







# Business Performance, Social Networks, and Workforce Mental Health in Post-COVID-19 Barranquilla, Colombia

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**Abstract**—In the contemporary global business environment, the interaction between business performance and various social, technological, and health factors has intensified markedly. This study explores how mental health, specifically depression and anxiety, along with the socioeconomic impact of the COVID-19 pandemic and the increasing use of social networks, influence business performance. The research is conducted in the metropolitan area of Barranquilla, Colombia, where Twitter data from 2020 was analyzed to assess sentiment trends related to workplace well-being. The findings suggest that mental health conditions and social network usage play a crucial role in shaping organizational resilience in a post-pandemic business landscape. The results highlight that while social networks can enhance communication and market reach, they also reflect significant emotional distress among the workforce. These insights contribute to a better understanding of how companies in Barranquilla adapted to pandemic-induced disruptions and emphasize the need for organizations to implement strategies that support employee mental health while leveraging digital tools for business sustainability.

**Keywords**—COVID-19, Mental health, social media, Sentiment Analysis.

## I. INTRODUCTION

Business performance is defined as the increasing ability of an organization to achieve its objectives and maximize its competitiveness [1], which is influenced by many internal and external factors [2]. Business competitiveness, which refers to the ability of a company to maintain comparative advantages that enable it to outperform its competitors, is a crucial aspect [3]. In this context, it is important to consider structural changes within companies, such as adaptation to new technologies and business models, and cultural changes that promote innovation and adaptability of the organization and its members to new processes, products, and strategy implementation [4].

Organizational performance theories have evolved significantly in recent years, focusing on understanding the factors

driving effective organizational performance. The Balanced Scorecard model enables companies to align their activities with vision and strategy by providing a framework for measuring performance across different perspectives: financial, customer, internal processes, and learning and growth [5]. This approach has proven particularly useful in organizations seeking to maintain a holistic view of performance. On the other hand, the Resources and Capabilities Theory (RBV) [6] posits that companies gain a competitive advantage by possessing valuable, rare, inimitable, and organized resources. This theory emphasizes that organizational performance depends on the firm's ability to effectively develop and exploit these resources.

In addition, the Evidence-Based Performance theory [7] stresses the importance of basing organizational decisions on empirical data and scientific evidence. This perspective considers that organizations can improve their performance by adopting practices and policies that are effective in previous research. Grant [8] discusses the motivation and organizational well-being model, which suggests that performance increases when employees are motivated and find a balance between their personal goals and those of the company. This model is aligned with current trends that emphasize the role of well-being and job satisfaction as key drivers of organizational performance.

Business strategy and business intelligence also play fundamental roles in business performance. Strategies allow companies to anticipate changes in the market, know their internal capabilities, and learn processes that enable them to proactively determine changes in the environment and thus adjust their operations and objectives [7]. Business intelligence, which involves collecting and analyzing data to improve decision-making, is essential to understand and respond to market dynamics and consumer needs [9]. Business intelligence makes a decisive inclusion of technology in the company's context, including standardization mechanisms in the storage of information, generation of systems to determine patterns of data behavior, and breaking down the distribution and forecast of its prospective. Finally, these data are used to minimize uncertainty in the decision-making process.

Another element that is considered within this research process is the mental health of the members of the organizations since it can become a critical determinant of business performance. Disorders such as depression and anxiety

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not only affect individual productivity but can also have a collective impact on the work environment, morale, and the capacity for innovation within organizations, so it could be considered that, at a complex level of analysis, the organization itself is depressed and anxious. In an increasingly demanding business environment, workers' emotional and psychological well-being becomes an asset that companies must learn to manage and promote because they are elements that are transferred to the rest of the workers and end up being the hallmark that identifies a particular place to work [10].

One of the elements that, in the same way, is studied as an effect on business performance is the COVID-19 pandemic. This has brought a global health crisis and profound social and economic repercussions [11]. Restrictions on mobility, social isolation, and financial uncertainty have changed the dynamics of work and consumption. Adapting to these changes has been a significant challenge for companies, requiring re-evaluating work practices, business models, and market strategies. Among the models that are part of these adjustments is the widespread use of social networks, which are part of the digital sphere and have established themselves as essential tools for marketing, communication, and management of business reputation and communications with suppliers and customers. The time spent by users on these platforms and their accessibility have transformed business strategies, allowing companies to reach broader and more diversified audiences. However, excessive use of social networks has also been associated with mental health problems, such as anxiety and depression, posing an additional challenge for business management.

The interaction between mental health, COVID-19 effects, and social network use presents a complex picture of business performance [12]. On the one hand, companies that manage to adapt their strategies to improve the mental well-being of their employees and leverage digital tools effectively can enhance their competitiveness and resilience. On the other hand, ineffective management of these factors can lead to decreased productivity and the ability to adapt to the market, which, in the end, represents one of the objectives organizations permanently seek.

This paper examines how the interplay between mental health, the COVID-19 pandemic, and the use of social networks influences business performance. By understanding these dynamics, companies can design better strategies that improve their competitiveness and promote a healthy and resilient work environment in the face of future challenges. This introduction lays the groundwork for a detailed exploration of these factors and their integrated impact on business performance and sustainability. The novelty of this study lies in integrating sentiment analysis from social media data, specifically Twitter, to assess the psychological and emotional impact of the COVID-19 pandemic on business performance, which has not been sufficiently explored in the existing literature. This approach allows for understanding how collective emotions expressed on social networks can influence organizational dynamics and business strategy formulation.

## II. REVIEW OF THE LITERATURE

Following the focus of this research, which explores the effects that mental health, the use of social networks, and COVID-19 had on business performance, in this space, we proceed to specify each analytical item through which the variables that make up the object of study are described and contextualized. These are business performance, mental health, COVID-19, and social networks.

### A. Business Performance

Business performance is a comprehensive area of study that encompasses aspects of the management and operation of an organization, and its study involves a holistic analysis of the processes and interactions between internal and external elements. Recent literature highlights several key components that influence performance. These include competitiveness, structural and cultural changes, strategy, and business intelligence. This section explores these elements from current sources, providing a basic overview of this area's state of the art.

The concept of competitiveness has been widely discussed in the literature, and contributions have been made in this area on comparative and competitive advantages to provide organizations with areas of opportunity. Likewise, collaboration strategies have been proposed to improve the possibility of overcoming competition, such as sectoral groupings or clusters, and have been part of key business performance indicators. A company's competitiveness is determined by its ability to innovate and optimize its resources more effectively than its competitors [13]. One of its relevant approaches has been the concept of "localized innovation systems" (LIS), which refers to how firms, research institutions, and governments within a specific locality interact to promote innovation and competitiveness [14]. This approach emphasizes the importance of the local and regional context in creating sustainable competitive advantages. Likewise, systemic competitiveness studies have been carried out, including levels of analysis that have increased the possibility of finding elements for improvement in the study of organizations and their impact [15]. In this context, innovation refers to products or services and internal processes, business models, and market strategies. Adaptability to technological changes and changing market demands are also crucial, emphasizing the need for a dynamic approach to competitiveness management [16].

Regarding the business strategy approach, recent literature points to the importance of strategically aligning business objectives with internal capabilities and market conditions. Research suggests that strategies incorporating predictive analytics and data-driven approaches to anticipate market trends and consumer behaviors can significantly improve decision-making and positively impact business performance, thus supporting the importance of properly managing the information handled within the company [17]. In addition, integrating sustainability strategies has proven to be a competitive advantage, aligning business operations with contemporary social and environmental expectations [18]. Business intelligence (BI)

has emerged as a crucial component of business performance analysis and improvement. BI tools provide real-time insights and predictive analytics that can transform business operations by accelerating and informing responses to market challenges [19]. This responsiveness is particularly valuable in turbulent business environments, where speed and accuracy of information can be critical to success.

### B. Mental Health

Mental health, an integral aspect of human well-being, has been the subject of intense research in recent decades. Especially depression and anxiety have captured the attention of the scientific community due to their prevalence and the profound impact they have on society and the work environment. Depression is a mood disorder characterized by persistent feelings of sadness, loss of interest in daily activities, and a significantly reduced ability to feel pleasure. According to the World Health Organization (WHO), depression is a leading cause of disability worldwide and affects millions of people. Recent approaches to its study highlight the biological and psychosocial complexity of depression, focusing on the impact of genetic, environmental, and psychological factors on its development [20].

Anxiety, on the other hand, is characterized by excessive worry, nervousness, and fear that are difficult to control and affect daily activities. Anxiety has been studied not only as a psychological disorder but also in its relationship to socioeconomic and environmental contexts [21]. These studies highlight the relationship between anxiety and physical health problems, suggesting that early intervention can mitigate long-term effects on overall health.

Socially, depression and anxiety have implications beyond the individual. At the community level, these disorders are linked to stigma and discrimination, which can hinder help-seeking and needed social support. Furthermore, the prevalence of depression and anxiety can exacerbate existing social problems, such as unemployment and social inequality, creating a vicious cycle that is difficult to break [22].

In business, employee mental health is crucial to productivity and organizational culture. Companies like Google and Microsoft have implemented wellness programs to address these issues directly, demonstrating a growing recognition of their importance. Workplace interventions that promote mental health improve employee well-being, operational efficiency, and talent retention [23].

Depression and anxiety are mental health disorders that require attention from both a societal and business perspective [24]. Addressing these disorders not only improves the quality of life of individuals but also benefits society and the economy as a whole [25]. Public policies and business strategies must include effective prevention, intervention, and ongoing support programs to manage mental health.

### C. COVID-19

Economically, COVID-19 has caused one of modern history's most significant global recessions, significantly impact-

ing numerous sectors, including tourism, hospitality, and services. Disruption of global supply chains and mobility restrictions have affected both developed and emerging economies. However, sectors such as e-commerce, information, and communication technologies have experienced significant growth [26]–[28].

From a social and business perspective, the pandemic has accelerated the adoption of digital technologies. It has encouraged re-evaluating work practices, promoted telecommuting, and made traditional work structures more flexible. This represents an opportunity to redefine the interaction between work and personal life and potentially diminish existing work inequalities. From a business point of view, companies are rethinking their business models to be more resilient to future crises and integrate sustainability and social responsibility practices [29].

It is determined that the COVID-19 pandemic has profoundly impacted business performance globally, disrupting industries, economies, and corporate operations. During the initial phase of the pandemic, many businesses experienced severe declines in demand, supply chain disruptions, and operational shutdowns. Research indicates that the adverse effects were particularly pronounced in sectors such as retail, tourism, hospitality, and manufacturing, where in-person services and physical infrastructure were heavily relied upon [30]. Businesses were forced to adapt quickly by adopting remote work practices, accelerating digital transformation efforts, and rethinking business models to survive in the uncertain environment. According to recent studies, companies that were more agile in transitioning to digital solutions and adopting flexible work arrangements showed greater resilience, helping mitigate some negative effects on performance [31].

However, the long-term impact of COVID-19 on business performance continues to vary across sectors. While some industries, like e-commerce and technology, witnessed growth due to the increased reliance on digital services, others struggled to recover from prolonged lockdowns and reduced consumer spending [32]. The pandemic also highlighted the importance of business continuity planning and crisis management, as firms with robust contingency strategies were better equipped to handle the disruptions. Furthermore, the pandemic accelerated the adoption of innovative business practices, such as digital marketing and virtual customer engagement, which have become critical drivers of performance post-pandemic [33]. Overall, the literature suggests that while the pandemic caused significant short-term challenges, businesses embracing innovation and digitalization emerged stronger in the aftermath.

### D. Concept and Use of Social Networks

Social networks are digital platforms that enable the creation and sharing of content and information between users. These platforms range from general social networking sites such as Facebook and X (formerly Twitter) to more specific platforms such as LinkedIn for professionals and TikTok for short

video content. Their primary function is to facilitate online communication and social interaction [34].

The use of social networks has multiple effects on users. It can enhance social connection and provide emotional support, especially in marginalized or isolated communities. However, it is also associated with several risks, including mental health problems such as anxiety and depression, especially among adolescents and young adults [35]. In addition, excessive use of social networks can lead to addiction and negatively affect productivity and personal well-being.

The time spent on social networks varies significantly between different age groups and demographics. Young people spend more time on these platforms, raising concerns about their impact on social and academic development. The accessibility of social networks has increased with the expansion of mobile connectivity, allowing near-constant access and, in many cases, changing the way we interact socially and perform everyday tasks [36].

From a social perspective, social networks have democratized information and given voice to previously underrepresented groups, but have also facilitated the spread of misinformation and polarization. In business terms, social media platforms have become essential tools for marketing, customer relationship management, and exploring new markets. Companies that adopt effective social media strategies can improve customer loyalty, increase brand visibility, and generate new revenue opportunities [37], [38].

#### *E. Mental health sentiment analysis of work teams from the COVID-19 pandemic*

The COVID-19 pandemic has created an unprecedented set of challenges for the mental health of individuals, including work teams in a variety of workplace settings. Sentiment analysis has become a crucial tool for understanding the psychological impact of this crisis on work teams.

Researchers have identified patterns and trends in workers' moods and psychological well-being by assessing emotional expressions and interactions on digital platforms and social networks.

Social networks represent fundamental platforms for communication, content, and building relationships between people. In the context of the COVID-19 pandemic, a significant increase in the use of these networks was observed through studies, platforms such as Facebook, WhatsApp, and Twitter being some of the main ways people express their feelings [39]. An analysis of sentiments expressed by Indian citizens about the COVID-19 pandemic and vaccination campaigns was performed using text data from social networks. Sentiments were evaluated using a combination of deep learning and lexicon-based techniques. Specifically, a lexicon-based approach was employed using tools such as VADER and NRCLex to classify the polarity of tweets. In addition, recurrent neural networks, including Bi-LSTM and GRU architectures, were trained to analyze sentiment patterns further. The models achieved high accuracies of 92.7 % and 91.24 % on the COVID-19 dataset and 92.48 % and 93.03 % on the vaccination-related tweets

dataset, respectively. The developed models have significant potential to support health professionals and policymakers make informed decisions during future pandemic outbreaks.

On the other hand, sentiments in tweets made in the context of COVID-19 and MPox were analyzed [40]. 61,862 tweets simultaneously focused on MPox and COVID-19, posted between May 7, 2022, and March 3, 2023, were studied to address this research gap. The contributions of this study are varied and significant. First, sentiment analysis conducted using the VADSR (Valence Aware Dictionary for Sentiment Reasoning) method revealed that nearly half of the tweets (46.88%) expressed negative sentiment, followed by positive sentiment (31.97%) and neutral sentiment (21.14%). Second, the study identifies the 50 most frequently used hashtags in these tweets. Third, it highlights the top 100 words, identified through tokenization, removal of stop words, and word frequency analysis. The results show that the tweets reflected considerable interest in topics related to COVID-19, Mpox, and other viruses.

Regarding the performance of work teams, a recent study analyzed people's feelings about working from home by analyzing social media activities [41]. One hundred thousand tweets were examined when working from home became the norm. The study results indicated that the work-from-home concept was generally well-received by people. The emotions associated with most tweets were confidence and anticipation, suggesting a positive attitude toward this new work model. This study provides an interesting perspective on how the population perceived and responded to the shift toward remote work during the pandemic. These findings may help better understand the acceptance and implications of working from home in different socioeconomic and cultural contexts.

Sentiment analysis and mental health in work teams can detect signs of stress, anxiety, depression, and other mental disorders that may arise due to work-related stress, social isolation, economic uncertainty, and health concerns associated with the pandemic. In addition, sentiment analysis can provide valuable information about the effectiveness of interventions and policies to improve emotional well-being and mental health at work during these challenging times. By better understanding the emotional challenges work teams face during the COVID-19 pandemic, more effective strategies can be developed to promote a healthy and resilient work environment.

A separate study [42] aimed to explore public attitudes and experiences regarding remote work by examining social media activity between 30 March and 5 July, 2020. More than 1 million tweets containing terms such as 'telecommuting', 'work from home', and 'remote work' were collected and analyzed using natural language processing (NLP) techniques. Sentiment analysis indicated predominantly positive perceptions of remote work, with slight fluctuations observed on weekends. The topic modeling identified consistent themes throughout the tweets, including home office setups, cybersecurity, mental health, work-life balance, teamwork, and leadership, with minimal changes over the 14-week period.

Unlike previous studies that have treated each variable—mental health, of social media, and the effects of the pandemic—in isolation, this study addresses them together, providing a holistic view of the post-pandemic environment. Additionally, sentiment analysis as a methodological tool in this context is innovative, as it assesses immediate impacts and offers predictions on how these factors may affect businesses’ long-term sustainability and resilience.

### III. RESEARCH HYPOTHESIS

Despite the existence of related research on the four constructs under study, it is considered essential to present proposals to reduce the theoretical gap and understand the impact that the variables of mental health, COVID-19, and social networks have on business performance.

One of these reasons is the need to empirically evidence the relationship between the independent and dependent variables underpinning this paper’s rationale. This perspective is proposed given the strategic need to prepare organizations to maintain a permanent attitude of alertness in the face of emerging and untimely environmental changes.

The COVID-19 pandemic demonstrated that social, business, economic, and political conditions change almost immediately in the face of the threat of disease. It also showed that human adaptability is highly effective, emergent, and efficient. It is, therefore, congruent to note that the possibility of analyzing the impact of these fortuitous conditions on people using traditional analysis techniques and sentiment analysis allows us to observe the effect on organizations and increase our understanding of this phenomenon to apply new knowledge to management strategies, human relations guidelines, and organizational interaction expectations.

The main hypothesis of the study integrates the three outline variables, suggesting a comprehensive relationship between mental health, the impact of COVID-19, social networks, and their combined influence on business performance [10], [12], [30]–[36]. Specifically, it posits that better employee mental health positively impacts business outcomes by enhancing productivity, creativity, and engagement [8], [10]. On the contrary, the disruptive effects of COVID-19 have imposed significant challenges on business performance, primarily in terms of operational disruptions and reduced profitability [12]. However, the strategic use of social networks has helped businesses mitigate these negative effects by improving communication, customer engagement, and overall market reach, enhancing business resilience and performance.

Thus, the central hypothesis asserts that the combined effects of mental health, the challenges posed by COVID-19, and the utilization of social networks collectively shape business performance in significant ways. While mental health and social networks positively influence business outcomes, COVID-19 introduces adverse factors that can disrupt performance. Therefore, companies prioritizing employee mental health and leveraging social networks are more likely to achieve better business performance despite the challenges brought by the pandemic [34]–[36].

### IV. METHODOLOGY

The type of research of the project is qualitative and non-experimental; it was not intended to manipulate the data in any way; these data were collected from the Twitter API belonging to the city of Barranquilla. Filtering parameters provided by the API were used to determine the geolocation.

In this instance, it was determined that no worker segmentation would be carried out because the data collected on social media in 2020 was of routine engagement, which is public and anonymous, making it challenging to identify the individual. This approach makes it simple to observe the pertinent correlations at the organizational level by allowing for the study of the broad relationships between mental health, the COVID-19 pandemic’s effects, and social network use and company performance.

#### A. Data Collection and Filtering Model

To achieve the above, stages were designed based on the model proposed by [43], as shown in Fig. 1. The first stage focuses on data exploration: In this stage of the project, the use of keywords (keyword) was made for initial filtering of the texts contained in the tweets, in addition to defining the structure that allows a visual exploration to understand what is in this dataset and the characteristics of these.

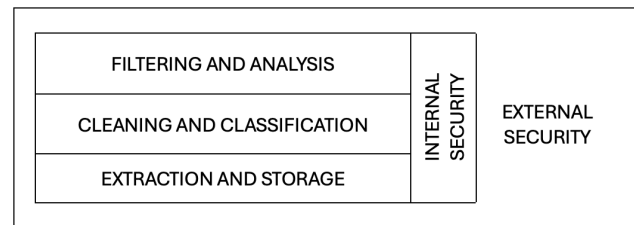


Fig. 1: Social network data collection and filtering model [34].

Likewise, the appropriate and relevant methods for information extraction, techniques for classifying information, and ways to apply filters to the social media were studied.

In the second stage, data preprocessing was performed, where a data set was built and used in the modeling. For this, data cleaning was performed (dealing with missing or invalid values, eliminating duplicate data, removing noise such as special characters or links), and the necessary transformations were applied to correct data processing and combine data with different search patterns. Finally, explanatory variables were added to the structured data.

In the third stage of information storage, once the information has been processed, the information is stored in a repository that allows data persistence. This will culminate in the modeling stage, where the characterized information is analyzed using natural or linguistic language to construct the model that predicts the disorder and supports the medical diagnosis.

## B. Data Analysis Architecture

The architecture used is shown in Fig. 2. It is based on the AWS platform with the following elements:

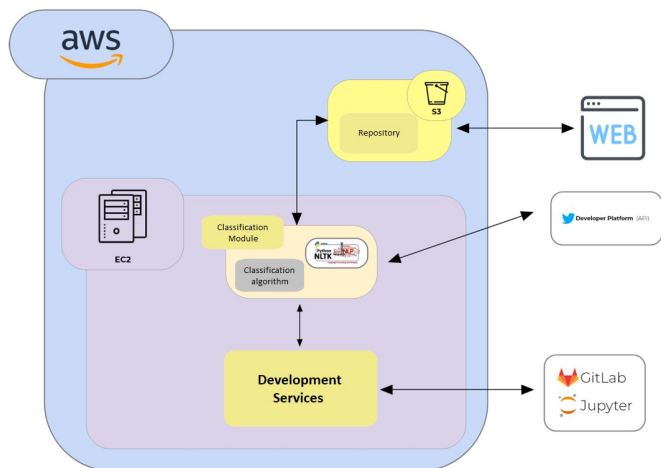


Fig. 2: AWS-based archyctecture to data analytics.

- An EC2 t2. large instance with Linux to run our algorithm with Python.
- The classification module relies on a few libraries for linguistic analysis and text processing and connects to social media for data retrieval.
- The output of the classification module is stored in S3 as a CSV file for public viewing.

Going into more details of the classification module, Python was used with the "searchtweets-v2" library to obtain a sample of 43,204 Tweets. Once received, a filtering procedure for the information was performed, i.e., special characters, links, subjective phrases, and phrases with little coherence were eliminated.

Once all the information was filtered, we used a natural language processing tool (NLTK) with more than 50 corpora and lexical resources to classify and tokenize the words.

## C. Algorithms Used

On the other hand, it is essential to specify that search, processing, and classification algorithms were developed at each stage to obtain the above results.

Fig. 3 shows an algorithm that has two methods. The first one oversees all the authentication parts with the Twitter API credentials. The second one is in charge of searching and reading the tweets, where the date range where the tweets are taken is selected, and we will use the max\_tweets parameter to control the amount. Finally, those tweets are returned.

The algorithm presented in Fig. 4 performs the data processing, starting with a text cleansing, where all the noise is removed from the tweets, a sentence splitter is made to divide by phrases and then perform the whole tokenization process, which is nothing more than the process of dividing a raw text string into meaningful tokens.

```

from searchtweets import ResultStream, collect_results,
gen_request_parameters, load_credentials

class SearchTweets:

    def __init__(self, config):
        self.search_args = load_credentials(filename=config,
            yaml_key="search_tweets_v2",
            env_overwrite=False)

    def search(self, query="", max_tweets=10000):
        def decorator(f):
            request_parameters = gen_request_parameters(query,
                results_per_call=100)
            rs = ResultStream(rule_payload={"from_date": "2020-3-01",
                "to_date": "2022-6-01"}, request_parameters=request_parameters,
                max_tweets=max_tweets, max_pages=1, **self.search_args)
            f(tweets=rs.stream())
            return f
        return decorator
    
```

Fig. 3: Algorithm for searching Tweets.

```

import csv
import emoji
import re
from textblob import TextBlob
from lib.searchTweets import SearchTweets

searchTweets = SearchTweets("./config/config.yml")

tweets_filter = []

@searchTweets.search(query="lang:es -is:retweet -the the",
max_tweets=40000)
def handleTweetsCovid(tweets):
    for tweet in list(tweets):
        if("id" in tweet):
            tweet_id = tweet['id']
            text_tweet = tweet['text']
            allchars = [str for str in text_tweet]
            emoji_list = [c for c in allchars if c in
            emoji.UNICODE_EMOJI_ENGLISH]
            clean_text = ''.join([str for str in text_tweet.split() if
            not any(i in str for i in emoji_list)])
            clean_text=
            re.sub(r'(https|http)?://\w+\.?\w+/?\s*\b', '', clean_text,
            flags=re.MULTILINE)
            tweets_filter.append([tweet_id, clean_text])
        with open('db.csv', 'w', newline='', encoding='utf-8') as file:
            writer = csv.writer(file)
            writer.writerow(["id", "tweet", "sentiment"])

    for tweet in tweets_filter:
        tweet_id = tweet[0]
        text_tweet = tweet[1]

        sentiment(text_tweet)

        writer.writerow([ tweet_id, text_tweet, s ])
    
```

Fig. 4: Algorithm for Tweets processing.

Finally, the algorithm performs stemming, lemmatization, and word removal processes to deliver the tweet ready for classification, as shown in Fig 5.

## V. RESULTS

### A. Results Analysis

In the initial classification, shown in Fig. 6, an initial scale was determined in which the algorithm yielded values ranging from -1 to 1. Values below 0 are those tweets that convey some negative sentiment. On the other hand, values greater than 0 are those that convey positive sentiment. Finally, they find tweets with zero value and represent a neutral message.

The study only focused on messages that convey some negative sentiment, corresponding to 4 % of the tweets analyzed, i.e., 1,728. With this information, we classified each one the

```
def sentiment(text_tweet):
    analysis = TextBlob(text_tweet)
    analysis = analysis.sentiment
    sentiment = ""

    if -1 <= analysis.polarity < -0.75:
        sentiment = "Odio, rabia, preocupación"
    elif -0.75 <= analysis.polarity < -0.6:
        sentiment = "Tristeza, decepción, necesidad"
    elif -0.6 <= analysis.polarity < -0.45:
        sentiment = "Desagrado, intolerancia"
    elif -0.45 <= analysis.polarity < 0:
        sentiment = "Duda, incertidumbre, neutral"
    else:
        print(analysis.polarity)

    return sentiment
```

Fig. 5: Algorithm for Tweets classification.

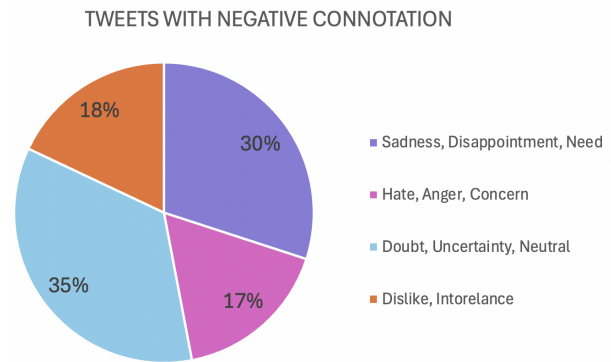


Fig. 7: Classification of tweets with negative connotations.

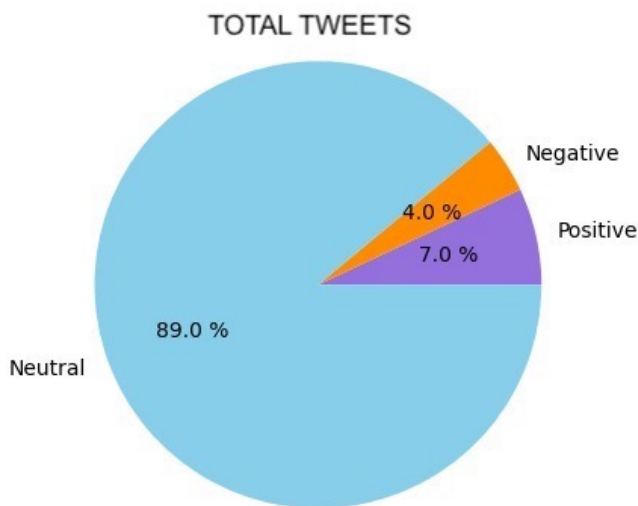


Fig. 6: Classification of tweets according to the initial scale.

sentiment they transmit in the different negative ranges, as shown in Fig. 7, comprised only between -1 to 0, as follows:

- [-1 to -0.75): Hate, anger, worry.
- [-0.75 to -0.6): Sadness, disappointment, neediness.
- [-0.6 to -0.45): Disgust, intolerance.
- [-0.45 to 0): Doubt, uncertainty, neutral.

The 4 % of results focusing on negative sentiment tweets is justified in the context of the study's specific objective of analyzing negative emotional expressions. Although 4% represents a small portion of the overall dataset, it still comprises 1,728 tweets, providing substantial data for exploring the nuances of negative sentiment. In exploratory sentiment analysis, this focused subset allows for a detailed classification of negative emotions, offering insights into the emotional states conveyed through social media, particularly in hate, anger, sadness, and uncertainty.

Furthermore, the classification of these tweets into specific negative emotional ranges, as shown in Figure 7, highlights

the study's intent to differentiate between various degrees of negative sentiment, from hate and anger to doubt and uncertainty. This granularity in categorizing emotions adds value to the analysis despite the relatively small percentage of negative tweets. By focusing on these negative sentiments, the study can contribute important findings about emotional communication patterns, which could otherwise be obscured in a more extensive, more generalized data set. Thus, the result 4%, while seemingly minor, plays a critical role in achieving the exploratory objectives of the study.

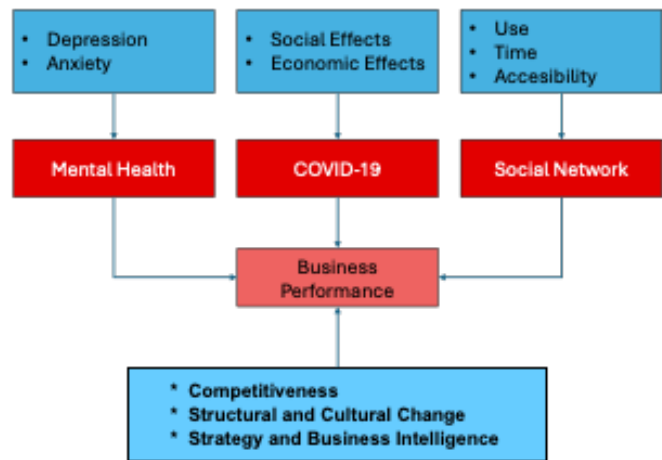


Fig. 8: Theoretical model proposed for business performance analysis.

The findings suggest that, while the emotional impact of COVID-19 is not manifested in a large number of extreme negative messages, the prevailing uncertainty among employees may influence their organizational performance. This interpretation is consistent with the hypothesis of the study, which posits that employee mental health, along with the impact of COVID-19 and the use of social networks, significantly affects business performance.

In addition, the results indicate that the sentiment analysis in social networks can serve as a useful indicator of organizational climate and work well-being. To improve the precision of the analysis and better differentiate emotional

states, we recommend the implementation of more advanced classification models, such as Nave Bayes algorithms or linear regression, and collaboration with mental health experts to refine emotion categorization in future research.

### B. Focus

The purpose of this work was to analyze information from social networks to in some way support the diagnosis of disorders related to mental health of members of the organization that, in this research, we refer to as anxiety and depression of participants considering the pandemic situation due to COVID-19 in the Barranquilla metropolitan area. In this research, the proposition is to broaden the scope of the analysis. Including this effect in the assessment of business performance, we propose to expand the scope of the study and include these effects and add two additional factors, which we show in the model illustration in Figure 8.

## VI. DISCUSSION

The results of the study confirm the central hypothesis. Uncertainty and concern about the future of work were found to be the main emotional factors expressed in social networks, suggesting that the COVID-19 pandemic had a lasting impact on the perception of the work environment. Although only 4% of the tweets analyzed were classified as negative, most of them reflect doubts about professional stability and job security.

This evidence supports the relationship between mental health and organizational performance by demonstrating that an uncertain emotional state can affect employees' decision-making and motivation. The study also confirms that social network monitoring through sentiment analysis can be a valuable tool for assessing the emotional state of the workforce and anticipating potential impacts on productivity and business resilience.

It is recommended that companies adopt strategies that promote the mental well-being of their employees and take advantage of digital tools that allow continuous analysis of the organizational climate. In addition, future research can deepen the relationship between the emotional perception of workers and their performance in different sectors and socioeconomic contexts.

## VII. CONCLUSIONS

Performing the whole process of collection, filtering, and categorization in a social network with an audience as varied as social media brought into play the level of subjectivity that must be taken into account when analyzing human expressions so that the current version and the results expressed do not reflect a perfect accuracy as would be ideal, there may be many discrepancies, however, for most extremist cases (positive and negative) an approach to reality was noted that may come to satisfy the need to frame the context of the message within a group of feelings related to the same.

Once the results have been analyzed, it can be concluded that most of the messages classified as 'negative' tend to

be related to neutral aspects or may demonstrate doubt and uncertainty in the person writing, followed by feelings of sadness, disappointment, or some need. It should be noted that this percentage of negative expressions corresponds to the minority of tweets analyzed in the metropolitan area of Barranquilla, Colombia, where the study was conducted. This geographical focus highlights the impact of the COVID-19 pandemic on the local labor market and provides insights into the emotional state of employees in this specific context. Therefore, these findings should be interpreted considering the particular socioeconomic conditions of Barranquilla, which may differ from other regions. Future research could explore similar dynamics in different geographical locations to assess the generalizability of these conclusions. Additionally, further training of the neural network is needed to improve the accuracy of message classification, and it is recommended that the project continue with the help of a specialist in mental health to refine the guidelines by which the algorithm is trained. The classification can be supported with a categorization model oriented in a linear regression algorithm or a 'Naïve Bayes' type classifier.

Thus, the COVID-19 pandemic not only transformed social, business, economic, and political structures, but also highlighted the adaptive capacity of human beings in the face of adverse and unforeseen circumstances. This phenomenon underscores the importance of deepening the study of organizational performance by integrating traditional and sentimental analysis to better capture and understand the impact of these abrupt changes. The understanding gained through such studies is vital to developing more resilient and adaptive management strategies, optimizing human relationships within organizations, and calibrating organizational interactions and expectations. Further investigation of these dynamics is therefore relevant and essential to prepare organizations to respond more effectively to future global crises, thus ensuring operational continuity and optimal organizational performance in times of uncertainty. A key reason for this is the need to empirically demonstrate the relationship between the independent and dependent variables that underlie this study. This approach is strategically vital to prepare organizations to maintain constant alertness in the face of emerging and unforeseen environmental changes.

In conclusion, the study findings provide empirical evidence supporting the central hypothesis: the combination of mental health, social networks, and the impact of COVID-19, to some extent, affects business performance. The emotional uncertainty reflected in social networks is linked to organizational adaptation and resilience, suggesting that companies should consider digital monitoring strategies to manage the well-being of their workforce and optimize their performance.

### A. Contributions

a) *Objectives consideration:* The research objectives in this study are confirmed by the successful process of collecting, filtering, and categorizing social network data, despite the inherent subjectivity involved in analyzing human expressions

on platforms like Twitter (now X). The research has captured key sentiments, particularly extreme cases of positivity and negativity, that frame messages within specific emotional contexts. Although there may be discrepancies in the results, especially in less extreme cases where doubt, uncertainty, or neutral aspects are dominant, the classification achieved provides an initial approach to understanding the emotional landscape of social media users. This confirms the objective of identifying and categorizing sentiments effectively, even if further algorithm refinement is needed to improve accuracy, particularly in the case of more nuanced emotional expressions.

Moreover, integrating traditional and sentiment analysis to examine the broader implications of the COVID-19 pandemic on social and business structures confirms another key research objective: understanding how abrupt global events affect organizational performance. The findings highlight the adaptability of humans in the face of uncertainty and the potential for these insights to inform more resilient management strategies. The study demonstrates that, while the COVID-19 pandemic transformed multiple dimensions of society, sentiment analysis allows for a deeper understanding of these shifts. Therefore, the primary goals of the research—exploring the impact of mental health, social networks, and COVID-19 on performance—have been fulfilled, with future work aimed at enhancing the understanding of these dynamics.

*b) Practical applications:* The findings of this paper present both practical and theoretical implications for understanding the interaction between mental health, social networks, and organizational performance, especially in the wake of the COVID-19 pandemic. Organizations can benefit from integrating mental health support systems and leveraging sentiment analysis tools to monitor employee well-being. By implementing wellness programs and digital tools that provide real-time insights, companies can proactively address mental health challenges, positively impacting productivity and organizational resilience [44]. This approach aligns with recent organizational strategies that emphasize the importance of mental health as a key component of business success, suggesting that monitoring and responding to employees' emotional states can lead to a more adaptive and supportive work environment [45].

*c) Theoretical applications:* Theoretically, this paper extends the current understanding by integrating mental health and social network usage into studying organizational performance. While previous literature primarily focused on isolated factors, such as mental health disorders or social network use, this study combines these elements to provide a holistic view. This research contrasts with traditional studies, which often emphasize single-variable impacts on performance [46]. Instead, it adopts a more complex approach, recognizing the interdependent nature of these factors. By using sentiment analysis of social media data to measure psychological impact, this paper also introduces a novel methodological tool that allows for a more in-depth understanding of the emotional climate within organizations, addressing a gap in the literature

where the collective impact of mental health, digital engagement, and pandemic-induced stress on performance has not been sufficiently explored [47].

### B. Study Limitations

Despite the contributions of this study, several limitations must be acknowledged. First, the study relies on sentiment analysis derived from Twitter data, which, while valuable, does not represent the entire workforce's experiences. The sample is limited to users who express their opinions on social media, potentially excluding those who do not engage on these platforms.

Second, the research focuses exclusively on the metropolitan area of Barranquilla, Colombia, meaning that the results are context-specific. The findings may not be directly applicable to regions with different cultural, economic, or social conditions. Future research should consider expanding the study to diverse geographical locations to assess whether the observed patterns hold in different environments.

Third, the study primarily examines the relationship between mental health, social networks, and business performance but does not account for other potential factors such as government economic policies, industry-specific resilience, or corporate mental health initiatives. A more comprehensive model integrating these variables could provide a deeper understanding of business performance in post-pandemic contexts.

Finally, the sentiment analysis algorithm, while effective, has inherent limitations. Contextual nuances such as sarcasm or implicit emotions may not always be accurately detected. Enhancing the model through deep learning and incorporating expert validation from psychology and business analytics fields could improve classification precision in future research.

### C. Future Research Lines

Building on the findings of this study, several areas warrant further investigation:

- 1) **Geographical expansion of the study** – Applying similar sentiment analysis methodologies to different cities or countries could help determine whether the relationships between mental health, social networks, and business performance remain consistent across various labor markets.
- 2) **Enhancement of sentiment analysis models** – Future research should focus on improving the sentiment classification algorithm by incorporating advanced natural language processing (NLP) techniques, such as contextual deep learning models, to better interpret emotions in social media data.
- 3) **Broader organizational factors** – Additional studies could integrate variables such as economic policies, industry-specific challenges, and corporate well-being programs to develop a more comprehensive framework for assessing business performance.
- 4) **Longitudinal analysis** – Conducting a long-term study tracking changes in employee sentiment over time

would allow researchers to evaluate whether mental health recovery trends influence business resilience post-pandemic.

- 5) **Impact of corporate interventions** – Future studies could explore how companies' mental health initiatives, remote work policies, and digital engagement strategies influence workforce sentiment and overall productivity. Understanding these dynamics could provide actionable insights for improving workplace well-being.

## REFERENCES

- [1] D. Chakraborty and W. Biswas, "Articulating the value of human resource planning (HRP) activities in augmenting organizational performance toward a sustained competitive firm," *Journal of Asia Business Studies*, vol. 14, no. 1, pp. 62-90, 2020.
- [2] M. I. Nasution, M. Fahmi, and M. A. Prayogi, "The quality of small and medium enterprises performance using the structural equation model-part least square (SEM-PLS)," in *Journal of Physics: Conference Series*, vol. 1477, no. 5, p. 052052, IOP Publishing, Mar. 2020.
- [3] L. Shaulska et al., "Strategic enterprise competitiveness management under global challenges," *Academy of Strategic Management Journal*, vol. 20, no. 4, pp. 1-7, 2021.
- [4] G. Ni et al., "Influence mechanism of organizational flexibility on enterprise competitiveness: The mediating role of organizational innovation," *Sustainability*, vol. 13, no. 1, p. 176, 2020.
- [5] R. S. Kaplan y D. P. Norton, *The Balanced Scorecard: Translating strategy into action*, Harvard Business Review Press, 2019.
- [6] J. Barney, "Resource-Based View: An updated approach," *Journal of Management*, vol. 46, no. 5, pp. 1205-1225, 2020.
- [7] D. M. Rousseau, "Evidence-Based Management: Foundations, development, and impact on organizational performance," *Academy of Management Annals*, vol. 15, no. 3, pp. 741-777, 2021.
- [8] A. Grant, "The Motivation and Well-being model: A pathway to enhancing organizational performance," *Organizational Psychology Review*, vol. 11, no. 1, pp. 34-55, 2022.
- [9] R. Dicarolo and Á. M. Niño, "Use dashboards to support decision making in operations management," in *2023 IEEE Colombian Caribbean Conference (C3)*, Barranquilla, Colombia, 2023, pp. 1-4.
- [10] Y. -r. Wang and Z. Yang, "Empirical study on job stressors of enterprise employees," in *2012 International Conference on Management Science & Engineering 19th Annual Conference Proceedings*, Dallas, TX, USA, 2012, pp. 1259-1263.
- [11] N. Moukaddam and A. Shah, "Psychiatrists beware! The impact of COVID-19 and pandemics on mental health," *Psychiatric Times*, vol. 37, no. 3, 2020.
- [12] K. Saha et al., "Psychosocial effects of the COVID-19 pandemic: large-scale quasi-experimental study on social media," *Journal of medical internet research*, vol. 22, no. 11, p. e22600, 2020.
- [13] D. Messner and J. Meyer-Stamer, "Systemic competitiveness: Lessons from Latin America and beyond – perspectives for Eastern Europe," *European Journal of Development Research*, vol. 6, no. 1, pp. 89-107, 1994.
- [14] B. Grechanyk et al., "Innovative development of national economies," in *Innovative development of national economies*, 2022.
- [15] K. Esser et al., "Competitividad sistémica: Nuevo desafío para las empresas y la política," 1996, pp. 39-52.
- [16] H. Savall, V. Zardet, and A. Savall, "New Trends in Organizational Challenges and Need for Change: The ISEOR Research Programs," *Organization Development Journal*, vol. 36, no. 4, pp. 41-54, 2018.
- [17] U. P. Singh, "Decision making and predictive analysis for real time data," in *Advances in Data Science and Analytics: Concepts and Paradigms*.
- [18] E. Ahumada Tello and J. M. A. Perusquia Velasco, "Business intelligence: Strategy for competitiveness development in technology-based firms, Inteligencia de negocios: Estrategia para el desarrollo de competitividad en empresas de base tecnológica," *Contaduría y Administración*, vol. 61, no. 1, pp. 127-158, 2016.
- [19] E. M. A. Qhal, "Role of Business Intelligence and Knowledge Management in Solving Business Problems," *Tehnicky Glasnik*, vol. 16, no. 3, pp. 371-378, 2022.
- [20] J. Smith, R. Zhang, and K. Williams, *The biology of depression: From genetics to therapies*. MIT Press, 2021.
- [21] A. L. Jones, B. Smith, and P. J. Taylor, *Anxiety in socio-economic contexts: Clinical and environmental interventions*. Routledge, 2022.
- [22] T. Treffers, P. Klarner, and Q. N. Huy, "Emotions, time, and strategy: The effects of happiness and sadness on strategic decision-making under time constraints," *Long Range Planning*, vol. 53, no. 5.
- [23] C. Brown and D. Perkins, *Workplace wellness programs and their impact on employee productivity and mental health*. Academic Press, 2023.
- [24] T. Kawada, Y. Kuratomi, and T. Kanai, "Depressive feelings, feelings of unhappiness, and subsequent psychological wellbeing among workers," *Work*, vol. 39, no. 3, pp. 315-319, 2020.
- [25] A. Jaiswal and C. J. Arun, "Impact of happiness-enhancing activities and positive practices on employee well-being," *Journal of Asia Business Studies*.
- [26] W. J. McKibbin and R. Fernando, "The Global Macroeconomic Impacts of COVID-19: Seven Scenarios," *SSRN Electronic Journal*, 2020.
- [27] J. M. Núñez-Sánchez, R. Gómez-Chacón, C. Jambrino-Maldonado, and J. García-Fernández, "Corporate well-being programme in COVID-19 times. The Mahou San Miguel case study," *Sustainability*, vol. 13, no. 11, p. 6189, 2021.
- [28] J. M. Núñez-Sánchez, C. Jambrino-Maldonado, J. García-Fernández, and R. Gómez-Chacón, "Managing Employee's Health While They Are Teleworking: A Corporate Well-Being Model in Times of COVID-19," in *Sport Management in the Ibero-American World*, pp. 25-41, Routledge, 2023.
- [29] H. Chesbrough, "To recover faster from Covid-19, open up: Managerial implications from an open innovation perspective," *Industrial Marketing Management*, vol. 88, pp. 410-413, 2020.
- [30] W. Kang, and Q. Wang, (2023) "The Impact of COVID-19 on Small Businesses in the US: A Longitudinal Study from a Regional Perspective". *International Regional Science Review*, vol. 46, no. 3, pp. 235-264, 2023. <https://doi.org/10.1177/01600176221132230>
- [31] B.D. Trump, and I. Linkov, (2022). "Resilience and lessons learned from COVID-19 emergency response". *Environment Systems Decisions*, vol. 42, no. 3, pp. 325-327, 2022. <https://doi.org/10.1007/s10669-022-09877-9>.
- [32] M. Ardolino, A. Bacchetti and D. Ivanov, "Analysis of the COVID-19 pandemic's impacts on manufacturing: a systematic literature review and future research agenda". *Operations Management Research*, vol.15, pp. 551-566, 2022. <https://doi.org/10.1007/s12063-021-00225-9>
- [33] S. C. Santos, E. W. Liguori, and E. Garvey, "How digitalization reinvented entrepreneurial resilience during COVID-19". *Technological forecasting and social change*, vol. 189, 122398, 2023. <https://doi.org/10.1016/j.techfore.2023.122398>
- [34] P. Sanmartín-Mendoza, R. Romero Zúñiga, D. Heredia Vizcaíno, and V. Quintero Méndez, "Los datos y las redes sociales: Caso Twitter," in *Datos, Información, Tendencias: Tres miradas sobre un contexto cambiante*, V. Quintero et al., Eds. Barranquilla, Colombia: Ediciones Universidad Simón Bolívar, 2018, pp. 55-75.
- [35] J. M. Twenge et al., "Increases in Depressive Symptoms, Suicide-Related Outcomes, and Suicide Rates Among U.S. Adolescents After 2010 and Links to Increased New Media Screen Time," *Clinical Psychological Science*, vol. 6, no. 1, pp. 3-17, 2018.
- [36] Y. Özkent, "Social media usage to share information in communication journals: An analysis of social media activity and article citations," *PLOS ONE*, vol. 17, no. 2, p. e0263725, 2022.
- [37] C. Jambrino-Maldonado, D. Rando-Cueto, J. M. Núñez-Sánchez, P. P. Iglesias-Sánchez, and C. De las Heras-Pedrosa, "Bibliometric analysis of international scientific production on the management of happiness and well-being in organizations," *Social Sciences*, vol. 11, no. 7, p. 272, 2022.
- [38] D. Chaffey and P. Smith, *Digital Marketing Excellence*. Routledge, 2017.
- [39] B. S. Ainapure et al., "Sentiment analysis of COVID-19 tweets using deep learning and lexicon-based approaches," *Sustainability*, vol. 15, no. 3, p. 2573, 2023.
- [40] N. Thakur, "Sentiment analysis and text analysis of the public discourse on Twitter about COVID-19 and MPox," *Big Data and Cognitive Computing*, vol. 7, no. 2, p. 116, 2023.
- [41] A. D. Dubey and S. Tripathi, "Analysing the sentiments towards work-from-home experience during COVID-19 pandemic," *Journal of Innovation Management*, vol. 8, no. 1, pp. 13-19, 2020.
- [42] C. Zhang, M. C. Yu, and S. Marin, "Exploring public sentiment on enforced remote work during COVID-19," *Journal of Applied Psychology*, vol. 106, no. 6, p. 797, 2021.

- [43] R. Romero, Modelo para recolección y análisis de datos para relacionar eventos, productos y usuarios a través de las redes sociales. Universidad Simón Bolívar, 2019.
- [44] C. Brown and D. Perkins, Workplace wellness programs and their impact on employee productivity and mental health. Academic Press, 2023.
- [45] A. Grant, "The Motivation and Well-being model: A pathway to enhancing organizational performance," Organizational Psychology Review, vol. 11, no. 1, pp. 34-55, 2022.
- [46] N. Thakur, "Sentiment analysis and text analysis of the public discourse on Twitter about COVID-19 and MPox," Big Data and Cognitive Computing, vol. 7, no. 2, p. 116, 2023.
- [47] K. Saha et al., "Psychosocial effects of the COVID-19 pandemic: large-scale quasi-experimental study on social media," Journal of Medical Internet Research, vol. 22, no. 11, p. e22600, 2020.



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