Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

Analysis of the Dynamics of the Bovine Sector in Colombia and its Determinants from an ARDL Model

Roberto Adolfo Diaz Diaz[1], Consuelo Arce Gonzalez[2], Jose Alejandro Vera Calderon[3]

Abstract

The article carries out a comprehensive analysis of the beef production sector in Colombia using historical data and a time series model called Autoregressive Distributed Lags (ARDL). This approach allows estimating the relationships and significance of various explanatory variables of production in the sector. The results of the model reveal that beef production in Colombia is highly sensitive to domestic production and the domestic price, while exports, the international price and the exchange rate (TRM) do not show considerable statistical significance. This analysis provides a detailed understanding of the factors influencing beef production in Colombia, highlighting the importance of the domestic market over external influences.

Keywords: *Beef Production, ARDL Model, Livestock Economy in Colombia and Explanatory Variables.*

Introduction

The bovine sector in Colombia is one of the most important agricultural activities for the country's economy. This sector not only contributes to supplying the domestic market, but also plays a key role in exports, being essential for food security and rural development. In addition, it has a considerable impact on job creation in rural areas and on maintaining the country's livestock traditions. Despite its importance, the sector faces a series of challenges, such as low productivity, fluctuations in domestic consumption, competition in international markets, and problems related to diseases in the livestock herd that affect exports (Fedegan, 2023; Martínez & Caro, 2019).

In this context, understanding the dynamics of the Colombian beef sector is crucial to design policies that promote its competitiveness and sustainability. This study offers a comprehensive description and analysis of beef production in Colombia using advanced econometric techniques, specifically the Autoregressive Distributed Lag (ARDL) model and an OLS multiple regression model, with the aim of estimating the determinants of production in this sector in the country (Pérez et al., 2021). These methodologies allow identifying short- and long-term relationships between relevant variables, providing a detailed understanding of the factors that influence beef production in Colombia.

The econometric analysis is based on monthly chronological data spanning from January 2010 to December 2023. This approach allows capturing seasonal fluctuations and long-term trends, which is essential for developing effective policies and strategies for the sector. The variables considered in the model include the domestic price of meat, the international price, domestic consumption, exports, the producer price index in the agricultural sector, a productivity variable, and the nominal exchange rate. These variables are key to understanding the supply and demand of beef in the Colombian context.

Conclusions based on the modeling results are also presented. These findings provide valuable insights on how to improve the competitiveness and sustainability of the beef sector in Colombia. The implications of the findings for producers, policy makers and other relevant stakeholders in the sector are also discussed.

Therefore, this paper offers a comprehensive overview of the beef subsector in Colombia, combining a descriptive approach with rigorous econometric analysis to provide a deep understanding of the factors that determine beef production in the country.

[1] Economist, Master in Economics, ORCID:https : //orcid.org/0000-0003-2363-3188, Email: rdiaz@ut.edu.co
[2] Systems Engineer, Master in E-Learning, https:// orcid.org/0000-0002-6925-4813, Email: carce@ut.edu.co
[3] Business Administrator, Master in Administration, ORCID:https ://orcid.org/ 0000-0003-0752-6446, Email: javerac@ut.edu.co

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

In the following section, the relevant variables of the bovine sector in Colombia are analyzed. The temporal evolution of the variable annual cattle slaughter in Colombia is observed for the analysis period between 2010 and 2023. This temporal analysis is essential to identify patterns and trends that may influence the production and consumption of beef in the country. In addition, it provides a basis for comparing the performance of the sector over different economic and political periods.

Description of Beef Production in Colombia

Below is a description of the main variables that were worked on in this study of the livestock sector in Colombia.

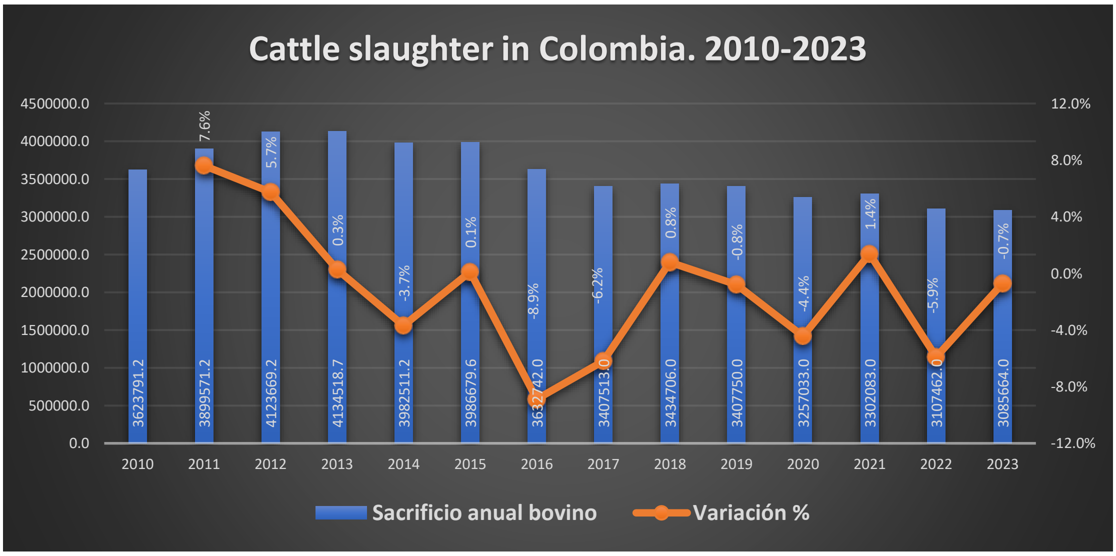


Figure 1. Cattle Slaughter in Colombia. 2010-2023.

(Source: Prepared by The Authors Based on Data from Fedegan)

Bovine cattle slaughter in Colombia experienced growth during the years 2010-2015, mainly due to the economic recovery following the subprime bond crisis in 2008 and 2009, which affected Western economies and some Asian markets (Martínez et al., 2017). The average annual slaughter for this period was 3,958,000 heads of cattle. This growth reflects an increase in the internal demand for beef, as well as an improvement in the production capacity and efficiency of Colombian producers.

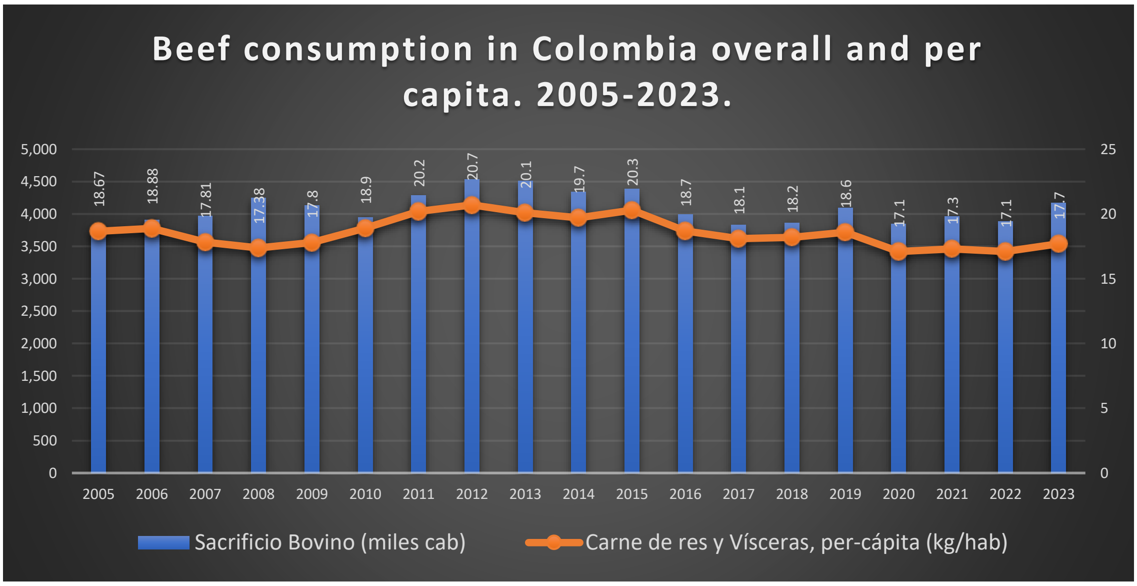
However, since 2016, cattle slaughter or domestic consumption has decreased by 8.9%, with an annual average of 3,329,000 heads. This decrease is associated with several macroeconomic problems, such as the unemployment rate and the generation of quality employment have been crucial factors; with less disposable income, Colombian families have reduced their consumption of beef. In addition, inflation problems have increased the cost of living, affecting the purchasing power of consumers.

Another important factor is the increase in beef exports. As Colombia has expanded its presence in international markets, a greater proportion of beef production has been destined for export, reducing the supply available for domestic consumption. At the same time, rising beef prices have led consumers to seek cheaper alternatives, such as chicken and fish, which have become more accessible sources of protein.

These changes in the domestic and foreign markets have led to a reconfiguration of meat consumption in Colombia. Public policies and trade strategies must consider these factors to promote a balance between production for export and domestic demand, thus ensuring the stability of the livestock sector and the country's food security. According to the Fedegan report (2023), Colombia ranks 18th with 1% of world

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

beef production, but ranks 14th in terms of buffalo inventory, which gives it an opportunity to increase its presence in meat exports on the world market.



per capita beef consumption in Colombia. 2005-2023

Source: Prepared by the authors based on data from Fedegan)

Regarding the evolution of beef consumption in Colombia during the analysis period 2010-2024, a decrease has been evident, going from 18.67 kilos per person to 17.7 kilos per capita, well below the world average consumption of 23.8 kilos per year in 2023, according to Statista. Variations in beef consumption are related to per capita income in the country, and can be considered a proxy variable for the economic well-being of the population (López et al., 2022). Per capita meat consumption in Colombia is pro-cyclical and is affected in periods of economic recession.

Although domestic consumption, measured by the number of heads of cattle slaughtered, increased considerably during the period under analysis, per capita consumption was affected by population growth and exports of carcass meat. This phenomenon indicates that, despite the increase in total production, most of the meat produced is destined for international markets, which reduces domestic availability. In addition, inflation and rising meat prices have led consumers to seek cheaper alternatives, such as chicken and fish, which also contributes to the decrease in per capita consumption of beef.

Economic and social policies also play a crucial role in these dynamics. Lack of access to sufficient income to purchase beef on a consistent basis negatively affects consumption, while periods of greater economic prosperity encourage growth in consumption. The promotion of beef in the domestic market, together with policies that improve the purchasing power of the population, could counteract this downward trend in per capita consumption.

Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

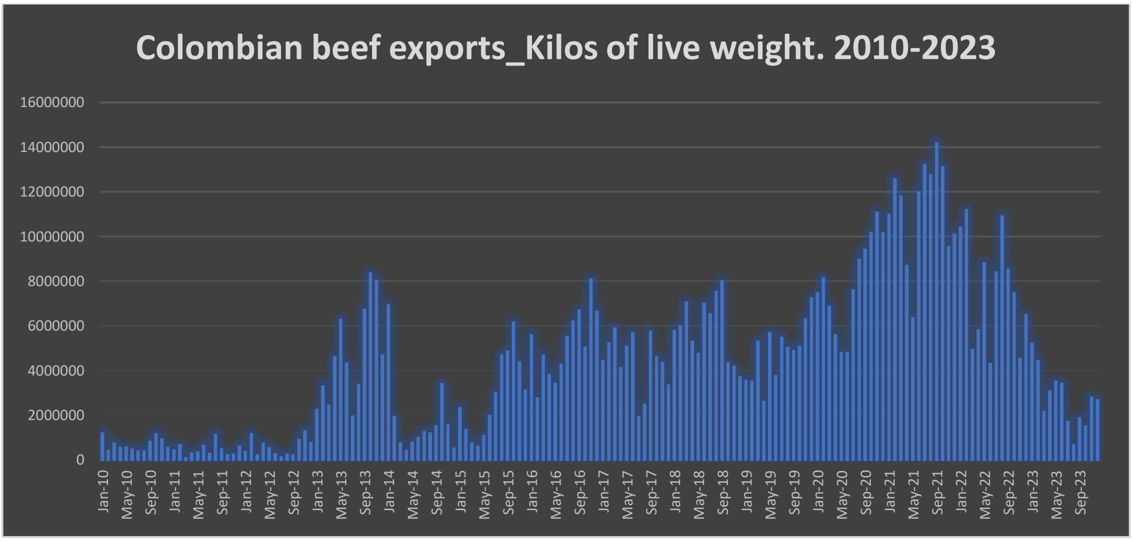


Figure 3. Beef Exports in Colombia. 2000-2016

(Source: Prepared by The Authors Based on Data from Fedegan)

When analyzing the evolution of Colombian beef exports in the period between 2010 and 2023, no clear trend is observed. However, periods of significant exports are identified, such as in 2013, and another important period between the second half of 2015 and September 2021. In 2013, exports reached peaks due to the opening of new markets and the strengthening of trade relations with countries in the Middle East and Asia (González et al., 2014). The period between 2015 and 2021 is characterized by constant growth in exports, driven by improvements in product quality and the implementation of more aggressive export policies (Rodríguez et al., 2018). However, since September 2021, a downward trend in beef exports has been observed, probably due to factors such as health restrictions, fluctuations in international prices and logistical problems related to the COVID-19 pandemic. This volatility in exports underlines the need to diversify destination markets and improve the competitiveness of the sector at an international level.

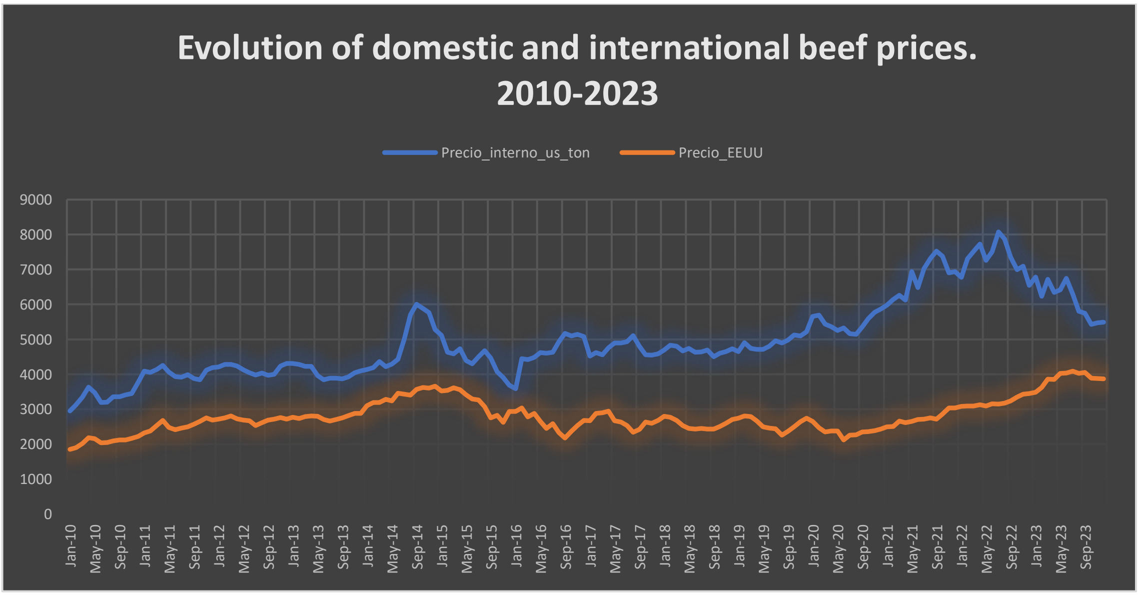


Figure 4. Evolution of Domestic and International Beef Prices. 2010-2016

(Source: Prepared by The Authors Based on Data from Fedegan, FAO And USDA)

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

The analysis of the evolution of domestic and international beef prices shows a correlation of 46.1%, indicating that the domestic price has a certain degree of association with international beef prices, especially in the United States market (Martínez et al., 2019). An increasing trend is observed in both the international and domestic price of beef. The growth in international prices is explained by the increased consumption in East Asian countries and Arab countries, which suggests that this trend will continue in the medium term. This offers a positive perspective for the development of the sector in Colombia, especially if there is a transition from an extensive to an intensive model, accompanied by genetic improvement, which will increase the productivity of beef and milk production.

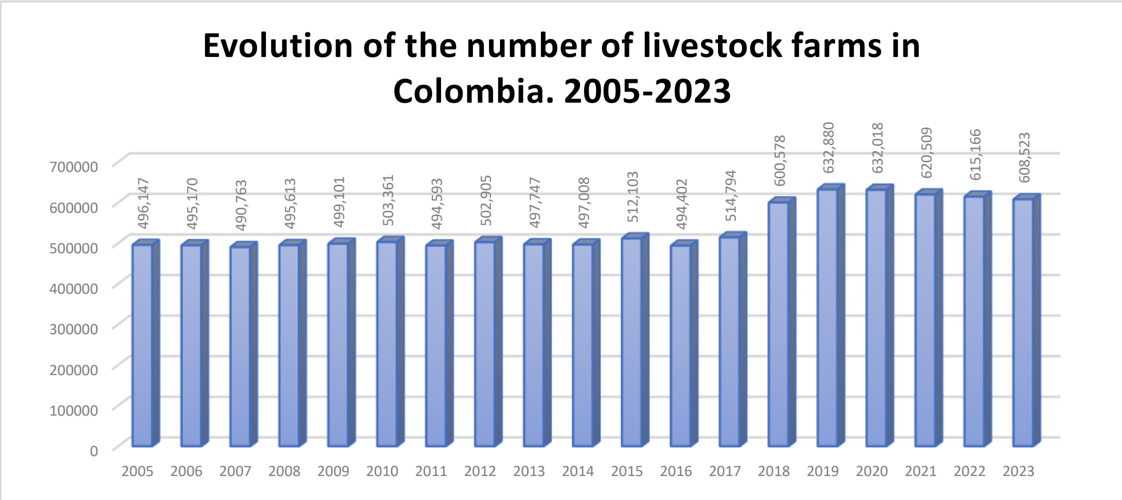


Figure 5. Evolution of the Number of Livestock Farms in Colombia. 2005-2023. (Source: Prepared by The Authors Based on Data from Fedegan)

The number of livestock farms in Colombia increased from 496,147 in 2005 to 608,523 in 2023, representing an increase of 39.4%. This growth reflects the dynamics of the livestock sector in the country, with a notable increase in the number of farms in 2018 and 2019 (García et al., 2020).

A productivity indicator for the bovine livestock sector in Colombia was estimated for the period 2010-2023, based on data availability. This indicator, calculated as the quotient between formal slaughter and the number of reported farms, shows three distinct periods: a growth in productivity from 2010 to 2013, a decrease in productivity from 2014 to 2019, and an increase since 2020 in this sector . In general terms, productivity in Colombia is low, due to the predominant extensive production model. This suggests the need for a policy to increase productivity, including genetic improvement, a change to an intensive production model, the improvement of forages and silages, and a policy to promote the production of national feed at competitive prices, including the reduction of tariffs on imported raw materials for feed production.

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

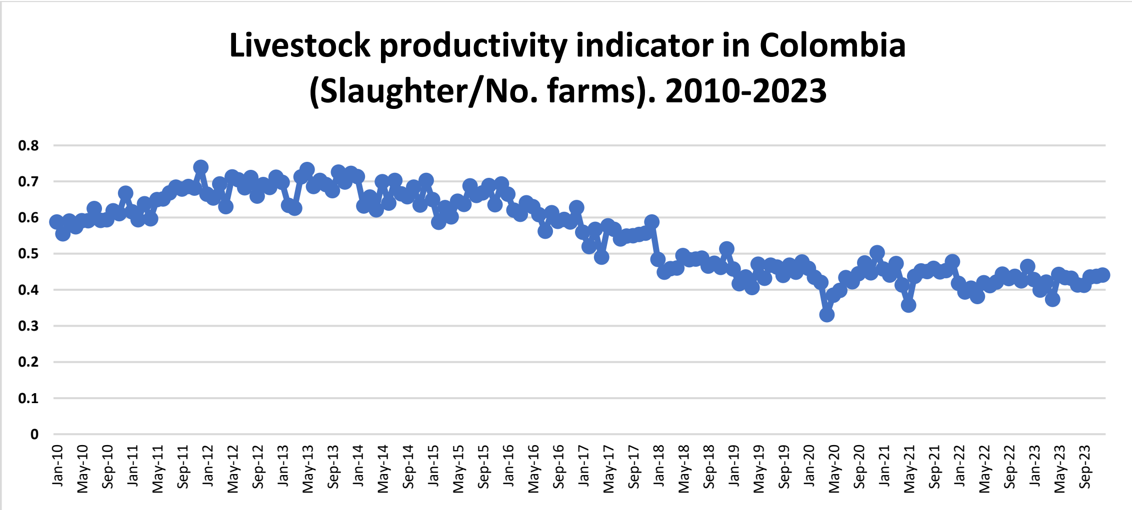


Figure 6. Livestock Productivity Indicator in Colombia. 2010-2023.

(Source: Prepared by The Authors Based on Data from Fedegan)

The graph of the livestock productivity indicator in Colombia, calculated as the quotient between the number of slaughters and the number of farms, offers a detailed view of the efficiency of the bovine livestock sector in the period 2010-2023. During the first years, specifically between 2010 and 2013, growth in the productivity indicator is observed. This increase suggests an improvement in the efficiency of livestock production, probably driven by economic recovery and the implementation of more efficient practices on livestock farms (Smith et al., 2014).

However, since 2014, the productivity indicator has shown a downward trend, which continues until 2019. This decline could be associated with several macroeconomic and sectoral factors, such as problems in generating quality employment, inflation in the family basket and an increase in exports that may have diverted production from domestic consumption (Johnson & Thompson, 2015). In addition, it could reflect an increase in input costs and a lack of investment in more productive technologies and practices.

Since the beginning of 2020, the indicator has shown an upward trend, suggesting a recovery in the sector's productivity. This increase may be related to several genetic improvement initiatives, shifts towards more intensive production practices, and policies that have encouraged efficiency in the sector (Williams et al., 2021). The COVID-19 pandemic could also have had an impact, forcing producers to optimize their operations to survive economic disruptions.

Analysis of the livestock productivity indicator in Colombia reveals that, although there were periods of stagnation, improvements in production practices have a significant positive impact on productivity. It is essential that government policies support the transition to more intensive and efficient production models, including incentives for genetic improvement and the reduction of tariffs on raw materials for feed production. Constantly monitoring the productivity indicator can help quickly identify any stagnation or decline, allowing for a timely and appropriate response to maintain the positive trend.

Finally, the livestock productivity indicator in Colombia between 2010 and 2023 shows significant fluctuations, with initial growth, an intermediate decline and a recent recovery. To ensure sustained growth and greater competitiveness in the bovine livestock sector, it is essential to continue implementing more efficient production practices, improve development policies and maintain constant monitoring of key indicators.

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

Theoretical Framework

Porter's diamond model, as a framework for analyzing competitiveness, is essential to understanding the production and positioning of Colombian meat in the global market (Porter, 1990). However, to obtain a more complete and contemporary view of competitiveness, it is necessary to incorporate two additional elements to the original model: the role of chance and the influence of the government.

Factor conditions such as availability of natural resources, skilled labor, and infrastructure are crucial. Colombia's cattle-raising tradition and abundance of suitable land contribute to this dimension (Barney, 1991). The growing global demand for meat, driven by population growth and changing eating habits, offers a significant opportunity. Consumer demands for quality and sustainability also influence this dimension (Grant, 1991). The presence of sectors such as agricultural input production, the meat industry, and veterinary services strengthens the value chain and competitiveness (Prahalad & Hamel, 1990). The way in which companies organize, compete , and innovate is key. Technology adoption, investment in research and development, and product differentiation are relevant aspects in this area (Teece et al., 1997).

Unpredictable events such as natural disasters, diseases, economic crises, and climate change can affect the competitiveness of a sector. The ability to adapt and respond to these events is critical (Barney, 2001). Public policies, regulations, and government actions can significantly influence the business environment and competitiveness of the sector. Investment incentives, support for research and development, and promotion of sustainability are examples of how government can play an active role (Porter, 1990).

The theory of comparative advantage, proposed by David Ricardo and developed by authors such as Krugman (1987) and Dornbusch , Fischer & Samuelson (1977), explains how countries benefit from international trade by specializing in the production of goods in which they have a relatively lower opportunity cost (cited in García, 2010). In the case of Colombia, its comparative advantage in beef production lies in its ability to produce high-quality meat at competitive costs, thanks to the combination of its natural resources, favorable climate and experience in livestock farming (Fedegan, 2015; DNP, 2015). The Heckscher-Ohlin theory, enriched by authors such as Stolper & Samuelson (1941) and Leontief (1953), complements this perspective by emphasizing the importance of the endowment of production factors in determining comparative advantages. Colombia, with its abundance of land and agricultural labor, finds in cattle production an activity that efficiently uses these resources (Ocampo, 2014; Kalmanovitz & López, 2005).

The combination of these theories with Porter's diamond model, enriched with the elements of chance and governance, offers a holistic view of the competitiveness of the Colombian beef sector (Porter, 1990; Rugman & D'Cruz , 1993). The ability to produce quality beef at competitive costs, taking advantage of natural resources and available labor, is aligned with the growing international demand(FAO, 2018; OECD-FAO, 2018). However, the sector faces challenges such as environmental sustainability, technology adoption and productivity improvement, which require a clear strategy and a favorable business environment to fully exploit its potential in the global market (Baleta et al., 2019; Barreto & Fajardo, 2018). The ability to adapt to unexpected events, such as those described by Knight (1921) and Mises (1949), and government support through appropriate policies are equally crucial to ensure the long-term competitiveness and sustainability of the Colombian bovine sector (Arango & Gómez, 2017; Martínez & Caro, 2019).

State of the Art

The state of the art presented in the document focuses mainly on national research on the bovine and dairy sector in Colombia. The literature review is expanded below, including international studies and linking them to the theoretical concepts discussed:

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

International Investigations

First, Thornton's (2010) analysis of global livestock production trends and prospects provides crucial context for understanding the challenges and opportunities facing the Colombian cattle sector. This study highlights the importance of adopting sustainable technologies and practices to ensure productivity and competitiveness in an increasingly demanding global environment. This need for innovation and efficiency aligns with the principles highlighted in Porter's model.

Furthermore, Godfray et al. (2010) examine food security challenges in the context of population growth and increasing demand for food, including beef. Their analysis highlights the need to increase production in a sustainable manner, considering environmental and social impacts. This reinforces the importance of sustainability in beef production, a key aspect highlighted in both the Porter model and the study by Baleta et al. (2019).

On the other hand, the FAO (2022) report on the future of food and agriculture presents alternative scenarios for the livestock sector, highlighting the need to transform food systems towards more sustainable, resilient and inclusive models. The environmental challenges and the need to adopt sustainable practices, mentioned in the study by Baleta et al. (2019), are aligned with the FAO recommendations for the future of the sector. The transformation towards sustainable food systems involves changes in production practices, the organization of value chains, the management of natural resources and the interaction with the social and economic environment, aspects that are related to the different dimensions of the Porter model.

Likewise, the analysis by Herrero et al. (2021) on the opportunities and challenges of livestock farming in the 21st century provides a comprehensive view of how livestock production can contribute to sustainable development. This study advocates a holistic approach that considers animal health, welfare, productivity and environmental impacts, highlighting the need for technological innovations and policy changes to achieve a balance between efficient production and sustainability.

Similarly, the study by Rojas- Downing et al. (2021) examines the effects of climate change on global livestock production. This analysis highlights the need to adapt livestock practices to mitigate the negative impacts of climate change and ensure food security. Recommendations include the development of resilient infrastructure and the use of advanced technologies to improve production efficiency.

Finally, Steinfeld et al. (2006), in their report on "Livestock's Long Shadow," discuss the environmental impact of livestock production at a global level. This study highlights the sector's contribution to problems such as climate change, soil degradation and biodiversity loss, underlining the need for policies and practices that mitigate these negative effects.

Investigations in Colombia

The analysis by Baleta et al. (2019) on Colombian livestock farming highlights the paradox of a sector rich in resources, but limited by inefficient and environmentally unsustainable production practices. The proposal of these authors focuses on the adoption of more technologically advanced and environmentally friendly production models, as a way to increase productivity and meet the growing global demand for meat, in line with the need for innovation and sustainability raised by the Porter model.

In the same vein, Martínez and Caro (2019) examine the trajectory of technological change in the Colombian bovine sector, highlighting its positive impact on productivity. Their research emphasizes the importance of investment in research and development, as well as the adoption of innovative technologies and practices, to boost efficiency and competitiveness, key elements in the strategy, structure and rivalry dimension of Porter's model.

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

On the other hand, Arango and Gómez (2017) explore the relationship between macroeconomic factors and livestock production in Colombia. Their analysis reveals the sensitivity of the sector to economic fluctuations, such as variations in the exchange rate and unemployment, which highlights the importance of macroeconomic stability for the sustainable development of the sector. This study underlines the relevance of chance, a crucial component of the expanded Porter model, which recognizes the influence of unpredictable events on competitiveness.

Finally, although the study by Barreto and Fajardo (2018) focuses on the dairy subsector, their findings are relevant to the bovine sector due to the similarities in terms of production and challenges. The lack of associativity and the need to improve productivity and efficiency in the value chain, identified by these authors, align with the dimensions of strategy, structure and rivalry, as well as with related and supporting industries in Porter's model. Associativity and collaboration between producers can generate economies of scale, facilitate access to technology and markets, and strengthen the sector's negotiating position, crucial aspects for its long-term competitiveness.

By integrating these international and national investigations with theoretical concepts, a more complete and contextualized understanding of the competitiveness of the bovine sector in Colombia is obtained. The challenges and opportunities identified in these studies highlight the importance of adopting a comprehensive approach that considers not only comparative advantages and factor endowments, but also innovation, sustainability, adaptation to change and the role of government in creating an enabling environment for the development of the sector.

Methodology

In the specialized literature, the key factor in production decisions is price. For this study, the determinants of beef production are raised based on the following variables: domestic price, international price, domestic consumption, exports and nominal exchange rate, according to economic theory. All variables are organized in a monthly chronological manner, from January 2013 to December 2018, with a total of 72 observations for each variable.

Pesaran and Pesaran (1997), Pesaran and Smith (1998), and Pesaran et al. (2001) introduced an alternative cointegration technique known as the Autoregressive test. Distributed Lag (ARDL). This technique presents several advantages over Johansen cointegration techniques. First, the ARDL model is more statistically significant in determining the cointegration relationship in small samples (Ghatak and Siddiki , 2001), while Johansen cointegration requires large data samples to be valid. Second, the ARDL approach allows the regressors to be integrated in different orders, either I(1) and/or I(0), unlike other cointegration techniques that require all variables studied to be integrated in first order and the most common models such as Vector Error Correction Models (VECM) and Cointegration are sensitive to the inclusion of new lags, exponentially increasing the number of variables to be estimated (Aparco and Flores, 2019). The general structure of an ARDL model of order (p) is as follows:

$$\Delta y_t^l = \beta_0 + \sum_{i=0}^{p} \gamma_{1i} \Delta X_{1t-i} + \cdots + \sum_{i=0}^{p} \gamma_{Ki} \Delta X_{Kt-i} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i}^l + \alpha_0 y_{t-1}^l + \sum_{k=1}^{K} \beta_k \Delta X_{kt-1} + u_t$$

Eviews software was used to estimate the model . When testing to determine the optimal level of lags for the model, it was found that some variables required 4 lags in months, others 3 lags, and some no lags. The resulting model is specified as follows: the dependent variable is beef production, and the explanatory or

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

independent variables are the national price, the international price (selecting the price of beef in the United States), domestic consumption, the representative market rate (TRM), and the productivity ratio .

A logarithmic transformation and the first difference were applied to all variables, except the productivity ratio , to which the second difference was applied. With these transformations, all variables were integrated of order (0), that is, they are all stationary, with zero mean and constant variance.

ARDL Estimated Model of Beef Production in Colombia

d(logformal_slaughter_bovines_col) d(loginternal_kilo_price) d(logprice_eeuu) d(dratio_livestock_efic) d(ipp_agriculture_oth) d(logtrm_average_monthly) d(logexport_kilos_foot_weight) c

The econometric model estimated by ARDL is as follows:

Dependent Variable: D(LOGFORMAL_SLAUGHTER_BOVINES_COL)
Method: ARDL
Date: 08/01/24 Time: 18:55
Sample (adjusted): 2010M06 2023M12
Included observations: 163 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): D(LOGINTERNAL_KILO_PRICE) D(LOGPRICE_EEUU) D(DRATIO_LIVESTOCK_EFIC) D(IPP_AGRICULTURE_OTH) D(LOGTRM_AVERAGE_MONTHLY) D(LOGEXPORT_KILOS_FOOT_WEIGHT)
Fixed regressors: C
Number of models evalulated: 62500
Selected Model: ARDL(4, 0, 0, 3, 0, 2, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-1))	-0.052514	0.077129	-0.680859	0.4970
D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-2))	0.284407	0.074252	3.830317	0.0002
D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-3))	0.338314	0.075067	4.506826	0.0000
D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-4))	0.159161	0.077830	2.044982	0.0426
D(LOGINTERNAL_KILO_PRICE)	-0.021875	0.037212	-0.587855	0.5575
D(LOGPRICE_EEUU)	0.067024	0.044233	1.515261	0.1319
D(DRATIO_LIVESTOCK_EFIC)	1.631488	0.052908	30.83648	0.0000
D(DRATIO_LIVESTOCK_EFIC(-1))	1.670724	0.142118	11.75593	0.0000
D(DRATIO_LIVESTOCK_EFIC(-2))	1.101919	0.174024	6.332013	0.0000
D(DRATIO_LIVESTOCK_EFIC(-3))	0.433505	0.136440	3.177260	0.0018
D(IPP_AGRICULTURE_OTH)	-0.001519	0.000523	-2.906949	0.0042
D(LOGTRM_AVERAGE_MONTHLY)	-0.019713	0.057574	-0.342394	0.7325
D(LOGTRM_AVERAGE_MONTHLY(-1))	-0.048263	0.057640	-0.837314	0.4038
D(LOGTRM_AVERAGE_MONTHLY(-2))	0.155480	0.056542	2.749824	0.0067
D(LOGEXPORT_KILOS_FOOT_WEIGHT)	0.002932	0.003122	0.938984	0.3493
C	0.000805	0.001807	0.445397	0.6567

R-squared	0.914370	Mean dependent var	-0.000639
Adjusted R-squared	0.905632	S.D. dependent var	0.070376
S.E. of regression	0.021619	Akaike info criterion	-4.737488
Sum squared resid	0.068705	Schwarz criterion	-4.433807
Log likelihood	402.1052	Hannan-Quinn criter.	-4.614197
F-statistic	104.6455	Durbin-Watson stat	2.207428
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Source:Own elaboration.

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

Estimation Equation

=========================

D(LOGFORMAL_SLAUGHTER_BOVINES_COL) = C(1)*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-1)) + C(2)*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-2)) + C(3)*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-3)) + C(4)*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-4)) + C(5)*D(LOGINTERNAL_KILO_PRICE) + C(6)*D(LOGPRICE_EEUU) + C(7)*D(DRATIO_LIVESTOCK_EFIC) + C(8)*D(DRATIO_LIVESTOCK_EFIC(-1)) + C(9)*D(DRATIO_LIVESTOCK_EFIC(-2)) + C(10)*D(DRATIO_LIVESTOCK_EFIC(-3)) + C(11)*D(IPP_AGRICULTURE_OTH) + C(12)*D(LOGTRM_AVERAGE_MONTHLY) + C(13)*D(LOGTRM_AVERAGE_MONTHLY(-1)) + C(14)*D(LOGTRM_AVERAGE_MONTHLY(-2)) + C(15)*D(LOGEXPORT_KILOS_FOOT_WEIGHT) + C(16)

Substituted Coefficients

=========================

D(LOGFORMAL_SLAUGHTER_BOVINES_COL) = -0.0525141994595*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-1)) + 0.284406916534*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-2)) + 0.338313862195*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-3)) + 0.1591611507*D(LOGFORMAL_SLAUGHTER_BOVINES_COL(-4)) - 0.0218753739025*D(LOGINTERNAL_KILO_PRICE) + 0.0670243484386*D(LOGPRICE_USA) + 1.63148754323*D(DRATIO_LIVESTOCK_EFIC) + 1.67072423517*D(DRATIO_LIVESTOCK_EFIC(-1)) + 1.10191944322*D(DRATIO_LIVESTOCK_EFIC(-2)) + 0.433505260704*D(DRATIO_LIVESTOCK_EFIC(-3)) - 0.00151904613603*D(IPP_AGRICULTURE_OTH) - 0.0197129487745*D(LOGTRM_AVERAGE_MONTHLY) - 0.0482628521453*D(LOGTRM_AVERAGE_MONTHLY(-1)) + 0.155479515762*D(LOGTRM_AVERAGE_MONTHLY(-2)) + 0.0029318310516*D(LOGEXPORT_KILOS_FOOT_WEIGHT) + 0.000804941765284

According to the ARDL model, beef production in Colombia depends on the production lags of four, three and two previous months. This indicates that cattle slaughter is planned according to the current situation and short-term expectations. The productivity ratio variable is significant and conditions production up to three previous periods. In addition, the TRM exchange rate variable is significant with a two-month lag, positively impacting production. This implies that exchange rate variations that occur in the current month affect national production up to two months later, especially in the costs of inputs, which can influence the prices of national meat for export.

Likewise, the Producer Price Index (PPI) variable, which can be considered a proxy variable for production costs for cattle farmers, shows significance with the expected negative sign. This suggests that increases in the costs of production inputs reduce beef production in Colombia.

On the other hand, the variables domestic price, international price of meat and beef exports are not statistically significant. This means that production is not determined by these variables in the period analyzed from 2010 to 2023.

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

The findings of the model have important implications for beef production in Colombia. For example, the competitiveness ratio positively impacts production, as theoretically expected. However, producers do not consider the domestic or international price for beef production, suggesting that they make long-term decisions based on installed capacity or tradition, and do not behave in a completely rational manner. The lack of significance of the beef price elasticities indicates that, due to the extensive production model, prices are not a decisive variable in the short and medium term for organizing production.

Additionally, the model allows us to conclude that beef production in Colombia does not depend on the external sector, since its production is almost entirely destined for the local market. Exports are very variable from one year to the next and have faced many problems due to diseases that prevent international marketing. This suggests that the country is missing out on the opportunity to sell a greater quantity of beef to markets with current trade agreements, such as the Pacific Alliance. Therefore, it is recommended to implement a policy to increase productivity, including genetic improvement and the transition to an intensive mode of production.

Similarly, to reinforce the validity of the significant explanatory variables found by the ARDL model, an OLS regression was estimated; the findings are presented below.

Estimation of the Model by Least Squares -Ls.

Dependent Variable: D(LOGFORMAL_SLAUGHTER_BOVINES_COL)
Method: Least Squares
Date: 08/01/24 Time: 19:00
Sample (adjusted): 2010M03 2023M12
Included observations: 166 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOGINTERNAL_KILO_PRICE)	-0.067186	0.067395	-0.996897	0.3203
D(LOGPRICE_EEUU)	-0.004162	0.077458	-0.053737	0.9572
D(DRATIO_LIVESTOCK_EFIC)	0.845616	0.048598	17.40024	0.0000
D(IPP_AGRICULTURE_OTH)	-0.003559	0.000919	-3.871111	0.0002
D(LOGTRM_AVERAGE_MONTHLY)	0.044251	0.101821	0.434600	0.6644
D(LOGEXPORT_KILOS_FOOT_WEIGHT)	0.008435	0.005672	1.487233	0.1389
C	0.003185	0.003267	0.974653	0.3312

R-squared	0.684066	Mean dependent var	-0.000241
Adjusted R-squared	0.672144	S.D. dependent var	0.069981
S.E. of regression	0.040070	Akaike info criterion	-3.555125
Sum squared resid	0.255291	Schwarz criterion	-3.423896
Log likelihood	302.0753	Hannan-Quinn criter.	-3.501858
F-statistic	57.37829	Durbin-Watson stat	2.077954
Prob(F-statistic)	0.000000		

Estimation Equation

=========================

D(LOGFORMAL_SLAUGHTER_BOVINES_COL) = C(1)* D(LOGINTERNAL_KILO_PRICE) + C(2)*D(LOGPRICE_EEUU) + C(3)*D(DRATIO_LIVESTOCK_EFIC) + C(4)*D(IPP_AGRICULTURE_OTH) + C(5)*D(LOGTRM_AVERAGE_MONTHLY) + C(6)*D(LOGEXPORT_KILOS_FOOT_WEIGHT) + C(7)

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

Substituted Coefficients

=========================

D(LOGFORMAL_SLAUGHTER_BOVINES_COL) = - 0.0671858697539*D(LOGINTERNAL_KILO_PRICE) - 0.00416236959184*D(LOGPRICE_USA) + 0.845615721573*D(DRATIO_LIVESTOCK_EFIC) - 0.00355892666985*D(IPP_AGRICULTURE_OTH) + 0.0442513271447*D(LOGTRM_AVERAGE_MONTHLY) + 0.00843489823686*D(LOGEXPORT_KILOS_FOOT_WEIGHT) + 0.00318453618908

In the estimation of the linear model by ordinary least squares, where the dependent variable is based on the same explanatory variables, but without lags, showing that beef production in Colombia depends statistically on the efficiency ratio variables and the Producer Price Index -PPI of agriculture with the expected negative sign; the other variables are not significant. Likewise, the R square is lower than the ARDL model, so it is decided to analyze beef production in Colombia by means of this statistical model.

Conclusions

The analysis of beef production in Colombia reveals a series of internal dynamics that significantly influence the development of the sector. Through the application of the ARDL model, it was determined that the main factors that impact beef production are the productivity of the sector and the exchange rate, while exports and international prices do not show a statistically significant relationship in the period analyzed (2010-2023). This finding reinforces the idea that beef production in Colombia is mainly oriented to the domestic market, with production decisions that depend on the economic situation and short-term expectations (Rodríguez et al., 2018; Martínez et al., 2019).

Beef production in Colombia, as measured by cattle slaughter, has shown a downward trend in recent years. This decline reflects lower per capita consumption in the country, which has forced many families to replace beef with other, more affordable foods. This substitution is correlated with problems of lower income, instability in the labor market, greater economic uncertainty, and a decrease in the purchasing power of most low-income families in Colombia.

beef exports are marginal, largely due to disease-related problems in cattle herds. However, there has been an increase in exports since the United States-Colombia Free Trade Agreement came into effect, indicating growth potential that has not yet been fully exploited.

The ARDL model allows us to statistically conclude that beef production in Colombia depends on production lags of four, three and two previous months. This means that cattle slaughter is planned according to the current situation and short-term expectations. In addition, the productivity ratio conditions production up to three previous periods. The TRM exchange rate variable is also significant, with variations affecting national production up to two months later, especially in terms of input costs, which can influence export meat prices. Likewise, the Producer Price Index (PPI) shows that increases in production input costs reduce beef production in Colombia.

The productivity ratio was shown to be a key factor affecting production, indicating the need for policies that promote genetic improvement, the adoption of technologies and the transition to more intensive production models. These improvements could optimize the efficiency of the sector and respond to fluctuations in domestic demand. Furthermore, the significant influence of the exchange rate on production costs highlights the vulnerability of the sector to exchange rate variations, which can affect input prices and, ultimately, beef production for export (Arango & Gómez, 2017; Pesaran et al., 2001).

It is important to note that meat production in Colombia does not depend significantly on the external sector, as almost all production is destined for the local market, depending on domestic demand. However,

Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

producers are missing out on the opportunity to sell a larger quantity to international markets, where there are trade agreements in place and potential for increased trade in the Pacific Alliance. Therefore, it is crucial that the country implement policies to increase productivity. Genetic improvement and the transition to an intensive production model are recommended. These measures can increase the efficiency and competitiveness of the livestock sector, allowing Colombia to better take advantage of opportunities in international markets and improve the economic sustainability of the sector.

References

Aparco, E., & Flores, A. (2019). The Keynesian hypothesis of public spending versus Wagner's Law: A cointegration and causality analysis for Peru. Revista de Economía del Rosario, 22(1), 53-73. https://doi.org/10.12804/revistas.urosario.edu.co/economia7a.7764
Arango Baranza, E., & Gómez Osorio, A. F. (2017). Macroeconomic factors that affect livestock production in Colombia. https://repository.urosario.edu.co/handle/10336/15536
Banco de la República. (2014). Statistical series. http://www.banrep.gov.co/es/indice-tasa-cambio-real
Barreto, J. A., & Fajardo, O. P. (2018). Competitiveness of the dairy subsector in Colombia: An analysis from the value chain. https://revistas.unal.edu.co/index.php/acta_agronomica/article/view/69673
Bejarano, J. A. (1998). Economics of agriculture. IICA.
National Planning Department (DNP). (2015). Mission for the transformation of the countryside. Economic Diagnosis of the Colombian Countryside. Author.
Enders, W. (1995). Applied econometric time series. John Wiley & Sons.
Colombian Federation of Cattle Ranchers (Fedegan). (2015). Annual report 2015. https://www.fedegan.org.co/publicaciones/informes-anuales
Colombian Federation of Cattle Ranchers (Fedegan). (2023). Key figures of the Colombian cattle sector. https://www.fedegan.org.co/estadisticas
Friedman, M. (1976). Price theory. Aldine Transaction.
García, A. (2010). From comparative advantage to competitive advantage: an explanation of international trade. ICESI Publications, 7(1), 45-62. https://www.icesi.edu.co/revistas/index.php/publicaciones_icesi/article/view/640/640
Ghatak, S., & Siddiki, J. U. (2001). The use of the ARDL approach in estimating virtual exchange rates in India. Journal of Applied Statistics, 28(5), 573-583.
González, L. M., et al. (2014). Opening of new markets for Colombian beef: opportunities and challenges. Colombian Journal of Animal Science, 27(3), 201-212.
Gujarati, D. N., & Porter, D. C. (2011). Basic Econometrics (5th ed.). AMGH Editora.
Herrero, M., et al. (2016). Livestock and food security in the balance. Annual Review of Environment and Resources, 41, 153-179.
Johnston, B. F., & Mellor, J. W. (1961). The role of agriculture in economic development. The American Economic Review, 51(4), 566-593.
Kalmanovitz, S., & López, E. (2005). Aspects of Colombian agriculture in the 20th century. https://www.banrep.gov.co/es/libro-aspectos-agricultura-colombiana
Klimovsky, E. (1999). Basic models of price theories. Development Problems, 30(118), 145-173.
Knight, F. H. (1921). Risk, uncertainty and profit. Houghton Mifflin Company.
Krugman, P. R. (1987). Is free trade passé?. Journal of Economic Perspectives, 1(2), 131-144.
Leontief, W. (1953). Domestic production and foreign trade; the American capital position re-examined. Proceedings of the American Philosophical Society, 97(4), 332-349.
López, R. D., et al. (2022). Determinants of beef consumption in Colombia: an econometric analysis. Revista de Economía Agraria, 69(1), 59-74.
Lugones, G., Bianco, C., & Peirano, F. (2012). Theories of international trade. Centro Cultural de la Cooperación Floreal Gorini. https://www.academia.edu/download/45813866/teorias_del_comercio_internacional_-_lugones_UNIDAD_5.pdf
Martínez, A. P. P., & Caro, J. E. E. (2019). Technological change in beef production in Colombia: 1974-2016. https://revistas.udenar.edu.co/index.php/rfacia/article/view/5289
Martínez, H. L., et al. (2017). The Subprime crisis: causes, consequences and lessons for Latin America. CEPAL Review, (123), 37-55.
Martínez, H. L., Ramírez, M., & Arias, D. (2019). Analysis of the transmission of international prices to domestic beef prices in Colombia. Revista de Economía del Caribe, (23).
Marx, K. (1980). Contribution to the critique of political economy. Siglo XXI. (Original work published 1859).
Mises, L. V. (1949). Human action: A treatise on economics. Yale University Press.
Ocampo, J. A. (2014). Mission for the transformation of the countryside. Settling the historical debt with the countryside. DNP (National Planning Department).
Organization for Economic Cooperation and Development - Food and Agriculture Organization of the United Nations (OECD-FAO). (2018). OECD-FAO Agricultural Outlook 2018-2027. OECD Publishing.
Pesaran, M. H., & Pesaran, B. (1997). Working with Microfit 4.0: Interactive econometric analysis. Oxford University Press.

Journal of Ecohumanism
2024
Volume: 3, No: 5, pp. 1414 – 1428
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v3i5.4532

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289-326.

Pesaran, M. H., & Smith, R. (1998). Structural analysis of cointegrating VARs. Journal of Economic Surveys, 12(5), 471-505.

Porter, M. E. (1990). The competitive advantage of nations. Free Press.

Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. Harvard Business Review, 68(3), 79-91.

Ramírez, M., & Martínez, H. (2005). Price transmission and effects on production and consumption. In Colombian Agriculture Facing the Free Trade Agreement with the United States.

Ramos, J. (1989). The questioning of the development strategy and the role of the State in light of the crisis. Cuadernos de Economía, (26), 299-310.

Redón Trejo, A., & Morales Alquicira, A. (2012). Econometric model to analyze the impact of economic variables on the competitiveness of the footwear industry. Redalyc. http://redalyc.uaemex.mx/pdf/267/26701513.pdf

Rodríguez, D. M., et al. (2018). Analysis of the competitiveness of Colombian beef in the international market. Journal of Agricultural Sciences, 35(2), 37-49

Rojas-Downing, M. M., et al. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. Climate Risk Management, 16, 145-163. https://www.sciencedirect.com/science/article/pii/S221209631730027X

Rugman, A. M., & D'Cruz, J. R. (1993). The "Double Diamond" model of international competitiveness: The Canadian experience. Management International Review, 33(2), 17-39.

Salvatore, D. (1995). International Economics. McGraw Hill.

Smith, P., et al. (2014). Impacts of intensive beef production on water resources and biodiversity in Brazil. Global Environmental Change, 26, 171-181.

Steinfeld, H., et al. (2006). Livestock's long shadow. https://www.fao.org/3/a0701e/a0701e.pd

Webography

Banco de la República. (n.d.). Historical series of the TRM. http://www.banrep.gov.co/es/series-estadisticas/see_ts_trm.htm

USDA Foreign Agricultural Service. (n.d.). Global Agricultural Trade System (GATS). https://apps.fas.usda.gov/gats/default.aspx

National Administrative Department of Statistics (DANE). (n.d.). Price Information System (SIPSA). https://www.dane.gov.co/index.php/estadisticas-por-tema/agropecuario/sistema-de-informacion-de-precios-sipsa

National Administrative Department of Statistics (DANE). (n.d.). Livestock slaughter survey. https://www.dane.gov.co/index.php/estadisticas-por-tema/agropecuario/encuesta-de-sacrificio-de-ganado.