

Determining the variables affecting the prices of animal products by the network analysis in Türkiye

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ARTICLE INFO

Article History

Received : 31.01.2022

Accepted : 03.08.2022

DOI: 10.33988/auvfd.1065921

Keywords

Animal products

Food prices

Livestock economics

Network analysis

Türkiye

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How to cite this article: Akın AC, Polat M, Mat B, Çevrimli MB, Arkan Mehmet S, Özel Z, Tekindal MA (2023): Determining the variables affecting the prices of animal products by the network analysis in Türkiye. Ankara Univ Vet Fak Derg, 70 (4), 359-366. DOI: 10.33988/auvfd.1065921.

ABSTRACT

Recently, Türkiye has seen significant increases in animal products and input prices. These recent increases in prices have made it even more important to examine the prices of animal products and their associated factors. This study aimed to reveal the pattern network structure and characteristics of the prices of animal products and related variables for the 2010-2020 period in Türkiye. For this aim, a network analysis covered the prices of animal products, input prices used in producing these foods, and some economic variables. The study results revealed that Producer Price Index (PPI) and Agricultural PPI are key variables that are highly active in the network and act as a bridge between other unconnected variables. In addition, the results of the analysis suggest that the overall network consists of highly correlated variables and that the PPI and Agricultural PPI are the two most important variables. As a result, the pattern network structure shows that economic variables have a high impact on the prices of animal products. The network structure visualizes Türkiye's import-substitution model in animal production and foreign dependency on feed inputs, and the market structure affected by high exchange rates. In addition, as can be understood from the positive connections between feed inputs, the pattern network of the variables affecting the prices of animal products is largely shaped by feed prices and the internal dynamics of economic variables.

Introduction

Recently, significant increases have been seen in the prices of animal products and related variables in Türkiye. During the 2010-2020 period as analyzed in this study, some basic economic indicators increased significantly (PPI by 236.6%, Agricultural PPI by 195.06%, and Dollar Exchange Rate by 445.58%) (15). These increases have resulted in the following rising feed prices in the Turkish Lira: The price of dairy feed increased by 402.3%, the price of fattening feed by 372.1%, the price of broiler feed by 290.8%, feed prices of egg hens by 312.7% (42). On the other hand, the input (corn, barley, soybean, wheat,

sunflower seed meal, and distillers dried grains with solubles-DDGS) prices increased between 306.7%-714.8% (42). The producer price of carcass meat and milk increased by 110.6%-138.7%, respectively (27). Consumer prices of animal products such as milk, beef, broiler meat and egg increased at the following rates 151.5%; 135.1%; 152.5%; 263.4%, respectively (43, 44). Such high increases make it even more important to examine the prices of animal products and their associated factors.

The price formations of animal products show an intricate structure on an international scale. It is known

that many factors have direct or indirect effects on this complex structure. Generally, the complexity of national and international trade structures prevents trade flows from being seen clearly, and as a result, it is often impossible to quickly resolve complex trade links (36). This also applies to the production of basic foodstuffs that are subject to national and international trade, especially animal products. Many inputs are involved in the production of animal products. In a free-market structure, strong and weak relationships can arise between the prices of these inputs and the prices of animal products. Depending on whether these relations are negative or positive, significant changes may occur in these products' supply and demand amounts. Various econometric models are used to examine the production amounts and prices of animal products, which have such a complex production structure. These models include different variables such as milk production quantity (3, 29), raw milk price (31, 34), consumer price of veal (5, 33), beef prices (4, 31), consumer prices index (4), broiler meat price (6), broiler feed prices (6), wheat price (1, 45), corn price (1, 10, 23), soybeans price (1) DDGS price (22). The network analysis method provides a different perspective for these recent studies' interpretation and visual expression. In addition, network analysis, which is widely used in social sciences, has, in recent years, been applied to data in the field of livestock, since it can visualize the relationship between variables (2, 35-37).

It is thought that such studies using network analysis can bring a new perspective to the relevant literature. In network analysis, networks provide a conceptual framework that can demonstrate the relationships among constituent elements (19 variables included in the study) (12). This analysis method allows identifying strong and weak connections in the network, determining the intensity of interaction in the network, revealing the roles of variables in the network, and visualising the animal products market through prices and rates. In other words, graph theory, which provides a rich analytical framework, can be used to examine the interactions between the prices of animal products and input prices (25), and where the connections between the constituents of these products have one direction (i.e., going from one node to another node), the network is represented by a directed graph (8).

Our aim and motivation are not to model or stochastically evaluate changes over time. Our main goal is to show all the path and process dynamics between the variables in a network. This study aimed to reveal the pattern network structure and characteristics of the prices of animal products and related variables for the 2010-2020 period in Türkiye. The present study aimed to apply a network analysis that included a total of 19 variables, consisting of the prices of animal products and inputs used

in their production, as well as some economic indicators and ratios.

Materials and Methods

Dataset: The dataset of the study includes the prices of animal products and the variables associated with these foods: (producer and consumer price of milk, prices of dairy feed, corn, barley, soybean, wheat, sunflower seed meal and DDGS, dollar exchange rate, PPI, agricultural PPI, consumer price of beef, price of fattening feed, producer price of carcass meat, broiler feed price, price of feed for egg hens, consumer price of broiler meat, and egg). The dataset includes monthly changes in the prices and rates of variables for the 2010-2020 period. The variables that constitutes the dataset were obtained from the Turkish Statistical Institute, Turkish Feed Industrialists Association, General Directory of Meat and Milk Board, and Central Bank of the Republic of Türkiye (16, 27, 42-44).

Method of Analysis: This study aimed to reveal the pattern network structure and characteristics of prices of animal products and related variables for the 2010-2020 period in Türkiye. Network analysis was applied to 19 variables to define the strong and weak connections in the network, to determine the intensity of interaction in the network, and to reveal the roles of the variables in the network. JASP (Version 0.14) [Computer software] was used for the structural determination and visualization of the relationships between variables in the analysis (28).

Within the scope of the study, the position of 19 variables in the network was determined. To evaluate the connections, major centrality measures such as degree, betweenness, closeness, and influence centrality, as well as network density measures were used. Each of these centrality measures has a different assumption in finding the most efficient node (variable). Therefore, each has a different approach that makes any node effective or central in a network. The variables are positioned using the Fruchterman-Reingold layout algorithm, which organizes the network according to the strength of the connections between nodes (26). The Fruchterman-Reingold layout algorithm uses random numbers. With these criteria, it is tried to determine which variable is important, effective, and most known.

The sparsity measure, one of the most used measures of graph theory, is obtained by subtracting the ratio of all existing connections in the network to the maximum possible connections from one. The sparsity measure of a network takes a value between 0 and 1 (32). Nodes with a high degree of betweenness are referred to as nodes that act as bridges between two or more clusters of nodes that cannot communicate with each other, and they have the potential to control the network (14, 15, 38, 47). The

degree of closeness shows how close a variable is to all other variables. The degree of closeness is defined as the inverse of farness, that is, the sum of the shortest distances between a node and all other nodes. This value indicates with which variable a variable will have a connection the fastest. It also measures the independence or effectiveness of the node (14, 15). Besides, a central node is quickly affected by changes in any part of the network with a high degree of closeness and can quickly affect changes in other parts of the network (13). In other words, the sphericity coefficient can also be defined as the statistical consistency level that measures the spherical density of the interconnected vertices in the network (24). In network analysis, the key member of the network is determined by degree centrality and betweenness centrality values (40).

Results

In the study, the relationship between the variables was visualized using network analysis (Figure 1). In Figure 1, the thickness of the lines indicates the severity of the relationship between the variables, the blue colors indicate the positive relationship between the variables, and the red colors indicate the negative relationship between the variables.

The graph consists of nodes (vertices) and edges (arcs, connections) connecting the nodes. The results of the analysis show that there are more connections between the variables indicating positive relationships. As can be seen in Figure 1, the total number of connections between the variables is 95. The maximum number of connections

for this network is 171. Accordingly, the degree of sparsity is 0.44. This value indicates a low degree of sparsity and shows that there is a high level of density in the network. For a network with 19 variables, this sparsity rate is sufficient.

Based on this finding regarding the general structure of the network, it can be said that there is a relationship between the variables and that the variables interact with each other. In the study, four types of measures were used to determine the centrality levels of the products. They were degree, closeness, influence, and betweenness centrality measures. Table 1 presents the centrality measures in detail.

It can be said that nodes with a high degree of betweenness have a relatively more important position. Accordingly, it can also be said that among the variables, PPI and Agricultural PPI are the key variables that are highly active in the network (Table 1) and act as a bridge between other unconnected variables (Figure 1). As a result, the overall network consists of highly correlated variables, and PPI and Agricultural PPI variables are the two most important variables.

Accordingly, the variables with the highest degree of closeness are Dollar Exchange Rate and PPI, and the variables with the lowest degree of closeness are soybean and consumer price of milk. Since these variables can be reached in the easiest way, reaching these variables is more important than reaching other variables and when these variables are reached, other variables can be reached, too.

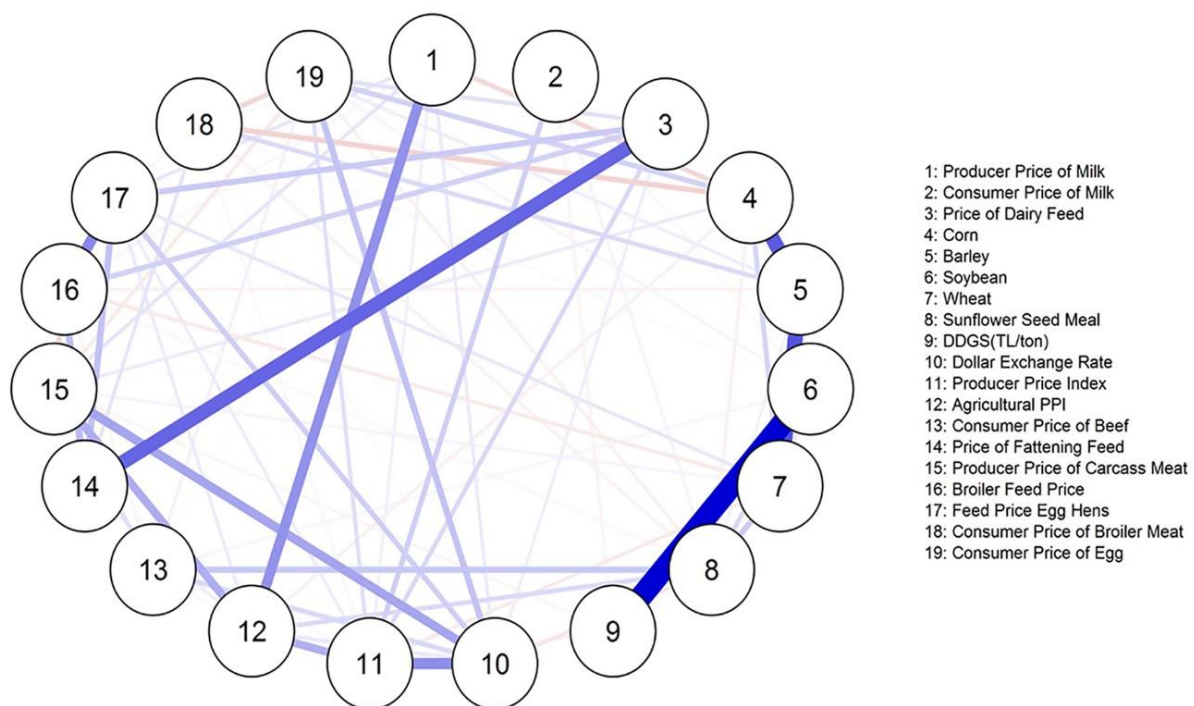
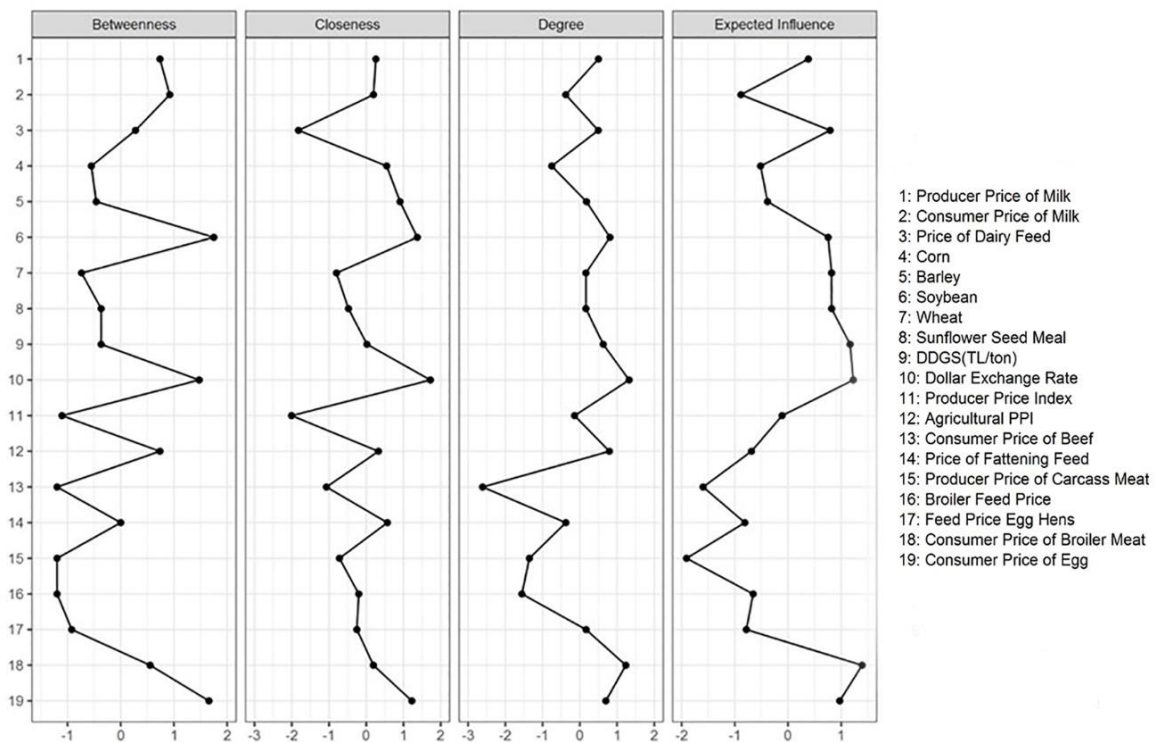


Figure 1. Network Structure Related to Variables.

Table 1. Centrality Values of the Network.

Variable	Betweenness	Closeness	Strength	Expected influence
Producer Price of Milk	-0.55	0.55	-0.75	-0.51
Consumer Price of Milk	-1.2	-1.07	-2.61	-1.6
Price of Dairy Feed	-0.37	-0.48	0.16	0.82
Corn	0.74	0.33	0.79	-0.69
Barley	0.55	0.19	1.24	1.39
Soybean	0.28	-1.82	0.49	0.79
Wheat	0.74	0.26	0.5	0.38
Sunflower Seed Meal	0.92	0.19	-0.38	-0.88
DDGS(TL/ton)	-1.11	-2	-0.14	-0.11
Dollar Exchange Rate	1.47	1.72	1.33	1.23
Producer Price Index	1.75	1.37	0.81	0.75
Agricultural PPI	1.66	1.22	0.7	0.97
Consumer Price of Beef	-1.2	-0.2	-1.55	-0.65
Price of Fattening Feed	-0.74	-0.8	0.16	0.82
Producer Price of Carcass Meat	-0.46	0.91	0.18	-0.38
Broiler Feed Price	-0.92	-0.25	0.17	-0.78
Price of Feed for Egg Hens	-0.37	0.02	0.63	1.17
Consumer Price of Broiler Meat	-1.2	-0.72	-1.35	-1.91
Consumer Price of Egg	0	0.57	-0.38	-0.81

**Figure 2.** Centrality Graph for the Network.

According to the degree centrality, which calculates centrality over the number of connections, the Dollar Exchange Rate had the highest value with 1.33. On the other hand, the Consumer Price of Milk had the lowest value with -2.61.

As for the influence values, the variables with the highest degree of influence are Barley and Dollar

Exchange Rate, respectively. They are followed by the Price of Feed for Egg Hens. In other words, Barley and Dollar Exchange Rate variables affect other variables in the pattern network. The graph made for these findings is given in Figure 2.

The clustering coefficient measures local cohesiveness and is defined as the fraction of connected

neighbours for any vertex. These coefficients reveal how strongly the variables are connected with their neighbours. Clustering coefficients for the variables are given in Table 2.

Figure 3 shows the graphs of clustering coefficients for the variables given in Table 2.

Clustering coefficients, which are used to measure the clustering tendency of the parameters in the network,

are used to measure the frequency of the parameters in groups, that is, their tendency to cliques. This coefficient, which gives the frequency of connecting the parameters with which they are connected, also shows the importance of the parameter for the groups. So a high clustering coefficient indicates a high correlation of the variables, and a low one indicates less frequent connections.

Table 2. Clustering Coefficients for the Variables.

Variable	Barrat	Onnela	WS	Zhang
Agricultural PPI	0.58	1.3	0.53	-0.65
Barley	0.54	-0.19	-0.44	0.59
Broiler Feed Price	-1.05	0.35	-1.4	0.84
Consumer Price of Beef	0.75	-0.47	0.44	0.26
Consumer Price of Broiler Meat	0.27	-1.09	-0.39	0.41
Consumer Price of Egg	0.86	0.22	0.83	-0.15
Consumer Price of Milk	-0.33	-1.36	1.99	-0.55
Corn	0.64	0.4	1.14	0.92
DDGS(TL/ton)	-1.69	-1.42	-0.92	-1.71
Dollar Exchange Rate	1.21	1.12	0.51	-0.68
Price of Feed for Egg Hens	-1.16	-0.04	-0.65	0.59
Price of Dairy Feed	1.34	2.65	1.16	1.38
Price of Fattening Feed	0.54	0.9	0.33	1.63
Producer Price Index	-0.89	-0.42	-1.71	-0.9
Producer Price of Carcass Meat	-0.66	-0.27	-0.76	-0.69
Producer Price of Milk	1.23	0.06	0.83	0.56
Soybean	-1.73	-0.98	0.44	-1.81
Sunflower Seed Meal	-0.83	-0.65	-1.18	-1
Wheat	0.39	-0.12	-0.72	0.96

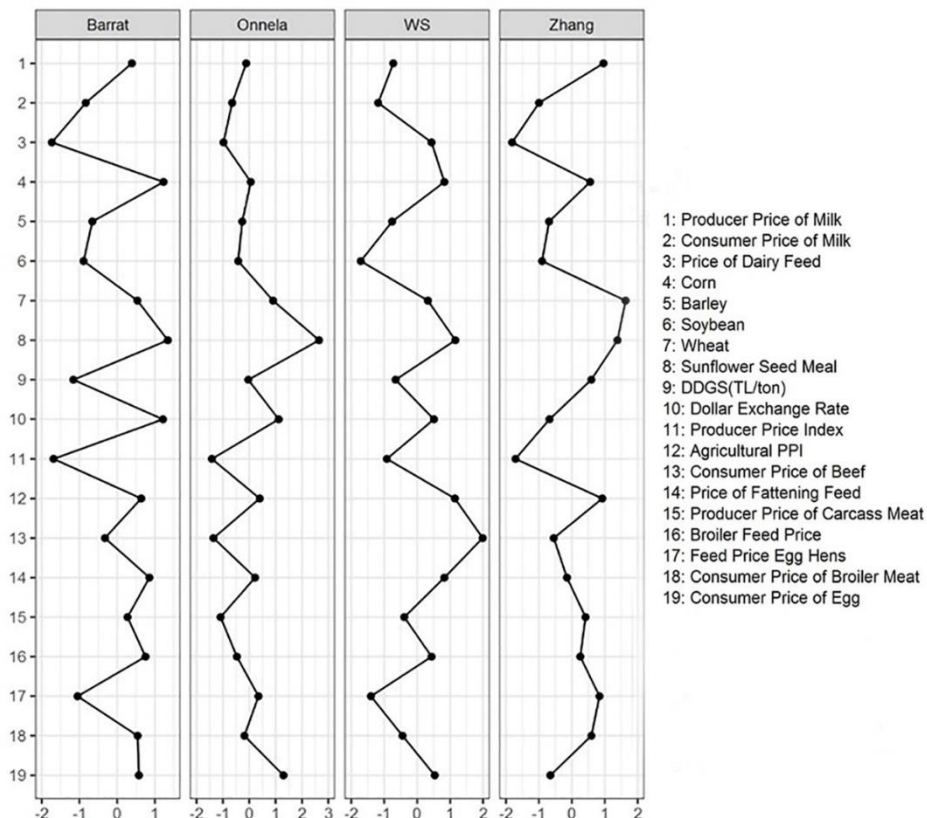


Figure 3. Graph of Clustering Coefficients for the Network.

Discussion and Conclusion

Animal products are one of the most basic needs of human beings. The increase in demand due to the increasing population limits the accessibility of these products due to both high prices and insufficient supply (7, 39). Nowadays in Türkiye, some basic economic parameters such as input prices and exchange rates are effective in the formation of the supply and demand amounts of these products. Due to the substitution effect of the products and the supply-demand relationship, the price of each product is interrelated, which, in turn, causes all products to be in a complex system as part of a whole (41). In this context, Figure 1 represents the pattern network structure of 19 variables determined for the prices of animal products and the severity and direction of the connections between them.

According to results, there is a positive and strong relationship between DDGS and soybean. The same positive relationship is seen between soybean and barley and between barley and corn. It is thought that these relations are based on foreign inputs-dependent production (7) of the Turkish poultry sector that has a production structure with vertical integration. The most important of these raw materials are soybean meal and corn (11). In Türkiye, 25-35% of corn and 90% of soybean are imported since production amounts cannot meet consumption (22). This structure leads to strong and positive relations between the prices of feed inputs used in many livestock sub-sectors, especially in the poultry sector. This structure in the poultry sector can be seen more clearly with the strong and positive connection that variables 9, 6, 5, and 4 given in Figure 1 have formed within themselves. As regards cattle breeding, the fact that feed costs constitute 60-70% of the total cost can be shown as the primary reason for the formation of the positive and strong connection between the price of fattening feed and the price of dairy feed (Figure 1). Based on Figure 1, most of the variables have a positive relationship and they are more pronounced and stronger than the variables with negative relationships. Similarly, it can be inferred from the same figure that the positive and relatively strong correlation of the number 10 variables (Dollar Exchange Rate) with the producer price index and the producer price of carcass meat is an important finding. This summarizes the general structure of the animal products market in Türkiye.

As a result of the network structure we have obtained, there are strong and positive relationships between feed inputs. To prevent increases in animal product prices, it is necessary to reduce input imports and support the production of feed inputs. On the other hand, the fact that producer prices are very effective on product prices requires livestock support at the input stage of the animal production process.

Indeed, the fact that the PPI, Agricultural PPI, and Dollar Exchange Rate nodes (Table 1) are nodes with a high degree of betweenness further reinforces the pattern network structure. Many studies have emphasized that economic variables such as inflation and dollar exchange rate interact with producer and consumer prices in Türkiye. According to the studies on this subject, there is a one-way causality relationship from exchange rate to PPI in Türkiye (9). Studies on feed inputs in Türkiye have revealed that wheat and sunflower seed prices interact with international reference prices (17). In another study, it was determined that the international prices of wheat interact with the domestic market prices, this interaction increases in crisis/drought periods, and the domestic prices of wheat move closer to the international prices with the depreciation of TL (30). According to another study, the change in the exchange rate is reflected in the cost of imports, and the increase in feed prices put more pressure on beef producer prices (20). It has been reported that a 10% increase in the price of soybean, which is the main imported feed inputs in Türkiye, causes an increase of 3.84% in chicken meat prices (18). This relationship has led to high feed prices for broilers, the import of most of the feed inputs, and a significant increase in broiler production costs. Because of this problem, Türkiye is at a disadvantage against competitor countries in terms of producer prices (46). This negative structure in feed costs has also become important for dairy cattle and fattening activities in recent years. International studies have also emphasized a similar situation, noting that both milk and feed prices have been so volatile in recent years that the profitability of dairy farms has been negatively affected (48). This price volatility in Türkiye is mainly a result of increases in exchange rates and costs. It has been found that there is a long-term positive effect between the uncertainty of agriculture and food prices and inflation in Türkiye (21) and that increases in agricultural price inflation are reflected in food price inflation and total CPI inflation in a statistically significant way (19). The degree of closeness measures the efficiency and independence of the node. Accordingly, the variables with the highest degree of closeness were found to be Dollar Exchange Rate and PPI (Table 1). Considering the position of both values in the network, the finding that they affect the network and exhibit an independent structure becomes clearer with their degree of closeness.

As a result of the network structure, the fact that the animal products market, especially the feed market, has an import-substitution production structure can be shown as the reason why these two variables have the highest degree of influence in the network. In this context, to minimize the impact of the activity experienced in the Dollar exchange rate in Türkiye on the animal products market,

the state should consider subsidy policies for import substitute products (feed inputs) in this area.

Considering the four different coefficients of the clustering coefficients given in Table 2, the variables with the highest density around are the Price of Dairy Feed and the Producer Price of Milk. The variable with the least density is the Consumer Price of Broiler Meat. These results support the effect values given in Table 1 and show that these two variables have a high degree of influence on other variables.

In conclusion, this network analysis visualizes the situation of Türkiye, which adopts the import-substitution model in animal production, is foreign-dependent in feed inputs, and has a market structure affected by high exchange rates. Besides, as can be understood from the positive connections that feed inputs have formed among themselves, the pattern network of variables affecting prices of animal products is largely shaped by feed prices and the internal dynamics of economic variables. Revising this existing structure is necessary for sustainable animal production. In this regard, with the right policies and support tools, the supply and demand mechanism of animal products can be kept under control. As can be understood from the network, bringing both economic variables, inputs prices and production and consumption to optimum levels will benefit all stakeholders of the sector in the future. Otherwise, possible economic fluctuations may jeopardize the continuity and sustainability of production. An import-substitution production model in feed inputs, together with the upward movements in the exchange rates, may reduce the production in the medium and long term, disrupting the animal food supply.

Financial support

This research received no grant from any funding agency/sector.

Conflict of Interest

The authors declared that there is no conflict of interest.

Author Contributions

ACA, MSA and MAT designed and planned the study. MP, BM and MBÇ collected data. ZÖ and MAT analyzes were performed. ACA, MBÇ and MSA contributed to the interpretation of the results. The ACA and MSA took the lead in writing the draft. All authors provided critical feedback and helped shape the research, analysis, and article.

Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethical Statement

This study does not present any ethical concerns.

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