Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3, 137-150
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i3.5151

Resilience and adaptability strategies of Moroccan companies amid the COVID-19 crisis: A K-means clustering analysis

ENNOUHI Zakaria[1*], LAKRARSI Abdelhalim[1], A. Riadsolh[2], Imane Lasri[2]
[1]Laboratory of Economic Competitiveness and Managerial Performance Faculty of Law, Economics and Social Sciences of Souissi, Mohammed V University, Rabat, Morocco; zakaria.ennouhi@um5r.ac.ma (E.Z.).
[2]Laboratory of Conception and Systems (Electronics, Signals and Informatics), Faculty of Sciences, Mohammed V University, Rabat, Morocco.

Abstract: This study examines the repercussions of the COVID-19 pandemic on Moroccan companies by employing the K-means clustering algorithm to classify them based on their performance. Owing to its efficiency, this algorithm excels in segmenting complex datasets, making it an ideal tool for clustering companies according to their size, sales volume, resilience, and adaptability to new economic realities. The literature indicates that sustainable governance practices are crucial in fostering resilience during crises. In this context, the study adopts a methodology that combines the K-means algorithm with data normalization techniques, which facilitate the creation of homogeneous groups of companies. The results reveal distinct clusters with varying sales performance and strategic orientations. On the one hand, high-performing companies tend to embrace digitization and diversification strategies, thereby reinforcing their resilience. On the other hand, clusters with weaker performance exhibit limited adoption of such measures, opting instead for approaches such as reducing working hours. These insights highlight the importance of adopting digital transformation and innovation as pivotal strategies to increase competitiveness. Ultimately, the study offers actionable recommendations to strengthen corporate governance and resilience, particularly in times of crisis.

Keywords: *COVID-19 pandemic, Data normalization, K-means clustering, Moroccan companies, Resilience strategies.*

1. Introduction

The K-means algorithm, first introduced in 1967 and further refined in 1982, has emerged as a cornerstone of clustering techniques, largely owing to its simplicity and operational efficiency. Essentially, this algorithm categorizes data into homogeneous groups, making it an invaluable tool across various domains such as economics and management. For example, it is extensively utilized to classify companies on the basis of their financial performance, revealing clusters of businesses with comparable behavioral patterns [1]. In addition, the banking sector leverages K-means to evaluate financial risk, underscoring its relevance in business analytics [2].

In the context of unprecedented challenges, the COVID-19 pandemic has significantly affected Moroccan businesses, particularly SMEs. These entities have demonstrated remarkable resilience amidst economic and operational pressures. From a methodological perspective, clustering techniques such as K-means hold particular relevance for analysing organizational responses to a crisis. Through this lens, K-means can segment companies on the basis of their adaptive capacities, helping identify those more resilient to disruptions [3]. As a case in point, this algorithm has been applied to assess the technological adaptability of companies during the pandemic, pinpointing those that embraced digital transformation effectively [4]. In addition, similar clustering methods have been employed in the study of supply chains, highlighting the diverse resilience strategies adopted by

History: Received: 31 December 2024; Revised: 19 February 2025; Accepted: 21 February 2025; Published: 3 March 2025
* Correspondence: zakaria.ennouhi@um5r.ac.ma

different firms [5].

Nevertheless, K-means is not without its limitations. One critical drawback lies in its sensitivity to the initial positioning of centroids and the necessity of predefining the number of clusters. To overcome these challenges, the K-means++ algorithm was developed to optimize centroid initialization, thereby improving its overall performance [6]. Alternatively, alternative algorithms such as DBSCAN are often preferred for more intricate analyses, particularly when dealing with irregularly shaped clusters, a frequent occurrence in nonlinear economic data [7].

Given this context, the current study aims to explore the commercial performance of Moroccan companies during the COVID-19 pandemic by employing the K-means algorithm. By delineating clusters on the basis of company size, sales volume, resilience, and adaptability to new economic realities, this approach seeks to uncover valuable insights into the differentiated resilience and adaptation strategies of firms to the crisis.

Accordingly, the research problem centers on the following question: how can classification algorithms be employed to assess and enhance the resilience and adaptation strategies of Moroccan companies in response to the economic disruptions caused by the COVID-19 pandemic?

2. Theoretical Background

The COVID-19 pandemic has exerted significant pressure on companies' sales performance across various sectors and regions, thereby revealing disparities in their adaptability. To illustrate, microenterprises in Querétaro demonstrated substantial vulnerability during this period, undergoing marked declines in sales [8]. From a broader perspective, companies across many countries have generally experienced notable sales, exports, and liquidity declines, with the service sector being particularly affected compared with manufacturing [9]. For example, noncore businesses experienced an average loss of 17% of their sales in 2020, with more severe declines in sectors such as hospitality, whereas online sales surged by 180% [10]. According to ARIMA models, the personal care and healthcare sectors in the U.S. presented correlations between COVID-19 cases and sales variations [11]. Simultaneously, owner demographics significantly influenced the pandemic's impact on U.S. businesses, although online sales experienced an average decline of 29% [12]. Similarly, the Indonesian financial sector was not immune, registering a drop in share performance and return on investment [13].

In terms of methodologies, clustering techniques such as K-Means, K-Medoids, and DBSCAN have proven effective in enabling nuanced business segmentation, thereby refining sales strategies. For example, K-means divides customers on the basis of RFM parameters, enhancing loyalty strategies [14]. Conversely, nonlinear data and outliers necessitate approaches such as DBSCAN, which is adept at identifying dense clusters [15]. More recently, hybrid models that integrate clustering methods with embeddings, such as LLM and DICE, have allowed for more precise segmentation [16].

Another noteworthy point is that standardizing sales data has become indispensable for enhancing the accuracy of analyses and forecasts. Moreover, classification algorithms such as naïve Bayes and k-means facilitate sales data segmentation, which is crucial for optimized strategies [17]. As a result, data standardization captures trends and seasonal patterns, improving forecasting [18]. Importantly, preprocessed data minimize bias and increase the precision of predictive models [19].

Interestingly, analysing the distribution and attributes of business groups has garnered increasing research interest, revealing critical dynamics between affiliated and independent firms. Business groups, often under the influence of a common shareholder, offer advantages in forecasting and social capital, although economic performance depends on size and structure. For instance, in family businesses, group size significantly affects financial management by curbing opportunistic behaviors within closely related companies [20, 21]. In the same vein, group affiliation impacts market competition, restricting new entrants and heightening economic concentration [22]. During turbulent times, companies often explore strategic approaches to navigate uncertainties. In this

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

context, Brazil's regional disparities and innovative resources highlight the varying potential for innovation [23]. Moreover, Moroccan firms implemented crisis strategies such as stakeholder engagement and social innovation, fostering resilience [24]. Likewise, effective supply chain management and adaptable processes reinforce organizational strength in challenging circumstances [25]. Notably, while innovation underpins resilience in the energy sector, a multifaceted strategy is vital for sustainable recovery [26]. Additionally, government financial support has been instrumental in reducing business failure [27].

By extension, digital transformation functions as a pivotal tool for enhancing companies' adaptability to market fluctuations, whereas adaptive leadership further bolsters resilience, ensuring more efficient uncertainty management [28]. Undeniably, businesses leverage digital technologies to optimize operations and expand market reach [29]. In particular, adopting technologies such as cloud computing and the Internet of Things strengthens organizational flexibility, enabling swift responses to market dynamics [30].

First, the COVID-19 pandemic underscores the necessity of resilience strategies, where tailored interventions such as technological adoption and financial assistance are pivotal in increasing SMEs' resilience, especially in Indonesia and Malaysia [31]. When aligned with social and environmental practices, these strategies have proven effective during crises, highlighting the role of sustainability in performance improvement [32]. Simultaneously, businesses with high circularity scores have demonstrated increased resilience during crises, suggesting that circular strategies are integral to strengthening organizational resilience [33].

Moreover, data standardization remains critical for improving business performance by bolstering strategic decision-making [34]. By streamlining processes, standardization reduces transaction costs and enhances operational efficiency, ensuring competitiveness in the digital economy [35]. Furthermore, the standardization of work processes has a positive effect on project performance, although its effectiveness depends on variables such as technical complexity and environmental stability [36]. Consequently, efficient data management via standardization enhances big data analytics, translating into financial and operational gains, particularly in sectors where data governance influences capital market outcomes [37, 38]. Through this lens, data standardization strengthens business performance and provides a lasting competitive edge [39].

In light of this, product diversification and distance-selling channels serve as effective countermeasures against crises. For example, digital diversification mitigates declines in physical sales channels [40]. Correspondingly, European agricultural producers leveraged distance selling during confinement periods to increase sales [41]. That said, excessive diversification may backfire, necessitating strategies tailored to specific markets [42].

Unquestionably, operational flexibility emerges as another essential resilience factor. Specifically, the manufacturing and digital sectors have adapted their product offerings, enabling improved sales performance [43]. In uncertain environments, flexibility safeguards operational efficiency and sustains competitive advantage, although operational disruptions can sometimes undermine efficiency without directly affecting the competitive edge [44]. In addition, integrating risk management with flexibility fosters sustainability and adaptability, as demonstrated by theoretical models linking resilience to sustainable development [45]. Nonetheless, innovation combined with flexibility enhances supply chain resilience, minimizing disruptions [46]. In contrast, service industries benefit from transparency and agility in improving resilience [47].

To summarize, the constraints of traditional sales performance models emphasize the necessity of adapting to uncertain contexts. Admittedly, conventional forecasting models often lack precision with dynamic data, reducing their reliability [48]. However, incorporating temporal and contextual variables into deep learning models enhances their accuracy, albeit with increased complexity and costs [49]. In the future, integrating factors such as creativity and salesperson effectiveness will be pivotal in increasing sales performance, underscoring the need for models that account for individual and contextual elements [50]. Ultimately, future prospects include optimizing models using

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

unstructured data and addressing decision-making barriers to encourage the adoption of predictive forecasting [51].

3. Methodology

The COVID-19 crisis has confirmed significant disparities in the resilience and adaptability of Moroccan companies, particularly SMEs, to economic disruption. Despite this, there is a lack of in-depth analysis regarding the specific strategies adopted by these companies to navigate through this crisis. Moreover, analytical methods such as the K-means algorithm to rank these companies according to their performance and governance are still underexplored. This lack of understanding limits companies' ability to identify vulnerabilities and strengthen governance practices to better cope with future crises.

3.1. Database Selection

The dataset utilized for this study comprises 4,388 organized companies spanning various sectors, including manufacturing, construction, energy, mining, fishing, trade, and nonfinancial market services. In July 2020, a survey was conducted to assess the activities of these companies in the context of a complete lockdown. Data were gathered through a questionnaire distributed to Moroccan companies and were initially formatted in Excel. This dataset encompasses both qualitative and quantitative information, incorporating variables that pertain to the characteristics of the companies involved.

3.2. Search Strategy

This study seeks to classify Moroccan companies into homogenous clusters by examining their key characteristics via the application of a K-means algorithm (section 4.1). It focuses particularly on sales volume and governance attributes pertaining to sustainability. The primary objective is to uncover shared risks, vulnerabilities, and latent correlations among these companies. A maximum normalization approach was employed to facilitate sales comparisons across different sectors (section 4.2). This analysis subsequently delves into the strategic adaptations adopted by Moroccan firms during the COVID-19 containment period, highlighting their resilience and innovative responses to unprecedented challenges (section 4.3). The results of this study enhance our understanding of the factors that influenced company performance during the COVID-19 crisis and offer a framework for strengthening governance and resilience during future crises.

4. Results

The COVID-19 crisis revealed notable differences in how Moroccan companies, especially SMEs, demonstrated resilience and adaptability to economic disruptions. While this issue is evident, comprehensive analyses of these businesses' strategies during the crisis are still lacking. Indeed, applying advanced analytical methods, such as the K-means algorithm, to classify companies on the basis of their performance and governance remains underutilized. This gap in understanding restricts companies from identifying weaknesses and improving governance practices, limiting their preparedness for future challenges.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

4.1. Clustering of Moroccan Companies

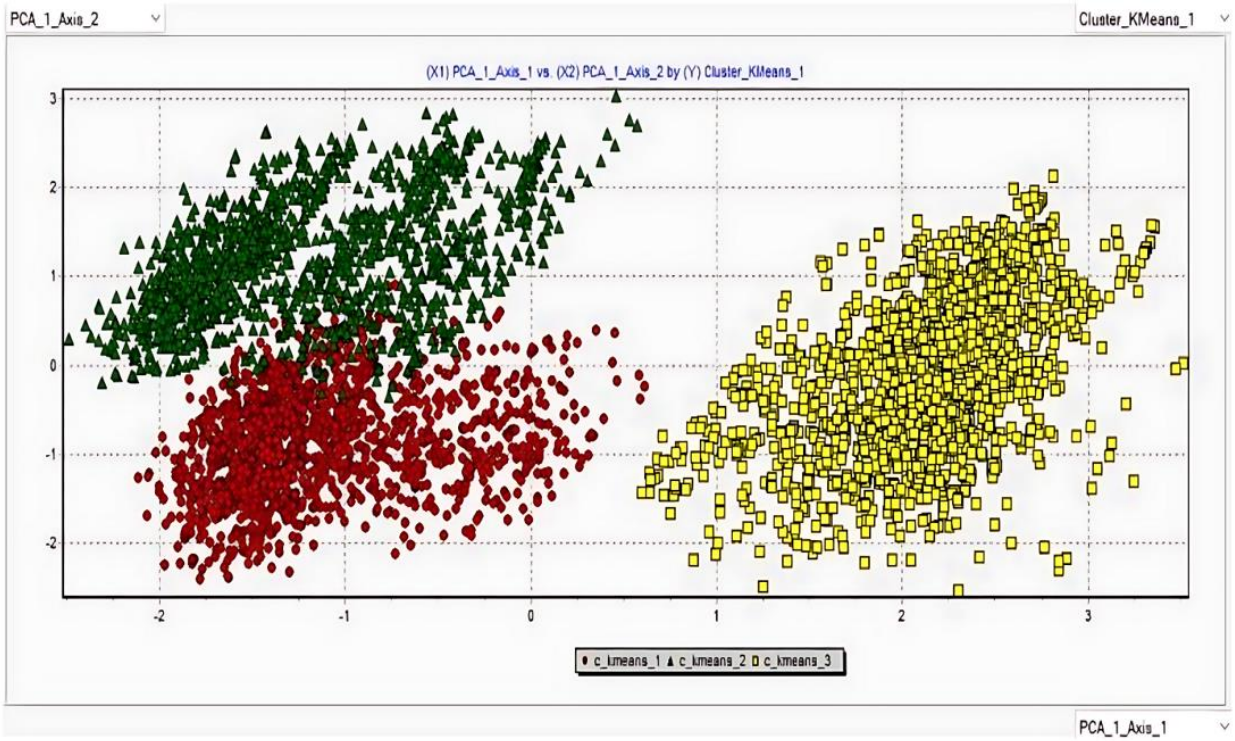

Figure 1.
Scatter diagram illustrating the clustering of companies according to their common characteristics.

The scatter diagram presented in Figure 1 vividly illustrates the presence of three distinct and well-defined clusters within the data. This clear differentiation indicates the significance of the variables employed in our analysis, as they effectively delineate the groups. Clearly, each cluster is visually distinguishable, utilizing distinct colors and shapes to enhance clarity. Specifically, the first cluster, designated as cluster 0, is represented by red circles, whereas cluster 1 is depicted with green triangles. Finally, cluster 2 is illustrated via yellow squares. The layout and organization of these clusters in the scatter diagram highlight their unique characteristics and suggest underlying patterns worthy of further exploration.

Table 1.
Distribution of companies across the defined clusters.

Clusters	**Distribution**	**Percentage**
Cluster 0	1 269	29%
Cluster 1	1 577	36%
Cluster 2	1 542	35%
Total	4 388	100%

Table 1 presents a comprehensive analysis of the population distribution resulting from the clustering methodology applied to the dataset. In this way, the data features that cluster 1 is the most prominent grouping, containing 1 577 companies, which corresponds to approximately 36% of the total population under consideration. This substantial representation highlights the potential significance of the characteristics associated with this cluster. Cliently behind, cluster 2 consists of 1 542 companies, accounting for approximately 35% of the total dataset. In fact, the proximity in size between clusters 1

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

and 2 suggests a competitive landscape among these groups, indicating that both clusters may share similar attributes or face similar market conditions that affect their formation. In contrast, cluster 0 is identified as the smallest cluster, comprising 1 269 companies and accounting for approximately 29% of the total population. Additionally, the relative size of this cluster may imply distinct characteristics or challenges that differentiate it from the larger clusters, potentially warranting further investigation into the factors that contribute to its smaller size. Overall, the distribution of companies across these clusters indicates a well-balanced representation of Moroccan firms, indicating that no single cluster overwhelmingly dominates the population. Consequently, this equilibrium points to healthy diversity within the dataset and reflects the varied natures of the companies included in the analysis. Thus, the clustering results affirm that the underlying attributes defining each group effectively capture the complexity of the Moroccan business landscape, validating the robustness of the clustering method employed.

4.2. Standardizing Sales Data

In this section, we implemented maximum normalization to create a more uniform dataset, allowing for better comparability of values across different companies. This approach is particularly beneficial because it enables us to pinpoint the companies that presented the highest sales within each cluster during the COVID-19 pandemic. By utilizing this normalization technique, we effectively categorize the data, ensuring that the metrics accurately reflect each company's performance in relation to its peers. Through this method, we not only improve the clarity of our analysis but also provide a more nuanced understanding of market dynamics during these unprecedented times, leading to deeper insights into how various companies have navigated the challenges brought about by the pandemic.

Table 2.
Five-level categorization of companies by sales volume.

Level 1(N1)	Companies with sales > 0.8
Level 2(N2)	Companies with sales > 0.6
Level 3(N3)	Companies with sales > 0.4
Level 4(N4)	Companies with sales > 0.2
Level 5(N5)	Companies with sales ≤ 0.2 (for others)

According to the insights presented in Table 2, companies classified as level 1 emerge as the foremost performers in terms of sales volume, exhibiting remarkable resilience and commercial efficiency. Their ability to effectively manage disruptions during periods of crisis emphasizes their capacity for adaptation and strategic foresight, positioning them as exemplary models for other organizations. In contrast, while level 2 companies do not achieve the same level of performance as their level 1 counterparts do, they nonetheless display significant resilience and adaptability. These companies have managed to sustain relatively high sales levels amidst market disruptions, reflecting a moderate degree of success. Despite this, they face a greater array of challenges than level 1 companies do and must engage in strategic adjustments to further enhance their sales efficiency. On the other hand, level 3 companies operate at an average performance level and face more substantial difficulties in maintaining their business activities. Effectively, crisis management strategies appear to be less impactful than those utilized by level 1 companies are, as evidenced by a greater decline in sales. Nevertheless, these corporations display a form of resilience, and by drawing on robust approaches employed by higher-performing organizations, they have the potential to improve their market position and better navigate future crises. At the lower end of the spectrum, level 4 companies are characterized by underperformance, with declining sales figures indicating ineffective crisis management and strategic foresight. In stark contrast to the resilience and efficiency of level 1 companies, these organizations face vulnerabilities that jeopardize their survival. Consequently, to withstand these challenges, level 4 companies must adopt more robust business strategies, potentially by integrating the successful practices of their more prosperous peers. Finally, level 5 companies grapple with the most critical

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

challenges, as their sales volumes are insufficient to sustain operations in the long term. This situation strongly contrasts with the resilience and sales effectiveness observed in level 1 companies. In fact, the significant decline in sales highlights to the urgency of immediate intervention and strategic re-evaluation. When level 1 companies serve as a compelling example of the resilience and adaptability that level 5 companies must achieve to recover and establish a sustainable presence in the market.

4.3. Strategic adaptations of Moroccan Firms During Containment

Moroccan companies have demonstrated remarkable adaptability in navigating the challenges brought about by the COVID-19 pandemic. In light of significant economic and health disruptions, businesses across various sectors have rapidly developed and implemented diverse strategies to sustain operations and ensure their employees' safety and well-being. To address these challenges, many companies have adopted flexible work arrangements, including remote working opportunities and staggered shifts, to minimize the risk of virus transmission. Additionally, organizations prioritized the implementation of stringent health protocols, such as the regular sanitization of workspaces, the provision of personal protective equipment, and health screenings for employees. In addition to health and safety measures, Moroccan businesses also pivoted their focus to align with shifting market demands. Many companies have embraced digital transformation, enhancing their online presence and adopting e-commerce solutions to reach customers unable to shop in person. Additionally, some enterprises explored new product lines or services tailored to the current environment, thereby not only adapting to and overcoming immediate obstacles but also positioning themselves for future growth in a postpandemic world. Overall, Moroccan companies' resilience and innovative spirit during this crisis highlighted their commitment to safeguarding their workforce while effectively responding to the evolving landscape of market expectations.

Table 3.
Strategies employed by Moroccan companies during the lockdown.

Notation	Strategy	Answers	Percentage
STRAT1	Flexible working (telecommuting)	1 790	25%
STRAT2	Recruitment of profiles with IT skills	776	11%
STRAT3	Digitization of internal and external services	1 282	18%
STRAT4	Diversification of the supply chain	910	13%
STRAT5	Development of distance commerce (internet, telephone...)	1 282	18%
STRAT6	Offering new products and services	1 023	14%
STRAT7	Other	129	2%
Total		7 192	100%

The strategies adopted by Moroccan companies during the period of total containment testify to their ability to adapt to the multifaceted challenges posed by the COVID-19 pandemic, with a focus on adaptability, digital transformation, and operational efficiency. According to Table 3, teleworking was the most striking change, with 25% of companies adopting it as a critical strategy during this period. This measure was aimed at maintaining operations while guaranteeing employee safety. The move to remote working addressed immediate health concerns and reflected a long-term trend toward more flexible working patterns. At the same time, although recruitment of IT-skilled profiles reached only 11%, this strategic choice, albeit a minority one, proved essential. Improving their technological capacity was crucial to implementing other digitization and distance commerce strategies for these companies. In this way, 18% of companies were concerned with digitizing internal and external services. They turned to digital solutions for workflow management and customer interaction. This underlines the importance of service continuity via online platforms despite physical restrictions. In addition, 13% of companies have adopted supply chain diversification, reflecting the impact of the pandemic on global supply chains. Faced with these disruptions, companies have sought to diversify their sources to maintain stability and reduce risk, giving preference to alternative or local suppliers. Indeed, 18% of companies have adopted remote commerce (internet, telephone), reinforcing the importance of online sales platforms and

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

telephone ordering, particularly with the closure or limitation of physical stores. This shows the shift in customer interactions toward digital channels, which requires rapid innovation for companies. In addition, 14% of companies innovated by offering new products and services adapted to pandemic conditions, such as hygiene products, delivery services, or other essential products, demonstrating their agility in changing consumer needs. Finally, a modest 2% of companies opted for different strategies, such as partnerships, financial restructuring, or strengthening corporate communications. This limited percentage indicates that the majority of companies concentrated their efforts on the aforementioned primary strategies.

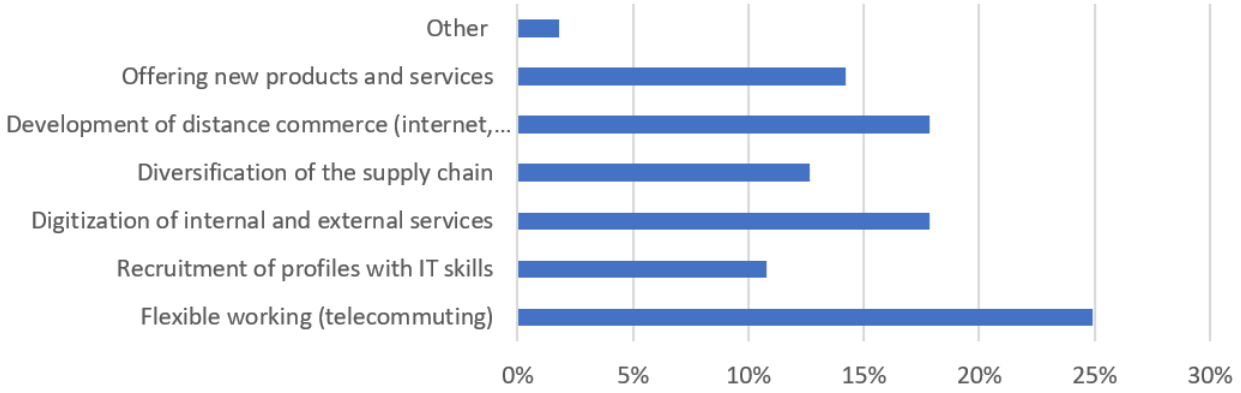

Figure 2.
Percentage view of strategies adopted during the lockdown.

As illustrated in Figure 2, many companies prioritize strategies linked to teleworking and digitization. This shift reflects a broader trend toward creating a more technological and flexible working environment, which is increasingly essential in today's fast-paced business landscape. In addition to these initiatives, many firms also adopt diversification and remote commerce strategies. Effectively, this perspective draws attention to a growing awareness of dependency risks and the need to adapt sales models. Thus, IT skill recruitment prioritizes investing in human capital to ensure a successful digital transition. Furthermore, the results show that Moroccan companies' strategies during the containment period focused primarily on digital transformation and operational resilience. At the same time, teleworking, digitization, and remote commerce were vital to ensuring business continuity while diversifying supply chains and offering new products, demonstrating their ability to adapt. Although the recruitment of specialized IT profiles has been less frequent, it remains fundamental to the long-term viability of these digital initiatives. These strategies are part of a broader global trend in which companies are asked to demonstrate greater agility, focusing on technological innovation and resilience planning.

5. Analysis and Discussion

5.1. Commercial Performance Analysis of the Best-Performing Companies Across Defined Clusters with Normalization-Based Categorization

The data derived from applying the maximum normalization technique to a sample of 4388 Moroccan companies yield the distributions detailed in the tables below. To effectively illustrate the categorization into distinct clusters, we identify the companies with the highest sales figures within each category and thus understand the strategy adopted by these companies to determine the critical elements of success in times of crisis. Figure 3 below summarizes these discoveries and provides a clearer understanding of the critical factors that contribute to their success.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

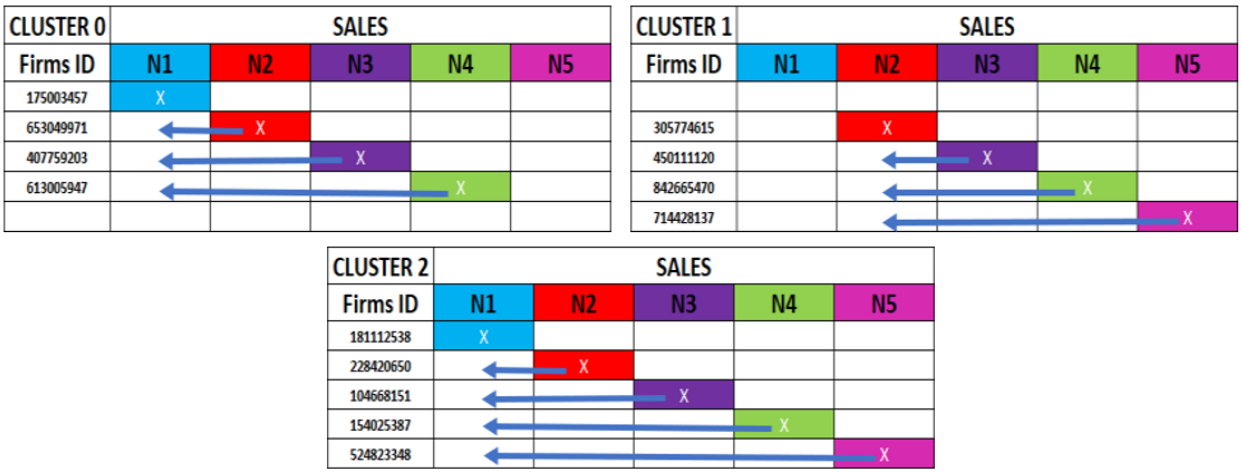

Figure 3.
Comparative analysis of commercial performance in high-performing companies across clusters.

First, cluster 0, as detailed in Figure 3, includes a total of 1 269 companies distributed among various performance categories: 501 classified as "N1," 491 as "N2," 271 as "N3," and 6 as "N4," with no representation in the "N5" category. Strikingly, 78% of the companies fall within the "N1" and "N2" classifications, signifying a dominant presence of firms demonstrating noteworthy sales performance. Companies in the "N3" category exhibit metrics that align closely with industry averages, indicating a moderate level of sales activity. In contrast, the "N4" category comprises firms with below-average sales performance, hint at challenges that may undermine their financial outcomes. The absence of "N5" companies underscores the cluster's concentration of businesses with robust sales capabilities. Taken together, the composition of cluster 0 indicates a preponderance of high-performing companies, offering meaningful perspectives for stakeholders aiming to grasp the dynamics of success in this group.

By comparison, cluster 1 is composed of 1 577 companies, with no representation in the "N1" category, a single firm in "N2," 216 in "N3," 557 in "N4," and 803 in "N5." This distribution paints a strikingly different picture from that of cluster 0, revealing a glaring lack of companies achieving strong sales performance. The overwhelming presence of "N4" and "N5" companies, which collectively account for 86% of the cluster, features a significant concentration of firms struggling with sales effectiveness. The limited representation in the higher-performing categories highlights the cluster's overall weak performance and competitiveness. Hence, these data accentuate the necessity of targeted measures to address sales-related challenges and enhance the market position of these companies.

Cluster 2 comprises 1 542 companies, presenting a comparatively balanced distribution across performance categories. Specifically, 369 companies are classified as "N1" and 366 as "N2," jointly making up nearly 50% of the cluster. This finding indicates that a considerable proportion of firms achieve high sales performance. Furthermore, 370 companies fall under the "N3" category, reflecting a notable presence of medium-performing firms and contributing to the cluster's overall diversity. Thus, "N4," with 298 companies, and "N5," with 139 companies, constitute approximately 30% of the cluster, suggesting that a significant portion of companies perform below average. This composition reveals a varied sales landscape, encompassing both exceptional performers and those with substantial room for improvement.

When the optimal performance categories, are assessed, "N1" serves as the benchmark for clusters 0 and 2, whereas cluster 1 aligns most closely with "N2" as its highest-performing classification. Consequently, for firms in the lower-performing categories, particularly "N4" and "N5," the adoption of innovative strategies aimed at enhancing sales effectiveness is imperative. Strengthening these approaches will not only facilitate their progression to higher performance levels but also enable them to establish resilience in competitive markets, thereby securing a more advantageous position in the

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

future.

5.2. Strategic Approaches of Best-Performing Companies Across Defined Clusters

This section delves into the distinct strategic approaches of the top-performing companies across the three clusters (Table 4). Significantly, it shows how differences in digital innovation, operational flexibility, and resource strategies shape resilience and performance. This comparison offers nuanced insights into the essential drivers of success during periods of transformation and disruption.

Table 4.
Comparative analysis of strategic approaches in high-performing companies across clusters.

Cluster 0							
Parameters	**Q19.1**	**Q19.2**	**Q19.3**	**Q19.4**	**Q19.5**	**Q19.6**	**Q19.7**
	STRAT1	**STRAT2**	**STRAT3**	**STRAT4**	**STRAT5**	**STRAT6**	**STRAT7**
175003457	Yes	No	Yes	No	Yes	No	Reduced working hours
653049971	No	No	No	No	No	Yes	Reduced working hours
407759203	Yes	No	No	No	Yes	No	Reduced working hours
613005947	No	No	No	No	No	No	Reduced working hours
Cluster 1							
305774615	Yes	Yes	Yes	Yes	Yes	Yes	Reduced working hours
450111120	No	No	No	No	No	Yes	Reduced working hours
842665470	No	No	No	No	No	No	Reduced working hours
714428137	No	No	No	No	No	Yes	Reduced working hours
Cluster 2							
181112538	No	No	No	No	No	yes	Reduced working hours
228420650	No	No	No	No	No	No	Reduced working hours
104668151	No	No	No	No	yes	yes	Reduced working hours
154025387	yes	No	No	No	No	No	Reduced working hours
524823348	No	No	No	No	No	No	Reduced working hours

Table 4 presents a detailed comparison of the strategic approaches adopted by companies across the three clusters, highlighting notable differences in their emphasis on digital innovation and operational flexibility. In cluster 0, a considerable number of companies demonstrate an active pursuit of digital and innovation strategies. Nevertheless, flexible work arrangements, such as telecommuting, and the development of remote commerce initiatives remain limited. Among the common measures in this cluster, reducing working hours stands out as a recurring practice, whereas supply chain diversification and digitization are comparatively uncommon. On the other hand, companies in cluster 1 display a more robust dedication to digital and innovation strategies. These firms employ a diverse range of methods, including teleworking, the recruitment of IT professionals, service digitization, supply chain diversification, and remote commerce development. Despite this comprehensive adoption of strategies, reducing working hours remains as a widely implemented approach within the cluster. In contrast, companies within cluster 2 exhibit a limited uptake of digital and innovation strategies. Only a few exceptions are observed, such as the development of remote commerce and the introduction of new products and services. Even so, reducing working hours remains a key measure adopted by most companies in this cluster.

To summarize, the analysis reveals that companies achieving the best performance across clusters have implemented critical strategies, including teleworking, service digitization, and remote commerce development. For cluster 0, the top-performing company has successfully integrated these approaches, whereas the underperforming firms have largely neglected them, indicating that embracing such strategies could increase resilience during crises. In cluster 1, the leading firms combine several strategies, such as digitization, supply chain diversification, IT talent acquisition, and remote commerce, which are crucial for building adaptability. Conversely, the weakest performers in this cluster lack a comprehensive approach, confirming the need for wider adoption of these methods to achieve better outcomes. Although cluster 2 shows limited adoption of strategic practices, the success of its leading

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

companies can be attributed to innovations in product offerings, coupled with remote commerce initiatives. These approaches, alongside digitalization and product development, emerge as fundamental drivers of resilience and operational effectiveness. Companies that have yet to adopt these strategies should prioritize them to improve their competitiveness and performance, particularly in the face of future disruptions.

6. Conclusion

This research delves into the sales performance of Moroccan companies over a timeline that transcends the COVID-19 pandemic, aiming to dissect sales patterns and illuminate the distinctive traits of each cluster. The ultimate ambition is to refine decision-making frameworks and craft impactful strategies for nurturing an economy better equipped to withstand global pandemics or external shocks. The outcomes underscore the pivotal role of clustering in extracting latent insights from expansive datasets. By grouping elements with analogous features, this technique paves the way for a more nuanced analysis while unravelling the complexities of intricate data structures.

Beyond that, the normalization process proves indispensable, as it ensures that variables are assessed on an equal footing. This approach facilitates the ranking of companies ranging from those with the weakest performance to those with the most robust performance, thus providing an unclouded perspective on their relative standing.

The scoring methodology, forged in a context laden with critical challenges, integrates variables that may either fortify or destabilize the market environment. This has yielded a framework of exceptional utility, one poised to act as a blueprint for evaluating sales performance amid similar market upheavals. Extending this model to other nations would serve not only to test its versatility but also to establish it as a universal tool for refining sales strategies across diverse markets.

The study's contributions manifest in two significant dimensions:

1. It highlights the theoretical underpinnings of the total lockdown phase that ensued from the COVID-19 outbreak, in tandem with a cluster analysis methodology, normalization strategies, and measures employed to maintain business continuity during turbulent times.
2. It presents an innovative perspective for regulators and policymakers, offering a roadmap for crafting targeted interventions to support companies in the face of severe economic stagnation.

To conclude, this research stands as a compass for organizations striving to fine-tune their sales approaches, fortify financial resilience, and cultivate sustainable growth, even amidst uncertain and unpredictable circumstances.

Abbreviations

The following abbreviations are used in this manuscript:

SMEs	Small and Medium-Sized Enterprises
DBSCAN	Density-Based Spatial Clustering of Applications with Noise
ARIMA	Autoregressive Integrated Moving Average
U.S.	United States
RFM	Recency, Frequency, Monetary
LLM	Large Language Model
DICE	Diversity, Inclusion, Cohesion, and Equity
IT	Information Technology

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

References

[1] M. Halkidi, Y. Batistakis, and M. Vazirgiannis, "On clustering validation techniques," *Journal of Intelligent Information Systems*, vol. 17, pp. 107-145, 2001. https://doi.org/10.1023/A:1012801612483

[2] N. Dardac and I. A. Boitan, "Cluster analysis approach for banks' risk profile: The Romanian evidence," *European Research Studies*, vol. 12, no. 1, pp. 109–118, 2009.

[3] B. Othman, R. Driss, and H. Malika, "Digital solutions and Moroccan companies during the Covid-19 pandemic," in *2022 14th International Colloquium of Logistics and Supply Chain Management (LOGISTIQUA), EL JADIDA, Morocco*, 2022, pp. 1-5, doi: https://doi.org/10.1109/LOGISTIQUA55056.2022.9938069.

[4] M. A. Kumar and D. N. Ayedee, "Technology Adoption: A Solution for SMEs to overcome problems during COVID-19," *Forthcoming, Academy of Marketing Studies Journal*, vol. 25, no. 1, pp. 1-16, 2021. https://doi.org/10.1108/JSTPM-05-2020-0080

[5] J. Sarkis, "Supply chain sustainability: Learning from the COVID-19 pandemic," *International Journal of Operations & Production Management*, vol. 41, no. 1, pp. 63-73, 2020. https://doi.org/10.1108/IJOPM-08-2020-0568

[6] D. Arthur and S. Vassilvitskii, "K-means++: The advantages of careful seeding," in *Proceedings of the 18th Annual ACM-SIAM Symposium on Discrete Algorithms*, 2007, doi: https://doi.org/10.1145/1283383.1283494.

[7] M. Ester, H.-P. Kriegel, J. Sander, and X. Xu, "A density-based algorithm for discovering clusters in large spatial databases with noise," in *Proceedings of the 2nd International Conference on Knowledge Discovery and Data Mining*, 1996, doi: https://doi.org/10.5555/3001460.3001507.

[8] C. Layman, "Sales performance during COVID-19, an analysis for microenterprises in the state of Querétaro," *Science Forum Journal*, vol. 3, no. 4, pp. 216–225, 2022. https://doi.org/10.46932/sfjdv3n4-016

[9] M. Olczyk and M. E. Kuc-Czarnecka, "Determinants of COVID-19 impact on the private sector: A multi-country analysis based on survey data," *Energies*, vol. 14, no. 14, p. 4155, 2021. https://doi.org/10.3390/en14144155

[10] B. N. Grego and B. C. Scarduelli Pacheco, "Early impacts of the COVID-19 pandemic on business sales," *Small Business Economics*, vol. 57, no. 3, pp. 1443–1460, 2021. https://doi.org/10.1007/s11187-021-00479-4

[11] N. Nik Zam Nik Wan *et al.*, "Impact of the COVID-19 pandemic on retail sales of Health and Personal care stores in the United States," *Business and Economics Journal*, vol. 44, p. 4786, 2023. https://doi.org/10.54691/bcpbm.v44i.4786

[12] J. Zhang, "Impact of COVID-19 on US firms," National Bureau of Economic Research Working Paper Series, No. 28314, 2021.

[13] G. Ali, A. Khan, and A. Rahat, "COVID-19 Pandemic's impact on financial performance and market performance in nine Indonesian Business Sectors," *Journal of Economics, Finance and Management Studies*, vol. 6, no. 1, p. 43, 2023. https://doi.org/10.47191/jefms/v6-i1-43

[14] B. Boyko and I. Protsik, "Use of clusterization algorithms for segmentation of the company's personnel," *Herald of Khmelnytskyi National University, Technical Sciences*, vol. 333, no. 2, pp. 92-98, 2024. https://doi.org/10.31891/2307-5732-2024-333-2-14

[15] S. F. Djun, I. G. A. Gunadi, and S. Sariyasa, "Analisis segmentasi pelanggan pada bisnis dengan menggunakan metode k-means clustering pada model data RFM," *JTIM*, vol. 5, no. 4, pp. 354-364, 2024. https://doi.org/10.35746/jtim.v5i4.434

[16] K. Pan and X.-G. Yue, "Enhancing customer segmentation using large language models (LLMs) and deterministic, independent-of-corpus embeddings (DICE)," presented at the IEEE International Conference on Artificial Intelligence and Robotics, 2024.

[17] P. Tamasiga, A. Guta, H. Onyeaka, and M. S. Kalane, "Sales data analysis and visualization using exploratory data analysis and K-Means Clustering. ," *Journal of Statistics and Operational Research*, vol. 5, no. 2, pp. 45–56, 2024. http://dx.doi.org/10.30865/json.v5i2.7180

[18] S. Pawar, A. Sheikh, and A. R. Sonule, "Sales analysis using data mining," *International Journal of Advanced Research in Science, Communication and Technology*, vol. 10, no. 2, pp. 45–55, 2023. https://doi.org/10.48175/ijarsct-9419

[19] A. Sani, S. Samuel Djaka, F. N. Hasan, A. D. Wiranata, and S. Aisyah, "Predicting the success of garment sales on transaction data using the classification method with the naïve bayes algorithm," presented at the IEEE International Conference on Cyber Security and IT Ecosystem (ICCoSITE), 2023.

[20] Y. Dong, C. Ni, F. Qiao, and C. Zhang, "Business Group Analysts," *European Accounting Review*, pp. 1-26, 2023. https://doi.org/10.1080/09638180.2023.2238787

[21] Y. Zhang and W. Qu, "Family business groups and real earnings management," *EAI Endorsed Transactions on Serious Games*, vol. 10, no. 4, pp. 1–10, 2023. https://doi.org/10.4108/eai.18-11-2022.2326862

[22] T. P. Pereira and M. Sousa, "Business group affiliation and product market competition," *Journal of Industrial and Business Economics*, vol. 51, no. 1, pp. 39-72, 2024. https://doi.org/10.1007/s40812-023-00275-z

[23] M. d. A. Monteiro, "Endogenous capabilities, technological trajectories, and corporate plans: Limits to development strategies for the Amazon," *Revista Brasileira de Inovação*, vol. 21, p. e022013, 2022. https://doi.org/10.20396/rbi.v21i00.8666824

[24] M. El Ouardi and S. Boushaba, "Stakeholders' involvement, organizational learning and social innovation: Factors for strengthening the resilience of moroccan cooperatives in the post-COVID-19 Era," *Sustainability*, vol. 15, no. 11, p. 8846, 2023. https://doi.org/10.3390/su15118846

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151

[25] S. Boushaba, *The impact of adaptation on performance through business resilience in times of crisis. In Adaptive Strategies for Business Resilience*. IGI Global. https://doi.org/10.4018/979-8-3693-1658-0.ch005, 2024.
[26] N. El Koudari, "Innovation as a determinant of organizational resilience in times of crisis: The case of the energy sector in Morocco," *SHS Web of Conferences*, vol. 175, p. 1023, 2023. https://doi.org/10.1051/shsconf/202317501023
[27] Y. Bourkia, "Impact of Covid-19 on SME portfolios in Morocco: Evaluation of banking risk costs and the effectiveness of state support measures," *Investment Management and Financial Innovations*, vol. 18, no. 3, pp. 299-306, 2021. https://doi.org/10.21511/imfi.18(3).2021.23
[28] K. Pengembangan, "Adaptive and flexible leadership: Enhancing organizational resilience in the era of digital transformation," *MESMAN*, vol. 3, no. 1, p. 314, 2024. https://doi.org/10.56709/mesman.v3i1.314
[29] H. C. Unegbu, D. Yawas, and B. Dan-asabe, "Impact of digital transformation on Nigerian SMEs in the global business landscape," *Jurnal Mekanikal*, pp. 66-85, 2024. https://doi.org/10.11113/jm.v47.478
[30] M. Ramadan *et al.*, "Toward digital transformation and business model innovation: The nexus between leadership, organizational agility, and knowledge transfer," *Administrative Sciences*, vol. 13, no. 8, p. 185, 2023. https://doi.org/10.3390/admsci13080185
[31] T. Kusumawati and A. Nugroho, "Investigating the factors of SMEs' business resilience in the post-pandemic crisis of COVID-19 with technology adoption as a quasi-moderator: a multigroup analysis of Indonesian and Malaysian SMEs," *Cogent Business & Management*, vol. 11, no. 1, pp. 1–15, 2024. https://doi.org/10.1080/23311975.2023.2301135
[32] W. Zhu and H. Li, "Calm after the storm? The role of social and environmental practices on small and medium enterprises resilience throughout COVID-19 crisis," *Business Ethics, Environment & Responsibility*, vol. 32, no. 1, pp. 27-34, 2023. https://doi.org/10.1111/beer.12528
[33] Y. Tanaka and M. Ishikawa, "Toward resilient organizations after COVID-19: An analysis of circular and less circular companies," *Resources, Conservation and Recycling*, p. 106681, 2022. https://doi.org/10.1016/j.resconrec.2022.106681
[34] O. Abdul-Azeez, A. O. Ihechere, and C. Idemudia, "Enhancing business performance: The role of data-driven analytics in strategic decision-making," *International Journal of Management & Entrepreneurship Research*, vol. 6, no. 7, pp. 2066-2081, 2024. https://doi.org/10.51594/ijmer.v6i7.1257
[35] J. Yang, L. Zhou, Y. Qu, X. Jin, and S. Fang, "Mechanism of innovation and standardization driving company competitiveness in the digital economy," *Journal of Business Economics and Management*, vol. 24, no. 1, pp. 54–73, 2023. https://doi.org/10.3846/jbem.2023.17192
[36] R. L. d. Moura, T. C. J. Carneiro, and T. L. Dias, "Effects of standardization-based coordination mechanisms in project performance," *Production Journal*, vol. 28, p. e5257, 2021. https://doi.org/10.1590/1806-9649-2021v28e5257
[37] R. Cui, Y. Wang, and Y. Wang, "The impact of data elements on enterprises' capital market performance: Insights from stock liquidity in china and implications for global markets," *Sustainability*, vol. 16, no. 9, p. 3585, 2024. https://doi.org/10.3390/su16093585
[38] M. Ertz, S. Sun, and I. Latrous, *The impact of big data on firm performance*. Springer Handbook of Big Data. https://doi.org/10.1007/978-3-030-71782-7_40, 2021.
[39] J. Song, "Establishment and evaluation of measurement and control system model based on data analysis optimization," presented at the IEEE Conference on Data Science and Business Analytics, 2022.
[40] G. Batsakis, P. Konara, and V. Theoharakis, "Digital sales channels and the relationship between product and international diversification: Evidence from going digital retail MNEs," *Global Strategy Journal*, vol. 13, no. 4, pp. 830-856, 2022. https://doi.org/10.1002/gsj.1465
[41] Z. Benedek *et al.*, "Farm diversification as a potential success factor for small-scale farmers constrained by COVID-related lockdown. Contributions from a survey conducted in four European countries during the first wave of COVID-19," *PloS One*, vol. 16, no. 5, p. e0251715, 2021. https://doi.org/10.1371/journal.pone.0251715
[42] M. D. Abd Rahman, M. K. A. Muhamad Senan, N. Y. Mhd Ban, F. Faturay, and M. Y. Saari, "Resilient trade during the COVID-19 pandemic: Why does export diversification matter?," *International Journal of Economics and Management*, vol. 16, no. Special Issue 1, pp. 45-57, 2022. http://doi.org/10.47836/ijeamsi.16.1.004
[43] N. Shekarian, R. Ramirez, and J. Khuntia, "Resilience through operational flexibility for crisis response: An international investigation of firm responses during COVID-19," *Aslib Journal of Information Management*, vol. 75, no. 6, pp. 1253-1279, 2023. https://doi.org/10.1108/AJIM-04-2022-0204
[44] M. Ali, A. A. Kazi, S. A. A. Rizvi, and H. Ghafoor, "How do operational disruption and resiliency impact a firm's operational efficiency and competitive advantage? Pakistan case," *Journal of Business Administration and Management Sciences*, vol. 4, no. 2, pp. 56-75, 2022. https://doi.org/10.58921/jobams.4.2.86
[45] D. Settembre-Blundo, R. González-Sánchez, S. Medina-Salgado, and F. E. García-Muiña, "Flexibility and resilience in corporate decision making: A new sustainability-based risk management system in uncertain times," *Global Journal of Flexible Systems Management*, vol. 22, no. Suppl 2, pp. 107-132, 2021. https://doi.org/10.1007/s40171-021-00277-7
[46] V. Ghomi, S. V. R. Nooraei, N. Shekarian, S. Shokoohyar, and M. Parast, "Improving supply chain resilience through investment in flexibility and innovation," *International Journal of Systems Science: Operations & Logistics*, vol. 10, no. 1, p. 2221068, 2023. https://doi.org/10.1080/23302674.2023.2221068

[47] D. Ofori, "Necessary condition analysis of organisational capabilities for a resilient service operation in the hotel industry in Ghana," *Heliyon*, vol. 10, no. 4, p. e26473, 2024. https://doi.org/10.1016/j.heliyon.2024.e26473
[48] P. Mehta, S. Das, and B. Ramesh, "Robust sales forecasting using deep learning with static and dynamic covariates," *Applied Sciences*, no. 5, 6, p. 85, 2023. https://doi.org/10.3390/asi6050085
[49] K. Sharma and J. Wang, "Improved sales forecasting using trend and seasonality decomposition with light GBM," presented at the IEEE International Conference on Artificial Intelligence and Big Data, 2023.
[50] S. D. Jena, A. Senapati, and A. Mohanty, *Developing customer networking quality model to improve SMES' marketing performance*. Springer. https://doi.org/10.1007/978-3-031-36895-0_39, 2024.
[51] M. Y. Lee, X. Zhang, and J. Kim, "A theory of predictive sales analytics adoption," *Journal of Business Analytics*, 2023. https://doi.org/10.1007/s13162-022-00252-0

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 3: 137-150, 2024
DOI: 10.55214/25768484.v9i3.5151