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Economic impact assessment of the pandemic in a veterinary clinic

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Abstract

Objective: This technological article presents the economic assessment of a veterinary clinic that increased human contact with animals during the pandemic.
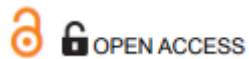**Methods:** Linear and negative binomial models were used for comparisons between years, SARIMA for semiannual forecasting, and cluster analysis to assess customer segmentation.
Results: There was growth in operations in 2020 and conservation in 2021.
Academic conclusions: Clients from two profiles found mostly sought services (neutering and vaccination) associated to some degree with the acquisition or adoption of animals, partially explaining the growth during the pandemic. The acquisition or adoption and the extra care enhanced by social isolation in the pandemic emerged to develop operations.
Practical conclusions: The article contributes to the assessment of the pet segment, which had a positive result with the pandemic's impact and a growth forecast for the next semester. It also encourages the assessment of financial, economic, and commercial analyses in evaluating veterinary clinics.

Keywords: pandemic, pet, time series, veterinary, forecast, cluster

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Resumo

Avaliação do impacto econômico da pandemia numa clínica veterinária

Objetivo: Este artigo tecnológico apresenta a avaliação econômica num mercado que intensificou o contato de humanos com animais durante o período da pandemia, o *pet* a partir dos dados de uma clínica veterinária.

Métodos: Foram utilizados modelos lineares e binomial negativo para comparações entre os anos, SARIMA para previsão semestral, e análise de conglomerado para avaliação da segmentação de clientes.

Resultados: Houve crescimento das operações em 2020 e conservação em 2021.

Conclusões acadêmicas: Clientes, de dois perfis encontrados, buscaram majoritariamente serviços (castração e vacinação) associados em certo grau à aquisição ou adoção de animais, explicando parcialmente o crescimento durante a pandemia. A aquisição ou adoção e o cuidado extra potencializados pelo isolamento social na pandemia aparentemente contribuíram para o crescimento das operações.

Conclusões práticas: O artigo contribui com a avaliação do segmento *pet* que teve um resultado positivo com o impacto da pandemia e com previsão de crescimento para o próximo semestre e fomenta a avaliação de métricas financeiras, econômicas e comerciais na avaliação de clínicas veterinárias.

Palavras-chave: pandemia, *pet*, séries temporais, veterinário, previsão, cluster

Abstracto

Evaluación del impacto económico de la pandemia en una clínica veterinaria

Objetivo: Este artículo tecnológico presenta la valoración económica de una clínica veterinaria que incrementó el contacto humano con animales durante la pandemia.

Métodos: Se utilizaron modelos binomiales lineales y negativos para comparaciones entre años, SARIMA para pronósticos semestrales y análisis de conglomerados para evaluar la segmentación de clientes.

Resultados: Hubo crecimiento en operaciones en 2020 y conservación en 2021.

Conclusiones académicas: Los clientes, de dos perfiles encontrados, buscaron en su mayoría servicios (castración y vacunación) asociados en algún grado a la adquisición o adopción de animales, explicando parcialmente el crecimiento durante la pandemia. La adquisición o adopción y el cuidado adicional potenciado por el aislamiento social durante la pandemia aparentemente surgieron para el crecimiento de las operaciones.

Conclusiones prácticas: El artículo contribuye a la valoración del segmento de mascotas, que tuvo un resultado positivo con el impacto de la pandemia y con una previsión de crecimiento para el próximo semestre, y fomenta la valoración de análisis financieros, económicos y comerciales en la evaluación de clínicas veterinarias.

Palabras clave: pandemia, mascota, series temporales, veterinaria, pronóstico, cluster

Introduction

The relationship between humans and pets is significant in the evolutionary history of Homo sapiens, playing an essential role in promoting human well-being and strengthening social bonds (Chambers et al., 2020; Paxton, 2021). In addition to psychological and emotional benefits, this relationship has driven the growth of specialized markets focused on animal care, such as food, medicines, and veterinary services (Abinpet, 2021). In Brazil, the third largest pet market in the world, the pet products sector recorded revenues of R\$68.7 billion in 2023, representing a growth of 14% over the previous year. The pet food segment accounted for 55.5% of this total, reaching R\$38.1 billion. Veterinary products (pet vet) and hygiene and well-being products (pet care) contributed R\$6.8 billion and R\$3.9 billion, respectively (Abinpet, 2021; Brasil, 2024).

The COVID-19 pandemic has brought about profound changes in patterns of social interaction, intensifying the human-animal relationship and generating new demands in the pet market (Ho et al., 2021; Holland et al., 2021). Social isolation has fostered increased pet adoptions and more attentive care by their guardians, especially in times of greater uncertainty. In addition, the economic impacts of the period varied between sectors, with the pet segment showing resilience and, in some cases, significant growth during the global health crisis. Studies have identified an increase of up to 250% in dog and cat adoptions in 2020 in several countries and substantial changes in consumer behavior, such as the expansion of online purchases of pet products (Ho et al., 2021; Kwak & Cha, 2021). In this context, veterinary clinics, playing an essential role in animal health care, have faced both challenges and opportunities. The ability to adapt to new demands and the identification of emerging consumer profiles have stood out as critical factors in sustaining the competitiveness and sustainability of these businesses. Economic indicators, such as average ticket, gross revenue, and number of monthly customers, are fundamental to understanding the economic impact of crises such as the pandemic and to base strategic decisions that increase organizational resilience.

This study investigates the economic impact of the COVID-19 pandemic on a veterinary clinic located in Botucatu, São Paulo, analyzing variations in these economic indicators and carrying out a detailed segmentation of customer profiles. More than a financial analysis, the article positions itself in the field of strategy, highlighting how data-driven decisions can strengthen organizational resilience and capture opportunities in times of crisis. The approach is based on the Resource-Based Competitive Advantage (RBV) theory, which positions data analysis capabilities

as a strategic resource for sustaining growth and competitiveness in dynamic and challenging environments.

The central hypothesis is that the pandemic has positively impacted the pet products and services market, creating new strategic opportunities for businesses that have demonstrated the ability to adapt to behavioral and environmental changes. The study contributes to the academic literature on organizational strategy and management practice by addressing these issues, offering insights into aligning economic decisions and competitive strategies in specialized and dynamic markets.

Literature Review

The COVID-19 pandemic has generated changes in pet owners' behavior, intensifying the human-pet relationship and creating demands for the veterinary market. Previous studies indicate that this period has been marked by a significant increase in pet adoption and more attentive and intensified care for pet owners, especially during social isolation (Ho et al., 2021; Holland et al., 2021). This scenario of accelerated transformation has presented challenges and opportunities for companies in the pet sector, highlighting the importance of adaptive strategies and efficient management of organizational resources.

In this context, the Theory of Resource-Based Competitive Advantage (RBV) offers a robust theoretical framework for understanding how companies can sustain their competitiveness during crises. The RBV proposes that organizations with valuable, rare, inimitable, and irreplaceable resources (VRIN) are more likely to achieve sustainable competitive advantages in their markets(Barney, 1991). In the case of the veterinary clinic analyzed, the ability to strategically collect, process, and interpret consumer data stands out as a resource for responding to the behavioral changes observed in the pet market during the pandemic.

The behavior analysis of pet owners revealed different consumer profiles, with an increase in the search for essential services, such as vaccination and castration, which are often associated with adopting new animals. In addition, the market segmentation in this study identified different consumption patterns, allowing us better to understand the demands of various groups of customers. This segmentation reflected the changes induced by the pandemic and provided input for strategically targeting, allocating staff and providing priority services. This approach reinforces the connection between the RBV and management practices in the pet sector, demonstrating how

identifying and taking advantage of strategic resources can turn challenges into growth opportunities.

Strategy literature also points out that crises often catalyze innovation and strategic adaptation (Jenelius & Cebecauer, 2020). During the pandemic, resilient and dynamic companies were able to quickly adjust their operations to meet the growing demand for animal services and products. This study positions veterinary clinics as key players in this scenario, where the ability to diversify services and invest in technologies, such as e-commerce platforms, emerges as a competitive differentiator. The segmentation identified revealed a growing interest in products aimed at exotic pets, signaling the importance of serving market niches that are often neglected.

By connecting the RBV with the practical results of this study, it is possible to see how strategic resources, such as data analysis and customer segmentation, enable adaptation to market conditions imposed by the pandemic. Integrating theoretical approaches, such as the RBV, with data-based management practices reinforces the article's relevance to literature and management practice. This perspective contributes to the field of strategy by demonstrating how companies in specialized markets can use crises as opportunities to consolidate their competitiveness.

In summary, this article's theoretical foundation establishes the RBV as the basis for understanding the dynamics of the pet market during the pandemic, integrating the emerging behaviors of guardians, segmentation strategies, and innovation practices in response to environmental changes. By articulating these elements, the study seeks to contextualize the practical findings and foster discussions about resilience and sustainable growth in small businesses in the pet sector.

Context of the reality investigated

The veterinary clinic began operations in December 2016 and is part of the pet segment. It offers various services (e.g., hospitalization, surgical procedures, vaccinations, etc.) and products (e.g., snacks, clothes, food, etc.) related to pets. It is in Botucatu (200 km from the capital), in the state of São Paulo, Brazil, with an estimated population of 148,130 inhabitants[1].

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[1] https://www.botucatu.sp.gov.br

Material and Methods

Data acquisition

The data used in this study covers the period from 2019 to December 2021 and is stored in the SimplesVet Tecnologia® management system. The system recorded information such as total consumption, number of items purchased, frequency of visits, and dates of service and classified them into services and products for later analysis.

Data pre-processing

The data used underwent a pre-processing process to ensure the quality of the analyses to be carried out. Initially, the database was evaluated to identify missing values, outliers, and record inconsistencies. Missing values in numerical variables, such as average ticket and gross revenue, represented less than 2% of total records and were imputed using the monthly median, respecting possible seasonality associated with consumption behavior. Records with missing values in categorical variables were excluded as they did not compromise the sample's representativeness.

Outliers were detected using the interquartile range (IQR) method, which considers observations outside the range $[Q1 - 1.5 \times IQR, Q3 + 1.5 \times IQR]$. These values were analyzed individually, and those associated with legitimate events, such as high-volume purchases or high-cost procedures, were kept. On the other hand, discrepant values with no operational explanation or seasonal justification were excluded to avoid distortions in the statistical results. Inconsistent records were also corrected, such as duplicates or incompatibilities between variables. Duplicates were removed, while inconsistencies, such as discrepancies between the total value of services/products and the sum of their components, were manually adjusted in the data available in the management system. Data was standardized using the Z scale to ensure comparability between variables on different scales, adjusting each variable about its mean and standard deviation. This procedure was essential for the cluster analyses and econometric models, allowing greater precision in identifying patterns and trends.

Finally, consistency tests were conducted to check that the data matched the models' assumptions. The tests confirmed the homogeneity of the variance, the absence of collinearity, and the normality of the distributions after the transformations. This ensured that the data was suitable for subsequent analysis, guaranteeing greater transparency and replicability of the study.

Justification for the Choice of Methods

The nature of the data guided the selection of the statistical methods used, the research objectives, and the relevance of the analyses carried out. Each technique was chosen considering its suitability for capturing specific data characteristics and answering the research questions. These were:

Linear and generalized models (GLMs): Linear models were used to compare continuous variables, such as average ticket and gross revenue, between the years analyzed since this approach allows trends and average variations to be identified. For the number of monthly customers, a generalized model with a negative binomial distribution was used due to the discrete and super-dispersed nature of the variable, which a normal distribution would not adequately model.

Cluster analysis with K-Means: Cluster analysis was chosen to segment customers into distinct profiles based on monthly consumption, frequency of visits, and quantity of services/products purchased. The K-Means method was selected because of its efficiency in grouping large volumes of continuous data, making it possible to identify relevant patterns for strategic business management. This choice was reinforced by its successful application in previous studies in the pet segment (Wei et al., 2016; Hill, 2020).

SARIMA modeling for time series: The SARIMA model was used to forecast half-yearly gross revenue because it robustly combines trend and seasonality components. It was selected due to the seasonal nature of the data and the method's ability to capture variations in univariate time series. The model is also widely used in economic and commercial forecasting analysis.

Multiple Correspondence Analysis (MCA): MCA was used to explore interdependencies between client profiles and categorical characteristics, such as the gender of the tutor and the type of animal cared for. This technique was chosen because it effectively visualizes relationships between qualitative variables, allowing a practical interpretation of the profiles identified.

The techniques selected were considered the most appropriate to achieve the study's objectives and guarantee robust and interpretable results. The combination of these methods makes it possible to explore the economic impact of the pandemic from different perspectives, connecting descriptive, predictive, and exploratory analyses in an integrated way.

Data processing

Statistical analyses were carried out in the R language using the RStudio integrated development environment (Version 4.1.0 (2020-06-22), RStudio, Inc.) with a significance level of 5%. The functions and packages were presented in R programming language in the format 'package::function'. The figures were constructed with a color palette distinguishable to the color blind ('ggplot2::scale_colour_viridis_d').

A priori, to qualitatively explore the temporal dynamics between 2019 and 2021 of monthly gross revenue, average monthly tickets and number of monthly customers about the start of the lockdown in Brazilian commerce (March 2020), line graphs were constructed for products only, services only and in general ('ggplot2::ggplot' and 'ggplot2::geom_line').

Next, separately for services and products, the difference in monthly gross revenue and average monthly ticket between the three years was investigated using a linear model ('stats::lm'), as well as a generalized linear model with negative binomial family adjustment for the number of monthly customers ('MASS::glm.nb'). The residual errors of the models ('stats::residuals') that showed adherence to the Gaussian distribution were examined by quantile-quantile graph ('stats::qqnorm'), histogram ('stats::hist') and by the Cramer-von Miser test ('nortest ::cvm.test'). For monthly gross revenue, this was achieved after the Box-Cox transformation (λ of 0.01761538) ('car::powerTransform'). The Breusch-Pagan test ('olsrr::ols_test_breusch_pagan') showed that the residuals of the linear models had homogeneous variance. The non-collinearity between the predictive variables in the linear models was confirmed by the variance inflation factor <5 ('olsrr::ols_coll_diag'). Therefore, the basic requirements for applying regression models were met. Multiple comparisons were made in the post-test of the models with the Bonferroni test for comparison between the qualitative predictive variables ('lme4::lsmeans' and 'multcomp::cld'). Box plots and violin plots ('ggplot2::ggplot', 'ggplot2::geom_boxplot', 'ggplot2::geom_point' and 'ggplot2::geom_violin') were constructed to present the results on the original scale of each predictor variable.

A non-hierarchical k-means clustering analysis for three groups ('stats::kmeans') was conducted a posteriori to identify customer segmentations (profiles). The non-hierarchical K-Means clustering technique was used to define the number of clusters based on statistical and visual criteria, ensuring that the partitioning chosen reflected the underlying structure of the data. Next, the elbow method was applied, which analyzes the total sum of intra-group squared errors

(SSE) as a function of the number of clusters, returning a marked reduction in SSE up to the third cluster, after which the rate of decrease became marginal, indicating that three clusters represented an adequate and economical partitioning of the data. In addition, silhouette analysis was conducted, which measures the internal cohesion and separation between clusters. The average silhouette index for the three clusters was 0.62, suggesting good clustering quality, with adequate separation between groups and low overlap. These results reinforced the choice of three clusters as the most appropriate configuration for segmenting the customers analyzed. Thus, based on these analyses, it was decided to maintain three clusters to ensure robust managerial interpretations in line with the study's objectives. This approach combined statistical validation and managerial practicality, facilitating the strategic analysis of the customer profiles identified.

The steps to identify and analyze the customer profile were duplicated, the first exclusively for services and the other for products. The k-means included monthly consumption, the number of monthly services/products, and the monthly frequency of visits to each client's clinic after standardization using a z-scale (stats::scale). The distribution of these variables and the number of clients in each profile in each year was presented by mean, standard deviation, minimum, and maximum. A chi-squared test ($\chi 2$; 'stats::chisq.test') was conducted to check whether or not the distribution of the client count in each profile was random each year. A multiple correspondence analysis (MCA; 'FactoMineR::MCA') was carried out to identify interdependencies between customer profiles and the type of service or product, customer gender, and animal species served. To do this, the matrix formed by the qualitative data was converted into a Burt table (X'X; 'GDAtools::burt') and subjected to the $\chi 2$ test to extract the residuals (observed value subtracted from the expected value) which were adjusted and standardized by the z-normal scale (observed value subtracted from the expected value divided by the square root of the residual; 'stats::chisq.test'). The Burt table represents the union of several contingency tables into a single table, enabling multiple analyses. When the occurrence of one of the classes of different variables was high at the same time, it was understood to be a significant interdependence between the qualitative variables. Therefore, residuals standardized by the z-normal scale (Z) > 1.96 determined the existence of interdependencies with a significance of 5% between the classes of qualitative variables, and the greater the distance from the cut-off point established by Z, the greater the magnitude of interdependence (Agresti, 2018). The interdependencies with the profiles were used to determine the composition of the profiles. The MCA was conducted with the Burt

table to illustrate in a two-dimensional perceptual map ('ggplot2::ggplot' and 'ggplot2::geom_point') the distribution of customer density in each profile for a qualitative judgment.

A time series forecast ('forecasting::forecasting') was conducted using a seasonal, univariate self-regressive moving average (SARIMA) model to predict the next semester's gross revenue for services and products. The forecasting models, particularly the SARIMA model for time series analysis, were validated to ensure their robustness and the reliability of the results. The validation process included dividing the data into training and test sets and applying cross-validation.

For the SARIMA model, the data was split into two parts: 80% for the training set, used to adjust the model, and 20% for the test set, reserved for evaluating the model's performance on data not used during training. This division ensured that the model was assessed in terms of its predictive capacity in a realistic scenario. In addition, rolling-origin cross-validation was carried out, which is appropriate for time series. This method allowed the model to be tested in several sequential data divisions, simulating forecasts in different future periods and assessing its consistency over time. The model's forecasts were evaluated using standardized metrics such as Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE). The MAPE showed values of less than 10%, indicating high forecast accuracy. These procedures guarantee the robustness of the models and the reliability of the results, as well as increase the study's replicability.

Thus, each variable was diagnosed by checking for trends and seasonality using qualitative graphical analysis of the decomposition of the time series ('ggplot2::autoplot' and 'stats::decompose'), stationarity analysis using the Dicky-Fuller test ('tseries::adf.test') and Kwiatkowski - Phillips - Schmidt - Shin (KPSS; 'tseries::kpss.test'), autocorrelation by the Box-Ljung test ('stats::Box.test') and adherence to the Gaussian distribution by the Cramer-Von Miser test. Due to the variation in prices that impact the average monthly ticket and the similar temporal dynamics of gross revenue and the number of customers, the forecasts were made using only monthly gross revenue.

Diagnosis and analysis of the opportunity

The results of this study show that the COVID-19 pandemic has impacted the economic performance of the veterinary clinic analyzed, especially in metrics such as average ticket, gross revenue, and number of clients. These findings align with the Resource-Based Competitive Advantage (RBV) Theory, which emphasizes the importance of strategic resources, such as analyzing data and adapting operations, to take advantage of opportunities in crisis scenarios. The clinic's ability to adjust its services and identify customer profiles with more significant loyalty potential exemplifies the practical application of RBV. Our results complement previous studies mentioned in the theoretical framework, such as Holland et al. (2021) and Ho et al. (2021), which identified changes in the behavior of pet owners during the pandemic but go further by demonstrating how these changes can be used strategically to sustain competitive advantages.

The originality of this study lies in the investigation of the economic impacts of the COVID-19 pandemic on business models that offer veterinary services and products to pets. The results showed economic growth for the veterinary clinic analyzed in the year the pandemic began (2020) and a mild increase in the following year (2021), with a growth forecast for the first half of 2022 for services and product fluctuations. This partially confirms the initial hypothesis that the social isolation caused by the COVID-19 pandemic has provided a favorable atmosphere for the pet market.

Impact of the Pandemic on the Clinic

The COVID-19 pandemic has caused national and international markets to close ('lockdown'), except for activities considered essential, such as veterinary care and the sale of pet products (Wayne & Rozanski, 2020). Therefore, this study was conducted to analyze the operations of a veterinary clinic from a temporal perspective. The exploratory analysis revealed a drop in monthly gross revenue and average monthly tickets and stagnation in the number of monthly customers in the first month of the lockdown in Brazilian commerce (March 2020), followed by exponential growth in monthly gross revenue and number of monthly customers, which was more pronounced for services than products, as well as a gradual growth in the average monthly ticket for services and a gentle drop and resumption of the average monthly ticket for products in the months following the establishment of the lockdown (Figure 1). In addition, monthly gross revenue and the number of monthly customers showed similar temporal dynamics.

The downward effect in the first month of lockdown was likely related to the insecurity and sense of panic caused by the pandemic scenario, which was reversed, and the business showed growth from the second month of lockdown onwards.

Figure 1

Monthly gross revenue and average monthly ticket per customer, including the number of monthly customers from January 2019 to December 2022 for products only, services Only, and overall
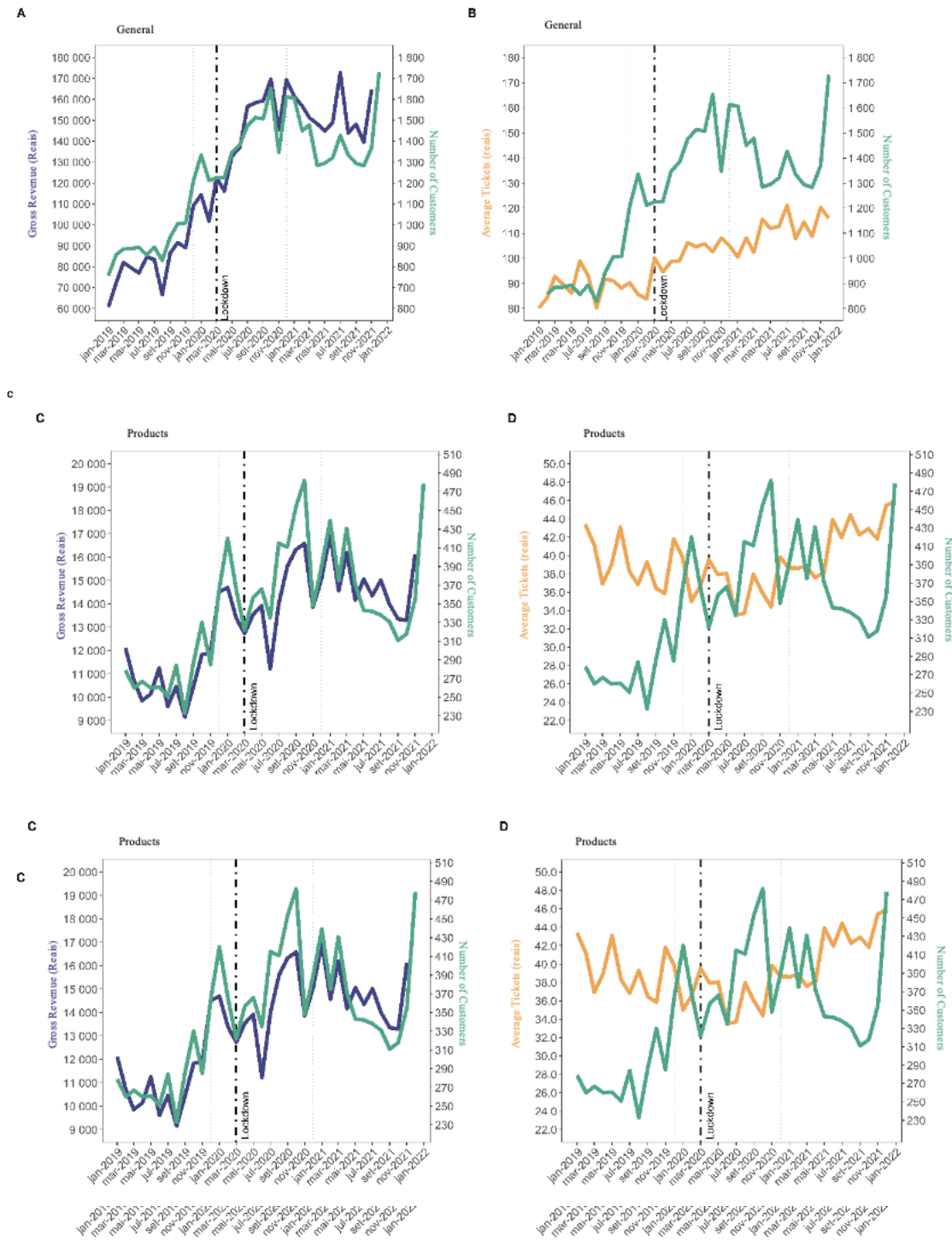
ote: The dashed line interspersed with posts indicates the month the lockdown in Brazilian commerce begins (March 2020).

Comparative Analysis of the Years

In comparisons between the years for services offered at the clinic, 2021 showed the highest average monthly ticket, while 2020 showed intermediate values and 2019 the lowest, showing growth throughout the period evaluated (Figure 2A). The same dynamic also occurred for the number of monthly clients (Figure 2C) and monthly gross revenue (Figure 2E) for services. However, 2021 and 2020 were statistically equivalent and higher than 2019, showing an increase followed by maintenance. As for products, the average ticket was lower in 2020 compared to 2021 (Figure 2B) and this decrease in the average monthly ticket can be partially explained by lower consumption of products by each customer, since the increase in the number of monthly customers around September 2020 was not accompanied by a proportional rise in monthly gross revenue in the same month. The number of customers and gross revenue from products in 2020 was the same as in 2021; both were higher than in 2019 (Figure 2D and F). These findings corroborate the results of this study of an upward trend in the business model in 2020 and 2021, which was more pronounced for services compared to products, with a slight depression for products. Like the rental of machinery used in construction, which maintained its operations during the pandemic, the results of this study show that the veterinary clinic increased its attendance and sales during the COVID-19 pandemic in 2020, which were maintained with a milder increase in the following year (2021). Thus, the business model expanded its operations in the short and medium term after the lockdown was determined, and the company's response could be interpreted as captivating and maintaining new clients.

Figure 2

Violin and box plot showing the distribution of the average monthly ticket, number of monthly customers and monthly gross revenue for services and products from January 2019 to December 2022
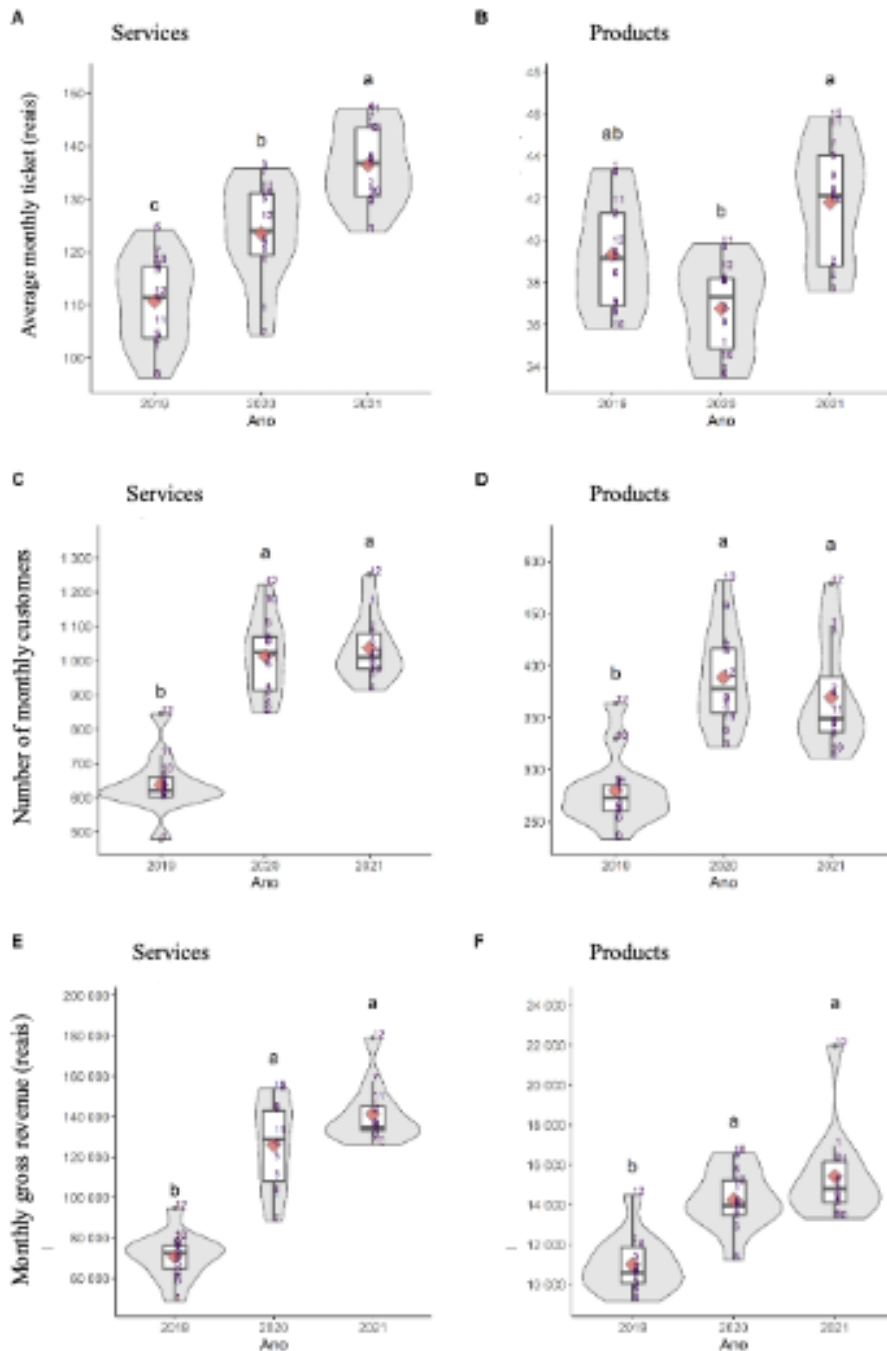
Note: The numbers indicate the distribution for each month of the year; the red diamond in the center represents the average

Customer Segmentation and Strategic Implications

Three customer profiles were identified for services and three for products: profile 1 with a high consumption pattern, many purchases and a high frequency of visits to the clinic; profile 2 made up of a moderate consumption pattern, quantity and frequency; and profile 3 with a low consumption pattern, quantity and frequency (Table 1). This segregation shows three slices of the business's customers, both for services and products, which help to understand the clinic's customer purchasing profile, which can be summarized as high (profile 1), moderate (profile 2) and low (profile 3) consumption.

Table 1

Average and standard deviation (minimum - maximum) of consumption, quantity of products/services and frequency of visits to the client clinic each month for services (A) and products (B)

(A) - Services

Profile	Year	Counting	Consumption (reais)	Number of services	Frequency at the clinic
	2019	17	3.877,54±2.275,84 (1.520,00 – 8.568,11)	99,26±38,49 (53 - 188)	24±12,42 (5 - 56)
1	2020	65	3.398,66±1.600,74 (1.520,00 – 8.618,00)	84,06±47,16 (26 - 290)	20,88±10,66 (5 - 54)
	2021	56	3.709,81±1.892,26 (972,00 – 9.999,00)	97,06±54,05 (15 - 319,5)	18,86±8,28 (4 - 40)
	Total	**138**	**3.583,92±1.809,11 (972,00 – 9.999,00)**	**91,21±49,3 (15 - 319,5)**	**20,44±10,07 (4 - 56)**
	2019	276	1.277,20±632,17 (185,00 – 3.805,00)	25,4±17,91 (4 - 76)	9,66±4,06 (3 - 30)
2	2020	428	1.441,37±666,49 (276,00 – 3.636,00)	26,71±20,48 (4 - 101,8)	9,65±3,91 (2 - 25)
	2021	476	1.508,87±692,37 (285,00 – 4.445,70)	24,73±20,94 (4 - 120)	9±3,22 (1 - 24)
	Total	**1180**	**1.430,20±674,72 (185,00 – 4.445,70)**	**25,6±20,1 (4 - 120)**	**9,39±3,69 (1 - 30)**
	2019	1668	245,01±190,04 (0,01 – 1.450,00)	3,38±3,69 (1 - 36)	2,61±1,66 (1 - 9)
3	2020	2437	266,77±209,79 (0,01 – 1.548,50)	3,46±3,71 (1 - 41)	2,65±1,64 (1 - 9)
	2021	2744	275,43±220,71 (5,00 – 1.940,00)	3,35±3,66 (1 - 37)	2,53±1,6 (1 - 9)
	Total	**6849**	**264,94±210,00 (0,01 – 1.940,00)**	**3,4±3,68 (1 - 41)**	**2,59±1,63 (1 - 9)**

(B) - Products

Profile	Year	Counting	Consumption (reais)	Number of services	Frequency at the clinic
	2019	61	370,26±153,23 (143,80 - 994,97)	49,39±22,55 (6 - 106)	7,21±2,6 (2 - 13)
1	2020	73	329,30±138,85 (138,72 - 850,05)	52,95±25,78 (11 - 126)	7,07±4,15 (2 - 27)
	2021	95	370,70±150,82 (129,80 - 1093,70)	51,14±29,04 (19 - 191)	6,73±2,02 (1 - 15)
Total		**229**	**357,39±148,38 (129,80 - 1093,70)**	**51,25±26,33 (6 - 191)**	**6,97±2,99 (1 - 27)**
	2019	322	173,07±83,81 (34,39 - 614,88)	18,04±10,62 (2 - 56)	4,27±1,51 (1 - 9)
2	2020	392	172,96±72,56 (38,70 - 541,20)	18,47±9,88 (1 - 48)	4,2±1,44 (1 - 9)
	2021	362	180,06±79,03 (40,60 - 518,50)	18,06±11,27 (2 - 62)	3,97±1,32 (1 - 8)
Total		**1076**	**175,38±78,24 (34,39 - 614,88)**	**18,2±10,58 (1 - 62)**	**4,15±1,43 (1 - 9)**
	2019	729	52,20±45,70 (1,50 – 209,00)	4,51±4,62 (1 - 25)	1,58±0,72 (1 - 4)
3	2020	1157	49,64±42,47 (0,00 – 242,00)	4,54±4,13 (1 - 28)	1,62±0,76 (1 - 4)
	2021	1226	51,77±44,83 (2,00 - 270,60)	4,53±4,35 (1 - 30)	1,54±0,69 (1 - 4)
Total		**3112**	**51,08±44,18 (0,01 - 270,60)**	**4,53±4,34 (1 - 30)**	**1,58±0,72 (1 - 4)**

The distribution of the count of each profile showed a significant relationship with the years, showing a difference in the number of profiles over the years (Table 2). This can be interpreted as an increase of over 46% in 2020, with maintenance and growth of 10% in 2021 for service profiles, except for profile 1, which showed a drop of 10%. For products, the profiles grew by at least 20% in 2020, and in 2021, there was less growth, except for profile 2, which showed a slight drop of 7%.

Table 2

Contingency table with the distribution of the count of service customers (A) and product customers (B) in each profile over the years

(A) - Services					Growth (%) compared to the previous year	
	2019	2020	2021	Total	2020	2021
Profile 1	17	65	56	138	282,4	-13,8
Profile 2	276	428	476	1.180	55,1	11,2
Profile 3	1.668	2.437	2.744	6.849	46,1	12,6
Total	1.961	2.930	3.276	8.167	49,4	11,8

$\chi^2 = 13,472$; df = 4; p = 0,0091

(B) - Products					Growth (%) compared to the previous year	
	2019	2020	2021	Total	2020	2021
Profile 1	61	73	95	229	19,7	30,1
Profile 2	322	392	362	1.076	21,7	-7,7
Profile 3	729	1.157	1.226	3.112	58,7	6,0
Total	1.112	1.622	1.683	4.417	45,9	3,8

$\chi^2 = 14,563$; df = 4; p = 0,0056

The customized segregation of clients, considering products and services, was recommended to obtain a better understanding of the profiles, considering the particularities of the veterinary business model (Hill, 2020). The composition of each profile (type of services or products, client gender, year, and animal species) is shown in Table 3. For services, profile one was mostly male clients, owners of dogs or rodents treated for cardiothoracic surgery, surgical probing, herniorrhaphy, and hospitalizations, i.e., extensive or emergency surgical procedures requiring hospitalization. Most of Profile 2 comprised female clients and cat owners seen for check-ups, dentistry, electrocardiography, biochemistry, echocardiography, and serology,

summarized as routine examinations and procedures. Profile 3 comprised owners of dogs, birds, or exotic animals for dermatological and ophthalmological examinations, vaccinations, general consultations, hematology, and acupuncture, summarized as initial consultations (emergency or elective) and general applications.

Profile 3 represents services (vaccinations) for acquiring or adopting new pets. Therefore, the increase in this profile in 2020 corroborates the findings of another study, pointing to a strong growth in the number of adoptions in the same year, possibly attributed to social isolation (Appiah et al., 2022; Ho et al., 2021). This finding signals that the acquisition or adoption of pets may have contributed to some extent to the growth of the pet segment during the first year of the pandemic. On the other hand, as the business model grew in 2020, including all the service profiles found, it is possible to understand that those owners who were already responsible for a pet showed extra care for their animals, as reported by a survey conducted in the United Kingdom with dog owners (Holland et al., 2021) and in the United States with cat owners (Appiah et al., 2022; Kogan et al., 2021). It is believed that acquisition or adoption behavior and extra care are strongly influenced by the social isolation caused by the COVID-19 pandemic, which may have substantially contributed to the business model's growth. This partially explains why the pet segment has not only remained warm during the global health crisis but has also shown growth. In addition, it must be speculated that the staff and structure of the veterinary clinic analyzed were prepared to meet the extra demand and were thus able to take advantage of the favorable weather conditions at the time. This may not have been the reality for all small animal veterinary clinics, as a survey of 119 respondents from pet shops or veterinary services in Brazil at the end of 2021 found that 60% of them reported a decrease in turnover after the lockdown, while 15% reported an increase; and 37% of them reported expecting worse sales at the end of the year, while 29% thought they would be better (Sebrae, 2022). This impact needs to be investigated in the future in other clinics and businesses in the segment.

For products, the composition of profile 1 showed male cat owners. In contrast, profile 2 was dog owners interested in clothing and accessories, and profile 3 was a cat, bird, rodent, rabbit, and exotic animal owners interested in buying supplements, feed, snacks, and anti-parasites (Table 3).

Table 3

Summary of significant interdependencies between each customer profile and the customer's gender and type of service or products

Services			Products		
Interdependencies with Profile 1	**Z-value**	**P-value**	**Interdependencies with Profile 1**	**Z-value**	**P-value**
Hospitalization 30-39.9Kg	10,1740	2,59E-24	Year 2019	5,2210	1,78E-07
Year 2020	9,4277	4,19E-21	Male (guardian)	2,5632	0,0104
Hospitalization 40-49.9Kg	5,4627	4,69E-08	Medications	3,9827	0,0001
Surgical Probes	5,2587	1,45E-07	Feline Species	2,8479	0,0044
Hospitalization 50-59.9Kg	3,6017	0,0003	Medications	4,0216	0,0001
Cavity Fluids	3,0360	0,0024			
Male Sex (client)	2,7788	0,0055			
Species Rodent	2,2816	0,0225			
Medications	2,1443	0,0320			
Cardiothoracic	1,9642	0,0495			
Additional Hospitalization	17,4707	2,40E-68			
Hospitalization 10-19.9Kg	15,3582	3,12E-53			
Other Procedures	14,7573	2,76E-49			
Inhalation Anesthesia	10,4855	1,01E-25			
Ophthalmological	7,5540	4,22E-14			
Hospitalization 0-9.9KG	7,1051	1,20E-12			
Dental	4,1810	2,90E-05			
Hospitalization 20-29.9Kg	3,4601	0,0005			
Species Canine	2,8561	0,0043			
Blood Transfusion	2,8416	0,0045			
Pathological	2,2679	0,0233			
Electrocardiography	2,2349	0,0254			

Interdependencies with Profile 2	Z-value	P-value	Interdependencies with Profile 2	Z-value	P-value
Feline Species	9,0249	1,80E-19	Dog Species	4,9392	7,85E-07
Reproductive Urogenital	8,4662	2,54E-17	Clothing and Accessories	3,8026	0,0001
PCRs	7,4483	9,45E-14	Male (guardian)	2,3923	0,0167
General Abdominal	7,2827	3,27E-13	Year 2021	2,7659	0,0057
Biochemical	6,5514	5,70E-11			
Nodulectomies Skin Biopsies	4,5875	4,49E-06			
Digestive	3,5261	0,0004			
Hospitalization 60-69.9Kg	2,6484	0,0081			
Herniorrhaphies	2,5467	0,0109			
Female (client)	2,4983	0,0125			
Inhalation Anesthesia	21,9102	2,08E-106			
Hospitalization 0-9.9KG	16,0407	6,64E-58			
Dental	12,0302	2,47E-33			
Additional Hospitalization	11,9844	4,29E-33			
Electrocardiography	8,4312	3,42E-17			
Pathological	8,0711	6,97E-16			
Other Procedures	6,0481	1,47E-09			
Ophthalmological	5,3519	8,70E-08			
Hospitalization 10-19.9Kg	4,6721	2,98E-06			
Hospitalization 20-29.9Kg	4,6631	3,11E-06			
Blood Transfusion	3,7351	0,0002			

Interdependencies with Profile 3	Z-value	P-value	Interdependencies with Profile 3	Z-value	P-value
General Clinic Consultation	20,2237	6,06E-91	Antiparasitics	9,8589	6,27E-23
Rabies	16,5664	1,22E-61	Supplements	8,3038	1,01E-16
V10	15,3560	3,23E-53	Exotic Species	3,2331	0,0012
V8	12,5868	2,50E-36	Feeds and Snacks	2,9467	0,0032
General Clinic Consultation On Call	9,5435	1,38E-21	Poultry Species	2,2860	0,0223
V5	8,4942	1,99E-17	Rodent Species	2,2860	0,0223
Applications	7,9673	1,62E-15	Cunicula Species	2,1164	0,0343
Bronchi	7,2761	3,44E-13	Year 2021	2,8396	0,0045
Giardia	7,1451	8,99E-13	Feline Species	2,5509	0,0107
Ophthalmological Exams	5,7193	1,07E-08			
Dermatological Exams	5,6020	2,12E-08			
V4	4,0491	0,0001			
Hematology	3,9299	0,0001			
Year 2019	3,2049	0,0014			
Avian Species	2,7995	0,0051			
Coproparasitological	2,7228	0,0065			
Exotic Species	2,4555	0,0141			
Sutures	2,4408	0,0147			
Other Species	2,2445	0,0248			
Acupuncture Physiotherapy Consultation	2,1702	0,0300			
Species	2,1564	0,0311			
Leptospirosis	2,1357	0,0327			
Sedation Tranquilization	2,1279	0,0333			
Splints	2,0307	0,0423			
Canine Species	2,3827	0,0172			

Note: Interdependencies highlighted in gray indicate those that occurred exclusively with a given profile

Figure 3

Perceptual map from the multiple correspondence analysis showing the distribution of customers in each profile for services (A) and products (B)
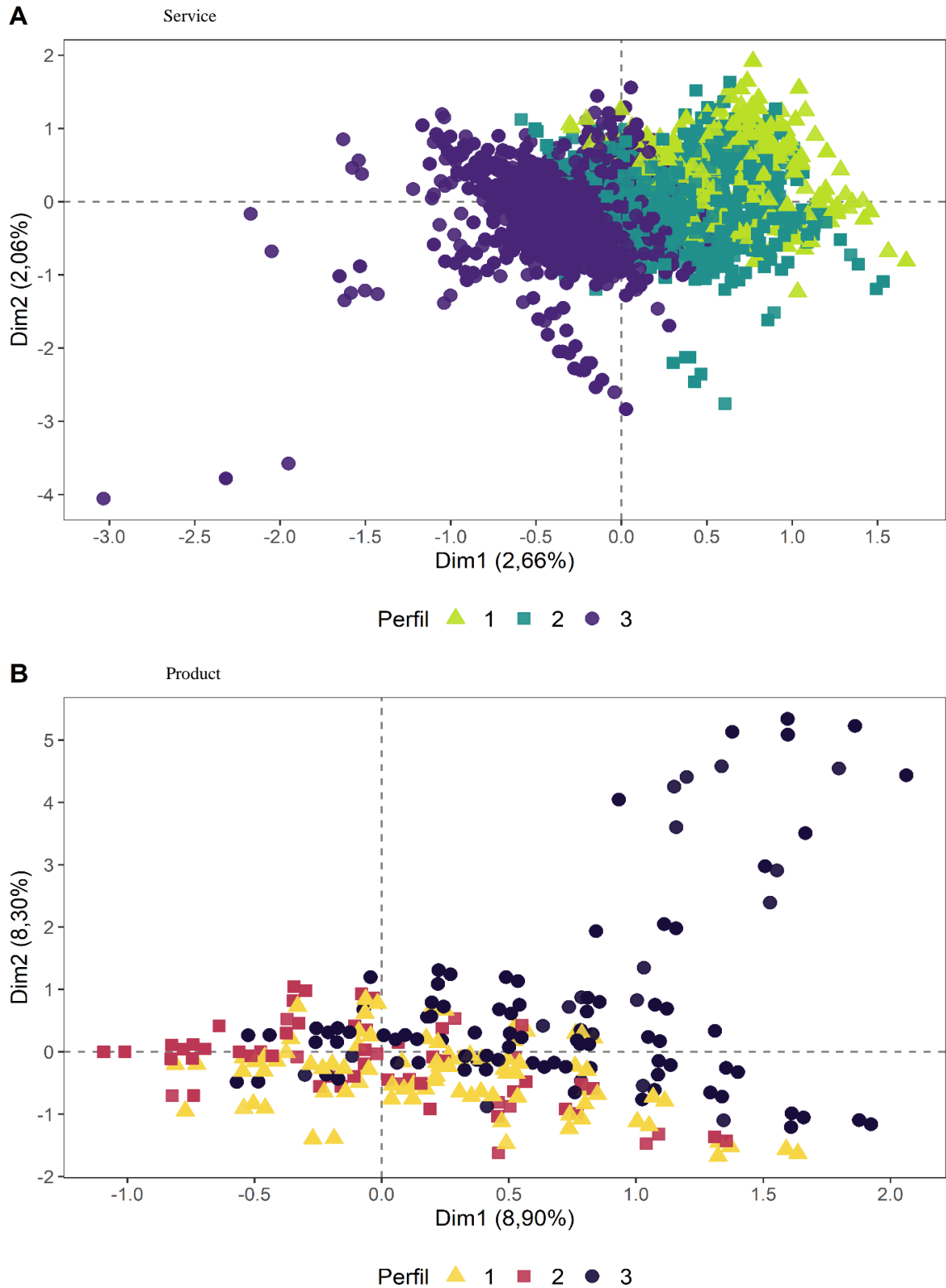
A veterinary clinic offers many types of service, but a timely strategy is to map the main ones among them (Hill, 2020). The key to rational resource management and competitive advantage in the market can be achieved by assessing the client profile (Gustriansyah et al., 2020). In this sense, although service profile 1 showed the highest percentage growth in clients in 2020 (282%), profile 3 was the most voluminous (2,744 clients) and accumulated the second highest average gross revenue (R$650,118.49) in the same year, however, the average gross revenue of profile 2 (R$716,794.12) was the highest, suggesting that profiles 2 and 3 represent the share of services with the highest gross revenue. Most services in profile 2 (routine exams and procedures) are related to dental procedures and in profile 3 (initial consultation and general applications) to general clinical consultations, which suggests that these two are the primary services. On a practical level, the clinic's management will be able to direct investments towards improving human resources, equipment, and facilities related to these services and apply targeted marketing to attract clients seeking these services. However, it is necessary to consider the net revenue from the services in each profile to establish the most profitable ones, information which was not available in this study.

Product profile 3 showed the highest percentage growth, which can be attributed to the sale of food and health products for cats, birds, rodents, rabbits, and other exotic pets, showing the expansion of the pet world beyond dogs, which represent the majority of pets in Brazil (40%) (Abinpet, 2021). Profile 2 showed a slight drop in 2021, which can be considered stagnation. This result reinforces the interest of the clinic's clients in birds, rodents, rabbits and exotic pets. In practice, the veterinary clinic's management could choose a catalog of products related to the most preferred purchase options, catering to different customer styles as suggested by previous studies (Wei & Bunjun, 2020; Wei & Murshed, 2019). The stagnation found in product profile 2 corroborates earlier results of a gentle drop in the average monthly ticket. A possible explanation for the reduction in consumption in offline purchases of products at the clinic could be the increase in e-commerce sales from other companies, as reported in South Korea by recent studies (Kwak & Cha, 2021; Sun et al., 2021). One strategy that the veterinary clinic could adopt is the implementation of e-commerce, expanding its capacity to sell products; however, this is a decision that needs to be analyzed in detail by the management team, considering the net revenue of each product, information that was not available in this study.

The implications of these forecasts are relevant for managers in the sector, after all, identifying seasonal patterns and their possible causes makes it possible to plan strategic actions, such as:

- Resource Management: Direct investments towards services with the highest identified demand, such as routine examinations (profile 2) and initial consultations (profile 3), including: specialized staff training; acquisition of specific equipment and adaptation of facilities;

- Segmented Marketing: develop specific campaigns for each customer profile identified, implement loyalty programs based on consumption patterns, create targeted communication for exotic pet owners, identified as a growing segment;

- Diversification of Services: expand preventive services with greater demand; implement customized service packages for each profile, and develop hybrid service options (in-person/remote).

However, the limitations mentioned reinforce the need to combine quantitative forecasts with a qualitative analysis of market conditions, ensuring that decisions are based on both historical data and contextual insights.
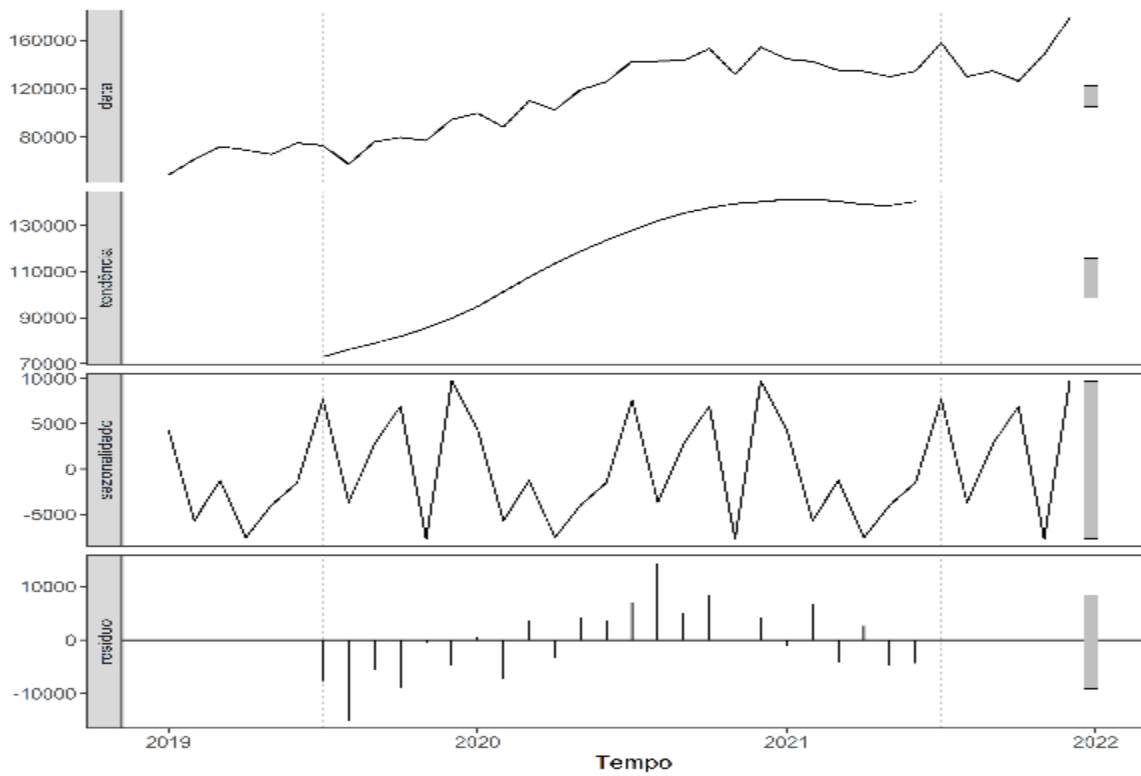
Projections and Trends

For gross revenue from services, the original univariate time series data graphically showed an apparently non-stationary distribution, while its decomposition revealed an upward trend until the beginning of 2021 and an additive seasonality each year, showing a drop near the middle of the year and a peak in the final and initial months of the year (Figure 4A). After differentiation, the series was not assumed to be stationary by the Dicky-Fuller (-2.5906; p = 0.3438) and KPSS (0.0796; p = 0.1) tests, nor was at least one group of autocorrelations different from zero according to the Box-Ljung test ($\chi 2$ = 3.5397; df = 1; p = 0.0592) and showed adherence to the Gaussian distribution by the Cramer-Von Mises test (W = 0.0694; p = 0.2460) after Box-Cox transformation (λ = 0.2829732) (Figure 4B), partially meeting the necessary assumptions for conducting a SARIMA time series model. It is possible that the peak observed at the end of the series made it difficult to transform the series into a stationary one, even after simulations with logarithmic transformation or various differentiations. It is thought that a differentiation associated with the Box-Cox transformation was the best possible option in this case.
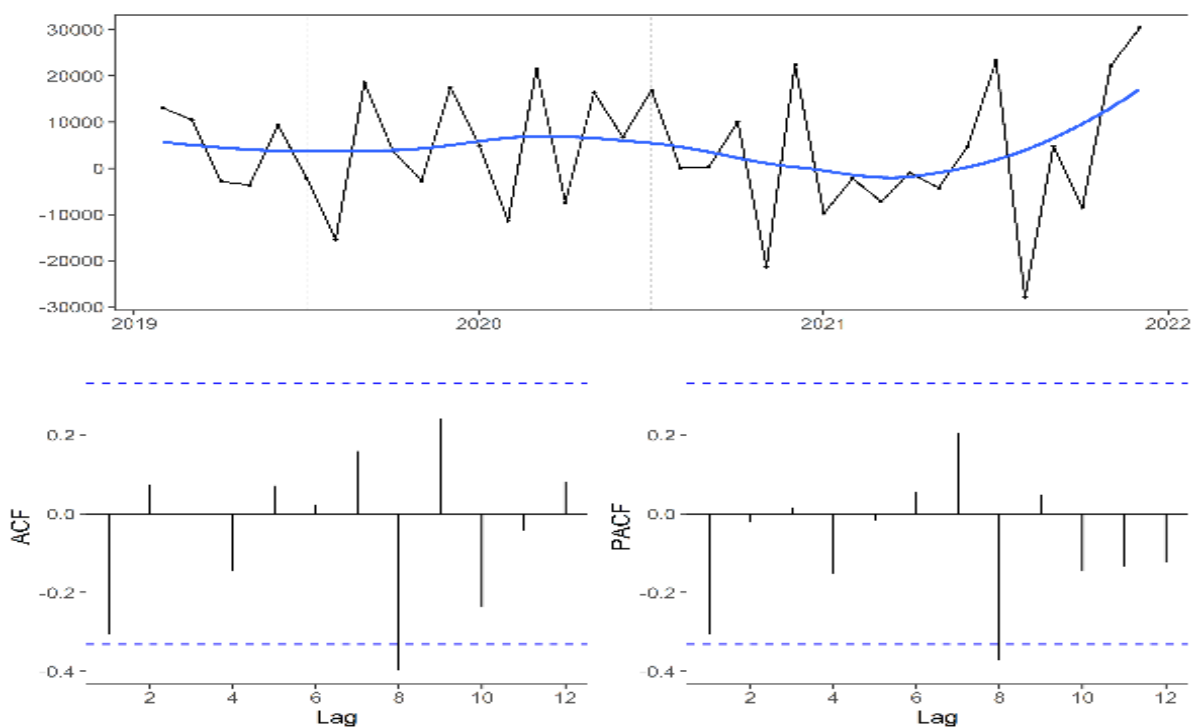
Figure 4

Decomposition with the original data (A) and correlogram after differentiation (B) of the univariate time series based on monthly gross revenue from services from January 2019 to December 2022

A

B

For gross product revenue, the original univariate time series data graphically showed a non-stationary distribution. At the same time, its decomposition revealed an upward trend until the middle of 2021 and an additive seasonality each year, showing a drop towards the end of the year and a peak in the middle of the year (Figure 5A). After differentiation, the series was not assumed to be stationary by the Dicky-Fuller (-2.4660; $p = 0.3921$) and KPSS (0.1847; $p = 0.1$) tests, nor was at least one group of autocorrelations different from zero according to the Box-Ljung test ($\chi2 = 0.1156$; df = 1; $p = 0.7338$) and showed adherence to the Gaussian distribution by the Cramer-Von Mises test (W = 0.0540; $p = 0.4426$) (Figure 5B), partially meeting the assumptions necessary to conduct a SARIMA time series model. As in the previous case, the peak at the end of the series may have negatively influenced the transformation of the series into a stationary one, even after simulations with logarithmic transformation, Box-Cox or differentiations. Differentiation was considered the best possible option in this case.
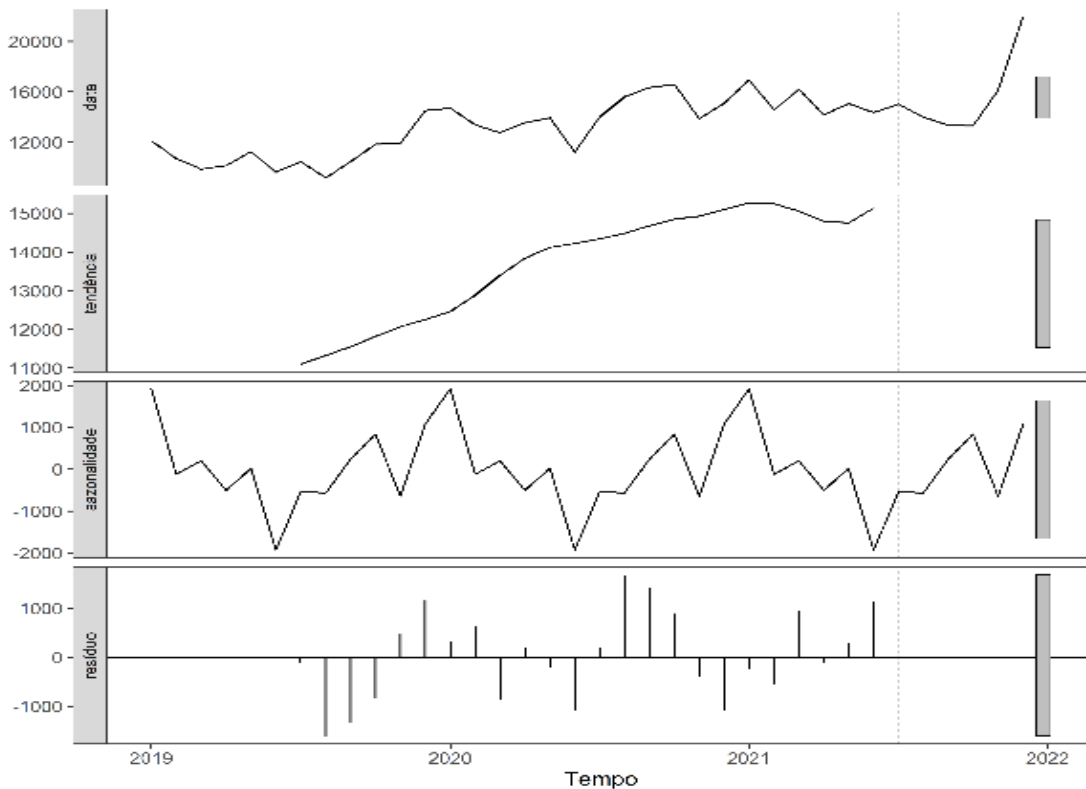
Figure 5

Decomposition with the original data (A) and correlogram after differentiation (B) of the univariate time series based on monthly gross revenue from products from January 2019 to December 2022

A
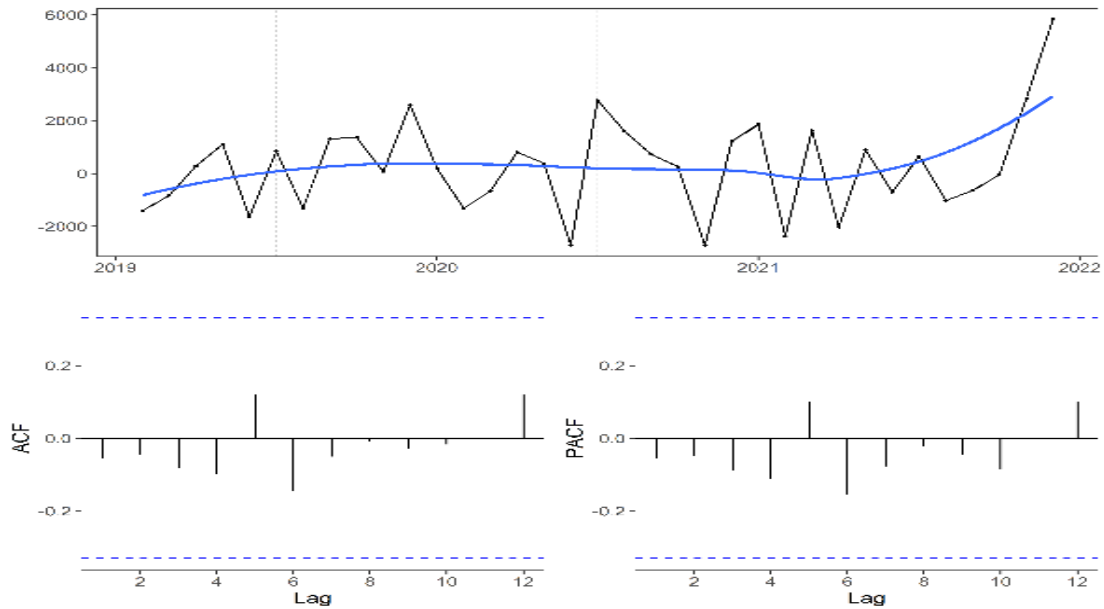
B

The combination of parameters p, q and d with the best fit were SARIMA (1,1,1) (0,1,1) [12] for gross revenue from services and SARIMA (0,1,0) (0,2,0) [12] for products (Table 4). The residuals were assumed to be random, independent and without autocorrelation by the Box-Ljung test for services ($\chi 2 = 0.0493$; df = 1; p = 0.8242), but dependent and with autocorrelation for products ($\chi 2 = 4.3741$; df = 1; p = 0.0364). The adherence of the residuals to the Gaussian distribution was confirmed by the Cramer-Von Mises test (for services and products respectively, W = 0.0283; p = 0.8641 and W = 0.1022; p = 0.1002).

Table 4

SARIMA parameters of the univariate time series based on monthly gross revenue from January 2019 to December 2022

Coefficients	Gross service revenue SARIMA (1,1,1)(0,1,1)[12]		Gross prodcuts revenue SARIMA (0,1,0)(0,2,0)[12]	
	Estimated	Standard Error	Estimated	Standard Error
ar1	-0,6326	0,5397	--	--
ma1	0,4182	0,5951	--	--
sma1	-0,7178	1,2140	--	--
σ^2	12,06	--	16563195	--
Log likelihood	-63,08	--	-110,57	--
AIC	134,17	--	223,15	--
BIC	138,71	--	223,54	--
ME	-1801,89	--	185,12	--
RMSE	12237,95	--	2249,61	--
MAE	8031,84	--	1015,09	--
MPE	-1,72	--	0,65	--
MAPE	6,04	--	6,45	--
MASE	0,21	--	0,35	--
ACF1	0,04	--	0,33	--

σ 2 is the squared sigma coefficient; AIC is the Akaike information criterion; BIC represents the Bayesian information criterion; RMSE indicates the root mean square error; MAE is the absolute mean error; MPE is the mean percentage error; MAPE is the absolute mean percentage error; MASE is the absolute scaled error; and ACF is the autocorrelation

The forecast for the next six months showed growth in monthly gross revenue from services (Figure 6A) and product fluctuations (Figure 6B). These findings suggest that the dizzying growth in the short term following the lockdown has been maintained in the medium term, with indications of an increase in the clinic's service operations, to some extent forecasting

a promising scenario for the business model evaluated. It is possible that investments in human resources, equipment, facilities and marketing focused on the main service client profiles described above (routine examinations and procedures, as well as initial consultations and general applications) could boost the gross revenue outlook for the next six months. It is speculated that the choice of a catalog of products available at the clinic considering the customer profiles that have grown the most (food and health products for felines, especially for birds, rodents, rabbits and other exotic pets) could be a strategy to convert the predicted oscillations in gross revenue from products into growth.

Figure 6

6-month forecast of the univariate time series analyzed by SARIMA based on monthly gross revenue from services (A) and products (B) from January 2019 to December 2022
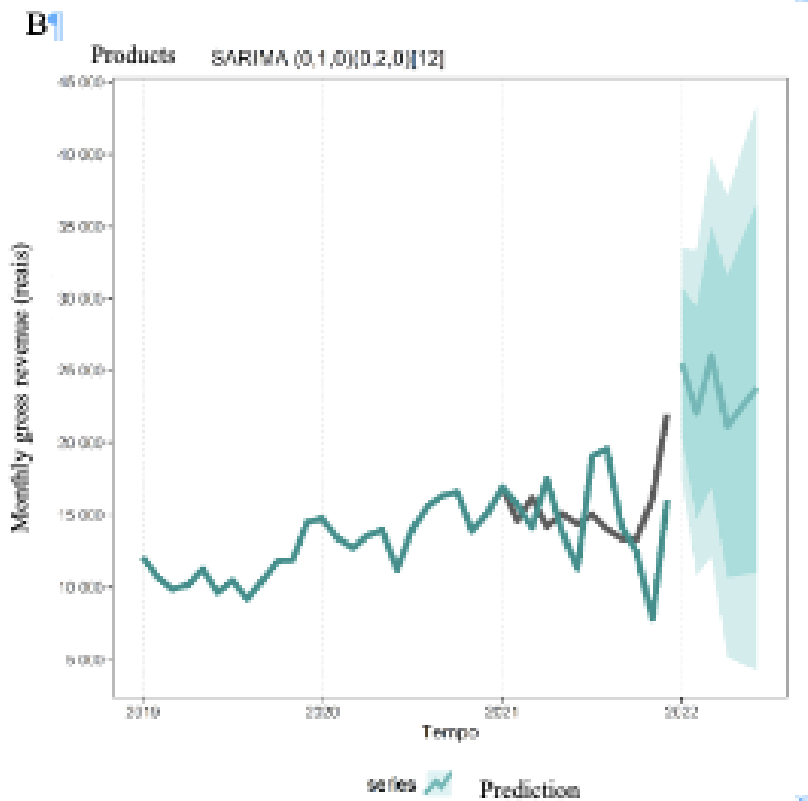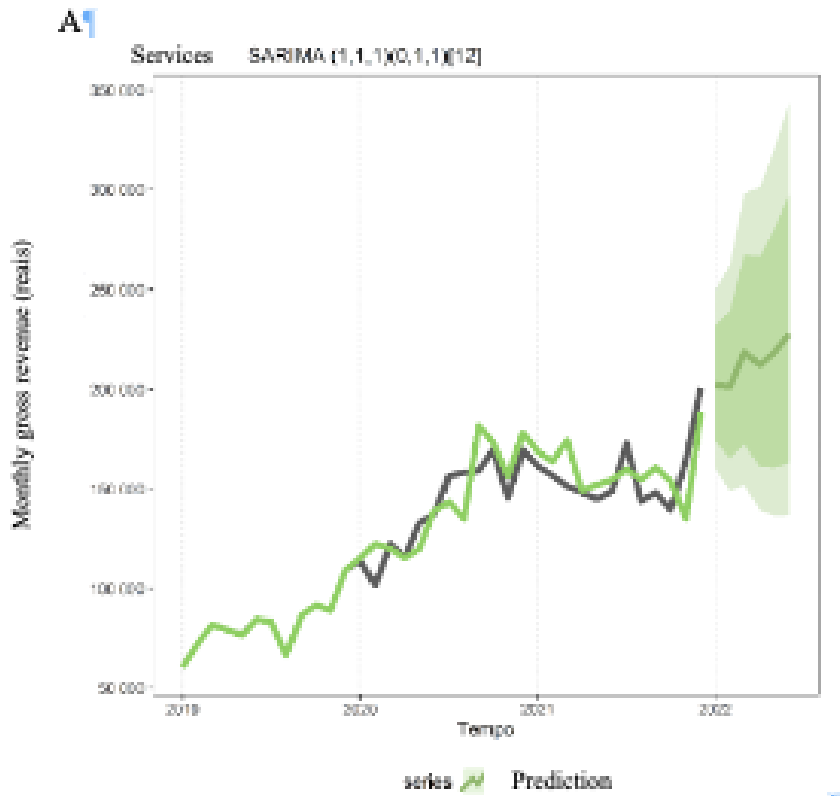
The forecasts made for gross revenue using SARIMA models showed fluctuations that can be explained by external and internal factors to the business. Among the possible causes of these variations are: the typical seasonality of the pet sector, which sees peaks in consumption in months when there is greater demand for animal health services (such as vaccinations and check-ups); the impact of promotional campaigns and seasonal discounts; and changes in consumer behavior, such as greater demand for preventive services after peak periods of the pandemic. These factors combined suggest that revenue dynamics are not only influenced by macroeconomic issues, but also by the specific strategies of the veterinary clinic analyzed.

The accuracy of the SARIMA models used was assessed using standard metrics such as Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE), which showed values of less than 10%, indicating a good fit of the model to the time series, reinforcing the reliability of the forecasts made. However, there are some limitations associated with the use of SARIMA. Firstly, the model assumes that the patterns observed in the past will be replicated in the future, which may not capture abrupt changes in the market, such as new economic crises or significant changes in consumer behavior. In addition, the analysis was based on data from a single veterinary clinic, which may limit the generalizability of the predictions for the sector. Including external variables, such as general economic indicators or public policies aimed at the pet sector, could refine the forecasts and provide a broader context for interpreting the observed oscillations. The results show that the COVID-19 pandemic has significantly impacted the economic performance of the veterinary clinic analyzed, especially in metrics such as average ticket, gross revenue, and number of clients. These findings align with the Resource-Based Competitive Advantage Theory (RBV), which emphasizes the importance of strategic resources, such as the ability to analyze data and operational adaptation, to take advantage of opportunities in crisis scenarios. After all, the clinic's ability to adjust its services and identify customer profiles with greater loyalty potential exemplifies the practical application of RBV.

Although the analysis focused on a single veterinary clinic, it is essential to contextualize the results within the panorama of the Brazilian pet sector. According to data from Abinpet (2021), the Brazilian pet market has shown resilience during the pandemic, with average growth of 13.5% in 2020. Our analysis showed that the clinic studied exceeded this sector average, with growth of 46% in services and products in 2020, suggesting a superior capacity for strategic adaptation to market changes. However, a survey containing 119 respondents from pet shops or veterinary services in Brazil at the end of 2021 (Sebrae, 2022) indicated that 60% of establishments reported a decrease in turnover after the lockdown, while only 15% reported an increase, suggesting that the positive results found in the study may not

be representative of the sector, but rather indicative of effective strategic management that allowed the clinic to capitalize on the opportunities that arose during the crisis.

Final Remarks

This study used econometric models and customer segmentation techniques to assess the economic impact of the COVID-19 pandemic on a veterinary clinic in Brazil. The results revealed significant growth in operations during the period analyzed, with an increase in demand for essential services and a diversification of client profiles. Although the findings have economic value, their relevance stands out in the field of strategy, as they illustrate how data-driven decisions can generate competitive advantages in challenging scenarios such as the pandemic.

From a strategic perspective, the econometric exercises provided inputs for understanding and managing the business. For example, identifying customer profiles made it possible to map segments with the greatest potential for revenue and loyalty, making it possible to direct resources and efforts to maximize strategic impact. In addition, forecasting models have highlighted how data analysis can be used to anticipate market trends and prepare long-term strategies, increasing organizational resilience. These practices are directly aligned with the Resource-Based Competitive Advantage (RBV) Theory, which emphasizes the role of valuable and rare resources - such as data analysis capabilities - in sustaining strategic market positions. Furthermore, the results contribute to the field of strategy by offering an empirical study of how companies in specialized markets, such as the pet sector, can exploit environmental changes to consolidate their competitiveness. The pandemic crisis has demonstrated the importance of adaptive strategies, such as diversifying products and services for different customer profiles, and investing in digital resources, such as e-commerce platforms, to expand reach and operational efficiency.

It is important to recognize this study's limitations, particularly the fact that it analyzed a single veterinary clinic in Botucatu-SP. Specific characteristics of the establishment, such as its location in a medium-sized city with a strong university presence and the different socioeconomic profiles of the clientele, may limit the generalizability of the results. In addition, challenges in data collection during the lockdown period and possible inconsistencies in records due to the adaptation of processes during the pandemic should also be considered when interpreting the results.

The strengthening of the human-animal relationship observed during the pandemic suggests lasting transformations in the pet sector, including a sustained increase in demand for

veterinary services, greater sophistication in the demands of pet owners and the need to specialize in specific niches. These changes have significant implications for the strategic management of veterinary clinics, requiring adaptations such as implementing digital platforms, developing segmented loyalty programs and continuous investment in professional training.

The study's practical contributions suggest that veterinary clinics can benefit from directing investments towards services in greater demand, such as routine examinations and initial consultations, and diversifying products aimed at various audiences, including owners of exotic pets. These strategies are fundamental to sustaining business growth and competitiveness. Future studies could expand this analysis by including multiple clinics in different regions, investigating the psychological impact of the pandemic on the owner-animal relationship and exploring the effectiveness of digital strategies in the veterinary sector. In addition, there is potential for research into new business models adapted to the post-pandemic reality and analysis of the impact of macroeconomic factors on the consumption of veterinary services.

This study reinforces the role of data analysis as an essential component for formulating strategies in times of crisis. The findings offer practical implications for managers while opening new research directions to explore the intersection between applied econometrics, market analysis, and strategic theory. In an increasingly volatile global scenario, integrating robust analytical methods and strategic frameworks can be key to small and medium-sized enterprises' resilience and sustainable growth.

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