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Selling vegetables through live streaming: sentiment and network analysis

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ABSTRACT

This study addresses the research problem of understanding digital interactions and dynamics in online environments, mainly focusing on sentiment analysis and Social Network Analysis (SNA). The methodology integrates sentiment analysis techniques to discern prevailing attitudes and emotions within digital content, coupled with SNA to unveil intricate network structures and user relationships. Concurrently, SNA unveils intricate network structures and relationships among users, illuminated by numerical metrics such as Diameter (2), Density (0.003982), Reciprocity (0.000000), Centralization (0.027240), and Modularity (0.978600). Additionally, the performance vector further enhances the evaluation with metrics including accuracy (97.68% +/- 2.44%), AUC (0.429 +/- 0.477), precision (97.68% +/- 2.44%), recall (100.00% +/- 0.00%), and f-measure (98.81% +/- 1.25%). The study utilizes a dataset of digital content and user interactions, applying sentiment analysis to quantify sentiments and SNA to map network connections. Findings reveal nuanced insights into audience perceptions, engagement patterns, and network dynamics within digital ecosystems. Moreover, the study employs numerical metrics to evaluate the performance of sentiment analysis and SNA methodologies. The results underscore the importance of integrating sentiment analysis and SNA in comprehensively understanding online behavior and communication dynamics, offering valuable insights for content creation, engagement optimization, and community management strategies in digital environments.

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1. INTRODUCTION

The digital marketing landscape has significantly transformed fresh vegetables' promotion and consumption patterns, necessitating a profound understanding of consumer behavior. In this contemporary era, the ubiquity of online platforms and social media has enabled marketers to engage with consumers directly, influencing their preferences and choices (Abarbanel & Johnson, 2020; K. Lin et al., 2022; Wongkitrungrueng et al., 2020; Zhang et al., 2022). Consequently, The intricate relationship between digital marketing strategies for fresh vegetables and the dynamic nature of the consumer behavior (Kim & Kim, 2020; Y. Liu et al., 2024). The proliferation of e-commerce platforms and targeted advertising campaigns represent the primary drivers in shaping consumer perceptions and preferences regarding fresh produce (L. C. S. Lin, 2021; L. Wang et al., 2023). Moreover, using data analytics and personalized content enhances the efficiency of digital marketing endeavors, catering to consumers' diverse needs and tastes (W. Wang & Fan, 2022). Despite the undeniable advantages, an opinion arises that the ethical implications of data-driven marketing strategies warrant careful consideration to ensure consumer trust and privacy (Sang et al., 2023; Wan & Jiang, 2023). In conclusion, the interplay between digital marketing and consumer behavior in fresh vegetables underscores the need for marketers to strike a balance between leveraging technological advancements and upholding ethical standards, thereby fostering a sustainable and mutually beneficial relationship with consumers.

The emergence of selling vegetables through live streaming has introduced a novel paradigm in agricultural marketing, revolutionizing the way fresh produce reaches consumers. This innovative approach capitalizes on the immediacy and interactivity of live video platforms to showcase the freshness and quality of vegetables directly from farms to consumers' screens (li & Hayes, 2023). Sellers can establish trust and transparency by leveraging real-time engagement and visual demonstrations, fostering stronger connections with potential buyers (X. Liu et al., 2022). However, while live streaming offers unparalleled direct sales and customer engagement opportunities, it poses logistical challenges, such as ensuring consistent internet connectivity and managing inventory in real-time (Li et al., 2023). Nevertheless, the potential of live streaming to enhance the accessibility and visibility of agricultural products presents a compelling case for its integration into contemporary marketing strategies (Brookwell, 2020). In conclusion, the advent of selling vegetables through live streaming underscores its transformative potential in bridging the gap between producers and consumers, paving the way for more dynamic and inclusive agricultural markets.

The advent of selling through live streaming represents a significant evolution in e-commerce, revolutionizing the traditional retail landscape by integrating real-time video broadcasts with online shopping experiences (Saura et al., 2023). This innovative approach enables sellers to engage directly with their audience, leveraging interactive features to showcase products, address inquiries, and provide personalized recommendations (Jin, 2023; Moore et al., 2022). Moreover, the immersive nature of live streaming fosters a sense of urgency and authenticity, driving impulse purchases and enhancing customer satisfaction (Addo et al., 2021). However, while live streaming offers unparalleled opportunities for direct sales and customer engagement, it also necessitates strategic planning and technical expertise to optimize the viewing experience and manage logistics effectively (Addo et al., 2021). Nonetheless, the growing popularity of selling through live streaming underscores its potential to reshape consumer behavior and redefine the future of retail in the digital age.

The integration of live streaming and digital content has ushered in a new era of interactive media consumption, reshaping the landscape of entertainment and communication. This convergence allows content creators to engage with audiences in real-time, fostering a sense of immediacy and authenticity (Sharma et al., 2024). Furthermore, the versatility of digital platforms enables the seamless distribution of live-streamed content across various channels, reaching a broader and more diverse audience (X. Liu et al., 2022). However, while live streaming and digital content offer unprecedented opportunities for engagement and interaction, they also raise concerns regarding privacy, data security, and the proliferation of misinformation (Sang et al., 2023). Nevertheless, the synergistic relationship between

live streaming and digital content epitomizes the dynamic nature of modern media consumption, driving innovation and shaping societal discourse in the digital age.

This research explores the intricate dynamics of selling vegetables through live streaming using sentiment and network analysis methodologies. The primary objective is to unravel the underlying sentiments expressed by both sellers and consumers during live-streaming events, shedding light on the emotional and attitudinal aspects that influence purchasing decisions (Zhang et al., 2024). By examining the network structures that emerge within the live-streaming context, this study seeks to elucidate the patterns of interaction and influence among participants (Ye et al., 2022). The research provides a nuanced understanding of the multifaceted relationships and sentiment-driven factors that characterize live-streaming commerce by employing sentiment and network analysis (Brand & Baier, 2022). As the digital landscape continues to evolve rapidly, this exploration is poised to contribute valuable insights into the dynamics of online selling, thereby informing future strategies and enhancing the overall efficacy of live streaming as a marketing tool.

The method proposed by this research is CRISP-DM (Cross-Industry Standard Process for Data Mining), a systematic and widely recognized framework for conducting data mining and analytics projects. The main topic revolves around using CRISP-DM as the methodological approach to guide the investigation into selling vegetables through live streaming. Firstly, CRISP-DM offers a structured and iterative process comprising six distinct phases: business understanding, data understanding, data preparation, modeling, evaluation, and deployment (Singgalen, 2023h, 2023g, 2023e, 2024). This methodological rigor ensures a comprehensive exploration of the phenomenon, from defining research objectives to implementing actionable insights (Singgalen, 2023a, 2023c, 2023b, 2023i). Secondly, adopting CRISP-DM aligns with best practices in data-driven research, enhancing the reliability and validity of findings while promoting transparency and reproducibility (Singgalen, 2022, 2023f, 2023d) and in conclusion, using CRISP-DM as the methodological framework underscores the commitment to rigorous and systematic inquiry, facilitating robust analysis and meaningful interpretation of data in the context of live-streaming vegetable sales.

The urgency of this research stems from its critical role in addressing contemporary challenges and advancing knowledge in the field. The main topic revolves around the pressing need to investigate and understand the implications of live streaming on consumer behavior, particularly in the context of selling vegetables. Firstly, the rapid expansion of digital platforms and the increasing reliance on online channels for commerce underscore the necessity of gaining insights into how live streaming influences purchasing decisions and consumer preferences (Fan et al., 2022). Secondly, the dynamic nature of the digital landscape demands timely research to inform businesses and policymakers about emerging trends and effective strategies (Oliveira et al., 2023). In conclusion, the urgency of this research lies in its potential to provide actionable insights, guide decision-making, and drive innovation in the rapidly evolving realm of digital marketing and consumer behavior, especially concerning live streaming and vegetable sales.

Theoretical and practical implications emanating from this research carry profound significance in both academic and real-world contexts. This study theoretically advances our understanding of online commerce's emotional and relational dimensions by delving into the complexities of selling vegetables through live streaming using sentiment and network analysis. Identifying sentiment patterns and network structures enriches academic discourse and lays the groundwork for future research in digital marketing and consumer behavior. Furthermore, the practical implications are evident as businesses can leverage these insights to tailor their live-streaming strategies, enhancing consumer engagement and fostering more effective marketing campaigns (Geng et al., 2020; Giuffrida et al., 2021). In conclusion, the dual impact of theoretical advancement and practical applicability underscores this research's value in shaping scholarly pursuits and strategic decision-making in the dynamic landscape of digital marketing.

Examining similar research and acknowledging limitations are crucial aspects that enhance the scholarly rigor of any study. The current research within the broader academic landscape recognizes

its inherent constraints. Firstly, by reviewing analogous studies, researchers can identify existing gaps, refine methodologies, and build upon prior findings, contributing to the cumulative knowledge in the field (Peng et al., 2024; Susanty et al., 2020). Secondly, delineating the limitations of the current research, be it in terms of scope, sample size, or methodological constraints, is imperative for maintaining transparency and ensuring the integrity of the study. Acknowledging limitations manages expectations and provides a roadmap for future research to address these constraints (Mou et al., 2020). In conclusion, the careful consideration of similar research and an explicit acknowledgment of limitations fortify the academic foundation of the study, promoting a nuanced understanding of its contribution and areas for potential refinement and expansion.

2. RESEARCH METHOD

The method employed in this research involves utilizing the CRISP-DM (Cross-Industry Standard Process for Data Mining) framework, a systematic approach widely recognized in data mining and analytics. The main topic revolves around adopting CRISP-DM as the chosen methodology for guiding the research on selling vegetables through live streaming. Firstly, CRISP-DM provides a structured and comprehensive framework comprising six iterative phases: business understanding, data understanding, data preparation, modeling, evaluation, and deployment. This systematic approach ensures a thorough exploration of the phenomenon, from defining research objectives to the practical implementation of insights. Secondly, using CRISP-DM aligns with best practices in data-driven research, offering transparency, repeatability, and a standardized process for data analysis. In conclusion, incorporating CRISP-DM into the research methodology exemplifies a commitment to a rigorous and systematic inquiry, facilitating robust analysis and meaningful interpretation of data in the context of live-streaming vegetable sales.

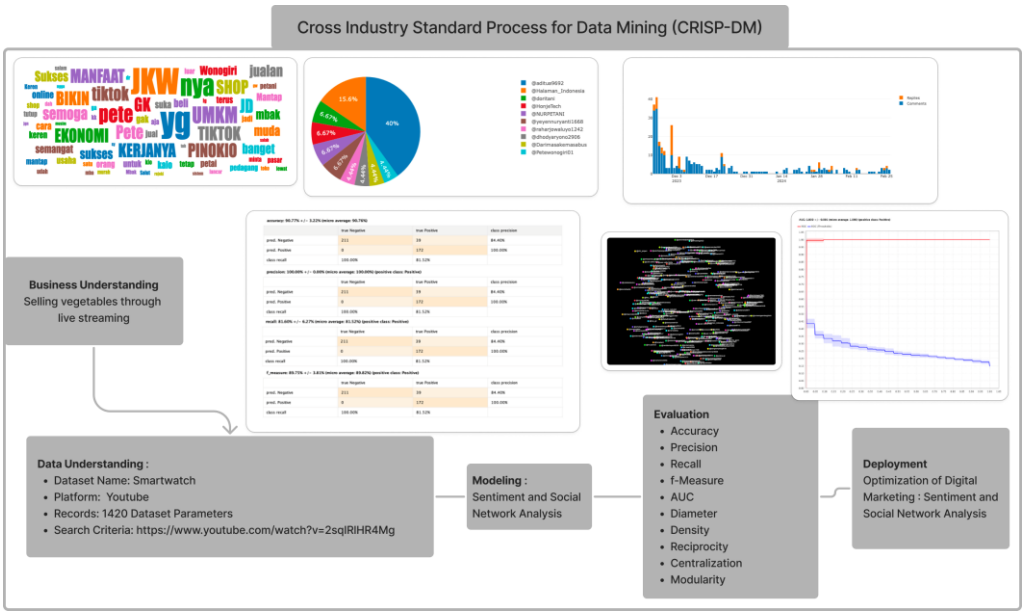

Figure 1. Cross Industry Standard Process for Data Mining (CRISP-DM)

The CRISP-DM (Cross-Industry Standard Process for Data Mining) framework stands out for its notable advantages in guiding comprehensive and practical data mining projects. The main topic centers on delineating the strengths of CRISP-DM as a methodology. Its systematic structure, encompassing six well-defined phases – business understanding, data understanding, data preparation, modeling, evaluation, and deployment- facilitates a clear and organized progression in handling complex data analytics tasks. Secondly, CRISP-DM promotes flexibility by allowing iterative

cycles within each phase, enabling researchers to refine and adjust their approaches as insights unfold. The adaptability and clarity embedded in CRISP-DM enhance its applicability across diverse industries and research contexts. In conclusion, the distinct advantages of CRISP-DM lie in its systematic nature, iterative flexibility, and widespread applicability, making it an invaluable framework for guiding sophisticated data mining endeavors.

2.1 Business Understanding

The primary data source in the initial business understanding phase is the dataset "*Pasangan Muda Sukses Jual Petai Online Ribuan Paket Terjual Tiap Hari*" from the YouTube platform. This dataset comprises 332 records and is instrumental in gaining insights into the thriving online selling of *petai* by young entrepreneurs, with thousands of packages sold daily. The dataset parameters include the search criteria specified by the YouTube video link: https://www.youtube.com/watch?v=67XZs5WNM3w. Leveraging this dataset enables researchers to comprehensively understand the business context, market dynamics, and consumer behaviors surrounding the online sale of petai. Consequently, this dataset is a foundational element in informing subsequent stages of analysis and decision-making within the research framework.

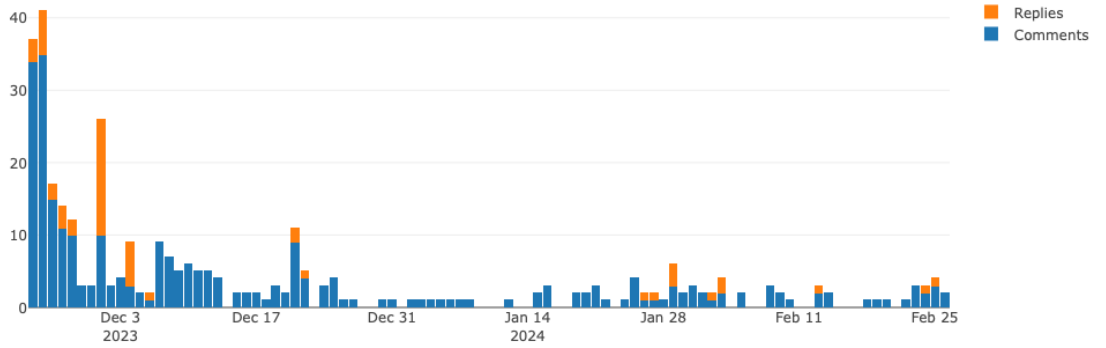

Figure 2. Post Per Day (Communalityc)

Based on the analysis of the post-per-day data, it is evident that there are fluctuations in the number of posts over the specified period. Specifically, on November 25, 2023, the highest number of posts was recorded, totaling 35, followed by November 24 with 34 posts, and a subsequent decline on November 26 with 15 posts. The trend continues with further decreases in the number of posts on November 27 and 28, indicating a potential shift in posting frequency or engagement patterns. However, a significant surge in activity was observed on December 1, 2023, with 16 posts recorded, suggesting a notable deviation from the preceding days' trends. These fluctuations underscore the dynamic nature of online activity and highlight the importance of analyzing temporal patterns to gain insights into user behavior and engagement trends.

The significance of sentiment analysis and social network scrutiny in the context of live-streaming videos promoting vegetable sales is paramount for both market strategists and agricultural entrepreneurs alike. The main topic concerns these analytical tools' pivotal role in gauging public reception and shaping marketing strategies. In contemporary commerce, especially in the digital landscape, understanding consumer sentiment through sentiment analysis offers invaluable insights into preferences, concerns, and trends. Furthermore, delving into the intricacies of social networks enhances the comprehension of consumer behavior within online communities, facilitating targeted outreach. In this era of live streaming, where direct engagement with potential customers is critical, integrating sentiment analysis and social network analysis can significantly bolster the effectiveness of promotional content. By meticulously examining viewer comments, reactions, and network

interactions, one can glean actionable intelligence to refine marketing approaches. Therefore, stakeholders in the vegetable industry must embrace these analytical tools to optimize live-streaming content and foster a dynamic and responsive online market presence.

2.2 Data Understanding

In the data understanding phase, it is imperative to comprehend the actors categorized as top posters in the video content. The main topic centers on the significance of identifying key contributors during this stage of the research process. Firstly, discerning the top posters among the actors provides crucial insights into the individuals or entities contributing to the content video dissemination. This knowledge aids in understanding the influencers and trendsetters within the given context, shedding light on potential opinion leaders and key figures driving engagement. Secondly, recognizing these top posters allows for a more targeted analysis of their content, behaviors, and impact, facilitating a nuanced understanding of the dataset's dynamics. In conclusion, a thorough exploration of top posters during the data understanding phase proves instrumental in unveiling influential actors and honing the focus of subsequent analyses, contributing to a more comprehensive understanding of the dataset.

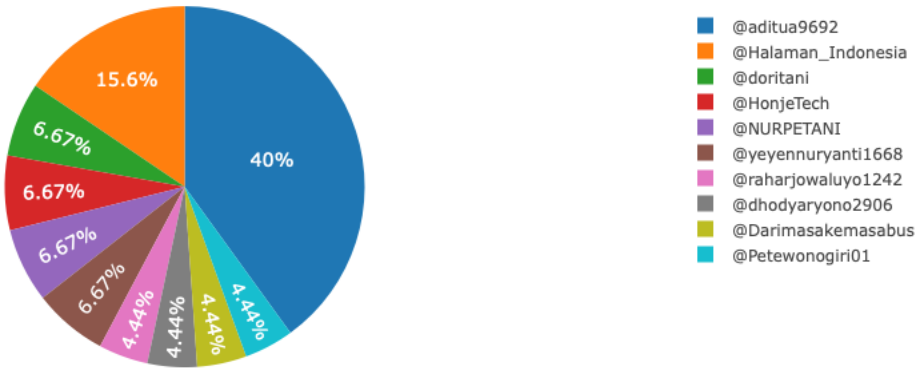

Figure 3. Top Ten Poster (Communalityc)

Based on the obtained data, it is evident that certain users are prominent as top posters within the analyzed content. The main topic emphasizes identifying these critical contributors in shaping the online discourse. Firstly, @aditua9692 emerges as the most prolific poster with 18 instances, indicating a significant presence and potential influence within the community. Other users such as @Halaman_Indonesia, @doritani, and @NURPETANI also exhibit notable activity, albeit to a lesser extent, suggesting a diverse range of contributors shaping the online conversation. These findings underscore the importance of understanding user engagement patterns and identifying influential actors in deciphering the dynamics of online discourse. In conclusion, recognizing top posters provides valuable insights into the individuals driving content dissemination and engagement, facilitating a deeper understanding of online community dynamics.

The transformation from conventional to digital sales methodologies necessitates a contextual investigation, mainly through a case study examining this video content. This approach allows for an in-depth exploration of the transition process, uncovering its complexities and nuances within the specific context. By focusing on a case study, unique challenges, opportunities, and influential factors related to adopting digital sales channels can be identified and analyzed comprehensively. Consequently, such a contextual examination provides valuable insights for informed decision-making and strategic planning in today's dynamic business landscape. In conclusion, leveraging case studies for contextual analysis is essential for understanding and optimizing the shift to digital sales methods in response to evolving market trends and consumer behaviors.

2.3 Modeling

In the modeling phase, sentiment and social network dynamics are analyzed, marking a crucial stage in the research process. The main topic highlights the significance of integrating these analytical approaches to gain comprehensive insights into the phenomena under investigation. Firstly, sentiment analysis allows for the classification and quantification of opinions expressed within the dataset, elucidating prevailing attitudes and emotional responses towards the content. Simultaneously, examining social network structures enables the identification of key influencers, communities, and interaction patterns, providing valuable context for understanding information dissemination and engagement dynamics. Together, integrating sentiment analysis and social network analysis enriches the understanding of online discourse, facilitating a nuanced interpretation of user behavior and interaction within the digital environment. In conclusion, the modeling phase is pivotal in unraveling the complexities of online phenomena, laying the groundwork for insightful interpretation and actionable insights.

Figure 4. Frequently Used Words (Communalityc)

Furthermore, in addition to sentiment and social network analysis during the modeling phase, identifying frequently used words plays a pivotal role in implementing topic modeling. The main topic underscores the significance of this approach in unraveling the thematic content within the dataset. Firstly, researchers can discern recurrent themes, topics, and discussions in the content by scrutinizing frequently used words. This step enhances the depth of understanding by uncovering underlying patterns and semantic structures that contribute to the overall discourse. Secondly, integrating topic modeling based on frequently used words provides a systematic means to categorize and organize content, contributing to a more nuanced and structured analysis. In conclusion, identifying frequently used words complements sentiment and social network analyses, enriching the modeling phase and contributing to a comprehensive interpretation of the content and its thematic elements.

2.4 Evaluation

During the evaluation phase, sentiment analysis is assessed by implementing both VADER and TextBlob algorithms. At the same time, Social Network Analysis (SNA) is evaluated based on metrics such as diameter, density, reciprocity, centralization, and modularity. The main topic emphasizes the systematic evaluation of the methodologies employed, reflecting a comprehensive approach to assessing the outcomes of sentiment analysis and social network analysis. Firstly, using both VADER and TextBlob ensures a robust evaluation of sentiment analysis, as these tools employ different

methodologies, providing a more nuanced understanding of sentiment expressions within the dataset. Simultaneously, evaluating SNA through metrics like diameter and density offers insights into network structure, connectivity, and information flow dynamics. Secondly, considering parameters such as reciprocity and centralization in SNA evaluation provides a more holistic understanding of the relational aspects within the network. In conclusion, the meticulous evaluation of sentiment and social network analyses, incorporating diverse algorithms and metrics, contributes to the reliability and validity of the research findings, enhancing the overall quality of the study.

accuracy: 90.77% +/- 3.22% (micro average: 90.76%)

	true Negative	true Positive	class precision
pred. Negative	211	39	84.40%
pred. Positive	0	172	100.00%
class recall	100.00%	81.52%	

precision: 100.00% +/- 0.00% (micro average: 100.00%) (positive class: Positive)

	true Negative	true Positive	class precision
pred. Negative	211	39	84.40%
pred. Positive	0	172	100.00%
class recall	100.00%	81.52%	

recall: 81.60% +/- 6.27% (micro average: 81.52%) (positive class: Positive)

	true Negative	true Positive	class precision
pred. Negative	211	39	84.40%
pred. Positive	0	172	100.00%
class recall	100.00%	81.52%	

f_measure: 89.75% +/- 3.81% (micro average: 89.82%) (positive class: Positive)

	true Negative	true Positive	class precision
pred. Negative	211	39	84.40%
pred. Positive	0	172	100.00%
class recall	100.00%	81.52%	

Figure 5. Sentiment Analysis using Vader (Rapidminer

The sentiment extraction and classification results utilizing SVM with SMOTE present a Performance Vector demonstrating promising performance metrics. The main topic emphasizes the significance of evaluating the effectiveness of sentiment analysis methodologies. Firstly, the accuracy rate of 90.77% ± 3.22% indicates high precision in classifying sentiments, with a micro average accuracy of 90.76%. Secondly, the confusion matrix illustrates robust classification capabilities, with 211 true negatives and 172 true positives, indicating minimal misclassification. Consequently, these results suggest the efficacy of the SVM with the SMOTE approach in accurately discerning sentiment polarity within the analyzed dataset. In conclusion, the performance metrics validate the reliability and effectiveness of the sentiment extraction and classification methodology, offering valuable insights for future sentiment analysis endeavors.

Based on the results of Social Network Analysis (SNA) focusing on the "who replies to whom" dynamic, several vital metrics provide insights into the structure and dynamics of the network. The main topic underscores the importance of understanding interaction patterns within the network. Firstly, the obtained diameter of 2 suggests that the maximum distance between any pair of users in the network is relatively short, indicating a compact and interconnected communication network. Secondly, the low density of 0.003982 signifies that the network is sparse, with only a tiny fraction of

possible connections realized, reflecting potential opportunities for increased interaction. Consequently, while the network exhibits low reciprocity and centralization, the high modularity value of 0.978600 suggests distinct community structures. In conclusion, the SNA metrics provide valuable insights into the communication dynamics, offering opportunities for further exploration and analysis to better understand the underlying patterns and relationships within the network.

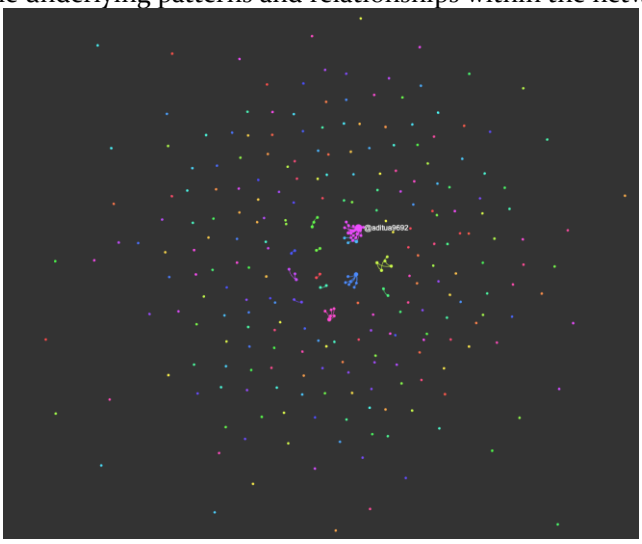

Figure 6. Social Network Analysis of the Content "Who Replies to Whom" (Netlytic)

The Social Network Analysis (SNA) outcomes focusing on "who mentions whom" reveal significant network metrics that comprehensively understand the interaction dynamics. The main topic underscores the importance of analyzing communication patterns within the network. Firstly, the obtained diameter of 0 indicates that the network is exceptionally compact, with users closely interconnected and all mentions occurring within a short distance. Secondly, the low density of 0.003448 suggests that while the network is sparse, the users who mention each other form a distinct and interconnected subset, contributing to a cohesive communication structure. Additionally, the inability to calculate reciprocity (NaN) and the minimal centralization of 0.000000 indicate a lack of mutual mentions and a decentralized communication pattern. The high modularity value of 0.996600 further accentuates the presence of well-defined communities within the network. In conclusion, the SNA results provide valuable insights into the nuanced patterns of user mentions, shedding light on the cohesive and community-based nature of communication within the analyzed network.

Social Network Analysis (SNA) offers multifaceted benefits in various fields of inquiry. Firstly, it enables the identification of influential nodes and structures within social networks, facilitating a deeper understanding of relational dynamics and power distribution. Secondly, SNA provides insights into information flow, communication patterns, and community formation, aiding in identifying key actors and subgroups. Consequently, this approach enhances decision-making processes, facilitates targeted interventions, and fosters the development of more effective strategies. In conclusion, the application of SNA illuminates complex social phenomena. It empowers researchers and practitioners to navigate and leverage social networks for various purposes, ultimately contributing to enhanced societal understanding and organizational outcomes.

2.5 Deployment

During the deployment phase, evaluating the effectiveness of live streaming content becomes paramount, particularly in its contribution to enhancing Micro, Small, and Medium Enterprises (UMKM). The main topic underscores the significance of assessing the impact of live-streaming

content deployment on the growth and visibility of UMKM. Firstly, by systematically evaluating the effectiveness of live-streaming content, businesses can gauge the reach, engagement, and conversion rates, providing tangible metrics to measure the success of their UMKM promotion efforts. Secondly, the potential for live streaming to boost UMKM lies in its ability to connect businesses directly with their target audience, fostering trust and brand loyalty. Consequently, the deployment phase becomes critical for businesses to refine their live streaming strategies, ensuring they align with the unique needs and challenges UMKM faces. In conclusion, the thoughtful evaluation of live streaming content during the deployment phase holds the key to maximizing its impact on UMKM, fostering growth, and contributing to the broader economic landscape.

3. RESULTS AND DISCUSSIONS

3.1. Sentiment Analysis of The Content Reviews

The evolution of digital marketing has provided Micro, Small, and Medium Enterprises (UMKM) with the opportunity to leverage live streaming as an effective medium to enhance sales volumes. The main topic underscores the transformative role of digital marketing in enabling UMKM to adapt to changing consumer behaviors and technological advancements. Firstly, live streaming offers UMKM a dynamic platform to showcase its products or services in real-time, allowing for interactive engagement with potential customers and fostering a sense of immediacy and authenticity in their marketing efforts. Secondly, the accessibility of live-streaming platforms and the widespread adoption of mobile technology have democratized the marketing landscape, enabling even small-scale businesses to reach a broader audience and compete effectively in the digital marketplace. Consequently, integrating live streaming into UMKM's marketing strategies represents a strategic approach to capitalize on emerging trends and drive business growth. In conclusion, using live streaming within digital marketing signifies a paradigm shift for UMKM, empowering them to thrive in an increasingly competitive and interconnected market environment.

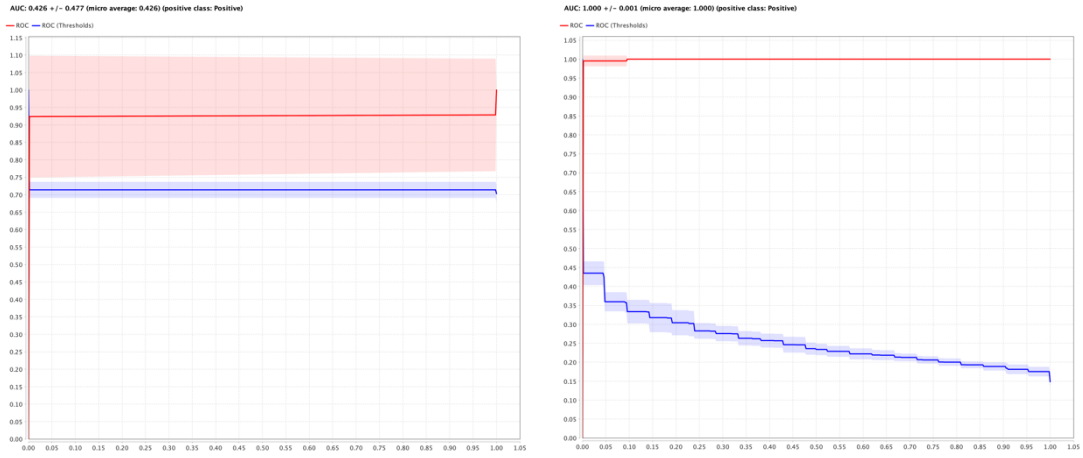

Figure 6. Area Under Curve of SVM with and without SMOTE (Rapidminer)

Based on the sentiment analysis results, it is evident that SVM utilizing SMOTE demonstrates commendable accuracy, precision, recall, f-measure, and AUC values. The main topic emphasizes the significance of these performance metrics in evaluating the effectiveness of sentiment analysis methodologies. Firstly, with an accuracy of 90.77% ± 3.22%, SVM with SMOTE achieves high levels of precision in classifying sentiments, as evidenced by the confusion matrix showing minimal misclassification. Secondly, the AUC values of 1.000 indicate robust performance in distinguishing between positive and negative sentiments, further corroborated by the precision, recall, and f-measure metrics demonstrating consistent and reliable sentiment classification. Consequently, these results

underscore the efficacy of SVM with SMOTE in accurately discerning sentiment polarity within the analyzed dataset, providing researchers with reliable insights into the emotional context of the content. In conclusion, the high-performance metrics validate the reliability and effectiveness of the sentiment analysis methodology, offering valuable insights for future sentiment analysis endeavors.

Compared to SVM without utilizing SMOTE, the performance metrics reveal noteworthy distinctions. The main topic emphasizes the significance of evaluating the impact of employing SMOTE in sentiment analysis methodologies. Firstly, SVM with SMOTE exhibits an accuracy of 97.68% ± 2.44%, showcasing a high level of precision in sentiment classification, as corroborated by the confusion matrix with minimal misclassification. Secondly, the AUC values, notably lower than SVM with SMOTE, indicate a diminished ability to distinguish between positive and negative sentiments. This difference is further reflected in precision, recall, and f-measure metrics, where SVM without SMOTE exhibits a significant drop in performance. Consequently, the comparison underscores the pivotal role of SMOTE in enhancing sentiment analysis accuracy, particularly in minimizing misclassification and improving the model's ability to discern positive sentiments within the analyzed dataset. In conclusion, these comparative performance metrics highlight the efficacy of incorporating SMOTE in SVM, emphasizing the importance of thoughtful methodology selection in sentiment analysis endeavors.

3.2. Social Network Analysis of the Content Reviews

The urgency of conducting Social Network Analysis (SNA) on Smartwatch Product Reviews is that mapping social network structures offers valuable insights into the dynamics of interconnections among entities, as illustrated by the findings within the category of "Who Replies to Whom." The main topic underscores the significance of understanding the network topology and its implications. Firstly, the obtained diameter 2 signifies the maximum distance between any pair of entities within the network, indicating a relatively compact and interconnected structure conducive to information dissemination and exchange. Secondly, the low density of 0.003982 suggests that the network is sparse, with only a tiny fraction of possible connections realized, potentially leaving room for increased engagement and interaction. Despite the absence of reciprocity and the modest centralization, the high modularity value of 0.978600 highlights the presence of distinct community structures within the network, each with its unique patterns of interaction. Consequently, these findings provide valuable insights into the complex relational patterns within the social network, emphasizing the importance of network analysis in elucidating the underlying dynamics of social interactions. In conclusion, the comprehensive mapping of social network structures offers researchers a robust framework for understanding the intricate interplay of entities and communities within the networked environment.

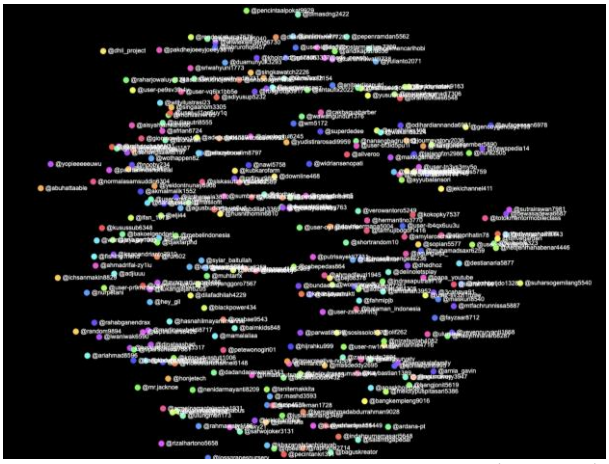

Figure 7. Who Replies to Whom Network (Netlytic)

The mapping of social network structures yields significant insights into the relational dynamics among entities, as evidenced by the findings within the category of "Who Mentions Whom." The main topic emphasizes the importance of comprehensively understanding network topologies and their implications. Firstly, the observed diameter of 0 suggests that the maximum distance between any pair of entities within the network is minimal, indicative of a tightly interconnected structure conducive to efficient information dissemination and collaboration. Secondly, while the density of 0.003448 indicates a sparse network, with only a tiny fraction of possible connections realized, the exceptionally high modularity value of 0.996600 underscores the presence of distinct and well-defined community structures within the network, each exhibiting internal solid cohesion and connectivity. Despite the absence of reciprocity and centralization, these findings highlight the robustness and coherence of the network, facilitating targeted analysis and intervention strategies. Consequently, the comprehensive mapping of social network structures provides researchers with invaluable insights into the intricate relational dynamics, underscoring the significance of network analysis in unraveling complex social phenomena. In conclusion, thoroughly exploring network structures enriches our understanding of entity interactions and community formations, enabling informed decision-making and strategic interventions within the networked environment.

In academic discourse, Social Network Analysis (SNA) emerges as a pivotal methodology for elucidating the intricate dynamics inherent in live-streaming content. This analytical framework affords scholars the means to meticulously map the interconnections among users, content creators, and platforms engaged in live-streaming activities. By employing SNA metrics such as degree centrality, betweenness centrality, and closeness centrality, researchers can identify pivotal nodes within the network, thereby discerning influential users and communities. Furthermore, SNA enables scholars to unveil patterns of interaction and information flow, shedding light on audience behaviors, preferences, and trending topics. Such insights inform content creators and platform administrators, empowering them to tailor content, optimize engagement strategies, and enrich user experiences. Moreover, within the academic domain, SNA holds promise for detecting and addressing issues such as misinformation and abusive behaviors, thus bolstering the integrity and inclusivity of live-streaming environments. In essence, the application of SNA in live-streaming content underscores its utility as a sophisticated analytical tool, facilitating nuanced research inquiries and fostering a scholarly understanding of contemporary digital phenomena.

4. CONCLUSION

In conclusion, integrating sentiment analysis results and Social Network Analysis (SNA) provides a comprehensive understanding of digital interactions and dynamics, complemented by numerical metrics such as accuracy, precision, recall, f-measure, and AUC. Through sentiment analysis, researchers discern prevalent attitudes and emotions within digital content, offering insights into audience perceptions and engagement patterns. Concurrently, SNA unveils intricate network structures and relationships among users, illuminated by numerical metrics such as Diameter (2), Density (0.003982), Reciprocity (0.000000), Centralization (0.027240), and Modularity (0.978600). Additionally, the performance vector further enhances the evaluation with metrics including accuracy (97.68% +/- 2.44%), AUC (0.429 +/- 0.477), precision (97.68% +/- 2.44%), recall (100.00% +/- 0.00%), and f-measure (98.81% +/- 1.25%). By merging these methodologies and numerical assessments, scholars gain a comprehensive perspective on the interplay between content, users, and communities, facilitating nuanced interpretations of online phenomena. Moreover, the combination of sentiment analysis and SNA enables the identification of key influencers, detecting emerging trends, and assessing sentiment impact on network dynamics. This holistic approach enriches scholarly inquiry and informs practical strategies for content creation, engagement optimization, and community management in digital environments. The synergy between sentiment analysis, SNA, and the

performance vector enhances our understanding of digital discourse and advances online behavior and communication research.

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