example, while the share of the livestock sector in total subsidies was 0.02% in the 1990s (Gürer, 2021), this rate increased to 29.5% in 2022 (SBB, 2022). After the 2000s, it was tried to create a structure from which mostly large-scale enterprises benefit with grants, loans, and subsidies given to the livestock sector in Türkiye; thus, it was aimed to increase the meat and milk productivity and to supply the animal products needed by the country domestically, thus preventing the increase in product prices (Acıbuca and Budak, 2021). The primary goal of these sector-specific supports is to boost animal productivity and production to raise the agricultural gross domestic product. The gross domestic product (GDP) is one of the few benchmarks for assessing the economic strength of a nation. The GDP measures the monetary value of all finished goods and services produced over time in a nation. The contribution of agriculture to the Turkish GDP fell from 14.1% in 2000 to 10.3% in 2005 and 5.8% in 2018 (Anonymous, 2019). In 2023, it was predicted that this share will decline to 5.4%. The reason for this decrease is considered to be the leading role of the industrial sector in productivity increases (Ergün and Bayram, 2021). Nevertheless, agriculture is an undeniable necessity for the development and economic prosperity of a country. While agricultural growth is an important indicator of economic growth and poverty reduction, it has a direct impact on the welfare and income levels of people living in rural areas.

The contribution of livestock products to agricultural gross domestic product (AGDP) in Türkiye from 1980 to 2020 was discussed in this study. There was no study in the literature that looked into the effects of animal products on AGDP in Türkiye. Consequently, the study aimed to contribute to filling the information gap in this field.

There are various national and international studies in the literature to examine the relationship between agricultural production, agricultural loans, and agricultural crops and GDP (Uzundumlu, 2012; Anwar et al., 2015; Awokuse and Xie, 2015; Hussain and Ajmair, 2016; Olgun et al., 2018; Şaşmaz and Özel, 2019). Some of these studies are listed below:

Uzundumlu (2012) examined the changes in the agricultural sector in Türkiye between 1995 and 2010, considering the food needs of the society, the supply of raw materials to the industrial sector, its contribution to exports, and the employment opportunities it created. Olgun et al. (2018) analyzed the change in fixed capital investments for the agricultural sector in Türkiye and the AGDP changes between 1983 and 2015 to reveal the effect of fixed capital investments carried out by both the public and the private sector on AGDP. Şaşmaz and Özel (2019) examined the long-term relationship and causality between the financial incentives provided to the agricultural sector in Türkiye, agricultural sector development, and economic growth during the 1980-2016 period. As a result of the study, the financial incentives provided in the agricultural sector did not have a significant effect on the development of the agricultural sector in the long term; however, economic growth positively affected the development of the agricultural sector. Bansal et al. (2021) used nonlinear autoregressive distribution lag (NARDL) and Granger causality test in their study in which they examined the effects of rice, wheat, and maize crop production on agricultural growth in India. The NARDL model indicated that in the long run, positive and negative shocks in maize and rice production and a positive shock in wheat production were positively correlated with agricultural growth. In a study by Uygur and Kaya (2022), in which they investigated the cointegration relationship between agricultural loans and agricultural growth, the results showed that there is a cointegration relationship between agricultural loans and agricultural growth and that the increase in agricultural loans extended by deposit and participation banks has a positive effect on AGDP in the long run.

While Türkiye's population was 43 million in 1980, this figure reached 85 million by 2023 (TUIK, 2023). In 1980, the total bovine and ovine livestock of the country was 81.5 million heads and decreased

to 66.2 million heads in 2019. Although animal husbandry has been the main sector of the Turkish economy for many years, the share of these products in imported goods has increased since the early 2000s because of the rapid increase in the domestic market prices of animal products, especially red meat and livestock (Acıbuca and Budak, 2021). Scholars have made significant achievements in research on the husbandry economy in Türkiye. Although improving the livestock economy to increase GDP growth has become the focus of international research, the effects of animal product values on AGDP in Türkiye have not been analyzed. Therefore, it is necessary to conduct a study to determine the contribution of animal products to Türkiye's AGDP. The aim of this study is to provide a theoretical basis as a reference for decision-making and policies of relevant stakeholders, to investigate the impact of animal products on AGDP, and to determine how animal products contribute to AGDP and thus to economic development of Türkiye.

2. Material and Methods

2.1. Study data

Annual time series data between 1980 and 2020 were used to examine the relationship between animal products and AGDP in Türkiye. Annual data from the Food and Agriculture Organization of the United Nations (FAO) were used for this purpose (FAO, 2020). Eight variables were used in the study to represent AGDP and livestock products. Animal product production variables include cow milk, sheep milk, beef, mutton, poultry meat, eggs, wool, and honey production. This study was limited to the chosen products because the FAOSTAT does not provide information on the values of other animal products during the period of choice (for instance, it was intended to include cattle hides and sheepskins, but no information was found). These data provide sufficient coverage and timeliness to accurately reflect the impact of animal products on AGDP. The model made accurate predictions by measuring the magnitude of the impact of animal products on AGDP. Annual data from the FAO website were used in this study. The AGDP (constant 2014-2016 thousand $) refers to the value of agricultural production. Animal product values correspond to the total value obtained by multiplying the production amount of each product by the average price of the base period.

Definitions of the variables used in the study:

Eggs: hen eggs in shell, fresh (constant 2014-2016 thousand $); honey: natural honey (constant 2014-2016 thousand $); beef: indigenous, meat of cattle with the bone, fresh or chilled (constant 2014-2016 thousand $); poultry meat: indigenous, meat of chickens, fresh or chilled (constant 2014-2016 thousand $); mutton: indigenous, meat of sheep, fresh or chilled (constant 2014-2016 thousand $); cow milk: raw milk of cattle (constant 2014-2016 thousand $); sheep milk: raw milk of sheep (constant 2014-2016 thousand $); wool: shorn wool, greasy, including fleece-washed shorn wool (constant 2014-2016 thousand $).

The descriptive statistics of the variables used in the analysis are given in Table 1. Figure 1 and 2 presents the production values of the analyzed animal products between 1980 and 2020.

Table 1 - Descriptive statistics of variables

	AGDP	Beef	Cow milk	Eggs	Honey	Poultry meat	Mutton	Sheep milk	Wool
Mean	54685106	3916582	4761474	1215198	567643	2223686	2217822	1031396	47146
Median	52161361	3574630	3904628	1281994	557776	1509674	2178436	1057176	47558
Maximum	86284392	9639114	9302746	2174043	946057	5298238	3429499	1599080	67490
Minimum	35430063	1036003	2972135	361403	208019	576852	875127	661463	32363
SD	13507211	2081721	1794792	545946	210700	1631538	832638	234355	9035
Skewness	0.67	0.98	1.20	0.05	0.09	0.75	−0.06	0.35	0.22
Kurtosis	2.52	3.58	3.13	2.02	1.98	2.05	1.72	2.43	1.99

AGDP - agricultural gross domestic product; SD - standard deviation.

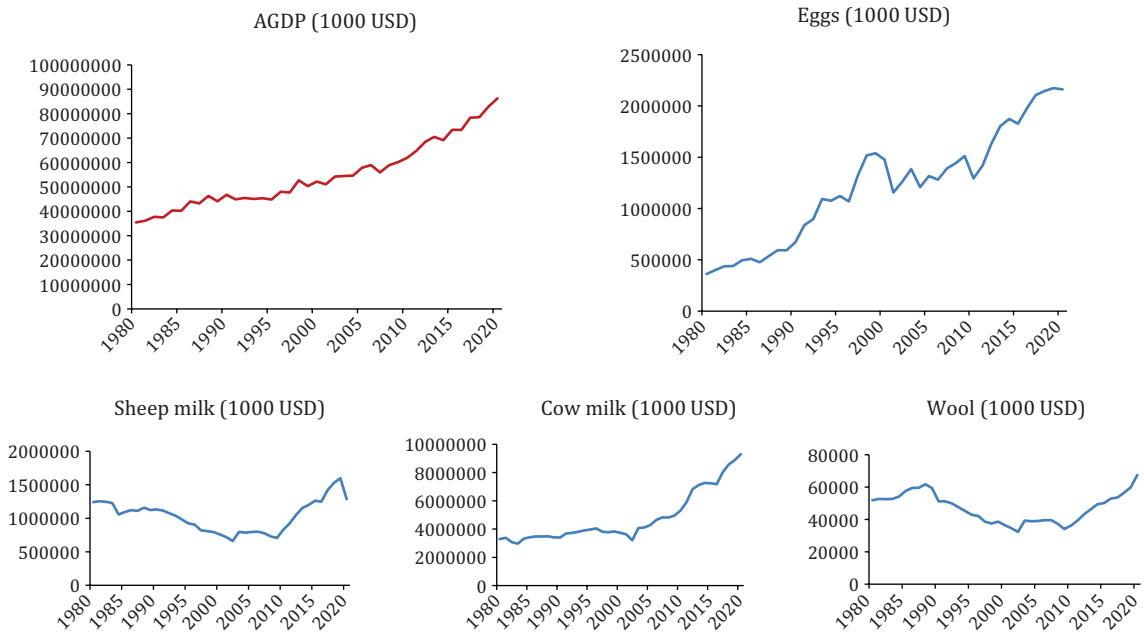

Figure 1 - AGDP and animal products (eggs, sheep milk, cow milk, wool) values in Türkiye between 1980-2020 (FAO, 2020).

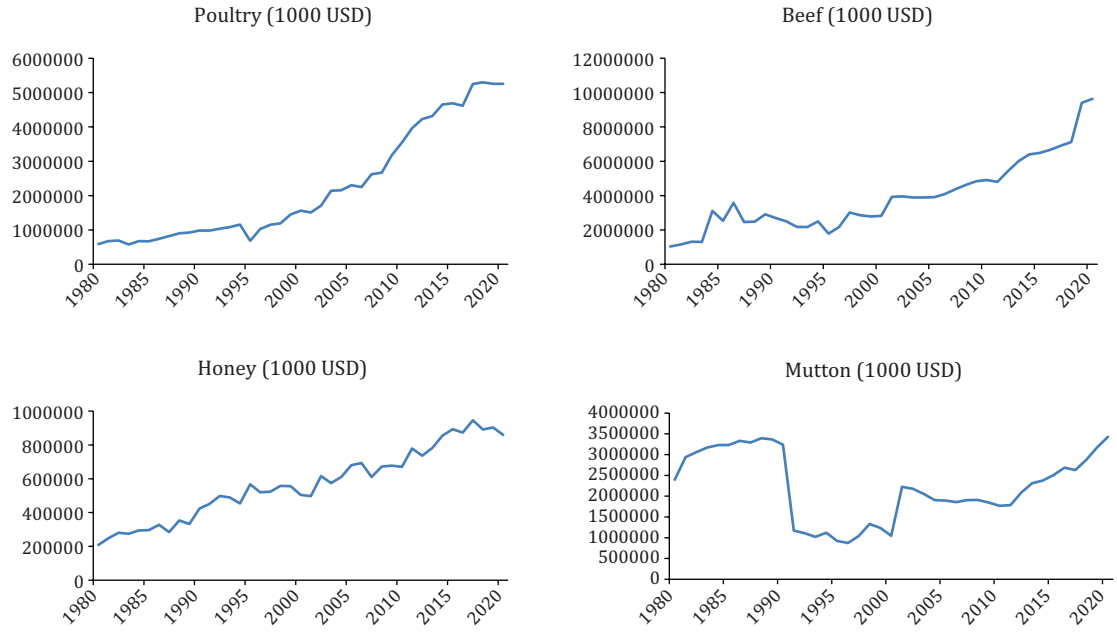

Figure 2 - Animal products (poultry, beef, honey, mutton) values in Türkiye between 1980-2020 (FAO, 2020).

2.2. The research model

All variables used in the analyses were included in the models by taking their Napierian logarithms. In time series analyses, the most important point to be considered is whether these series are stationary or non-stationary. To obtain econometrically significant relationships between variables, the analyzed series should be stationary series.

The stationarity of the series was checked using the Augmented Dickey-Fuller (ADF) unit root test (Dickey and Fullar, 1981). The test is used to evaluate the existence of a unit root or stationarity of the time series. There are two approaches to run unit root tests: with and without a structural break. The Augmented Dickey-Fuller (ADF) test was applied to determine whether the series are stationary in our model.

Afterwards, the Johansen cointegration test was applied to examine the long-run relationship between AGDP and animal product production from 1980 to 2020. The basic model used in the study to investigate the relationship between AGDP and animal products is as follows:

$$Y = AX_1\beta^1 X_2\beta^2 X_3\beta^3 X_4\beta^4 X_5\beta^5 X_6\beta^6 X_7\beta^7 X_8\beta^8 \quad (1)$$

Taking the Napierian logarithm of the above equation, it can be expressed as:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \varepsilon t \quad (2)$$

in which β_0 represents the Napierian logarithm of A (the intercept), lnY is the Napierian logarithm of annual AGDP, $\ln X_1$ is the Napierian logarithm of cow milk production value, $\ln X_2$ is the Napierian logarithm of sheep/goat milk production value, $\ln X_3$ is the Napierian logarithm of beef production value, $\ln X_4$ is the Napierian logarithm of mutton production value, $\ln X_5$ is the Napierian logarithm of poultry meat production value, $\ln X_6$ is the Napierian logarithm of egg production value, $\ln X_7$ is the Napierian logarithm of wool production value, $\ln X_8$ is the Napierian logarithm of honey production value, and εt represents the error term. As a result, the model can be shown as follows:

$$\ln(AGDP) = \beta_0 + \beta_1 \ln(CMilk) + \beta_2 \ln(SMilk) + \beta_3 \ln(Beef) + \beta_4 \ln(Mutton) + \beta_5 \ln(Poultry) + \beta_6 \ln(Eggs) + \beta_7 \ln(Wool) + \beta_8 \ln(Honey) + \varepsilon t \quad (3)$$

Following the application of unit root and cointegration tests, Pedroni's (2000) Full Modified Ordinary Least Square (FMOLS) method was used to test the consistency of the estimators within the context of our expectations to estimate the final unbiased coefficients of this relationship. To investigate the relationship between AGDP and animal products, the E-Views software package was used in the study.

3. Results

3.1. Unit root test results

In the present study, in which the time series approach was chosen as the econometric method, unit root testing was used to examine the stationarity of the variables that make up the initial stage of the analysis.

The ADF test revealed that the dependent and independent variables in the equation are not stationary since they have a unit root in the level value (probability >1%, 5%, 10%). As a result, the first difference in the series was taken, and the ADF test was repeated. The series became stationary at the 5% significance level at the first difference (Table 2).

3.2. Cointegration test results

The Johansen cointegration test was employed to determine whether the series moved together in the long term. The number of latencies in the model is crucial when determining the long-term relationship between the variables. We used trace statistics and the Max-Eigen cointegration test to determine the long-term relationship between livestock products and AGDP. Calculated trace statistics for the Johansen cointegration test revealed a cointegrated relationship at the 5% significance level (Table 3).

According to the Max-Eigen Statistics computed as a result of the Johansen cointegration test, a cointegrated relationship existed at the 5% significance level. As a result, it is possible to conclude that AGDP and animal products have a long-term relationship (Table 4).

Table 2 - Results of ADF test

Variable	I(0)		I(1)	
	ADF statistic	Probability	ADF statistic	Probability
Ln(AGDP)	−0.938766	0.9409	−12.22081	0.0000*
Ln(eggs)	−1.865025	0.6538	−6.285531	0.0000*
Ln(honey)	−3.691589	0.3046	−10.02788	0.0000*
Ln(beef)	−2.432735	0.3581	−8.085304	0.0000*
Ln(poultry)	−2.954355	0.1574	−8.388118	0.0000*
Ln(mutton)	−1.932458	0.6191	−6.756741	0.0000*
Ln(cow milk)	−1.518491	0.8064	−6.315307	0.0000*
Ln(sheep milk)	−0.771338	0.9599	−4.684189	0.0029*
Ln(wool)	0.590821	0.9992	−4.770649	0.0023*

AGDP - agricultural gross domestic product; ADF - Augmented Dickey-Fuller.
* Indicates significance at 5% level.
Note: Maximum delay lengths were selected automatically and Schwarz Information Criteria was used.

Table 3 - Johansen cointegration test using trace statistic

Lags interval: 1–1

Eigenvalue	Trace statistic	0.05 critical value	Probability**	Hypothesized no. of CE(s)
0.798916	276.7969	197.3709	0.0000	None*
0.719317	214.2396	159.5297	0.0000	At most 1*
0.699016	164.6889	125.6154	0.0000	At most 2*
0.643557	117.8618	95.75366	0.0007	At most 3*
0.52027	77.63015	69.81889	0.0104	At most 4*
0.439005	48.98343	47.85613	0.0390	At most 5*
0.310051	26.43977	29.79707	0.1161	At most 6*
0.253045	11.96538	15.49471	0.1586	At most 7*
0.014942	0.587131	3.841466	0.4435	At most 8*

* Indicates significance at 5% level.
** Indicates values are accurate.

Table 4 - Johansen cointegration test using Max-Eigen statistic

Eigenvalue	Max-Eigen statistic	0.05 critical value	Probability**	Hypothesized no. of CE(s)
0.798916	62.55727	58.43354	0.0187	None*
0.719317	49.5507	52.36261	0.0945	At most 1*
0.699016	46.82718	46.23142	0.0431	At most 2*
0.643557	40.23161	40.07757	0.0480	At most 3*
0.520270	28.64672	33.87687	0.1853	At most 4 *
0.439005	22.54366	27.58434	0.1938	At most 5*
0.310051	14.47439	21.13162	0.3274	At most 6*
0.253045	11.37825	14.2646	0.1362	At most 7*
0.014942	0.587131	3.841466	0.4435	At most 8*

* Indicates significance at 5% level.
** Indicates values are accurate.

3.3. Regression results

The FMOLS long-term coefficient estimator was used to analyze the cointegration coefficients (Table 5). The value of R^2 in the FMOLS regression results was found to be 0.986, indicating that the independent variables accounted for about 99% of the variance in AGDP and that the model as a whole was significant. Consequently, a 1% increase in honey production resulted in a 0.16% increase in AGDP. It was also found that AGDP rose by about 0.05% for every 1% increase in beef production

by approximately 0.13% for every 1% increase in poultry meat production and by about 0.06% for every 1% increase in mutton production. A 1% increase in egg production increased AGDP by approximately 0.12%, and a 1% increase in wool production increased it by approximately 0.21%. Therefore, there was a positive relationship between honey, beef, poultry meat, mutton, eggs, and wool production and AGDP. Although a 1% increase in cow milk production increased AGDP by approximately 0.02%, it was not statistically significant. Likewise, a 1% increase in sheep/goat milk production reduced AGDP by approximately 0.07% and is not statistically significant (Table 5).

Table 5 - Regression analysis (FMOLS)

Dependent variable: Ln(AGDP)				
Method: Fully Modified Least Squares (FMOLS)				
Sample (adjusted): 1980-2020				
Included observations: 40				
Corresponding coefficient	Coefficient	Standard error (SE)	t-Statistic	Probability
C	10.80755	0.50066	21.58662	0.0000*
Ln(honey)	0.157479	0.047666	3.303824	0.0024*
Ln(beef)	0.05118	0.019124	2.676231	0.0118**
Ln(poultry)	0.132011	0.018545	7.118438	0.0000*
Ln(mutton)	0.055069	0.01828	3.012498	0.0051*
Ln(cow milk)	0.021898	0.05416	0.404314	0.6888
Ln(sheep milk)	−0.07587	0.045941	−1.65147	0.1087
Ln(eggs)	0.117702	0.027219	4.324207	0.0001*
Ln(wool)	0.211946	0.051297	4.13177	0.0003*
R^2	0.986054	Mean dependent variance		18.73208
Adjusted R^2	0.982455	Standard deviation dependent variance		0.214285
SE of regression	0.028384	Sum squared residual		0.024974
Long-run variance		0.000404		

AGDP - agricultural gross domestic product.
* Indicates significance at 1% level.
** Indicates significance at 5% level.

4. Discussion

The results showed a positive relationship between the production of honey, beef, poultry, mutton, eggs, wool and AGDP. The total effect of the examined animal products on AGDP was determined to be 0.61%. According to data from the Turkish Statistical Institute for 2020, the share of animal products in the total agricultural production value was approximately 19.6% (TUIK, 2020). The low impact of the examined animal products on AGDP is due to their low production values compared with other animal products and agricultural products (crop products and live animals), as well as their high costs and low productivity. The results obtained from the study reveal that milk production, which plays an important role in the maintenance of livestock activities, has no effect on AGDP. The increase in migration from rural areas in Türkiye since the 1980s, a lack of shepherds because young people do not want to live in villages, and the fact that people in villages have been forced to migrate to cities due to terrorist incidents in the eastern and southeastern regions of the country, which are important livestock centers, have all had a negative impact on small cattle breeding activities (Acıbuca and Budak, 2021). Furthermore, because milk prices were not adequately supported despite the increase in input prices that began in the Covid-19 period and is still ongoing (Demirkılıç et al., 2022), the decrease in cattle presence and the increase in imports had a negative impact on both cattle breeding activities and milk production value. Although sheep milk had a production value of 0.8 billion dollars in 1980, it increased to 1.1 billion dollars only in 2019 in the 40-year period examined. On the other hand, honey production increased continuously to a production value of 0.7 billion dollars in 2020, although it had a production value of 0.1 billion dollars in 1980. The results showed that wool was the most important

contributor to AGDP (0.21%). Wool is a high-value fiber material used in the textile industry. Even if produced in limited quantities, wool can have a high economic impact on AGDP because of its higher quality and durability compared with other synthetic or natural fibers, its high demand in international markets, and its high added value.

In similar studies, Rehman et al. (2017) examined the relationship between animal products and AGDP in Pakistan using annual time series data from 1980 to 2015. The data were analyzed using the Ordinary Least Squares (OLS) method and the ADF test, and the results were interpreted using the Johansen co-integration test. Accordingly, while beef, poultry meat, wool, hair, and leather production had a negative relationship with Pakistan's AGDP, milk, fat, egg, bone and sheep meat production had a positive relationship. In their investigation of the percentage contribution of agriculture subsectors in the GDP of the overall agriculture sector of the Philippines, Fernandez et al. (2022) analyzed time series data from 1980 to 2020. Ordinary least squares, multiple regression analysis, multiple correlation, and normality tests were used by the researchers in the analysis of the data. The dependent variable was the percentage of GDP that is accounted for by agriculture, while the independent variables were the growth rates of various agricultural sub-sectors such as crops, livestock, poultry, and fisheries. The results they obtained showed that agriculture contributes positively and significantly to the Philippines' GDP; however, the contribution of livestock and poultry to AGDP is low in comparison with crops and fisheries. In a similar study, Rehman et al. (2019) examined the relationship between AGDP and beef, mutton, and poultry meat and reported that the results of long-run analyses showed that beef production had a positive and significant effect on AGDP, while mutton production and poultry meat production showed a non-significant relationship with Pakistan's AGDP. The contribution of livestock to the AGDP varies widely across countries. While this contribution averages 25% for low- and middle-income countries, it is approximately 50% for high-income countries (Baltenweck et al., 2020). This reflects that countries with developed economies have larger and better coordinated livestock sectors. This positive relationship supports the claim that livestock contributes to economic growth. Similarly, it can be concluded that the demand for food of animal origin is higher in countries with developed economies, which leads to a stronger livestock sector. Compared with countries such as Australia, New Zealand, and Argentina, where the livestock sector is developed, the impact of animal products on AGDP is quite low in Türkiye. Factors such as the fact that the livestock sector in Türkiye generally consists of small holdings, low use of technology in livestock activities, and insufficient exports of animal products cause low productivity and value added in the livestock sector.

5. Conclusions

The results found in the present study revealed that honey, beef, poultry, mutton, eggs, and wool had a positive and significant relationship with AGDP in Türkiye. The relationship between sheep milk and cow milk and AGDP was not significant. However, considering which animal products support AGDP, and therefore agricultural growth, it is advised that policymakers encourage the production of sheep milk and cow milk, which are unrelated to AGDP, and develop funding strategies to expand the production of these products. Some of the main problems facing the livestock sector in Türkiye are high feed costs, a lack of qualified manpower engaged in livestock activities, animal diseases, low productivity, infrastructure problems, and technological inadequacies. It is important to take various measures, such as policy arrangements, investments, training, and technical support, to increase productivity in livestock enterprises, develop policies to reduce migration from rural areas, and solve the stated problems. In addition, cooperation and coordination between farmers, breeders, local governments, non-governmental organizations, and academic institutions can benefit the development of the sector and, thus, increase the contribution of animal products to AGDP.

The results in this study are limited to the data set used and the period covered by the analysis. As a result, to estimate the impact of all animal products on AGDP, national and international data must be organized in a way that includes all products in question. The results will be more beneficial in future academic studies when different econometric techniques are used and all animal products are examined.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: Acibuca, V. **Data curation:** Acibuca, V. **Formal analysis:** Acibuca, V. **Funding acquisition:** Acibuca, V. **Investigation:** Acibuca, V. **Methodology:** Acibuca, V. **Project administration:** Acibuca, V. **Resources:** Acibuca, V. **Software:** Acibuca, V. **Supervision:** Acibuca, V. **Validation:** Acibuca, V. **Visualization:** Acibuca, V. **Writing – original draft:** Acibuca, V. **Writing – review & editing:** Acibuca, V.

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