 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

European Scientific Journal, *ESJ*

July 2025

European Scientific Institute, ESI

The content is peer reviewed

ESJ Social Sciences

July 2025 edition vol. 21, No. 19

ISSN: 1857-7431 (Online)
ISSN: 1857-7881 (Print)

European Scientific Journal, ESJ
July 2025 edition Vol.21, No.19
ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Generativity is a Core Value of the ESJ: A Decade of Growth

Erik Erikson (1902-1994) was one of the great psychologists of the 20th century[1]. He explored the nature of personal human identity. Originally named Erik Homberger after his adoptive father, Dr. Theodore Homberger, he re-imagined his identity and re-named himself Erik Erikson (literally Erik son of Erik). Ironically, he rejected his adoptive father's wish to become a physician, never obtained a college degree, pursued independent studies under Anna Freud, and then taught at Harvard Medical School after emigrating from Germany to the United States. Erickson visualized human psychosocial development as eight successive life-cycle challenges. Each challenge was framed as a struggle between two outcomes, one desirable and one undesirable. The first two early development challenges were 'trust' versus 'mistrust' followed by 'autonomy' versus 'shame.' Importantly, he held that we face the challenge of **generativity** versus **stagnation in middle life**. This challenge concerns the desire to give back to society and leave a mark on the world. It is about the transition from acquiring and accumulating to providing and mentoring.

Founded in 2010, the European Scientific Journal is just reaching young adulthood. Nonetheless, **generativity** is one of our core values. As a Journal, we reject stagnation and continue to evolve to meet the needs of our contributors, our reviewers, and the academic community. We seek to innovate to meet the challenges of open-access academic publishing. For us,

[1] Hopkins, J. R. (1995). Erik Homburger Erikson (1902–1994). *American Psychologist*, 50(9), 796-797. doi:http://dx.doi.org/10.1037/0003-066X.50.9.796

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

generativity has a special meaning. We acknowledge an obligation to give back to the academic community, which has supported us over the past decade and made our initial growth possible. As part of our commitment to generativity, we are re-doubling our efforts in several key areas. First, we are committed to keeping our article processing fees as low as possible to make the ESJ affordable to scholars from all countries. Second, we remain committed to fair and agile peer review and are making further changes to shorten the time between submission and publication of worthy contributions. Third, we are looking actively at ways to eliminate the article processing charges for scholars coming from low GDP countries through a system of subsidies. Fourth, we are examining ways to create and strengthen partnerships with various academic institutions that will mutually benefit those institutions and the ESJ. Finally, through our commitment to publishing excellence, we reaffirm our membership in an open-access academic publishing community that actively contributes to the vitality of scholarship worldwide.

Sincerely,

Daniel B. Hier, MD

European Scientific Journal (ESJ) Natural/Life/Medical Sciences

Editor in Chief

European Scientific Journal, ESJ
July 2025 edition Vol.21, No.19
ISSN: 1857-7881 (Print) e - ISSN 1857-7431

International Editorial Board

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

European Scientific Journal, ESJ
July 2025 edition Vol.21, No.19
ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table of Contents:

Dance and social engagement in motion: An Emotional Text Mining analysis.....1
Gabriele Caruso
Carlotta Bonta

A Quantum-Safe, Interoperable, and Decentralized Payment Infrastructure for the Post-Classical Era as a Strategic Framework for Secure Global Transactions.....17
Md. Abul Mansur

Crisis, Recovery, and Regional Asymmetries: A Firm-Level Financial Analysis of Italian Food and Beverage SMEs.....54
Maria Garbelli

The Intersection of Culture and Innovation in Georgian Business.....72
Tinatin Zhorzholiani

Supply Chain Resilience: The Role of Total Quality Management on the Performance of Kenya Medical Supplies Authority.....92
Wahome John Ndungu
Stephen Makau Muathe

Determinants of Competitiveness Among Georgian Commercial Banks in the Financial Market.....121
Natia Gadelia

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Conceptual Formation of Curvature in the Logic of Art: An Educational Mathematical Approach.....139
Vassileios Petrakis
Lambrini Seremeti
Ioannis Kougias

Understanding of stoichiometry by learners from Form Four to final year of general secondary education in Cameroon.....156
Jeremie Awomo Ateba
Josephine Nita Tematio Woukeng
Lawrence Ntam Nchia
Ayina Bouni

Identification des risques comme moyen d'amelioration des performances des projets de developpement rural au Cameroun.....173
Hubert Bessi Aboganina
Benjamín Otto Ortega Morales

Evaluation de la rentabilité de la production de la banane plantain dans le village Mansende au Kongo central en République Démocratique du Congo.....198
Mireille Kimanda Asha
Désiré Bisimwa Byamungu
Alphonse Roger Ntoto M'Vubu

Évolution de la pauvreté et des inégalités en Guinée de 2007 à 2019.....218
M.D. Dilé Diallo

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Approche sociologique de l'économie Informelle dans la ville de Bouaké en Côte d'Ivoire.....241

Adou Paul Venance

Valoua Fofana

ESJ Social Sciences Peer-reviewed

Dance and social engagement in motion: An Emotional Text Mining analysis

Gabriele Caruso, PhD
Carlotta Bonta, PhD
University of Catania, Department of educational science, Italy

Doi:10.19044/esj.2025.v21n19p1

Submitted: 23 May 2025
Accepted: 02 July 2025
Published: 31 July 2025

Cite As:
Caruso, G. & Bonta, C. (2025). *Dance and social engagement in motion: An Emotional Text Mining analysis.* European Scientific Journal, ESJ, 21 (19), 1.
https://doi.org/10.19044/esj.2025.v21n19p1

Abstract

This study explores the intersection between emotions, collective action and artistic expression, highlighting the role of dance as expressive language through which affective experiences are socially and politically articulated. In particular, it seeks to understand how performative art, particularly dance, is communicated and perceived as a means of political and social engagement. The research combines sociological theory with computational text analysis, adopting an Emotional Text Mining methodology implemented via T-Lab software. The analysis focuses on a corpus of 50 performance synopses produced by three Italian art collectives (De Anima Movement, Spellbound Contemporary Ballet and Compagnia Zappalà Danza) between January 1, 2023, and March 31, 2025. Using a hybrid clustering approach (Ward + K-Means), the study identifies recurrent emotional themes and symbolic patterns in artistic discourse. Semantic saturation and thematic density guided the validity of results, while statistical metrics confirmed corpus adequacy. Findings confirm that embodied artistic practices are communicated and perceived by these activists as a means of political and social mobilization. They are not viewed only as aesthetic expressions, but as emotional catalysts, capable of instigating a change, transforming individual affect into shared meaning.

Keywords: Affective experiences, collective action, embodied practice, dance, youth

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Introduction

Youth creativity, cultural activism, and artistic expression constitute a powerful lens through which to explore how young people perceive themselves within the social environment and how they choose, collectively, to act upon it. Identity, emotion, and artistic production, through the symbolic, converge in contested spaces (Melucci, 1996), linking young activism and "radical imagination" that underscores the need to "imagine a different world and oppose the status quo through innovative and effective expressions that establish new representations of the self and of the world" [1] (Daher et al., 2022: p.65). Emotions play a central role in this process, far from being merely personal responses, they function as socio-cultural and political constructs, shaping social agency (Behrens, 2024; Durnová and Karell, 2023), while structuring collective imaginaries and fueling mobilization (Jasper, 2018). Therefore, creative forms of activism are powerful because of their ability to evoke emotions and stimulate imagination (Duncombe and Harrebye, 2022; Derkach, 2022). A paradigmatic site of this convergence between creativity, emotion, and political participation is dance. As argued by Parkes and Pruitt (2025), Mills (2021), Ibrahim (2020) and Shapiro (2016), dance operates as a meta-corporeal space, where bodies articulate meanings that are simultaneously aesthetic and political.

However, despite a growing interest in the sociopolitical function of art, empirical research in this area remains limited. This study, aimed at filling this gap, explores the role of artistic expression, particularly dance, as a medium for identity construction, youth activism, and social cohesion. It investigates how embodied performance contributes to protest, mobilization, and transformation of social imaginaries. In particular, it seeks to understand how performative art, particularly dance, is communicated and perceived as a means of political and social engagement. Using a framework that integrates sociological theory and computational text analysis, the research examines the communicative dimension of young artistic dissent. Specifically, the performance synopses (n=50), produced between 01/01/2023, and 03/31/2025, by three Italian artistic collectives (De Anima Movement, Spellbound Contemporary Ballet, and Compagnia Zappalà Danza) were analyzed. An Emotional Text Mining (ETM) methodology through T-Lab was adopted to identify the recurring emotional themes of their artistic discourse. The findings reveal how artistic production's emotional and political nature contributes to the definition of new collective imaginaries and alternative futures (Farro and Maddanu, 2019).

[1] Translation from original language: "immaginare un mondo diverso e opporsi allo status quo attraverso espressioni innovative ed efficaci per stabilire nuove raffigurazioni di sé e del mondo".

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The Emotional Dynamics of Activism: From Collective Protest to Embodied Resistance

The analysis of emotions in activism and protest has highlighted their pervasive influence on collective behavior and, more specifically, politically oriented actions (Derkach, 2022). Crowd-based theories have long acknowledged the role of emotions, generally integrating macrostructural tensions with a predominantly pejorative psychoanalytic perspective on participants' affective states[2]. This view largely dismisses the importance of the emotional dimension of protest, which is not merely an episodic occurrence, but it is integral to the very foundation of collective action. For instance, fervor, rage, and empathy play a crucial role in shaping the meaning that participants attribute to their involvement in movements, representing key drivers of involvement (Derkach, 2022). Thus, while recognizing that collective actors are rational, political, and organized, Melucci (1996) emphasized the importance of participants' "emotional investment" in collective identities. It enables individuals to feel part of a common unity. […] To understand this part of collective action as 'irrational', as opposed to the parts that are 'rational' (a euphemism for 'good'), is simply nonsensical. There is no cognition without feeling and no meaning without emotion" (Melucci, 1996: p.17). Similarly, Daher et al. (2022) argue that emotions are not only integral to identity formation but also serve as tools for constructing alternative imaginaries and counter-narratives, especially among marginalized youth. Emotions such as outrage, hope, and solidarity are not peripheral to activism, but they are central forces that sustain collective action over time. Outrage functions as a motivational force that transforms grievances into action, while hope fosters resilience and long-term commitment to a caus,e and solidarity strengthens collective identity, creating a sense of belonging among activists that enhances their willingness to persist in the face of adversity (Jasper, 2018).

Drawing from Bourdieu's (1986) theoretical framework, emotions function as both a resource and a constraint in contentious politics, shaping power dynamics and structuring collective engagement. Hence, emotions are not merely personal experiences but socially structured forces embedded within political struggles, acting as a form of symbolic capital (Bourdieu, 1986) providing movements with legitimacy in public discourse, while transforming grievances into political engagement and strengthening collective identity and inter-group alliances (Durnová and Karell, 2023). At the same time, emotions can also impose limitations, deterring individuals

[2] For instance, Le Bon described crowds as driven by contagious emotions and a "primitive" group mind, contrasting with rational institutions: "Whether the feelings exhibited by a crowd be good or bad, they present the double character of being very simple and very exaggerated" (Le Bon's, 1895: p.21).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

from participating in high-risk activism. Marginalized groups are particularly susceptible to this phenomenon, often facing stigmatization while their emotions, such as anger, are framed as irrational or dangerous by dominant actors (Durnová and Karell, 2023; Emirbayer and Goldberg, 2005). Therefore, beyond individuals, emotional experiences and expressions may act as powerful emotional catalysts, shaping political narratives and influencing activists' artistic expressions, especially among young people (Behrens, 2024). In this regard, Danaher (2010) and Eyerman (2002) underscore the role of music, artistic interventions, and other cultural forms in embedding emotions within collective memory and protest rituals. Artistic expression is a key component in developing social movement subcultures, nurturing collective identities and serving as an important mechanism for solidarity when participants move beyond "free spaces" to more contested ones (Campbell, 2022; Danaher, 2010). So, it not only communicates movement ideals but also generates emotional resonance, deepening participants' attachment to the cause and fostering broader public support (Eyerman, 2002). Artistic production, as an emotionally charged medium, reinforces mobilization efforts by providing valuable symbolic resources that help to sustain movements and challenge dominant ideologies beyond single actions. Through collective emotional experiences, activists generate new forms of public discourse capable of contesting existing power relations in the long term, increasing a movement's overall impact (Duncombe and Harrebye, 2022; Suesca Carreño et al., 2020).

Especially noteworthy is the intersection between dance and activism that can illustrate how embodied emotions may contribute to political struggles. From a historical perspective, Mills (2021) explores how dance can mobilize marginalized communities and express radical hope, reinforcing the idea that dance is inherently political. It has played a key role in protest movements from the 1920s to the 2020s, with connections to contemporary phenomena such as Black Lives Matter and #MeToo. Moreover, dance can serve as a vital tool for solidarity in times of division and conflict, underscoring its potential to foster community building (Mills, 2021). Additionally, from a feminist perspective, Shapiro (2016) underlined that dance can be analyzed under the broader umbrella of "aesthetic activism", combining artistic expression with social critique and transforming movement into a vehicle for profound meanings, often addressing issues such as gender inequality and violence against women. Therefore, it may evolve into a means of resistance against oppression that fosters empathy and mutual understanding within communities (Shapiro, 2016) while simultaneously catalyzing embodied political engagement across borders as a transnational vehicle of political struggle (Escobar, 2024). A significant example is the work of S. Kermani in Pakistan, whose organization, *Tehrik-e-Niswan*, utilizes

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

dance to empower working-class women and raise awareness about violence against women, demonstrating how cultural initiatives can inspire courage and drive social change, contrasting the rise of fundamentalism (Basu, 2023). Similarly, Parkes and Pruitt (2025) show how, in refugee camps along the Jordan-Syria border, dance becomes a vehicle for displaced youth to express loss, reclaim cultural identity, and articulate political agency. As a transcultural medium, it fosters both resistance and the imaginative reconstruction of possible futures.

The physical and sensory aspects of dance make it not only a form of art but also a means of engaging with political and social issues on a visceral level, connecting body and activism (Farro and Maddanu, 2019). However, despite being widely recognized as an artistic expression, dance still faces challenges in being acknowledged as a legitimate form of activism, and its commercialization may dilute its political message, raising questions about its effectiveness as a tool for social change (Mills, 2021).

Methods

The following analysis requires a methodological approach capable of capturing nuances and latent manifestations within the communication of artistic production. Emotional Text Mining (ETM) is a text analysis method that aims to identify and interpret emotions expressed in texts, going beyond simple keyword identification. Relying on advanced Natural Language Processing (NLP) techniques and semantic models, ETM, as implemented through T-LAB operates through a semi-automated lexicometric clustering method based on the co-occurrence of lemmatized words across context units. As such, traditional assumptions of normality or homoscedasticity are not applicable, since the units of analysis are not continuous numerical data but categorical lexical segments and validity is rooted in semantic saturation and thematic density (Greco and Polli, 2021; Greco, 2016).

Through the analysis of the manifest content of 50 performance synopses (from 01/01/2023 to 31/03/2025) of 3 Italian art collectives[3], the research aims to identify the dominant themes of their discourse. In particular,

[3] De Anima Movement (Veneto, Padua), Spellbound Contemporary Ballet (Lazio, Rome), Compagnia Zappalà Danza (Sicily, Catania) are three dance companies with distinct artistic identities and backgrounds, but brought together by addressing social and political issues. The first, led by Samuele Barbetta, places the body at the center of a transformative process in relation to dynamic space and emotions. The second, under the direction of Mauro Astolfi, explores the connection between gesture and language through strong musical and symbolic integration. The third, directed by Roberto Zappalà, develops a dramaturgy that intertwines body, memory, and scenic landscape. The scraping was conducted on their website or, if not present on their Instagram page: https://www.instagram.com/deanima_movement/; https://orbitaspellbound.com/en/spellbound-contemporary-ballet/; https://scenariopubblico.com/compagnia-zappala-danza/.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

this study adopts an ETM approach, based on a hierarchical method that combines Ward and K-Means methods, used respectively to identify and refine the grouping, on T-LAB. The analysis of word co-occurrence in the text and the identification of thematic clusters made it possible to make assumptions on the role of emotions in artistic discourse and on their impact on the construction of common identity and consciousness (Cordella et al., 2014). Due to the limited size of the phenomenon analyzed, a small-sized sample (20,989 words/tokens) was examined. However, some quantitative characteristics of the corpus were studied to define if it was possible to process the data statistically: the type/token ratio (0.157) which is considered adequate for a value less than 0.2 and the hapax percentage (42%), which should be less than 50% for large corpora, while for small size ones may be acceptable a slightly higher value (Cordella et al., 2014; Giuliano and La Rocca, 2010).

The corpus collected was, firstly, pre-processed automatically by T-LAB that performed a text normalization, segmenting it and conducting a lemmatization, which reduces the words to their linguistic roots. Subsequently, a selection of keywords was conducted, excluding the high-occurrence elements that may distort the analysis, such as the names of the art collectives and their founders. Additionally, a minimum occurrence threshold value was fixed. It was set to 3, so that each term could appear at least once in each of the 3 subcorpora analyzed (Greco, 2016). The cluster analysis was initially set to 20 partitions to identify thematic recurrences, excluding all those elementary contexts that do not have at least 2 co-occurrences. Each cluster is characterized by lexical units that share common elementary context units (484). This procedure of keyword selection allows the analysis to be carried out on a part of the elementary contexts, which should be generally greater than 90% to be acceptable (Greco, 2016). In the present corpus, it is 99.59%.

The data interpretation process was carried out individually by the researchers. The analysis began with the identification of key terms in the synopses, which were used to define the main conceptual dimension, called factorial axes, structuring the data, as well as the internal polarity of each axis. Next, the words most strongly associated with each thematic cluster were examined in order to infer the underlying dimensions that shape how social actors perceive and relate to specific issues discussed in each cluster. Each researcher's findings were then compared to identify shared themes and core categories, which led to the creation of a matrix linking clusters and factors. This helps to map out the symbolic and emotional meanings embedded in the narratives. To test the robustness of these associations, a chi-square analysis was conducted to verify whether specific clusters were significantly related to each collective group’s identity. Instead, in cases with low expected frequencies, Fisher’s Exact Test was used. Lastly, a residual analysis was

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

conducted to examine the deviations between the expected and actual frequencies of responses, allowing to identify which groups' identities were more strongly associated with each thematic cluster.

Table 1. Relevant elements for data processing[4]

Quantitative index of the corpus		Keyword selection criteria	
Tokens	20989	Upper frequency threshold	106
Type	3291	Lower frequency threshold	3
Hapax	1395	Keywords	825
TTR	0.157	Total EC	484
Hapax/Type	0.42	EC in analysis	482
EC in Tot	484	% EC in analysis	99.59%

Results

The analysis led to the identification of four clusters, organized within a three-dimensional factorial space (n = 3). Determination of the optimal number of clusters was performed using the Elbow method, which revealed an inflection point in the intra-cluster variance curve, thus allowing the clusters to be reduced from 20 to 4 in a robust and justified manner. This method identifies the point beyond which adding more clusters results only in a marginal increase in the explanatory power of the model. To further validate the coherence and separability of the resulting partition, both the Silhouette index and the Calinski-Harabasz index were computed[5]. The first evaluates how well each datum fits within its assigned cluster compared to neighboring clusters. The latter compares the compactness within clusters with the dispersion between them to evaluate the quality of clustering. The Calinski-Harabasz index shows a higher value for k=2 and k=3, the value for k=4 (3.63) remains relatively high compared to configurations with a larger number of clusters, suggesting good internal cohesion and separability among the groups. The Silhouette score for k=4 (0.006) is not the highest; it remains comparable with other intermediate values and might be acceptable in contexts where a more interpretable segmentation is sought than an excessive number of clusters. Moreover, while the maximum score is reached at k=9, the improvement beyond k=4 is gradual rather than substantial. Together, these metrics support k=4 as a balanced solution that maintains good partition quality while avoiding the fragmentation of data.

[4] Totals may vary slightly across clusters due to lexical overlap and segmentation of text into elementary context units (ECUs). ETM's interpretative validity stems from relational patterns, not exhaustive corpus coverage.

[5] The computation of clustering indices across a range of values (*k = 2 to 20*; maximum and minimum number of clusters considered) was performed using a custom Python script. The script leveraged the libraries of *nltk*, *scikit-learn*, *matplotlib, pandas*, and *numpy.*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

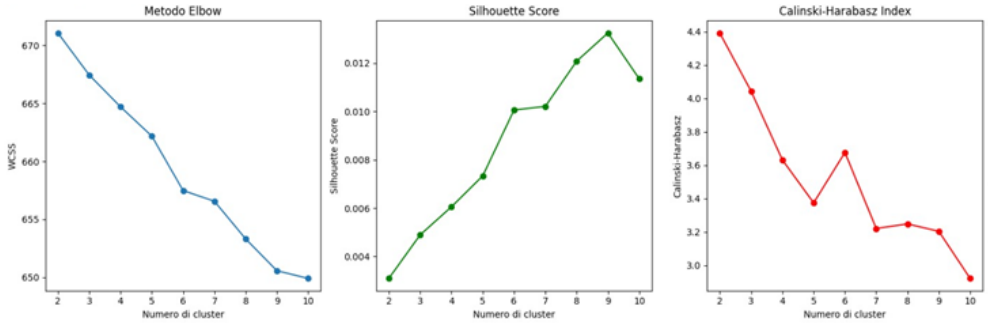


Figure 1. Clustering indices

As far as the interpretation of the words in the factor axes is concerned, the lexical units have been reduced to facilitate the factors' interpretation, following established procedures in semi-automated textual data analysis (Giuliano and La Rocca, 2010). In fact, when working with small corpora, the presence of shared words in different factorial axes can hinder the interpretation (Cordella et al., 2014). To solve it, when lexical units were repeated in more than one axis, only the one with the largest absolute contribution was considered. Therefore, the number of keywords has been reduced to 515.

Factor 1 articulates a contrast between two distinct modalities of engaging with the thematic content of the corpus. In its negative polarity, it aggregates lexical units that are linked to the aesthetic dimension of dance (*aesthetic, beauty, theater, performance, company, choreographer, protagonist*)[6]. In the case-studies, aesthetics is not intended as merely related to technical and performative perfection, but rather to the desire to bring to the stage something with which the spectator can empathize. Aesthetic, thus, becomes a tool that astonishes and brings the audience closer, engaging publics' emotions and political imagination (Shapiro, 2016; Mills, 2021). In contrast, the positive polarity of this factor brings together words that are related to the symbolic meaning of dance (*meaning, create, path, artistic, moment, language, passion*). The first factor can be summarized within the macro-dimension of *performance*, pointing out a tension between the aim of the artistic work that should be, at once, aesthetic and socially committed. Factor 2 is characterized by terms that appear to relate to the *production* of the different pieces. The negative polarity includes words associated with the

[6] The lexical units presented in this paragraph (within parentheses) have been selected on the basis of their absolute contribution, in relation to the overall inertia explained by each dimension. This value reflects the semantic relevance of the terms within the emerging dimensions. For cluster 1 (CL_01), the absolute contribution values range from 1.30% to 0.28%; for cluster 2 (CL_02), from 2.80% to 0.09%; and for cluster 3 (CL_03), from 1.26% to 0.37%.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

organizational dimension, emphasizing a management and preparatory framework, fundamental for the concrete realization of the performances (*making, co-production, contribution, ministry*). Conversely, the positive polarity gathers terms tied to *creative* activity, directly connected with an imaginative dimension (*choreographic, conceptual, dance, cultural, dynamic*). The creative act is intended as a dynamic process in which symbolic elements orient bodily movement toward critical reflection and political awareness (Shapiro, 2016; Escobar, 2024). Factor 3 introduces an additional interpretative axis, emphasizing the *relationship* between the pieces and mthe aterial or human world. The negative polarity terms are linked to the *human world*, which connects the dancer with the alter (*human, encounter, generation, identity, contact, touch*). The dancer does not act in a vacuum, becoming at once a social actor embedded in a system and a transformative actor within the system (Bourdieu, 1985). The human world is thus the engine of the creative act, as well as the relationship with the other is the relational terrain of artistic representation and experimentation. In contrast, the positive polarity is characterized by terms referring to the *material world,* which represents the spatial dimension from which the creative process comes to life (*Etna, Fuji, seeing, time, door, happening, moon, limits*). The surrounding tangible reality is both the object and part of the representation. Within this emerging semantic space, the analysis provides four distinct clusters, each capturing a unique configuration of the lexical fields that represent alternative ways of framing and interpreting the phenomenon analyzed[7].

The first cluster (*Mimesis*) seems to refer to the construction of a process strongly linked to a creative and aesthetic experience (*beauty, aesthetic, theatre, performance*)[8]. The process of observation and re-creation of the world as it is, with its problems and antinomies, preserving its integrity in the narrative and imaginative effort is central in meaning negotiation (*space, Panopticon, dancers, choreographers, companies*). The second cluster (*Social function*) appears to be connected to the human world pole, anchoring organizational and aesthetic dimensions (*choreography, realize, activities*) to the social function of dance and its discourse construction (*culture, ministry)*, aiming at representing the world as it should be. This mediates interactions while fostering awareness of relevant issues (*cultural, contribution, project*). The third cluster (*Medium*) emphasizes the symbolic nature of communication, shifting from a focus on mere representation to a perspective centered on creation and transformation (*living, form, finding, possibility*).

[7] All the terms in text have been translated from Italian to ensure the legibility of the text.
[8] The lexical units presented in this paragraph (within parentheses) have been selected on the basis of their frequency within the corpus segments associated with each thematic cluster, reflecting the relative salience of individual terms in shaping the semantic identity of the cluster.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

This shift calls for a change in interpretative frameworks, enabling a new understanding of how symbolic mediums (*art, encounter, return, generation*) can shape the interactions with the material world. Indeed, as Duncombe and Harrebye (2022) argue, collective symbolic production represents a critical terrain where identities are formed and renegotiated. The fourth cluster (*Metalanguage*) is composed of terms focused on the potential of artistic language to reflect on itself, particularly through symbolic systems (*thinking*, *body*, *movement*, *history)*. The central theme concerns the creation of interpretative frameworks (*speaking, seeing, time*) that enable critical engagement with reality (*necessary, conflict, desire, instrument)*, defining artistic production both as a field of power and of reflection on legitimacy and cultural hierarchies (Campbell, 2022; Bourdieu, 1985).

Table 2. Clusters*factors (each cluster is accompanied by the percentage of elementary contexts classified)[9]

Cluster	Factor 1 (Performance)	Factor 2 (Production)	Factor 3 (Relation)	Meaning space
CL_01 (41.9%)	Aesthetic	Creation		Art as representation and imitation of reality
CL_02 (13.7%)	Aesthetic	Organization	Human world	Socially driven artistic expression
CL_03 (17.4%)	Symbolic	Creation	Material world	Art as a medium for expressive and transformative action
CL_04 (27%)	Symbolic	Creation	Material world	Self-reflections on art and experimental innovation

The four clusters, while addressing the same overarching thematic field (factors), delineate distinct action logics, discursive frameworks, and modes of engagement between actors and the phenomenon under analysis. This differentiation enables a multidimensional interpretation of it, spanning from a positive sentiment (clusters 3 and 4) to a neutral sentiment (clusters 1 and 2). Hence, the dominant emotional landscape appears to be predominantly neutral, with an emphasis on structural and reflective engagement, while the positive sentiment clusters suggest a more constructive and transformative approach. From this linguistic analysis, it emerges a positive and deep emotional connection emerges between the creative process of the artistic production and the social commitment of the collectives studied. Communication is performed not merely through the artistic performance itself, but connecting it with the social context in which it unfolds, considered as a space to be interpreted, represented, and embodied (Farro and Maddanu, 2019). Therefore, artistic production is not only an act of performativity but

[9] All conceptual poles reported in the table exceed the threshold of 0.20, used as minimum value to interpret a meaningful relationship in factorial terms (Greco, 2016). There is only one exception indicated by a blank space.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

also a channel through which emotions are directed onto the creation of shared transformative meanings and revolutionary collective narratives. This intertwining of artistic expression and emotional mobilization resonates with multiple theorizations of collective emotions in social movements (Derkach, 2022; Jasper, 2018; Emirbayer and Goldberg, 2005) and young mobilization (Behrens, 2024; Daher et al., 2022).

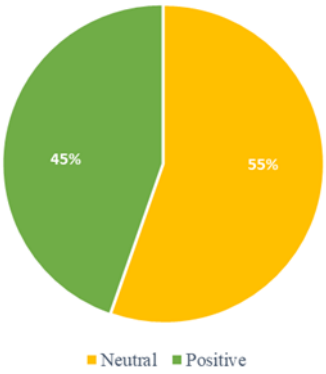


Figure 2. Sentiment results

Thematic clustering revealed a significant differentiation in the discursive-emotional positioning of the collectives, validated by chi-square analysis ($\chi^2 = 21.29$, df = 6, p = .0016). Although chi-square is appropriate for frequency-based lexical clusters, assumptions were verified to ensure that no expected cell had a frequency below 5. In borderline cases, Fisher's Exact Test was used to confirm statistical reliability (p = .048). Furthermore, Cramer's V = 0.28 suggests a moderate effect size, indicating a meaningful association between clusters and each collective group's identity. Standardized residuals[10] support the interpretation of cluster-collective differentiation. The association of Compagnia Zappalà Danza with cluster 1 (residual +1.57) suggests a discursive-emotional emphasis on embodiment and performance. Although not exceeding the threshold value for statistical significance, this result still indicates a noteworthy conceptual proximity. Conversely, the residual (−2.91) of De Anima Movement clearly distances it from representational aesthetics, potentially reflecting an intentional avoidance of traditional codes, showing a stronger alignment with cluster 4 (residual +2.21) and reflecting an interest in experimental narratives, whereas the other collectives reveal a moderate engagement. These findings suggest that while all three collectives engage with shared thematic terrains, their artistic identities diverge significantly in

[10] It represents the deviation between observed and expected frequencies within the contingency matrix between semantic clusters and analyzed entities. Positive values indicate a higher-than-expected presence of a given entity in a cluster, while negative values indicate semantic distance. In literature a commonly accepted threshold for significant residuals is ±1.96 (p < .05) (Clauset et al., 2009).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

symbolic investment and, consequently, in their emotional tone. While residuals alone are exploratory, they align with ETM's goal to map symbolic positioning within emotionally coded discourses (Greco and Polli, 2021). Moreover, De Anima Movement exhibits a clear inclination toward positive sentiment, emphasizing reflexivity and conceptual abstraction. In contrast, Spellbound Contemporary Ballet and Compagnia Zappalà Danza adopt a more neutral emotional tone, rooted in representational and performative frameworks.

Table 3. Distribution of standardized residuals by thematic cluster

	De Anima Movement	Spellbound Contemporary Ballet	Compagnia Zappalà Danza
CL_01	-2,91	-0,68	1,57
CL_02	1,02	-0,16	-0,20
CL_03	0,87	1	-1,16
CL_04	2,21	0,16	-0,88

Conclusions

The findings of this study highlight how the collectives analyzed, although following divergent artistic paths, share a strong critical stance toward the present and a deep connection to their own socio-cultural contexts. Compagnia Zappalà Danza stages a collective action rooted in Mediterranean heritage and global south marginalization, addressing migration, exclusion, and tradition. Spellbound Contemporary Ballet articulates a more existential and introspective form of dissent, drawing from urban alienation and identity fragmentation through an abstract and universalized aesthetic. De Anima Movement embodies a more generational protest, emerging from industrial and urban settings, addressing climate justice and social urgency with an experimental and explicitly political choreographic language. Adopting an advocacy-oriented goal, as shown by the high occurrence in the corpus of terms such as awareness, engagement and receptivity. The collectives promote a creative process of reinterpretation of reality, fostering the emotional re-socialization of their members (Tijoux et al., 2012).

The ETM analysis revealed three structuring communicative factors (Performance, Production, and Relation) which shape the symbolic space in which these works are situated. These dimensions reflect the aesthetic tension between formal experimentation and symbolic visibility; organizational stability and creative transformation; human and material worlds of artistic representation. These axes do not operate in isolation but rather intersect with the emotional and discursive configurations that define how meaning is

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

constructed and shared. This interplay reinforces the idea that dance is not merely an expressive outlet but a site of cognitive and political labor, where the body becomes a locus of signification, contestation, and memory.

Building on this foundation, the research also revealed four clusters (Mimesis, Social function, Medium, and Metalanguage) which articulate distinct emotional orientations and discursive strategies in a common thematic space. The first two clusters, predominantly neutral in sentiment, identify dance as a reflective and pedagogical tool for narrating and structuring social realities. The latter two, marked by a positive sentiment, emphasize the capacity of dance for symbolic transformation and critique. Within this framework, the three companies act differently: De Anima Movement shows a strong orientation toward symbolic and linguistic experimentation (cluster 4), while Compagnia Zappalà Danza and Spellbound Contemporary Ballet engage more with a representational and performative dimension (clusters 1 and 2). However, across all cases, dance emerges as a medium (cluster 3) for mobilizing affective resources to build shared imaginaries that challenge dominant narratives. These findings echo broader sociological theories of emotional dynamics in activism (Jasper, 2018; Melucci, 1996), which recognize affect as a fundamental condition of grassroots action. The study further supports the role of art in the democratization of daily life and in the emotional re-socialization of individuals (Tijoux et al., 2012).

The absence of negative sentiment among the synopses analyzed is significant. The prevalence of neutral and positive sentiments within the corpora, associated respectively with explicative and proactive textual expressions, suggests a strong symbolic investment in transformation rather than a mere critique. Therefore, dance is not intended by these actors only as a mirror of society. It is instead a performative re-articulation of reality, a vehicle through which new social imaginaries and affective grammars are forged through hope. This is particularly evident in De Anima Movement's dataset, which is highly characterized by a transformative positive sentiment. Ultimately, this study suggests that embodied artistic practices are intended and perceived by these "artivists" as a means of political and social mobilization, capable of instigating a change.

Building on the current findings, future research might extend this work by investigating the reception of activist performances among diverse audiences to offer a more comprehensive account of the relational dynamics activated by artistic engagement. Longitudinal and comparative studies could also explore the lasting impact of these performances on individual political attitudes and social cohesion to understand how performative activism could shape public discourse in different socio-political contexts.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Author contributions

Although the present article is the outcome of a common reflection among the authors, Gabriele Caruso has edited the paragraph "The Emotional Dynamics of Activism: From Collective Protest to Embodied Resistance", the metodology and the conclusions; Carlotta Bonta the introduction and the results.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

Funding Statement: The authors did not obtain any funding for this research.

References:

1. Basu, P. (2023). Dance, Gender and Activism in Pakistan: Interview with Performer-Activist Sheema Kermani. *Feminist Encounters: A Journal of Critical Studies in Culture and Politics*, *7*(1), 1. https://doi.org/10.20897/femenc/12889
2. Behrens, S. (2024). The Weight of Emotions: Exploring How Young Activists Feel About Their Identity, Agency and Political Participation. *YOUNG, 32*(5), 508-530. https://doi.org/10.1177/11033088241254247
3. Bourdieu, P. (1985). The forms of capital. In J. G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241–258). New York: Greenwood.
4. Campbell, H. (2022). Hip hop as critical pedagogy: Re-Imagining education. *Canadian Journal for New Scholars in Education/Revue canadienne des jeunes chercheures et chercheurs en éducation*, *13*(3).
5. Clauset, A., Shalizi, C. R., & Newman, M. E. (2009). Power-law distributions in empirical data. *SIAM review*, *51*(4), 661-703. https://doi.org/10.1137/07071011
6. Cordella, B., Greco, F., & Raso, A. (2014). Lavorare con corpus di piccole dimensioni in psicologia clinica: Una proposta per la preparazione e l'analisi dei dati. *Actes JADT*, 173-184.
7. Daher L. M., Mavica G., Scieri A., Cappello N. (2022). Immaginare, esprimersi, opporsi. La creatività dei giovani nell'azione collettiva, in S. Leone & M. Della Mura (Eds.), *Creare società. Approcci e contesti di youth work e agire creativo* (pp. 64–82). FrancoAngeli.
8. Derkach, E. M. (2022). Emotion and social movements. In *The Wiley-Blackwell Encyclopedia of Social and Political Movements* (pp. 1–6). https://doi.org/10.1002/9780470674871.wbespm433.pub2

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

9. Duncombe S. & Harrebye S. (2022). The Copenhagen Experiment: testing the effectiveness of creative vs. conventional forms of activism. *Social Movement Studies, 21(6)*, 741–765. https://doi.org/10.1080/14742837.2021.1967125
10. Durnová, A., & Karell, D. (2023). Emotions and the 'truths' of contentious politics: Advances in research on emotions, knowledge and contemporary contentious politics. *Emotions and Society.* https://doi.org/10.1332/26316897y2023d000000004
11. Emirbayer, M., & Goldberg, C. A. (2005). Pragmatism, Bourdieu, and collective emotions in contentious politics. *Theory and Society, 34*(5–6), 469–518. https://doi.org/10.1007/s11186-005-1619-x
12. Escobar, L. M. (2024). Danser la lutte : féminisme et activisme dans la circulation transnationale d' Un violador en tu camino. *Communications, 115*(2), 93–104. https://doi.org/10.3917/commu.115.0093
13. Eyerman, R. (2002). Music in movement: Cultural politics and old and new social movements. *Qualitative Sociology, 25*(3), 443–458. https://doi.org/10.1023/A:1016042215533
14. Farro A.L. & Maddanu S. (2019), Occupying the city: From social housing to the theatre. In *Youth and the Politics of the Present*, (pp. 141–152). Routledge.
15. Giuliano, L., & La Rocca, G. (2010). *Analisi automatica e semi-automatica dei dati testuali* (Vol. 2). Milano: LED.
16. Greco, F. (2016). *Integrare la disabilità: Una metodologia interdisciplinare per leggere il cambiamento culturale*. Milano: FrancoAngeli
17. Greco, F., & Polli, A. (2021). Security Perception and People Well-Being. *Social Indicator Research,* 153(2), 741-758. https://doi.org/10.1007/s11205-020-02341-8
18. Jasper, J. M. (2018). *The emotions of protest.* Chicago: University of Chicago Press. https://doi.org/10.7208/chicago/9780226561813.001.0001
19. Le Bon, G. (1895). *The crowd: A study of the popular mind* (T. Fisher Unwin, Trans., 2009 ed.). https://www.files.ethz.ch/isn/125518/1414_LeBon.pdf
20. Melucci, A. (1996). *Challenging codes: Collective action in the information age*. Cambridge: Cambridge University Press.
21. Mills, D. (2021). *Dance and activism*. London: Bloomsbury Publishing. https://digital.casalini.it/9781350137028
22. Parkes, N., & Pruitt, L. (2025). Youth Choreographing Peace: Dance in and Beyond the Refugee Camp. *Journal of Peacebuilding &*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Development, 20(1), 38-53. https://doi.org/10.1177/15423166241293857

23. Shapiro, S. B. (2016). Dance as activism: The power to envision, move and change. *Dance Research Aotearoa, 4*(1), 3–33. https://doi.org/10.15663/dra.v4i1.53
24. Suesca Carreño, M. F., Romo Muñoz, L., & Ibarra Padilla, A. M. (2020). Movimientos sociales : El papel de las emociones y los derechos humanos en la transformación del derecho local e internacional. *Análisis Político, 33*(98), 210–225. https://doi.org/10.15446/anpol.v33n98.89418
25. Tijoux M. E., Facuse M., & Urrutia M. (2012). El Hip Hop: ¿Arte popular de lo cotidiano o resistencia táctica a la marginación? *Polis (Santiago)*, *11* (33), 429-450. https://doi.org/10.4067/s0718-65682012000300021

ESJ Social Sciences Peer-reviewed

A Quantum-Safe, Interoperable, and Decentralized Payment Infrastructure for the Post-Classical Era as a Strategic Framework for Secure Global Transactions

Md. Abul Mansur
Nuspay International Inc., United States

Doi:10.19044/esj.2025.v21n19p17

Submitted: 26 May 2025
Accepted: 11 July 2025
Published: 31 July 2025

Cite As:
Mansur, A.M. (2025). *A Quantum-Safe, Interoperable, and Decentralized Payment Infrastructure for the Post-Classical Era as a Strategic Framework for Secure Global Transactions.* European Scientific Journal, ESJ, 21 (19), 17.
https://doi.org/10.19044/esj.2025.v21n19p17

Abstract

The rise of quantum computing introduces a profound threat to existing digital security frameworks, particularly those that underpin modern payment systems. Current cryptographic standards, such as RSA, ECC, and ECDSA are susceptible to being broken by quantum algorithms like Shor's and Grover's, jeopardizing the confidentiality, authenticity, and integrity of transactions across financial networks. This study presents a comprehensive investigation into the design, feasibility, and architecture of a universal quantum-safe payment platform capable of processing all types of digital transactions, ranging from mobile money and bank transfers to blockchain-based and card payments through existing delivery channels on a decentralized infrastructure. The research synthesizes current developments in post-quantum cryptography (PQC), including lattice-based, hash-based, and code-based algorithms, and evaluates their suitability for real-time financial systems. The proposed platform incorporates a permissioned distributed ledger, API-level compatibility with legacy financial protocols, and an identity-governed, modular architecture that enables cryptographic agility and policy compliance. Through architectural modeling and critical analysis, this research provides a forward-looking blueprint for building quantum-resilient financial infrastructure. It concludes that while performance and governance hurdles remain, quantum-safe payment networks are both technically feasible and urgently necessary. This work aims to equip stakeholders, especially

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

fintech firms, banks, and regulatory bodies, with a detailed roadmap for transitioning to secure, interoperable, and scalable payment systems in the quantum era.

Keywords: Quantum computing, post-quantum cryptography, payment systems, blockchain, decentralized ledger, digital finance, cryptographic agility, lattice-based encryption, financial security, PQC

Introduction

Quantum computing brings a major change in how we process information. It can solve complex problems that current computers cannot. However, it also creates a serious threat to cybersecurity. Quantum computers can break public-key cryptographic systems used to protect financial data, digital identities, and secure communications. Today's digital payment systems, such as mobile wallets, banking APIs, and crypto networks, rely on RSA, elliptic curve cryptography (ECC), and similar methods. These systems are considered secure because current computers can't break them easily. But quantum algorithms like Shor's can quickly solve problems that these cryptosystems depend on. This makes most of today's encryption methods unsafe in the face of quantum attacks (Deloitte, 2020).

Motivation: The Quantum Threat

The integrity of financial systems rests upon the assumption that digital transactions cannot be forged, modified, or eavesdropped upon by malicious actors. However, quantum computing directly undermines this trust. If an adversary were to gain access to a scalable quantum computer, they could compromise not only the confidentiality of encrypted payment messages but also the authenticity of digital signatures used to authorize transfers, verify identities, and maintain distributed ledgers (Entrust, 2025). As early as 2022, government agencies and standards bodies began issuing warnings and mandates to prepare for a post-quantum era. The U.S. National Institute of Standards and Technology (NIST) initiated a six-year project to develop and standardize post-quantum cryptographic algorithms (NIST, 2022), while central banks and international consortia launched pilot initiatives to evaluate the impact of quantum-safe encryption on payment infrastructure (BIS, 2023a). The potential economic impact of failing to act is enormous: a compromise of high-value financial systems like RTGS networks or SWIFT could cause cascading losses and trust erosion in global finance (World Economic Forum, 2024).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Research Objectives

This research aims to explore and design a universal quantum-safe digital payment platform capable of processing all forms of digital transactions, ranging from mobile money to banking transfers and digital currencies, through existing delivery channels within a decentralized architecture. The objectives include:

- Analyzing the quantum computing threat to existing cryptographic systems used in payments;
- Reviewing and comparing post-quantum cryptographic algorithms suitable for financial applications;
- Assessing industry pilots and regulatory frameworks addressing the quantum threat;
- Proposing a multi-layered, quantum-resilient architecture integrating decentralized ledger technology (DLT);
- Identifying the technical and regulatory challenges of transitioning to quantum-safe systems.
- Demonstrating a use case of a real-time cross-border payment conducted on a quantum-resistant network.

These objectives collectively support the strategic goal of equipping stakeholders in the financial and cybersecurity sectors with the frameworks and tools necessary to future-proof digital payments in a quantum-disrupted world.

Scope and Relevance

The scope of this study is centered on digital payment systems and the cryptographic mechanisms they employ. It encompasses peer-to-peer transactions, retail payments, card-based authentication, interbank settlement mechanisms, and emerging platforms such as central bank digital currencies (CBDCs) and blockchain networks. While the focus is technical, regulatory and economic considerations are also included due to their role in enabling or constraining technological adoption. This research does not cover other quantum-secure fields like secure multi-party computation or post-quantum authentication tokens, except where directly relevant to financial transactions. Given the predicted timeline for quantum computer development estimated at 8 to 15 years to threaten RSA-2048 and ECC (Utimaco, 2024), the relevance of preemptive preparation cannot be overstated. Institutions that fail to begin migration efforts today may find themselves vulnerable in the near future, especially considering the “Harvest Now, Decrypt Later” model, where intercepted data today could be decrypted post facto using future quantum resources (NACHA, 2024).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Methodological Approach

This research employs an applied analytical method, leveraging a synthesis of scholarly literature, standards documents, pilot project results, and technical specifications to design a viable architecture. A case study analysis of BIS's Project Tourbillon and related initiatives is used to ground theoretical proposals in practical insights. Architectural models are evaluated based on criteria such as cryptographic robustness, integration feasibility with existing systems, and compliance with regulatory mandates. The design framework is conceptualized in modular layers to reflect modern financial infrastructure while allowing cryptographic agility and protocol upgrades. The approach further incorporates a security-by-design principle, ensuring that post-quantum protections are embedded into every transaction stage from API calls and identity verification to consensus mechanisms and ledger storage.

Literature Review

As the specter of quantum computing grows nearer, an increasing body of research is being produced to understand its potential impact on digital infrastructures. For the payments sector, where trust, speed, and cryptographic integrity are non-negotiable, this literature reveals deep vulnerabilities and urgent paths toward post-quantum resilience. In this section, we examine (1) the foundational cryptographic systems at risk, (2) the mechanics of quantum algorithms and their effect on digital security, (3) the families of post-quantum cryptographic (PQC) algorithms, (4) comparative performance analysis for financial applications, and (5) existing industry and government-led initiatives aimed at mitigating these threats.

Cryptographic Foundations at Risk

Modern payment networks, whether online banking, card authorization, or blockchain-based platform,s are underpinned by public-key cryptography. Schemes such as RSA and elliptic curve cryptography (ECC) enable secure key exchanges, digital signatures, and message confidentiality. Their security relies on mathematical problems like integer factorization (RSA) and the discrete logarithm problem (ECC), which are computationally infeasible to solve using classical computers. However, these foundational assumptions collapse under quantum computation (Deloitte Insights, 2020). A major risk arises from the fact that most TLS (Transport Layer Security) connections, including those used by banks and fintech APIs, rely on RSA/ECDSA for handshake and authentication. If these keys are compromised by a quantum attacker, even encrypted sessions could be decrypted retroactively. Similarly, digital signature schemes used in blockchain transactions (e.g., ECDSA in Bitcoin) become forgeable once the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

public key is exposed on-chain, potentially leading to asset theft (Scientific Reports, 2023).

Quantum Algorithms and Their Impact

Two primary quantum algorithms directly threaten current cryptographic protocols:

- Shor's algorithm enables efficient factorization of integers and computation of discrete logarithms, breaking RSA, DSA, and ECC (Shor, 1994).
- Grover's Algorithm accelerates brute-force attacks on symmetric key systems, effectively halving their security level (Grover, 1996).

Shor's algorithm is especially dangerous, as it can retroactively compromise encrypted traffic or signed transactions once a quantum computer becomes capable of handling sufficient qubits. This underpins the urgency of preparing for what many researchers term Q-Day, the point at which cryptographic protections fail at scale (NACHA, 2024).

Families of Post-Quantum Cryptographic Algorithms

In response to these risks, the cryptographic community has developed several families of PQC algorithms. These are based on hard mathematical problems believed to resist quantum attacks:

- Lattice-based Cryptography (e.g., Kyber, Dilithium, Falcon): Relies on the hardness of lattice problems like Learning With Errors (LWE). Efficient and versatile, NIST selected Kyber (encryption) and Dilithium (digital signatures) as primary standards (NIST, 2022).
- Hash-based Signatures (e.g., SPHINCS+): Build secure signature schemes from cryptographic hash functions. Offers strong security guarantees but larger signatures (Utimaco, 2024).
- Code-based Cryptography (e.g., McEliece): Uses error-correcting codes; well-studied but suffers from large public key sizes.
- Multivariate Quadratic Systems (e.g., Rainbow): Once promising, but several schemes have been broken or retired from consideration (Utimaco, 2024).
- Isogeny-based Cryptography (e.g., SIKE): Originally favored for small key sizes, but recently compromised by classical cryptanalysis (Castryck et al., 2022).

Each family has trade-offs in terms of key size, computational efficiency, and deployment feasibility. NIST's current standards prioritize lattice-based and hash-based solutions due to their maturity and performance profiles (NIST, 2024) (Castiglione, Esposito, & Loia, 2024).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Comparative Analysis of PQC for Payments

Digital payment platforms require cryptographic algorithms that are not only quantum-safe but also fast, scalable, and compatible with constrained environments like smart cards and mobile apps. Among NIST's selections:

- Kyber is optimal for key encapsulation in TLS and VPNs due to small ciphertexts and fast computation.
- Dilithium offers strong digital signature performance, with moderate key and signature sizes (~2.5 KB), suitable for transaction signing.
- Falcon produces much smaller signatures (~0.5 KB) than Dilithium, but requires floating-point operations and a more complex implementation.
- SPHINCS+ has large signature sizes (10–40 KB) and slower signing, which limits its use in high-throughput payments but makes it a good fallback for certificate systems.

Code-based and multivariate schemes remain niche due to their inefficiencies or security setbacks. Table 1 summarizes the main characteristics of these algorithms for payment use cases.

Table 1: Summary Comparison of PQC Algorithms for Payment Applications

Algorithm	Type	Key Size	Signature Size	Speed (sign/verify)	Suitability
Kyber	Lattice	~1 KB	~1 KB	Fast	High
Dilithium	Lattice	~1.3 KB	~2.5 KB	Fast	High
Falcon	Lattice	~1 KB	~0.5 KB	Medium	Moderate
SPHINCS+	Hash	~32 KB	~20 KB	Slow	Backup
McEliece	Code	~200 KB	N/A	Medium	Limited

Industry and Government Initiatives

Several pilot projects and government directives are already paving the way for quantum-safe payments:

- BIS Project Leap (2023) tested hybrid classical/post-quantum encrypted communications between central banks using Kyber and Dilithium, demonstrating secure real-world payment message transmission (BIS, 2023a).
- Project Tourbillon implemented privacy-preserving, lattice-based blind signatures in a retail CBDC pilot, showing that anonymity and quantum safety can coexist, albeit with a 5× increase in latency and 200× drop in throughput (BIS, 2023b).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- Banco Sabadell conducted a practical migration assessment of cryptographic systems in partnership with Accenture, finding that crypto-agility middleware can enable PQC adoption without replacing legacy infrastructure (Accenture, 2024).
- FS-ISAC and G7 Cyber Experts Group have called for an immediate inventory of cryptographic assets and the development of PQC migration plans in financial institutions (FS-ISAC, 2024; G7, 2024).
- The Quantum-Resistant Ledger (QRL) has run a hash-based quantum-safe blockchain since 2018, illustrating that full-stack PQC in value transfer systems is viable, even if limited in throughput (QRL, 2024).

These efforts form a growing consensus: the quantum threat is real, and a proactive, phased transition to PQC is the only viable response. They also validate that integration is possible even in high-complexity financial networks.

Methodology

This research employs a multi-pronged analytical methodology to design and validate a universal quantum-safe payment platform. Given the interdisciplinary nature of the problem spanning cryptography, distributed systems, financial architecture, and regulatory policy, our approach integrates structured literature synthesis, case study evaluation, conceptual modeling, and feasibility assessment grounded in real-world constraints. The methodology is framed to address not only theoretical robustness but also practical deployment considerations.

Research Design (Applied Analytical Method)

The central research method is an applied analytical framework that synthesizes cryptographic, architectural, and economic insights from recent scholarly and institutional studies. We begin with a comprehensive literature review of existing quantum risks and post-quantum cryptographic standards. From this, we derive the criteria for quantum-resilient payment platforms encompassing key attributes such as cryptographic agility, scalability, interoperability, latency, and compliance. The study focuses on conceptual design, where the architecture of the proposed platform is developed layer by layer, integrating technical, operational, and governance components. Each element is evaluated for quantum resilience and interoperability with legacy financial systems. By structuring the research into functional modules (e.g., cryptographic services layer, API integration, DLT core), the platform can be analyzed and validated component-wise and as a holistic system.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Case Study Analysis (e.g., BIS Project Tourbillon)

To ground this research in practical application, we incorporate case study analysis of recent quantum-safe payment trials, especially from high-trust institutions such as the Bank for International Settlements (BIS) and central banks participating in its innovation hub. Of particular relevance are:

- Project Leap (2023): A cross-border experiment between Banque de France and Deutsche Bundesbank that evaluated hybrid encryption of payment messages using Kyber and Dilithium. This study serves as evidence of feasibility in a regulated environment with legacy infrastructure (BIS, 2023a).
- Project Tourbillon (2023): A retail CBDC initiative focused on maintaining payer anonymity while implementing lattice-based blind signatures. This case study is critical for understanding PQC's performance and privacy trade-offs in real-time retail use (BIS, 2023b).
- Banco Sabadell PQC Pilot (2024): A commercial case demonstrating how legacy banking infrastructure can transition to PQC using middleware, without wholesale architectural changes. It informs our integration and migration strategies (Accenture, 2024).

Insights from these case studies shape our technical design and risk mitigation strategies. They also validate certain assumptions about latency, throughput, and regulatory viability.

Architectural Modeling and Simulation Review

The proposed architecture of the quantum-safe platform is modeled conceptually using modular systems engineering principles. Each subsystem cryptographic core, ledger design, API gateway, smart contract logic, and identity management, is mapped with specific cryptographic dependencies and performance expectations. Simulated transaction flows are analyzed to understand latency impacts, signature size propagation, and validator workload. For example, PQC signature sizes (e.g., 2–3 KB for Dilithium) are evaluated in the context of network bandwidth, block size, and storage overhead. Latency benchmarks from BIS Tourbillon are used to forecast system responsiveness and guide performance optimizations.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

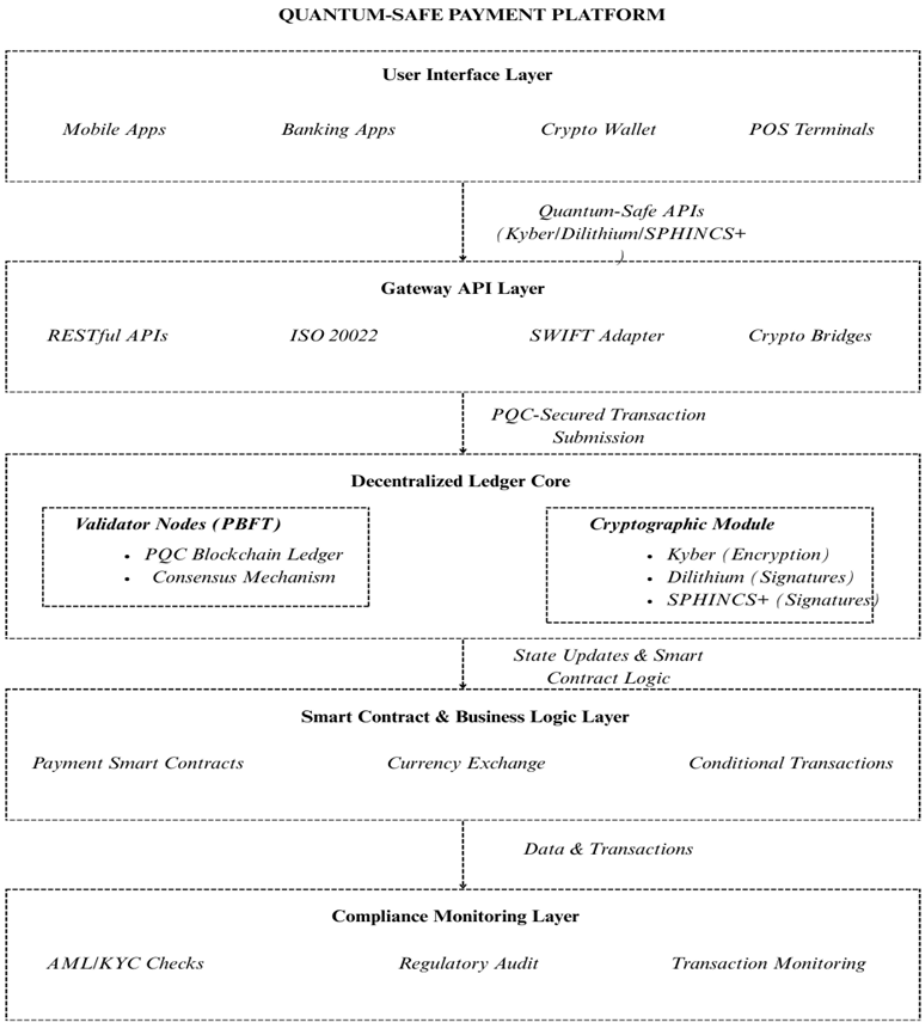


Figure: Conceptual Architecture of the Quantum-Safe Payment Platform

We plan a data flow analysis to visualize how a typical payment (e.g., mobile money to bank account) traverses the system and how PQC is applied at each point: key exchange, signature validation, transaction finality, and audit trail confirmation.

The proposed infrastructure for quantum-safe cross-border remittance leverages a multilayered, decentralized platform architecture, emphasizing robust security through post-quantum cryptography (PQC). It incorporates specialized layers starting from the user interface—such as mobile money apps and banking applications—down through secure gateway APIs and into a decentralized ledger core utilizing advanced PQC algorithms, including Kyber, Dilithium, and SPHINCS+. This decentralized core integrates

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

cryptographic modules and smart contracts to execute transactions securely, while a dedicated compliance monitoring layer ensures strict adherence to AML and KYC regulatory standards. Such infrastructure is strategically designed to mitigate quantum-computing threats, maintaining transaction security and trustworthiness in a post-classical cryptographic environment (Nwaga & Idima, 2024).

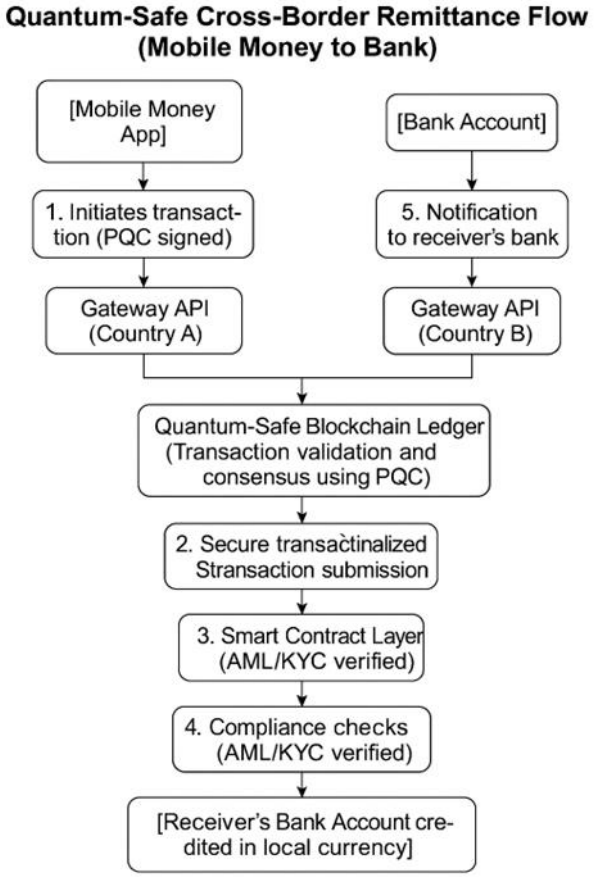


Figure: Conceptual Architecture of the Quantum-Safe Cross-Border Remittance Flow (Mobile Money to Bank)

This illustrates a practical application of this infrastructure in a quantum-safe cross-border remittance scenario, originating from a mobile money account in the sender's country and concluding with credit to a bank account in the receiver's country. The diagram visually details each transaction step, beginning from the initiation of a PQC-secured request at the sender's mobile interface. This transaction securely traverses the gateway API and is validated by the quantum-safe decentralized ledger. Post-validation, smart contracts facilitate foreign exchange conversions and enforce business

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

logic rules. Compliance modules subsequently perform critical AML/KYC checks, ensuring regulatory compliance. Finally, the verified transaction is securely communicated to the receiving bank through APIs, resulting in successful crediting of funds in local currency, thus demonstrating the secure, efficient, and compliant cross-border financial transaction in a quantum-threatened future.

Limitations and Scope Control

Several limitations are inherent in this research:

- Lack of empirical hardware benchmarking: While this paper draws on published pilot data and simulations, it does not conduct real-world PQC deployment due to resource and infrastructure constraints.
- Evolving standards: NIST PQC standards are still maturing. This paper focuses on first-generation algorithms (Kyber, Dilithium, SPHINCS+), acknowledging that new schemes may emerge post-publication (NIST, 2024).
- Jurisdictional variance: Regulatory requirements differ across countries. This study assumes a generalizable regulatory framework aligned with global standards (e.g., FATF, ISO 20022, PSD2) but does not delve into localized compliance laws.
- Selective focus: This work concentrates on quantum threats to payment systems, not broader sectors such as identity management, quantum-resistant messaging, or hardware-based quantum security (e.g., quantum key distribution), except where payment-relevant.

Despite these limitations, the research provides a thorough conceptual foundation and operational roadmap for building a quantum-resilient digital payment network. The layered methodology ensures that each element from cryptographic protocol selection to legacy integration is critically analyzed and contextually grounded.

Quantum Threats in Digital Payment Systems

The advent of quantum computing represents a paradigm shift with far-reaching consequences across digital infrastructures, and the payment ecosystem stands as one of its most vulnerable sectors. Payments, by their nature, involve the exchange of value, sensitive information, and irrevocable commitments, factors that demand cryptographic certainty. Most of the cryptographic primitives currently securing these operations were not designed with quantum capabilities in mind. As such, the emergence of cryptographically relevant quantum computers introduces a multifaceted threat to the digital payment infrastructure (Turpu, 2024).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Vulnerabilities in TLS, Blockchain, and Banking APIs

The most immediate threat from quantum computing lies in its ability to undermine the foundational public-key cryptography (PKC) used in securing communication channels and digital identities. Transport Layer Security (TLS), the backbone of secure communication over the internet, typically uses RSA or elliptic-curve Diffie–Hellman (ECDH) for key exchange and authentication (Mansoor, Afzal, Iqbal, & Abbas, 2025). In the context of banking APIs and fintech integrations, TLS ensures the confidentiality and authenticity of transmitted data (Das, 2025). However, once quantum computers can efficiently run Shor's algorithm, they can break RSA and ECC by factoring or computing discrete logarithms exponentially faster than classical machines (Shor, 1994). This would allow an adversary to decrypt past recorded TLS sessions and impersonate legitimate financial institutions. Blockchain systems are equally vulnerable. For instance, cryptocurrencies like Bitcoin use the ECDSA signature scheme (Weinberg, Petratos, & Faccia, 2024). Once a public key is revealed, such as when a transaction is made, a quantum-capable adversary could derive the corresponding private key and steal funds. The security assumption behind ECDSA is completely broken in a post-quantum context (Deloitte Insights, 2020). Moreover, blockchain consensus mechanisms that rely on cryptographic signatures (e.g., validator authentication in proof-of-stake systems) could also be compromised, leading to governance failures and double-spending attacks. Banking APIs, mobile wallets, and cloud-based financial services typically rely on digital certificates (issued under PKI systems) to authenticate users and services. These certificates, again, use RSA or ECC-based keys (Agrawal, 2024). Once these keys are vulnerable, attackers can forge certificates, impersonate service providers, and intercept or alter financial transactions (NACHA, 2024). This opens the door not only to financial theft but to large-scale systemic disruption of trust in payment networks.

The "Harvest Now, Decrypt Later" Model

Even before quantum computers become practically usable, there exists a credible and pressing threat in the form of the "Harvest Now, Decrypt Later" (HNDL) attack model. In this model, malicious actors today can intercept and store encrypted payment data, be it TLS-secure API traffic, encrypted financial messages, or blockchain transaction records with the intention of decrypting it in the future once quantum capabilities mature. This threat model is particularly concerning for financial institutions because many types of financial data have long lifespans. For example, banking records, account information, and transaction logs may need to be kept secure and confidential for decades. A breach in the future, even if the data was captured

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

years earlier, could expose historical financial behavior, account details, and personally identifiable information (PII). Institutions that have not adopted quantum-safe encryption would be unable to retroactively protect such data (BIS, 2023a). Moreover, the widespread reuse of keys such as static server keys for TLS or certificate-based identities further exacerbates the problem. If even one long-lived key is compromised, all past messages encrypted under it become vulnerable. This presents an existential risk to regulatory frameworks like the Payment Card Industry Data Security Standard (PCI-DSS) and GDPR, which mandate stringent protection of user data (NACHA, 2024).

Socioeconomic Impact of Inaction

Failing to act on the quantum threat could have dire socioeconomic consequences. At the systemic level, the breakdown of trust in financial transactions could lead to a loss of faith in digital commerce, banking platforms, and payment systems. Imagine a scenario where attackers forge digital signatures on interbank payment instructions. The results could include unauthorized fund transfers, cascading defaults due to mistrusted settlement instructions, and liquidity crises in clearing systems. Studies suggest that a successful quantum attack on high-value payment systems like the U.S. Federal Reserve's Fedwire could cause economic contractions of over 10% of GDP due to the loss of transactional trust (World Economic Forum, 2024). In retail scenarios, the compromise of consumer-facing applications such as mobile wallets or contactless cards would erode confidence in digital payments and could drive regression to cash-based economies. This would disproportionately affect regions where digital inclusion has only recently been achieved.

In global trade, quantum threats could disrupt supply chains by targeting financial messages exchanged over SWIFT or ISO 20022 standards. A compromised SWIFT infrastructure, even for a short duration, would paralyze international payments and settlements. Furthermore, if adversarial nation-states or state-sponsored entities develop a quantum advantage first, it could lead to geopolitical imbalances in financial power and economic security. The reputational damage to institutions that fall victim to quantum-era breaches would be severe, both in customer trust and regulatory penalties. Legal liability, class-action lawsuits, and heightened scrutiny from financial regulators would follow. Hence, preparing for quantum threats is not just a technical necessity but a strategic imperative for long-term financial stability. The threats posed by quantum computing to digital payments are systemic, far-reaching, and imminent. From protocol-level vulnerabilities to long-term data privacy breaches, quantum capabilities challenge the very assumptions that secure modern financial ecosystems. Organizations must adopt a forward-looking stance, transitioning to quantum-safe cryptography, auditing

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

cryptographic assets, and establishing governance frameworks that anticipate the next cryptographic revolution. As the literature and pilot studies clearly show, the time to act is not when quantum computers arrive, but now during the preparation window that remains open.

Post-Quantum Cryptographic Solutions

The emerging threat landscape shaped by quantum computing has necessitated a re-evaluation of cryptographic foundations across the digital ecosystem. In response, the cryptographic community, supported by standardization bodies such as the National Institute of Standards and Technology (NIST), has developed a set of post-quantum cryptographic (PQC) algorithms designed to resist known quantum attacks. These algorithms are not merely theoretical constructs; they are practical tools currently being standardized, implemented, and piloted across payment networks, with a growing body of research and trials validating their feasibility. This section explores the major families of PQC algorithms with specific attention to their applicability in real-time, high-volume financial environments. Each family is assessed in terms of security assumptions, performance metrics (key size, signature size, computational cost), maturity, and integration potential in payment platforms.

Lattice-Based Cryptography

Lattice-based cryptography has emerged as the most promising family of quantum-resistant algorithms for both encryption and digital signatures. These algorithms derive their security from hard problems in high-dimensional lattices, such as the Learning With Errors (LWE) or Shortest Vector Problem (SVP), which remain hard even in the presence of quantum adversaries (Alkim et al., 2016).

NIST's primary selections for its PQC standardization process were lattice-based:

CRYSTALS-Kyber for encryption and key encapsulation
CRYSTALS-Dilithium and FALCON for digital signatures

These algorithms offer a favorable balance between performance and security. Kyber, for example, enables secure key exchange with compact keys (~1 KB) and ciphertexts and is fast enough to support TLS handshakes in payment APIs. Similarly, Dilithium produces moderate-sized signatures (~2.7 KB) and public keys (~1.3 KB) while avoiding complex floating-point operations, making it easier to implement in constrained environments (NIST, 2024). FALCON offers even smaller signatures (~0.8 KB) but requires more complex implementations and hardware floating-point support.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

In real-world financial scenarios, lattice-based schemes are well-suited to:

Signing interbank transactions and instructions
Authenticating user identities and wallet keys
Securing API communications between payment gateways and processors
Enabling secure key exchange in TLS and VPNs for data in transit

The financial sector has begun piloting lattice-based solutions. For instance, the BIS Tourbillon project implemented lattice-based blind signatures for CBDC payments with privacy features (BIS, 2023b). While the project noted increased latency and reduced throughput (5× slower processing and 200× drop in TPS), ongoing optimizations and hardware acceleration are expected to mitigate these issues over time.

Hash-Based and Code-Based Cryptography

Hash-based cryptography is another mature and well-understood approach. These schemes rely on the pre-image resistance of secure hash function primitives believed to withstand quantum attacks, barring Grover's algorithm ,which only provides a quadratic speedup. NIST selected SPHINCS+, a stateless hash-based digital signature scheme, as an alternative standard (Hülsing et al., 2020). While hash-based signatures are theoretically robust and straightforward to analyze, their practical deployment faces challenges:

Large signature sizes (10–40 KB)
Slower signing operations compared to lattice schemes

In payment systems, hash-based signatures are best suited for applications where long-term integrity and robustness are paramount, and where signature size is less of a constraint. For instance:

Signing critical software updates for payment hardware
Issuing root certificates in a quantum-safe public key infrastructure (PKI)
Authenticating interbank messages where bandwidth is ample

Code-based cryptography, epitomized by the Classic McEliece scheme, offers extremely conservative security. McEliece has withstood decades of cryptanalysis and is resistant to both classical and quantum attacks. Its primary drawback lies in its massive public key sizes (up to hundreds of kilobytes), which makes it ill-suited for high-frequency transactions or resource-constrained devices (Bernstein et al., 2008).

Nonetheless, in payment infrastructures, code-based schemes can be viable for:

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Encrypting bulk archival data
Root key storage in high-security modules
Specialized one-time communication (e.g., initial device onboarding)

Isogeny- and Multivariate-Based Cryptography

Isogeny-based and multivariate quadratic equation-based cryptography were initially promising avenues for PQC due to their compact key sizes and fast operations. However, both families have suffered major cryptanalytic setbacks in recent years. For example, the SIKE (Supersingular Isogeny Key Encapsulation) scheme was completely broken in 2022 by a classical attack, undermining its assumed hardness (Castryck & Decru, 2022). Similarly, Rainbow, a leading multivariate signature scheme, was broken in practice shortly before NIST was to standardize it. These collapses have severely limited the deployability of these algorithm families in mission-critical applications like payments. Given the current state of cryptanalysis, isogeny- and multivariate-based schemes are not recommended for production deployments in payment platforms. However, academic research continues, and future iterations may address existing vulnerabilities.

Hybrid Schemes for the Transition Period

A practical challenge in migrating to PQC is ensuring backward compatibility with existing systems and preserving security during the transition. To this end, hybrid cryptographic schemes are recommended. These schemes combine classical and quantum-safe algorithms in a single transaction or session. For example:

Dual TLS key exchange using both ECDHE and Kyber
Transactions signed with both ECDSA and Dilithium (dual signature fields)

This ensures that data remains secure as long as one of the two algorithms remains unbroken. Hybrid schemes are already being tested in protocols like TLS 1.3 (Open Quantum Safe Project) and are particularly useful for:

Protecting data-in-transit against HNDL threats
Allowing phased migration of systems and devices
Gaining regulatory and institutional confidence in PQC deployment

Institutions such as JPMorgan and Banco Sabadell have already piloted hybrid deployments, illustrating the feasibility of dual-crypto architectures in complex financial networks (Accenture, 2024; JPMorgan, 2022). In conclusion, post-quantum cryptographic solutions offer a comprehensive set of tools to secure payment systems in the face of quantum

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

adversaries. Lattice-based algorithms provide a balance of efficiency and security suitable for most payment operations. Hash- and code-based schemes offer specialized robustness for archival or infrequent use cases. While isogeny and multivariate cryptosystems have yet to reach production readiness, the combination of lattice and hash-based methods, coupled with hybrid strategies, enables immediate transition paths. Financial institutions should begin deploying PQC in critical systems, prioritize cryptographic agility, and participate in standards alignment to future-proof digital payments in the quantum era.

Proposed Quantum-Safe Payment Platform Architecture

In response to the growing risks posed by quantum computing and the urgent need for cryptographic agility, this section introduces a comprehensive architecture for a universal quantum-safe payment platform. The platform is designed to process all forms of digital payments, including mobile wallets, bank transfers, cards, and cryptocurrencies via existing delivery channels, while embedding quantum-resistant cryptographic primitives at every layer (Agrawal, 2024). The architectural model leverages decentralized technologies, modular design, and industry-compliant interfaces to ensure both forward compatibility and practical deployment feasibility.

Platform Objectives and Design Principles

The primary objective of the proposed platform is to establish a secure, interoperable, and scalable payment infrastructure that resists quantum-era threats while maintaining the flexibility to integrate with legacy financial systems. To meet this goal, the architecture adheres to the following key principles:

- Quantum Resilience: All cryptographic operations, including digital signatures, key exchanges, and identity validation, must employ post-quantum cryptographic algorithms approved or recommended by international standardization bodies like NIST.
- Decentralization and Redundancy: To avoid single points of failure and centralized vulnerabilities, the platform uses permissioned distributed ledger technology (DLT) operated by a consortium of trusted entities (e.g., banks, fintechs, central banks).
- Legacy Compatibility: The architecture must allow seamless integration with existing systems (e.g., ISO 20022 messaging, REST APIs, SWIFT), enabling a smooth transition for institutions and end-users.
- Cryptographic Agility: To allow future upgrades, the system must support pluggable cryptographic primitives, with metadata indicating the algorithms in use for each transaction or communication.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- User Transparency: While underlying cryptographic protocols will evolve, the user-facing experience (e.g., mobile payments, bank transfers) must remain intuitive and consistent.

Functional Layers: From API to Ledger Core

The architecture is structured into distinct functional layers, each responsible for a specific aspect of the system's operations.

User and Channel Integration Layer

This layer interfaces with external payment systems and user applications. It includes:

Mobile banking apps
E-commerce payment gateways
Point-of-sale systems
Internet banking portals
Cryptocurrency wallets

These endpoints communicate with the platform via standardized APIs. Crucially, these channels are protected using quantum-safe TLS (e.g., Kyber for key exchange, Dilithium for mutual authentication).

API and Gateway Layer

To ensure backward compatibility, the API and gateway layer performs protocol translation and message formatting. It supports:

ISO 20022 (PACS, CAMT) for banks
RESTful or gRPC APIs for fintechs
EMV/NFC interface translation for card processors

Each message is authenticated and secured using a combination of post-quantum digital signatures and symmetric encryption. A digital signature using CRYSTALS-Dilithium or FALCON confirms authenticity, while AES-256-GCM ensures confidentiality (Utimaco, 2024).

Distributed Ledger Core

The ledger core serves as the transaction recording and consensus layer. It is a permissioned blockchain with the following attributes:

- Validator nodes run by consortium members (banks, central banks, regulated fintechs)
- PBFT or HotStuff consensus, with validator messages signed using PQC
- Account-based or UTXO-based model, depending on implementation preference

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Each transaction is signed using PQ digital signatures. Blocks include Merkle trees hashed with quantum-safe functions like SHA-384 or SHA3-512. Validator nodes authenticate one another using post-quantum certificates, possibly anchored in a decentralized identity framework.

Cryptographic Services Layer

This cross-cutting layer includes:

- Quantum-Safe Key Management: Key generation and storage using hardware security modules (HSMs) supporting PQC
- Public Key Infrastructure (PKI) or decentralized identity (DID) systems using SPHINCS+ or Dilithium for long-term certificates
- Multi-signature schemes and threshold signatures, allowing high-security operations (e.g., corporate approvals or interbank transfers)
- Hybrid signature engines, enabling dual-algorithm transactions during migration phases

Smart Contract and Application Layer

Where programmable logic is required (e.g., conditional payments, currency exchange, escrow), this layer supports smart contracts. These contracts must use PQC-aware cryptographic opcodes and can include:

PQ signature verification
Zero-knowledge proofs (e.g., PQ-secure zk-SNARKs for privacy)
Atomic swaps with hash-locking using quantum-safe hashes

The platform may provide precompiled contracts or native opcodes for PQC operations to reduce gas and latency costs.

Cryptographic Services and Key Management

Key management is central to quantum-safe infrastructure. The platform introduces a quantum-safe key lifecycle involving:

- Key provisioning: Devices (e.g., mobile apps, ATMs) receive keys from certified PQC-enabled CAs or issuers.
- Key rotation policies: Avoiding excessive reuse of signatures by rotating keys regularly (especially relevant for lattice and hash-based schemes).
- Recovery and revocation: Compromised keys can be revoked using quantum-safe certificate revocation lists or ledger-anchored proofs.

Where possible, multi-algorithm agility is built in. For example, a transaction format may include an algo_type field, specifying the signature algorithm used. This allows validators and clients to interpret and verify transactions under varying algorithm choices.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Smart Contracts and Payment Applications

Smart contracts extend the platform's capability to support complex payment scenarios, such as:

- Cross-border remittance logic
- Escrow or dispute resolution
- FX conversions using oracle feeds
- Compliance checks embedded into transaction logic

Contracts can verify PQC digital signatures, compute Merkle proofs, and validate zero-knowledge claims for privacy. Additionally, smart contracts may be used for programmable compliance, for example, preventing a transaction above a certain value unless approved by multiple signatories (multi-sig logic based on Dilithium threshold schemes).

The architecture ensures that smart contracts are extensible, formally verifiable, and sandboxed to prevent attacks, especially important in the financial context where logic bugs could have monetary consequences.

Table 1: Comparative Analysis of PQC Schemes for Platform Layers

Platform Layer	Recommended PQC Algorithm(s)	Key Advantages	Potential Limitations	Ideal Use-Cases
User Interface Layer	Dilithium, Falcon	Efficient digital signatures, moderate sizes	Slightly higher computational overhead	Mobile wallets, POS terminals, web apps
Gateway API Layer	Kyber, Dilithium	Fast encryption and signature verification	Increased message sizes	Secure API requests, session encryption
Decentralized Ledger Core	Dilithium, SPHINCS+	Robust long-term security, widely vetted	Larger signatures (SPHINCS+)	Blockchain consensus, transaction signing
Cryptographic Module	Kyber, Dilithium, SPHINCS+	Algorithm diversity, cryptographic agility	Complexity managing multiple schemes	Key management, PKI infrastructure
Smart Contract Layer	Dilithium, Falcon	Rapid verification, lower signature sizes (Falcon)	Implementation complexity (Falcon)	Payment logic, conditional transactions
Compliance Monitoring Layer	SPHINCS+, Dilithium	Highly secure, long-term quantum resistance	Signature size overhead	Regulatory audits, AML/KYC verification

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Decentralized Ledger Integration

The core of a universal quantum-safe payment platform lies in its ledger infrastructure. A decentralized ledger offers a unified, tamper-resistant, and continuously available substrate for payment processing that minimizes reliance on central intermediaries. In this section, we explore the integration of decentralized ledger technology (DLT) with quantum-safe cryptographic primitives to ensure a robust and scalable foundation for next-generation payments.

PQC-Enabled Blockchain Model

The integration begins by replacing classical cryptographic primitives used in existing blockchains, primarily RSA and ECDS,A with post-quantum cryptographic (PQC) algorithms. Given the existential vulnerabilities of public key cryptography in a post-quantum world (Deloitte, 2020), this transition is foundational.

A permissioned blockchain architecture is preferred due to its ability to enforce performance, governance, and compliance guarantees while retaining decentralization through consortium governance (BIS, 2023a). The blockchain operates with:

- Dilithium/Falcon-based signature schemes for signing transactions and validator messages
- Kyber or hybrid key exchanges for node-to-node encrypted communication
- SHA-3-384 or SHA-512 for hashing block contents and building Merkle trees
- SPHINCS+ for long-term identity credentials or certification anchors

Unlike public blockchains like Ethereum or Bitcoin, which still rely on ECDSA and SHA-256, the proposed system avoids exposing public keys until necessary and ensures that even old transactions cannot be retroactively forged or decrypted.

Each transaction submitted to the blockchain must be:

- Digitally signed using a PQ signature algorithm (e.g., Dilithium3 for general use, Falcon for low-bandwidth contexts)
- Accompanied by metadata indicating the algorithm used, its version, and a reference to the user's post-quantum public key

Validators, upon receiving transactions, verify signatures using standardized PQC libraries, apply application-specific logic (e.g., balance checks, authorization), and participate in consensus voting, all secured by PQ signatures.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Consensus Mechanisms and Signature Verification

Consensus is the backbone of ledger trust. For a high-throughput, low-latency payment system, Byzantine Fault Tolerant (BFT) protocols are ideal. Protocols like Practical Byzantine Fault Tolerance (PBFT) or HotStuff are widely adopted in financial-grade DLTs due to their deterministic finality and bounded communication complexity.

Each round of consensus involves:

- A leader proposing a block
- Other nodes verifying transactions and voting via PQ signatures
- Aggregation of at least 2/3 validator approvals before finalizing a block

These messages are signed using PQ signature schemes (e.g., Dilithium), which, while heavier than ECDSA, are manageable in networks with limited validator counts (typically <100). The additional CPU and network overhead can be mitigated by:

- Signature batching and pipelining
- Use of GPU/FPGAs for PQC operations
- Selective fast paths for low-value or internal transactions

For instance, Tourbillon, a BIS pilot, successfully used a lattice-based signature system in a permissioned blockchain setting, despite latency and throughput hits (BIS, 2023b). Engineering solutions such as signature aggregation (where possible) and parallel verification can improve these metrics significantly.

Interoperability and Bridging to Legacy Systems

True payment ubiquity requires seamless interoperability with existing financial infrastructure. This includes:

- SWIFT messages (ISO 20022 and legacy MT)
- National ACH and RTGS systems
- Mobile money operators using proprietary APIs or telecom integrations
- Card networks (EMVCo and PCI DSS systems)
- Public blockchains (e.g., Bitcoin, Ethereum)

The platform implements interoperability gateways, which:

- Receive classical cryptographically signed messages from legacy systems
- Authenticate them using existing mechanisms (e.g., TLS + JWT or OAuth2 tokens)
- Re-sign or wrap the transactions using PQC before ledger inclusion

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- Translate response data back to legacy formats (e.g., ISO 20022 PACS.008 to bank system)

During the transition phase, the system may also support dual-signature transactions, whereby legacy and PQ signatures are both required for validation. This protects against "harvest-now, decrypt-later" attacks during early adoption (NACHA, 2024).
In cross-chain contexts, atomic swaps using hash-locks and bridging contracts can allow tokenized representations of external assets (e.g., wrapped BTC, or synthetic fiat tokens) to exist within the platform, all secured with PQ signatures.

Governance and Identity Systems

Governance is vital for maintaining trust and ensuring regulatory compliance in decentralized infrastructures. The platform proposes a hybrid governance model, combining:

- A consortium council composed of major financial stakeholders (central banks, PSPs, card schemes)
- A technical advisory board responsible for cryptographic standards and software updates
- A compliance panel to audit protocol adherence and respond to legal inquiries

Each participant, whether a user, node, or institution has a unique quantum-safe digital identity, managed via:

- A post-quantum PKI system for certificate-based authentication
- A Decentralized Identity (DID) layer using blockchain-resident identity mappings
- Role-based permissions and transaction scopes (e.g., regulator nodes can observe but not write, PSP nodes can initiate payments, etc.)

The identity infrastructure ensures that all participants can:

- Prove their legitimacy cryptographically
- Revoke compromised credentials instantly
- Maintain pseudonymity when needed (e.g., for retail users), while still satisfying regulatory requirements such as Know Your Customer (KYC) or Anti-Money Laundering (AML) policies (FS-ISAC, 2024)

It is acknowledged that the platform focuses on software-defined solutions, while quantum computing itself is a fundamentally hardware-centric paradigm based on phenomena such as quantum entanglement, tunneling, and photon-based interactions. Nevertheless, post-quantum

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

cryptography seeks to preempt quantum threats by designing algorithms secure even when attacked by hardware-capable quantum machines. PQC is a defensive software response to the prospective offensive capability of quantum hardware (Turpu, 2024; Das, 2025).

Implementation Challenges and Considerations

Developing and deploying a universal quantum-safe payment platform is not merely a cryptographic challenge but a multidisciplinary endeavor that intersects with system engineering, regulation, user experience, and infrastructure planning. This section outlines the key implementation challenges and provides insights into how each can be mitigated through architectural foresight, protocol design, and stakeholder collaboration. The proposed platform assumes deployment within dedicated servers or cloud-native infrastructures hosted in highly secure environments. This aligns with current cybersecurity best practices, especially when integrating post-quantum cryptographic (PQC) toolchains that require secure key management, memory isolation, and tamper-proof computation modules. Server-grade hardware with hardened operating systems will be essential in ensuring that the PQC primitives are not vulnerable to side-channel attacks or state recovery mechanisms.

Performance and Scalability

Post-quantum cryptographic algorithms, especially lattice-based and hash-based schemes, introduce significant computational and bandwidth overhead compared to classical counterparts. For instance, a Dilithium signature can be between 2.5 KB and 4 KB, compared to a 64-byte ECDSA signature, and verification can consume millions of CPU cycles (NIST, 2024). The architecture supports major operating environments Microsoft, Linux, and iOS, using language-agnostic APIs and portable cryptographic libraries. However, this heterogeneity introduces challenges in vulnerability management. Legacy protocols, fragmented update cycles, and dependency on platform-specific entropy sources may affect PQC module integrity. A centralized vulnerability disclosure program and regular PQC patch rollouts will be vital for operational resilience (Castiglione et al., 2024).

Performance Bottlenecks:

- Signature size inflates transaction payloads, increasing block size and network traffic.
- The computation cost for signing and verifying degrades transaction throughput.
- Consensus rounds become more communication-intensive due to larger authentication payloads.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Mitigation Strategies:

- Hardware acceleration: Deploy FPGA- or GPU-based cryptographic modules to offload PQC operations (Johnson & Murchison, 2019).
- Pre-signing and caching: Allow wallets to generate signatures ahead of time for likely transactions.
- Signature batching and aggregation: Combine multiple signatures in consensus blocks, where supported.
- Sharding and regional subnetworks: Distribute load across zones (e.g., domestic vs. cross-border payment ledgers).
- Layer-2 scaling: Implement off-chain channels or rollups for high-frequency retail payments, similar to the Lightning Network.

Despite early pilot concerns (e.g., Project Tourbillon's 5× latency hit and 200× throughput drop), incremental software and hardware optimization can drastically reduce these figures (BIS, 2023b).

Latency and Real-Time Payment Needs

Users and merchants demand instantaneous payment confirmation, particularly for retail and contactless payments. PQC introduces additional signing and verification steps, which can delay processing.

Latency-Sensitive Areas:

- Point-of-sale (POS) authorization
- Mobile wallet transfers
- ATM withdrawal confirmations

Solutions:

- Use optimistic confirmation models: provide provisional approval immediately while final settlement occurs in the background.
- Tiered validation: lightweight real-time checks followed by full PQC verification asynchronously.
- Fast-finality consensus protocols (e.g., PBFT, HotStuff) that can confirm transactions in under 1–2 seconds.

Additionally, PQC algorithms like Falcon provide shorter signatures (compact ~700-byte range), suitable for bandwidth-constrained or latency-sensitive environments such as mobile SIMs and cards (NIST, 2024).

Regulatory Compliance (e.g., AML, KYC)

In a decentralized system, compliance enforcement must be integrated without compromising decentralization or privacy.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Challenges:

- Regulatory bodies demand traceability, identity verifiability, and auditable records.
- Some jurisdictions require data localization and transactional record retention.
- Zero-trust environments make it hard to centrally enforce rules.

Design Responses:

- Implement programmable compliance logic (e.g., smart contracts that block large payments without AML checks).
- Utilize zero-knowledge proofs to satisfy conditions (e.g., KYC-passed) without revealing private user data.
- Develop privacy zones: sub-networks where transaction visibility is role-based (e.g., regulator nodes can decrypt selected fields).
- Comply with evolving regulatory guidance (e.g., Financial Action Task Force on virtual assets).

A regulator's observer node can audit consensus and access compliance data via encrypted backdoors (governed by legal warrants) while user-facing systems preserve privacy and usability.

Hardware and Cryptographic Agility

A significant challenge in PQ migration is the heterogeneity of hardware, particularly in embedded environments such as:

- Smart card chips
- Mobile SIMs
- POS terminals
- ATM security modules

These devices often lack the processing power or memory footprint to handle large PQC key sizes and heavy operations.

Roadmap for Hardware Migration:

- Develop dual-stack support: allow continued use of ECDSA in these devices while wrapping communications in PQC (e.g., a POS sends an ECDSA transaction, which is then re-signed by the issuer bank using Dilithium before submission to the ledger).
- Promote vendor adoption: encourage chipset makers to support Kyber, Dilithium, SPHINCS+ in HSMs and secure elements (Accenture, 2024).
- Introduce quantum-safe SDKs for mobile wallets and banking apps with hybrid crypto support.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Furthermore, cryptographic agility must be embedded into the platform's design: if a PQC scheme is later deprecated (as SIKE and Rainbow were), the system must support algorithm swapping without breaking the transaction chain (Utimaco, 2024).

Privacy and Zero-Knowledge Strategies

While quantum-safe cryptography secures transaction authenticity and confidentiality, privacy remains a complex domain, especially in decentralized systems that are inherently transparent.

Privacy Tensions:

- Public ledgers expose transaction flows.
- Financial data must be both auditable and confidential.
- PQC privacy technologies are still emerging.

Approaches:

- Use quantum-resistant zero-knowledge proofs (zk-SNARKs) based on hash primitives (e.g., Poseidon) rather than number-theoretic assumptions.
- Implement blind signature mechanisms (e.g., lattice-based) for anonymous digital cash.
- Adopt selective disclosure protocols for regulators, allowing compliance checks without full public transparency.
- Design privacy tiers: consumer-to-consumer payments may be private, while institution-to-institution flows are visible.

The BIS Project Tourbillon validated a working prototype of private quantum-safe CBDC using blind lattice-based signatures (BIS, 2023b). Similar techniques can be scaled for broader privacy-sensitive use cases in our platform (De Haro Moraes, Pereira, & Grossi, 2024).

Use Case Demonstration

To validate the technical and architectural concepts proposed in this study, we present a real-world use case demonstration involving a cross-border remittance scenario. This scenario highlights how a quantum-safe decentralized payment platform can enable secure, interoperable, and regulation-compliant transactions across borders, channels, and financial systems while preserving performance, auditability, and post-quantum resilience.

Scenario Overview: Mobile Wallet to Bank Transfer (Cross-Border)

Consider a user in Kenya who wants to send money from their mobile money wallet (e.g., M-Pesa) to a merchant's bank account in Germany.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Traditionally, this transaction would traverse multiple intermediaries: mobile operator, local bank, remittance aggregator, foreign exchange bureau, SWIFT messaging, and the recipient bank, incurring fees and delays. With our quantum-safe decentralized payment network, this same transaction is executed securely, transparently, and rapidly across a unified platform.

Transaction Workflow (Step-by-Step)

1. User Authorization & Key Binding

The sender's mobile wallet app interfaces with the platform via a quantum-safe SDK that integrates a Dilithium keypair. Upon account registration, the user's identity is linked with a post-quantum public key using a decentralized identity (DID) credential issued by their mobile money provider. The wallet app signs the transaction request using the user's private key.

2. Transaction Creation

The user initiates a transfer: "Send 10,000 Kenyan Shillings (KES) to merchant@examplebank.de (EUR equivalent)."
The mobile money provider's API gateway receives this request and translates it into the platform's transaction schema. The transaction object includes:

- Sender's address (tied to Dilithium public key)
- Recipient's address (tied to the recipient bank's custodian node)
- Amount, currency, timestamp
- Optional memo or invoice ID
- Digital signature from sender (PQC)

3. API Gateway & Currency Conversion

The API gateway checks KYC compliance, verifies the signature, and forwards the transaction to the platform. If currency conversion is required, the gateway interfaces with an on-chain FX contract or a liquidity provider. Conversion rates are retrieved from authenticated price oracle feeds, signed using SPHINCS+ for authenticity.

4. Submission to Ledger

The validated and signed transaction is submitted to the PQC-secured ledger. The validator nodes verify:

- Signature authenticity (Dilithium verification)
- Sufficient balance in sender's account
- Recipient identity validity
- Transaction limits, sanctions screening (via compliance contract)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

5. Consensus and Finality

Using a HotStuff-based consensus protocol, the validator nodes sign the block proposal containing this transaction using their PQC keys. Upon 2/3 quorum, the block is finalized. This process takes under 2 seconds due to the permissioned architecture.

6. Settlement and Notification

The recipient's German bank receives a notification via its node interface that funds (in EUR) have been credited to its on-platform custody account. The bank updates its internal core ledger via API integration and reflects the amount in the merchant's actual bank account. The sender receives a confirmation in their mobile app.

7. Regulatory Audit and Proof

The transaction metadata (including time, origin, FX rate, and compliance flags) is recorded in an auditable Merkle proof. Regulators with permissioned observer nodes can independently verify:

- That the transaction passed AML/KYC checks
- That currency conversion used authentic data
- That no tampering occurred post-submission

This flow achieves cryptographic end-to-end security under quantum threat models. No part of the transaction key exchange, digital signature, or ledger commitment relies on classical vulnerable cryptography. Moreover, the user retains a standard mobile interface experience, while the institutions maintain regulatory oversight.

Stakeholder Roles

- User: Holds a mobile wallet with PQ key integration; initiates the transaction.
- Mobile Money Provider: Onboards the user, verifies identity, and signs transactions as needed.
- Payment Platform: Performs core ledger operations, FX, consensus, and compliance enforcement.
- Recipient Bank: Receives funds, credits merchant account, and participates in ledger validation.
- Regulator: Audits the transaction trail using observer nodes and zero-knowledge verifications if required.
- Liquidity Provider: Offers real-time FX services on-chain, protected by post-quantum signature mechanisms.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Audit Trail and Compliance Record

The ledger maintains:

- A signed transaction receipt, verifiable via PQC tools
- A hash-anchored compliance log, detailing AML checks passed
- A zero-knowledge proof of origin (optional) to protect user privacy while enabling audit

This system aligns with guidance from global regulators (e.g., G7 Cyber Expert Group, FSB) who demand cryptographic agility and verifiability in cross-border payment innovations (FSB, 2023).

Strategic Discussion and Roadmap

Building a universal quantum-safe payment platform is an ambitious yet necessary endeavor that requires strategic planning across technical, institutional, and regulatory domains. This section outlines a phased roadmap for deployment, discusses ecosystem readiness, and provides actionable recommendations for key stakeholders including central banks, fintechs, and financial regulators. The goal is to transition global payments to quantum-resilient rails before cryptographically relevant quantum computers (CRQCs) arrive estimated within the next 10–15 years (World Economic Forum, 2024).

Phased Deployment Strategy

Given the complexity and scale of global payment systems, a staged rollout allows gradual adoption while mitigating risk and building confidence.
Phase 1: Immediate Preparations (Year 1–2)

- Cryptographic Inventory: Institutions conduct a detailed audit of cryptographic components across payment APIs, communication channels (TLS/VPN), authentication systems, and internal messaging layers.
- Hybrid Pilots: Begin integrating PQC algorithms (e.g., Kyber, Dilithium) in non-critical channels, such as internal VPNs, bank-to-bank test environments, and sandbox APIs using hybrid modes.
- Stakeholder Consortia Formation: Form industry consortia under regulatory supervision (e.g., central banks or BIS Innovation Hub) to coordinate strategy, reference architecture, and pilot parameters.
- Regulatory Alignment: Collaborate with compliance bodies to define legal status of PQ signatures, ledger finality, and digital identities under financial laws.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Phase 2: Prototype Network Launch (Year 2–4)

- Deploy a limited-scope quantum-safe DLT network with 5–10 participating institutions processing test payment flows (e.g., interbank clearing, payroll disbursements, or controlled remittances).
- Integrate core features: PQ identity system, validator consensus with post-quantum signatures, and API gateways supporting ISO 20022 messages.
- Validate latency, scalability, and auditability; implement metrics to track TPS, finality time, and transaction cost.
- Collaborate with national and cross-border payment operators to run simulations comparing current infrastructure and PQ network behavior.

Phase 3: Real-World Corridor Deployment (Year 4–6)

- Choose a payment corridor (e.g., Kenya–Germany, Philippines–UAE) with engaged institutions and implement full-stack PQ infrastructure in production volumes.
- Introduce tokenized fiat currencies, verified user wallets, mobile API support, and real-time currency conversion with compliance features.
- Evaluate economic benefits (cost reduction, faster settlement) and performance against legacy systems.
- Start onboarding large PSPs and regional banks to increase transaction diversity.

Phase 4: Gradual Legacy Replacement (Year 6–10)

- As PQC standards are formalized (e.g., FIPS certification, EMV updates), move to full PQC mandates for high-value payments, central bank operations, and critical financial infrastructure.
- Use the platform as a settlement backbone for card networks, ACH systems, and government disbursement programs.
- Explore embedding CBDCs or stablecoins on the platform, facilitating atomic swaps, programmable money, and privacy-preserving regulatory mechanisms.
- Formalize exit plans for vulnerable cryptographic algorithms set a cutoff date for RSA/ECC retirement in payment systems.

This roadmap aligns with the notion of crypto-agility and ensures quantum-safe protections are in place before real quantum threats materialize (Entrust, 2025).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Stakeholder Readiness and Collaboration Models

Effective migration to quantum-safe payments hinges on coordinated participation across public and private sectors. Each actor has a unique role:

- Central Banks: Provide legal and operational guidance; possibly run validator nodes; issue digital fiat or CBDC over the network; fund research; coordinate pilot corridors (De Haro Moraes, Pereira, & Grossi, 2024).
- Commercial Banks and PSPs: Transition infrastructure (e.g., APIs, signing modules, encryption libraries); implement wallet and interface changes; participate in node operation.
- Fintechs and Wallet Providers: Rapid adopters of PQC SDKs; bridge services for users and merchants; push PQ features (e.g., faster payments, transparency) as competitive advantages.
- Standardization Bodies (NIST, ISO, ETSI): Finalize PQC specs; define secure parameters; create PQC-compatible protocols (e.g., updated ISO 8583, EMV).
- Developers and Startups: Innovate privacy-preserving smart contracts, bridges to legacy networks, and tools for key management, auditing, and cryptographic agility.

To ensure a common operational model, a governance framework should be established that:

- Defines minimum compliance and operational standards (e.g., signing key lifecycle, API security).
- Certifies node software implementations and cryptographic modules.
- Manages cryptographic updates (e.g., replacing or retiring algorithms).
- Provides dispute resolution mechanisms for smart contract misbehavior or regulatory escalations.

Recommendations for Institutions

Drawing from research and pilot observations, we outline targeted recommendations:

- Start Migration Early: Begin replacing classical crypto now where feasible TLS tunnels, internal APIs, backup certificates (Accenture, 2024).
- Adopt Hybrid Cryptography: Until full PQC systems mature, use hybrid modes (e.g., ECDSA + Dilithium) in signatures and hybrid KEMs in TLS to preserve forward secrecy (NIST, 2024).
- Focus on Crypto Agility: Architect systems that can swap algorithms easily use metadata in transaction formats to specify algorithms; avoid hardcoded cryptographic primitives.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- Invest in Performance R&D: Support research on signature aggregation, hardware acceleration, and protocol optimization (BIS, 2023b).
- Engage with Standardization Bodies: Ensure your feedback and use-cases are part of shaping global PQC payment standards.

These steps will position financial institutions to withstand future quantum attacks, improve interoperability, and capitalize on the efficiency gains of decentralized clearing.

Conclusion

The financial world stands at the edge of a historic transformation driven by the rise of quantum computing. With quantum algorithms capable of breaking the cryptographic foundations of existing digital payment infrastructures, the need to prepare is no longer speculative; it is a pressing and strategic imperative. This study has presented a comprehensive exploration of the threat landscape, evaluated the maturity of post-quantum cryptographic (PQC) solutions, and proposed a detailed, technically grounded design for a universal quantum-safe payment platform built upon decentralized architecture. Through an in-depth literature review, we analyzed the weaknesses of current protocols TLS, ECDSA, RSA and demonstrated how quantum computers, using algorithms like Shor's and Grover's, can compromise them. We outlined the families of PQC algorithms, particularly lattice-based schemes like Kyber and Dilithium that provide strong security guarantees under quantum threat models and meet the performance demands of real-time financial transactions (NIST, 2024). Our assessment extended beyond cryptographic primitives to encompass full-stack architectural needs: from API gateway integration, digital identity management, and consensus protocols, to smart contract logic and compliance oversight.

The proposed platform unifies diverse payment channels, bank wires, mobile money, card systems, and cryptocurrencies on a single, quantum-resilient ledger. The architecture emphasizes cryptographic agility, compliance interoperability, and performance engineering to ensure practical adoption. Importantly, the design embeds privacy safeguards, supports regulatory mandates, and offers a roadmap for incremental migration without disrupting existing financial operations. The use case demonstration of a cross-border remittance showcased the feasibility of deploying PQC-based digital signatures, key exchanges, and API-level integration in real-world flows. Furthermore, the strategic roadmap charts a realistic multi-phase path for rolling out this platform from hybrid pilots and institutional readiness audits to corridor-specific deployments and eventual mainstream adoption. Ultimately, the findings validate the technical and institutional feasibility of

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

building a future-proof, universal, decentralized payment system. The cryptographic tools are ready, and the industry is increasingly aware of the risks. What remains is committed leadership, sustained research investment, and coordinated regulatory support.

The long-term implications of transitioning to a quantum-safe platform are profound. Beyond defending against quantum threats, such a platform can improve settlement efficiency, reduce operational costs, enhance interoperability, and foster trustless collaboration across borders. It redefines what "secure payments" mean in the 21st century, laying the foundation for resilient global commerce in the quantum age. As the "Q-Day" approaches, the day when quantum computers render current cryptography obsolete, institutions that act early will safeguard not just their infrastructure but the trust of their users and the stability of global finance. This research offers the blueprint to begin that journey, secure, decentralized, interoperable, and quantum-ready (Andriani, Bencivelli, & Castellucci, 2024).

Glossary

- AML (Anti-Money Laundering): Regulations and procedures aimed at preventing and detecting financial crimes like money laundering.
- API (Application Programming Interface): An Interface allowing software components to interact and exchange data securely and efficiently.
- Blockchain: Distributed ledger technology (DLT) where transaction records are stored in linked blocks across multiple decentralized nodes.
- Consensus Mechanism: An Algorithm enabling decentralized nodes within a blockchain network to agree on transaction validation and state updates.
- Cryptographic Agility: Capability of a system to rapidly adapt and integrate new cryptographic algorithms without major architectural changes.
- Decentralized Ledger: A distributed database spread across multiple nodes, eliminating central authority while enhancing data security and transparency.
- Dilithium: Post-quantum cryptographic algorithm based on lattice mathematics, primarily utilized for secure digital signatures.
- DID (Decentralized Identifier): A Digital identification system operating without a centralized issuing authority, empowering users with direct control of their identity data.
- Falcon: A lattice-based signature scheme optimized for efficiency and security against quantum computing attacks.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- HotStuff: An Efficient leader-based Byzantine Fault Tolerant (BFT) consensus algorithm designed to enhance scalability and transaction throughput.
- HSM (Hardware Security Module): A Physical computing device providing secure storage, generation, and management of cryptographic keys.
- ISO 20022: International messaging standard facilitating structured electronic communication between financial institutions.
- Kyber: Quantum-resistant encryption algorithm selected by NIST as part of its standardization efforts, based on lattice cryptography.
- KYC (Know Your Customer): Regulatory procedure involving verification of user identities to mitigate fraud and financial crime risks.
- Lattice-Based Cryptography: Quantum-resistant cryptographic techniques relying on mathematical lattice structures, effective against quantum attacks.
- PBFT (Practical Byzantine Fault Tolerance): Consensus algorithm enabling robust agreement among decentralized nodes, tolerant against malicious or faulty behaviors.
- POS (Point of Sale): Hardware and software interfaces enabling secure processing of retail payment transactions.
- Post-Classical Era: Future period dominated by quantum computing capabilities, requiring advanced cryptographic safeguards.
- Post-Quantum Cryptography (PQC): Cryptographic methods designed explicitly to remain secure against quantum-computer-enabled cryptanalysis.
- Quantum-Safe: Cryptographic solutions and practices capable of resisting attacks from quantum computing algorithms.
- RESTful API (Representational State Transfer API): An Architectural style for designing networked APIs that are lightweight and interoperable.
- Smart Contract: Self-executing digital contracts stored and executed automatically on blockchain platforms based on predefined conditions.
- SPHINCS+: Hash-based cryptographic signature algorithm providing robust, quantum-resistant digital signatures.
- SWIFT (Society for Worldwide Interbank Financial Telecommunication): Global network enabling secure financial communication between banks and institutions.
- TLS (Transport Layer Security): A Security protocol providing encrypted communication between systems over networks, securing data privacy and integrity.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- zk-SNARKs (Zero-Knowledge Succinct Non-interactive Argument of Knowledge): Cryptographic method allowing proofs of validity without revealing underlying sensitive information.

Conflict of Interest: The author reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

Funding Statement: The author did not obtain any funding for this research.

References:

1. Accenture. (2024). *Banco Sabadell explores adoption of PQC in banking infrastructure*.
2. Bank for International Settlements [BIS]. (2023a). *Project Leap: quantum-proofing the financial system.*
3. Bank for International Settlements [BIS]. (2023b). *Project Tourbillon: exploring privacy, security and scalability for CBDCs.*
4. Deloitte. (2020). *Quantum computers and the Bitcoin blockchain.*
5. Entrust. (2025). *The post-quantum era demands quantum-safe payments.*
6. Financial Services Information Sharing and Analysis Center [FS-ISAC]. (2024). *Quantum threat preparedness recommendations.*
7. National Institute of Standards and Technology [NIST]. (2024). *PQC final standardization: CRYSTALS-Kyber, Dilithium, Falcon, SPHINCS+.*
8. NACHA Payments Innovation Alliance. (2024). *Protecting payments in the quantum era.*
9. PQShield. (2025). *Identity and payments: Preparing for the quantum threat.*
10. Scientific Reports. (2023). *Quantum-resistance in blockchain networks.*
11. Utimaco. (2024). *Types of post-quantum cryptography public key schemes.*
12. World Economic Forum. (2024). *Safeguarding CBDC systems in the post-quantum age.*
13. Adeoye, S. (2025). *Blockchain-enabled, post-quantum cryptographic framework for securing electronic health records: A next-generation approach to healthcare data.*
14. Turpu, R. R. (2024). *Fortifying banking transactions: Harnessing post-quantum cryptography for next-generation security.*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

15. Agrawal, S. (2024). *Harnessing quantum cryptography and artificial intelligence for next-gen payment security: A comprehensive analysis in distributed ledger environments.*
16. Nwaga, P., & Idima, S. (2024). *Post-quantum cryptographic algorithms for secure communication in decentralized blockchain and cloud infrastructure.*
17. Das, P. (2025). *Quantum computing in payments security: Preparing for the post-quantum era.*
18. De Haro Moraes, D., Pereira, J. P. A., & Grossi, B. E. (2024). *Applying post-quantum cryptography algorithms to a DLT-based CBDC infrastructure: Comparative and feasibility analysis.*
19. Weinberg, A. I., Petratos, P., & Faccia, A. (2024). *Will central bank digital currencies (CBDC) and blockchain cryptocurrencies coexist in the post-quantum era?*
20. Andriani, C., Bencivelli, L., & Castellucci, A. (2024). *The quantum challenge: Implications and strategies for a secure financial system.*
21. Castiglione, A., Esposito, J. G., & Loia, V. (2024). *Integrating post-quantum cryptography and blockchain to secure low-cost IoT devices.*
22. Mansoor, K., Afzal, M., Iqbal, W., & Abbas, Y. (2025). *Securing the future: Exploring post-quantum cryptography for authentication and user privacy in IoT devices.*

ESJ Social Sciences Peer-reviewed

Crisis, Recovery, and Regional Asymmetries: A Firm-Level Financial Analysis of Italian Food and Beverage SMEs

Maria Garbelli, Senior lecturer
University of Milano Bicocca, Italy

Doi:10.19044/esj.2025.v21n19p54

Submitted: 23 May 2025
Accepted: 04 June 2025
Published: 31 July 2025

Cite As:
Garbelli, M. (2025). *Crisis, Recovery, and Regional Asymmetries: A Firm-Level Financial Analysis of Italian Food and Beverage SMEs*. European Scientific Journal, ESJ, 21 (19), 54. https://doi.org/10.19044/esj.2025.v21n19p54

Abstract

This study investigates the financial impact of the COVID-19 pandemic on small and medium-sized enterprises (SMEs) in Italy's food and beverage processing sector. Drawing on firm-level panel data from the AIDA database, the analysis spans the period 2019–2022 and focuses on structural resilience and heterogeneity across firm sizes and regions. A sample of 1,600 SMEs was examined, segmented by workforce size and macro-geographical area through a cluster analysis. A correlation matrix is also performed to validate results. Key performance indicators - Return on Equity, Return on Investment, debt ratio, and EBITDA per employee - were analyzed to track changes before, during, and after the crisis. Findings reveal a substantial contraction in profitability in 2020, with ROE declining by 147% in the North, while Southern firms demonstrated relatively greater resilience. ROI dropped sharply across all areas, with incomplete recovery by 2022. Debt ratios exceeded 70% sector-wide during the crisis, underscoring high financial vulnerability. EBITDA rebounded after a 10% contraction, though rising labor costs - up 8.3% by 2022 - constrained operational efficiency. Supplementary analyses include a firm-level classification of performance evolution, a correlation matrix revealing moderate alignment between investment and profitability metrics, and a cluster analysis that distinguishes between typical SME trajectories, distressed micro-firms, and structurally distinct large enterprises. The results highlight asymmetrical recovery paths shaped by firm size and regional conditions. Overall, the study underscores the importance of differentiated policy approaches tailored to the structural and territorial

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

characteristics of the sector, to support long-term resilience and mitigate the effects of future systemic shocks.

Keywords: Food Industry; Beverage Industry, Small and Medium Industries, post-pandemic recovery, Italy, COVID-19, resilience

Introduction

The food and beverage processing sector (FBP), as defined by the European Union, encompasses all industries involved in converting agricultural raw materials into consumable food and drink products. It holds a pivotal role in supporting food security, economic resilience, and the broader objectives of sustainable development across the EU. In the national context, the FBP sector contributes significantly to GDP - accounting for nearly one-quarter - and is widely recognized as a reliable source of employment and a cornerstone of the manufacturing industry.

Based on the last report of the *Food and Drink Europe* (available at www.fooddrinkeurope.eu), in 2024 the sector in Italy, roughly 304,000 enterprises, employs approximately 4.7 million people: those numbers witness the leading positioning of this Italian sector within European manufacturing. Generating in 2024 €249 billion in added value, it is basically made of small and medium-sized enterprises (SMEs) counting for around 99% of all businesses within the sector, and deeply embedded in their local economies, contributing to social cohesion, employment but regional development too.

The sector reported consistent growth during the last years, driven by ongoing investments in modernization and technological innovation. Capital is primarily directed toward upgrading machinery, enhancing production facilities, and implementing agricultural infrastructure. Notably, renewable energy systems have emerged as a particularly dynamic area of investment, attracting increasing interest from both public and private actors.

While domestic demand for food and beverage products has shown a relatively stable progression over the years, the sector's international expansion has emerged as a critical engine of growth. Between 2015 and 2023, export revenues increased by an impressive 72.1%, underscoring the enhanced global competitiveness of Italian food and beverage producers. This expansion reflects the sector's growing ability to position its products successfully in foreign markets, supported by sustained improvements in quality, branding, and supply chain capabilities.

Revenue trends in the industry reveal two distinct phases. The pre-pandemic years were characterized by steady and incremental growth, whereas the post-2020 period marked a clear inflection point, with accelerated gains. This surge not only signals a robust recovery but also indicates a strategic shift among firms toward innovation, internationalization, and

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

diversification. Many enterprises reoriented their operational models in response to the pandemic by investing in digital tools, enhancing export logistics, and improving supply chain resilience.

This transformation is particularly evident among small and medium-sized enterprises (SMEs), many of which demonstrated rapid adaptability by implementing lean production techniques and targeting niche international markets. These combined efforts have strengthened the sector's reputation as a benchmark for resilience and adaptability in times of crisis.

As of 2022, Italy's food and beverage processing sector included 52,414 active firms employing nearly 468,000 workers, of whom 85% were salaried employees. Micro-enterprises (fewer than 10 employees) made up approximately 85% of the total number of firms and provided employment to 28.5% of the workforce. In contrast, large enterprises (250+ employees) accounted for less than 2% of all firms, according to data from the Italian National Institute of Statistics (ISTAT, www.istat.it).

The COVID-19 pandemic has prompted a substantial body of academic research examining its effects on the food supply chain, with a particular focus on the immediate disruptions experienced during the health emergency (e.g., Galanakis, 2020; Hobbs, 2020; Nakat & Bou-Mitri, 2021), as well as the longer-term structural consequences that have unfolded in the post-pandemic period (Hassoun et al., 2023; Naseer et al., 2023; Vlachos, 2024). Despite this growing interest, relatively limited attention has been directed toward food processing firms as distinct entities within the broader supply chain. When such firms are studied, the analysis typically occurs at the national or macroeconomic level (Hailu, 2020; Thulasiraman et al., 2023), often overlooking the specificities of organizational responses at the firm level. Recent contributions have begun to fill this gap, with studies like Rinaldi and Bottani (2023) offering important insights into how food processing industries manage resilience in the face of compound disruptions, including public health emergencies and geopolitical instability (Bargoni et al., 2022; Barile et al., 2024; Timpanaro et al., 2024).

In the Italian context, scholarly work has predominantly concentrated on broader issues of food systems sustainability and national food security (Banterle & Cavaliere, 2022). However, focused investigations into the dynamics of the Italian food and beverage processing (FBP) sector - particularly regarding its performance, adaptation strategies, and structural resilience during and after the COVID-19 crisis - remain comparatively underexplored. This gap calls for more granular analyses that consider firm-level heterogeneity and the sector's strategic role within national and regional supply chains. Thus, the performance of food and beverage processing firms - particularly SMEs - relatively underexplored. This study aims to fill that gap by examining firm-level financial data for SMEs operating in the sector.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Drawing on the hypothesis that SMEs possess greater operational flexibility and crisis-response agility than larger enterprises (Zutshi et al., 2021), the analysis investigates how these firms absorbed and recovered from the financial shocks of the COVID-19 pandemic, providing new insight into sectoral resilience and post-crisis adaptation.

Methods

This study draws on financial data from a proprietary sample of 2,450 small and medium-sized enterprises (SMEs) operating in Italy's food and beverage processing sector. The sample was developed in collaboration with the national association representing SMEs in the food and beverage industry (www.unionalimentari.it), which selected member businesses to ensure representativeness in terms of firm size and geographical distribution. Data were sourced from the AIDA database and cover the years 2019 through 2023, allowing for a comparative analysis of pre-pandemic conditions, the peak of the COVID-19 crisis, and the initial recovery period. However, due to the incomplete nature of the 2023 data at the time of analysis, the empirical investigation focuses on the 2019–2022 period. To capture sectoral diversity and regional disparities, the sample is disaggregated by both company size and geographic location. For analytical consistency, Italy's regions are grouped into three macro-areas:

- **North**: Aosta Valley, Piedmont, Liguria, Lombardy, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, and Emilia-Romagna
- **Center**: Tuscany, Umbria, Marche, and Lazio
- **South and Islands**: Abruzzo, Molise, Campania, Apulia, Basilicata, Sicily, and Sardinia

As shown in Table 1, micro-enterprises (those with fewer than five employees) account for approximately 55% of the total sample. Additionally, 58% of the firms are located in the South and Islands, with a particularly high concentration in Campania, Apulia, and Sicily. This distribution highlights the territorial significance of the sector and its deeply rooted presence within the economic fabric of southern Italy.

Table 1. Final sample by employees and geographical location

		total Sample	*Center*	*South + islands*	*North*
total		***100%***	***15%***	***59%***	***27%***
workforce	**01 - 05**	55%	61%	58%	*45%*
	giu-15	28%	28%	28%	*29%*
	16 - 50	13%	10%	11%	*20%*
	50	3%	1%	2%	*6%*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

This study is guided by a central research question:

To what extent did the COVID-19 pandemic affect the financial health of small and medium-sized enterprises (SMEs)?

A secondary objective is to examine whether performance outcomes varied significantly across firm categories - specifically between small and medium-sized enterprises - and among Italy's major geographical regions.

To provide empirical evidence and address these questions, the analysis is structured in two principal stages, offering a comprehensive perspective on the sector. The first stage presents a descriptive analysis of key financial indicators for the period 2019–2022, disaggregated by firm size and macro-regional location (North, Center, and South & Islands).

The indicators examined include:

- Return on Equity (ROE)
- Return on Investment (ROI)
- EBITDA

To enrich this assessment, labor dynamics - such as workforce size and growth - are also considered essential indicators of business resilience and development.

Statistical and econometric techniques were employed to identify underlying trends and resilience patterns over time. To enhance data reliability and ensure the robustness of aggregated results, outlier values were excluded using both the interquartile range (IQR) and standard deviation methods. Specifically, observations that fell significantly outside the IQR or beyond ±2 standard deviations from the mean were removed. This process resulted in a final sample of 1,600 SMEs distributed across the entire Italian territory. The chosen method aligns with analytical standards adopted by regional Italian agencies (e.g., Unioncamere Lombardia) and was preferred over strict IQR filtering due to its capacity to retain a broader segment of the sample while minimizing distortions.

It is worth noting that firms with more than 50 employees exhibited some irregularities in their performance data. These anomalies are likely attributable to their limited representation within the sample, as they comprise only 3% of the total firms observed.

To deepen the analysis, the study focuses on key performance indicators (KPIs) for the two benchmark years - 2019 and 2022. A three-level analytical framework is applied to classify firms as strengthened, weakened, or stable based on changes in each KPI (EBITDA, ROE, ROI). Specifically, the following analyses are conducted:

1. Cross-tabulated analysis by geographic area and firm size
2. Correlation Matrix (Pearson Coefficients)
3. Cluster analysis

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Also, to validate and to better understand firm-level resilience and vulnerability during the 2019–2022 period, firms were classified based on changes in key financial indicators: EBITDA, ROE, and ROI (table 8), and categorized as *strengthened*, *weakened*, or *stable*, using a ±10% threshold to define meaningful performance shifts.

Results

The findings related to each financial indicator are presented in the following sections, beginning with Return on Equity (ROE). The data clearly illustrate the disruptive impact of 2020 - a year characterized by unprecedented economic stress - evidenced by a marked deterioration in ROE across all firm sizes and regional groupings. Table 2 reports average ROE values disaggregated by company size and geographical area, offering a more detailed view of the observed performance heterogeneity.

Following the initial shock, signs of recovery began to emerge in late 2020 and continued into 2021. However, this positive trend lost momentum in 2022. The slowdown can be partially attributed to ongoing external pressures - most notably, the rising cost of raw materials and persistent volatility in energy markets - both of which contributed to the erosion of operational margins.

The most severe decline was observed in Northern Italy, where ROE fell by approximately 147% in 2020, pushing average profitability into negative territory. In contrast, firms located in Southern Italy - which make up the majority of the sample (55%) - exhibited comparatively more stable performance. Despite the challenging macroeconomic context, firms in the South managed to maintain relatively favorable ROE levels throughout the study period.

Over the four-year timeframe, the North–South performance gap in ROE remained relatively stable in terms of direction, though differences in magnitude persisted. From a firm size perspective, the data point to a differentiated response to the crisis: smaller enterprises were more vulnerable to the downturn, while larger firms demonstrated stronger financial resilience, showing a greater capacity to absorb shocks and preserve profitability over time.

Table 2. ROE average by categories

ROE	NORTH	CENTER	SOUTH+ISLANDS	1-5 employees	6-15 employees	16-50 employees	50+ employees
2019	6,8	9,1	11,8	6,9	10,8	12,5	14,4
2020	-3,2	6,3	6,0	1,8	7,6	9,7	11,7
2021	6,3	8,2	11,9	8,6	12,3	12,2	12,1
2022	2,2	8,2	7,9	5,3	11,1	12,8	4,1

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 3 presents the results for Return on Investment (ROI), revealing a general decline in investment efficiency across the sample during the 2019–2022 period. The overall trend indicates that ROI was among the financial indicators most adversely affected by the COVID-19 pandemic, with its negative effects persisting well into the recovery phase.

From a regional perspective, ROI dynamics closely mirror those observed for ROE, particularly in Northern and Southern Italy, including the island regions. The year 2020 marked a clear turning point, with firms across all areas experiencing a sharp deterioration in investment returns - largely attributable to halted production, disrupted supply chains, and declining domestic and international demand. A modest recovery began to emerge in 2021 and extended into 2022; however, the rebound proved insufficient to restore ROI to pre-pandemic levels. In some instances, the limited gains achieved in 2021 were again lost by 2022, underscoring the fragile and uneven nature of the recovery.

Of particular concern is the pattern observed in Central Italy. While this area reported marginally positive ROI in 2019, it consistently underperformed in the subsequent years. ROI values turned negative starting in 2020, with a notable decline in 2021. This persistent inefficiency may reflect deeper structural weaknesses within the productive fabric of the Central regions, which appear to have struggled more than others in adapting to post-pandemic economic conditions.

These findings underscore the importance of spatial differentiation when assessing financial resilience and suggest a pressing need for region-specific policy interventions aimed at revitalizing investment performance.

Table 3. ROI average

ROI	NORTH	CENTER	SOUTH+ISLANDS	1-5 employees	6-15 employees	16-50 employees	50+ employees
2019	3,8	1,4	4,6	3,5	4,0	4,8	5,9
2020	-0,3	-0,9	1,3	-1,5	1,6	3,5	5,0
2021	1,7	-2,2	2,5	-0,5	3,4	3,0	5,0
2022	1,0	-1,6	2,1	0,6	2,5	1,8	1,3

A disaggregated analysis of ROI by firm size offers valuable insights into the differentiated impact of the crisis and the varied paths of recovery. A consistent pattern emerges: firm size is positively associated with resilience to external shocks, particularly with respect to investment returns.

The sample can be broadly divided into two segments. The first comprises micro and small enterprises - those employing up to 15 individuals - which account for approximately 83% of the total dataset. These firms were most severely impacted by the downturn in 2020, experiencing sharp declines in ROI due to limited financial buffers, restricted access to liquidity, and reduced operational flexibility. Nonetheless, many of these smaller businesses

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

demonstrated a notable rebound in 2021 - a trend that, while uneven, persisted into 2022. Although micro-enterprises recovered more slowly, small firms succeeded in regaining positive ROI levels by the end of the observation period. Still, overall profitability for this group remained modest in absolute terms.

In contrast, the second group - firms with more than 15 employees, representing roughly 17% of the sample - followed a different trajectory. These firms were initially better positioned to weather the crisis, likely benefiting from greater access to credit, diversified income streams, and more robust cost structures. However, over time, their ROI gradually declined, nearing critical thresholds in 2022. This downward trend raises concerns about diminishing returns on capital investments and may reflect deeper issues related to operational inflexibility or delayed strategic adaptation.

Table 4. Debt ratio variation

Debt ratio	NORTH	CENTER	SOUTH+ISLANDS	1-5 employees	6-15 employees	16-50 employees	50+ employees
2019-2020	1,0%	2,3%	0,0%	2,5%	-1,6%	-1,9%	-4,7%
2020-2021	0,0%	1,7%	0,5%	0,3%	-0,4%	1,8%	0,7%
2021-2022	1,6%	-3,7%	-0,5%	-1,7%	0,9%	-0,6%	2,2%
2019-2022	2,6%	0,3%	0,0%	1,1%	-1,1%	-0,7%	-1,8%

The analysis presented in Table 4 shifts focus to financial leverage, measured through the debt ratio - defined as the proportion of total liabilities to shareholders' equity. This metric provides a dynamic assessment of each firm's dependence on external financing and reveals structural differences across firm size categories.

A low debt ratio is generally indicative of sound financial health, reflecting limited reliance on borrowed capital and stronger internal financing capacity. In most financial analyses, a debt ratio between 25% and 50% is considered optimal. Ratios exceeding this threshold may signal heightened financial risk, especially during periods of economic turbulence.

Among the Italian food and beverage processing firms examined in this study, the data indicate consistently high levels of financial leverage throughout the 2019–2022 period. As shown in Table 4, debt ratios remained above 70% across nearly all firm types and regions. The situation was particularly critical in Central Italy, where average debt ratios surpassed 80% during the 2020–2021 period, coinciding with the peak of the pandemic and associated economic constraints.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Despite increased awareness of financial vulnerability during the crisis, no significant deleveraging was observed in the short term. On the contrary, a combination of overlapping disruptions - including supply chain instability and inflationary pressures - impeded firms' efforts to restore financial independence. Larger enterprises exhibited some ability to reduce debt levels in 2020; however, this trend reversed by 2022. In Northern Italy, debt levels rose gradually but remained relatively stable. In contrast, firms located in the South and Islands demonstrated more consistent debt ratios and even outperformed the North in 2022 in terms of financial balance.

From a size-based perspective, micro-enterprises exhibited the greatest vulnerability to debt accumulation. A substantial rise in leverage was observed in 2020, reflecting an increased reliance on external credit to absorb pandemic-induced shocks. While moderate improvements were noted over the following two years, full financial recovery remained out of reach. Medium and large firms showed comparatively greater stability, with a temporary decline in debt levels during 2020. Nevertheless, this progress was reversed in 2021, offsetting previous gains. A modest correction followed in 2022, though it did not signify a consistent trend toward deleveraging.

The subsequent section focuses on EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization), a key metric of a firm's core operating performance. EBITDA was first analyzed as an average per category and then assessed on a per-employee basis to capture operational efficiency and the effects of scale across firm sizes and regional clusters.

In 2020, average EBITDA declined markedly across all firm sizes and geographical areas, reflecting the widespread disruptions to operations caused by the pandemic. By 2021, however, a strong rebound was evident, with most firms regaining pre-crisis levels of core profitability. This recovery trend continued into 2022, suggesting a period of relative stabilization following the volatility of the previous years.

Table 5. EBIDTA variation

EBIDTA	NORTH	CENTER	SOUTH+ISLANDS	1-5 employees	6-15 employees	16-50 employees	50+ employees
2019-2020	-13,4%	-25,1%	-4,6%	-19,6%	-8,4%	-5,6%	-13,3%
2020-2021	18,8%	33,7%	15,1%	22,5%	23,2%	16,1%	17,0%
2021-2022	3,6%	9,5%	-10,7%	21,8%	3,4%	-4,3%	-18,4%
2019-2022	6,5%	9,6%	-2,0%	20,0%	16,7%	4,9%	-17,2%

The results for 2022 are particularly noteworthy. They suggest that the sector not only recovered from the immediate impact of the COVID-19 crisis

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

but also began to align with a more sustainable growth trajectory. However, this recovery unfolded under a complex set of pressures. While firms intensified efforts to close the performance gap caused by the 2020 downturn, they simultaneously faced a highly inflationary environment. Rising energy and input costs, alongside increasing labor expenses, placed substantial pressure on profit margins and slowed the pace of EBITDA growth.

EBITDA trends are closely linked to labor market dynamics, which play a pivotal role in shaping operational performance within the food and beverage processing sector. Between 2019 and 2022, national employment in the industry increased by 23%, highlighting both the sector's resilience and the scaling-up of production during the recovery phase. Table 6 provides a detailed breakdown of employment growth by firm size category, offering deeper insight into how workforce expansion contributed to the rebound in core business profitability across different types of enterprises.

Table 6. Workforce in the sample

workforce	NORTH	CENTER	SOUTH+ISLANDS	1-5 employees	6-15 employees	16-50 employees	50+ employees
2019	*12.090*	*3.490*	*13.264*	*5.199*	*7.128*	*9.384*	*7.133*
2020	12.595	3.695	13.940	*5.206*	*7.062*	*9.876*	8.086
2021	13.731	3.860	15.064	*5.484*	*7.551*	*10.448*	9.172
2022	14.914	4.028	15.563	*5.788*	*7.768*	*11.153*	9.796
% CHANGE 2019-2022	23,4%	15,4%	17,3%	*11,3%*	*9%*	*18,9%*	37,3%

Among Italy's macro-regions, Northern Italy recorded the highest employment growth in the food and beverage processing sector between 2019 and 2022, with a cumulative increase of 23.4%. This surge likely reflects both the greater concentration of firms in the North and their earlier, more effective access to post-pandemic support measures and recovery programs. The South and Islands, along with Central Italy, also experienced notable employment expansion, albeit at slightly lower rates. This pattern reinforces the broader narrative of resilience among small and medium-sized firms, even in regions historically marked by structural economic fragility.

A closer inspection reveals that Central Italy posted more modest employment gains relative to the other macro-areas. This is consistent with previous findings that pointed to weaker financial performance and higher levels of indebtedness among firms in the region - factors that may have limited their hiring capacity during the recovery phase.

From the perspective of firm size, the strongest employment growth was observed among large enterprises (those with more than 50 employees), which expanded their workforce by 37.3% over the same period. This underscores the significant role of large firms in driving national job recovery

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

after the pandemic. Mid-sized enterprises (16–50 employees) also demonstrated steady employment gains, suggesting robust growth capacity. In contrast, micro and small firms (1–15 employees), which constitute the majority of the sector, showed slower employment growth - averaging around 10%. Their more limited financial and operational flexibility likely constrained their ability to scale up hiring.

It is important to note that rising employment was accompanied by increasing labor costs, driven largely by inflationary pressures. Between 2019 and 2022, companies granted wage increases averaging 6.5% per year across the country. These escalating personnel expenses exerted downward pressure on EBITDA margins. To capture the combined effect of these developments, the following table reports EBITDA per employee, offering a clearer view of operational efficiency relative to workforce size during the recovery period.

Table 7. EBIDTA per worker variation

EBIDTA per worker	NORTH	CENTER	SOUTH+ISLANDS	1-5 employees	6-15 employees	16-50 employees	50+ employees
2019	25.521	16.573	21.176	*10.680*	*18.300*	*20.671*	24.569
2020	21.764	12.642	20.250	*9.132*	*16.697*	*18.717*	20.881
2021	25.259	17.106	22.980	*11.571*	*19.865*	*20.686*	22.422
2022	24.138	17.949	19.605	*13.183*	*20.003*	*19.063*	16.756

Table 7 reveals a steady upward trend in EBITDA per employee among smaller firms, particularly those with a workforce of 1 to 15 individuals. This trend suggests that micro and small enterprises, despite being more vulnerable to the initial economic shock, demonstrated notable adaptability and operational resilience in the recovery phase. Their leaner structures may have allowed for faster strategic adjustments and more flexible cost management, facilitating efficiency gains as demand rebounded.

In contrast, larger firms - especially those with over 50 employees - faced greater challenges in 2022. Their performance weakened relative to smaller enterprises, likely due to the rigidity of fixed cost structures, higher exposure to energy and wage inflation, and slower responsiveness to external volatility. These conditions may have eroded their operational margins, despite higher production capacity and broader market reach.

Regionally, Northern Italy continued to lead in terms of EBITDA performance, maintaining relatively strong efficiency levels throughout the period. However, signs of strain began to emerge in the South and Islands by 2022. Following an initially stable rebound, firms in these regions started to feel the cumulative effects of prolonged inflation and slower demand normalization.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The sample has been further categorized and businesses qualified as *strengthened*, *weakened*, or *stable*. The following section disaggregates these outcomes by macro-regional location and size class.

Table 8: Grouping Firms by indicator

	EBITDA	ROE	ROI
weakened	45,8%	53,0%	58,5%
strengthened	45,0%	42,1%	36,3%
stable	9,2%	4,9%	5,1%

The correlation matrix results (Table 8) revealed a strong relationship between EBITDA in 2019 and 2022 (r = 0.80), indicating operational consistency. Moderate correlations were found between ROI and ROE, particularly post-crisis, suggesting a growing alignment between investment and equity returns. Weak correlations between EBITDA and ROE underscore distinct structural dynamics. As in the table 8, we fund a strong positive correlation (0.80) between EBITDA 2019 and EBITDA 2022, indicating high temporal consistency in operational performance; firms with high EBITDA in 2019 tended to maintain strong performance in 2022.

On the contrary, a moderate correlations exists between EBITDA and ROI (EBITDA 2019 vs ROI 2019: 0.17; EBITDA 2022 vs ROI 2022: 0.15). This suggests that while profitability from core operations supports investment efficiency, the relationship is not particularly strong - likely due to external cost and capital structure variations.

Table 9: Correlation matrix

	EBIDTA 2019	EBIDTA 2022	ROE 2019	ROE 2022	ROI 2019	ROI 2022
EBIDTA 2019	1	0,80	0,07	0,03	0,17	0,08
EBIDTA 2022	0,80	1	0,05	0,05	0,13	0,15
ROE 2019	0,07	0,05	1	0,07	0,30	0,10
ROE 2022	0,03	0,05	0,07	1	0,09	0,26
ROI 2019	0,17	0,13	0,30	0,09	1	0,37
ROI 2022	0,08	0,15	0,10	0,26	0,37	1

EBITDA and ROE have weak correlations throughout (max 0.07), indicating that EBITDA (an operational metric) and ROE (a shareholder return metric) may reflect different dimensions of firm performance - possibly due to variations in equity levels or financing structures. ROI and ROE show a moderate link in 2019 (0.30) and a higher correlation in 2022 (0.26): this suggests convergence between investment returns and equity returns post-COVID, possibly due to capital structure adjustments during recovery.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The cluster analysis applied K-means clustering to group firms based on their financial evolution (EBITDA, ROE, ROI) between 2019 and 2022 (table 10 and 11). Three distinct clusters were identified.

Cluster 0 (Majority Group) defines the "normal SME trajectory" (modest recovery in EBITDA, but sharply declining ROE and ROI**,** suggesting long-term fragility despite short-term operational recovery.

Includes a broad mix of firm sizes and all three regions; it is dominated by micro (1–5 employees) and small firms (6–15).

Likely represents firms with moderate to stable performance, as they dominate the data distribution. The cluster shows broad geographic and dimensional representation → potentially "baseline" performers.

Cluster 1 (Select Small Survivors) identifies outliers or distressed micro-firms, critical if you are exploring financial vulnerability or insolvency risk. It contains mostly very small firms (1–15 employees), but in small numbers, and it could reflect firms with unusual performance paths, such as extreme volatility or unique recovery profiles.

Table 10: Cluster Distribution by Region

cluster	center	north	south+islands	total
0	12%	24%	64%	98%
1	0%	46%	54%	1%
2	6%	67%	28%	1%
total	12%	25%	63%	100%

Cluster 2 (Large Firms Only) isolates large firms with distinctly higher performance, both in absolute and relative terms. It contains exclusively large enterprises (>50 employees). The concentrated cluster suggests that larger firms followed distinct financial dynamics, separating them from the SME majority. Also, it may indicate either greater resilience or delayed impact, depending on performance trajectory.

Table 11: Cluster Financial Profiles

cluster	EBIDTA_2019	EBIDTA_2022	ROE_2019	ROE_2022	ROI_2019	ROI_2022
0	275477,9	290615,3	10,12	1,25	5,33	2,78
1	-205347	-8743,62	-781,18	-52,82	-13,01	-3,77
2	8485019	8721750	18,97	8,84	11,94	5,47

Micro and small enterprises demonstrated notable resilience and adaptive capacity, gradually increasing their workforce as market conditions stabilized. Their ability to recover employment levels reflects flexible organizational models and localized strategies that allowed them to respond effectively to evolving economic challenges. Meanwhile, large enterprises continued to act as key engines of job creation, leveraging their structural resources to support aggressive hiring, even in a context of cost inflation and market volatility.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

In contrast, medium-sized firms displayed a more cautious approach to workforce expansion. Their hiring patterns suggest a heightened sensitivity to fluctuating input costs, financial constraints, and broader economic uncertainty. Positioned between the resource-rich large firms and the agile micro-enterprises, medium-sized companies may have faced more complex trade-offs in balancing growth opportunities with financial sustainability.

Overall, the table highlights the nuanced ways in which firms of different sizes and regions contributed to post-COVID labor market recovery, underscoring the importance of tailored support policies that account for structural and geographic disparities in the sector.

Discussion

The analysis highlights considerable heterogeneity in financial performance across both geographical regions and firm size categories within Italy's food and beverage processing sector. The economic shock of 2020 significantly impacted key financial indicators - most notably Return on Equity (ROE) and Return on Investment (ROI) - which reflect firms' profitability and investment efficiency, respectively.

ROE experienced a dramatic decline in 2020, particularly in Northern Italy, where average returns dropped by 147%, pushing many firms into negative profitability. Although some recovery occurred in 2021, this trend was uneven. Micro-enterprises (1–5 employees) displayed notable resilience, particularly in Southern Italy, where ROE returned to near pre-pandemic levels by 2022. In contrast, large firms (50+ employees), despite initially withstanding the shock more effectively, experienced a steady decline in returns in subsequent years.

ROI followed a similar trajectory. While most firms showed some improvement post-2020, only medium-sized enterprises (16–50 employees) maintained consistently positive ROI throughout the observed period. Central Italy emerged as the most vulnerable region, with ROI remaining negative for three consecutive years - suggesting deeper structural inefficiencies.

Debt ratio trends further expose systemic financial fragility. Average debt levels exceeded 70% across all firm groups, with Central Italy peaking above 80% during the crisis years of 2020–2021. Although Northern firms showed signs of deleveraging by 2022, the Center remained highly dependent on external capital. Smaller enterprises, while making some progress, continued to face significant financial strain.

EBITDA analysis provides additional insight into operational resilience. After a sharp contraction in 2020, EBITDA rebounded in 2021 and stabilized in 2022. However, this recovery was tempered by rising labor costs - averaging 6.5% between 2019 and 2022 and reaching 8.3% in 2022 - which eroded EBITDA per employee. Micro-enterprises showed encouraging gains

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

in per-capita EBITDA, indicating greater cost agility, whereas larger firms recorded declines, likely due to inflexible cost structures and delayed adjustment to inflationary conditions.

Labor market trends offer further context. Between 2019 and 2023, sectoral employment expanded substantially. The most significant increases were observed in Southern regions (+25%) and among micro-enterprises (+24%). Large firms also played a major role in job creation, expanding their workforce by 38%. In contrast, medium-sized enterprises pursued more cautious hiring strategies, possibly constrained by narrower margins and higher risk sensitivity.

Taken together, these findings reveal a recovery landscape marked by asymmetrical trajectories. Micro-enterprises, though initially the most vulnerable, displayed substantial adaptive capacity. Larger firms, despite early stability, began to encounter operational and financial strain during the later phases of recovery. These dynamics suggest that future policy must be structurally differentiated and geographically tailored to support long-term resilience and equitable growth across the sector.

Conclusions

This study assessed the mid-term financial impacts of the COVID-19 pandemic on small and medium-sized enterprises (SMEs) in Italy's food and beverage processing industry. Using firm-level panel data from 2019 to 2022 and applying descriptive statistics, Difference-in-Differences estimation, and exploratory techniques, the research identifies differentiated recovery paths across regions and firm sizes. While SMEs bore the brunt of the initial shock, many - especially micro-enterprises - showed significant recovery potential over time. Conversely, large firms, although more resilient in the early phase, experienced declines in investment efficiency and EBITDA per employee in the post-crisis years, likely due to structural inflexibility. Regionally, Southern Italy outperformed expectations in terms of profitability, while Central Italy exhibited persistent weaknesses, especially in ROI and debt levels. These findings have clear policy relevance. The findings of this study carry significant implications for policymakers and stakeholders seeking to strengthen the resilience and competitiveness of the SME sector. The observed heterogeneity among firms - particularly in terms of size, resource availability, and geographical distribution - highlights the need for differentiated policy approaches. Uniform recovery measures are unlikely to yield equitable outcomes across the sector. Instead, a nuanced strategy is required, tailored to the specific needs and capacities of various categories of enterprises.

Micro and small firms, often characterized by limited financial buffers and operational flexibility, stand to benefit most from interventions that enhance access to credit, facilitate digital transformation, and support process

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

innovation. Furthermore, policies aimed at reducing the burden of labor costs - such as targeted tax relief, wage subsidies, or simplified hiring procedures - could alleviate immediate financial pressures and foster long-term viability.

In contrast, larger SMEs, which may face more rigid cost structures and complex organizational models, may require targeted support aimed at improving operational efficiency and facilitating investment in energy efficiency, supply chain optimization, and advanced technological upgrades. Given their relatively greater access to capital markets, support instruments for these firms should prioritize incentivizing strategic investments that enhance their resilience and global competitiveness.

At a broader level, these findings underscore the importance of context-sensitive policymaking. Regional characteristics - such as industrial specialization, local infrastructure, labor market dynamics, and governance quality - play a crucial role in shaping both the vulnerabilities and opportunities of SMEs. As such, national recovery strategies should be supported by regional and local implementation frameworks capable of adapting support instruments to territorial specificities.

From a research perspective, this study opens several avenues for further exploration. Future studies should investigate the structural determinants of resilience in SMEs, such as governance models, leadership competencies, and network embeddedness. A deeper understanding of these factors could inform the development of tailored resilience frameworks, particularly those aimed at promoting long-term financial sustainability and strategic adaptability.

Moreover, there is a growing need to explore financial instruments and support mechanisms that are both scalable and responsive to future systemic shocks. Research should also consider the role of public-private partnerships, cooperative models, and digital platforms in fostering inclusive growth and collaborative innovation, especially in regions with high concentrations of microenterprises.

Future research should expand the time frame to include data beyond 2022 to capture the enduring effects of inflation, global uncertainty, and climate-related disruptions. Additionally, integrating qualitative evidence - such as managerial decision-making or governance responses - could enrich the understanding of organizational resilience in the agri-food system.

Finally, to address a key limitation of this study - namely the limited representation of large enterprises (only 3% of the sample) - future work should incorporate a more balanced sample, enabling more robust comparisons and extending the generalizability of the findings.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Acknowledgments

The author would like to express sincere gratitude to Unionalimentari for their support in this research, significantly contributing to data collection and, to the advancements presented in this paper.

Funding Statement: The original data used in this study were extracted from AIDA database. However, the interpretations, analyses, and conclusions presented in this article were independently developed by the author and do not reflect any official request or position of the funding organization.

Data Availability: Data available on request due to privacy restrictions. The data presented in this study are available on request from the corresponding author.

Conflict of Interest: The authors reported no conflict of interest.

References:

1. Banterle, A., & Cavaliere, A. (2022). Food security and sustainability in the Italian food system: Challenges and policy responses. Italian Journal of Food Science, 34(2), 123–135.
2. Barile, L., Rossi, F., & Santini, C. (2024). Resilience strategies in the Italian agri-food sector post-COVID-19. Journal of Agricultural Economics, 75(1), 45–60.
3. Bargoni, A., Esposito, M., & Romano, D. (2022). Supply chain disruptions and recovery strategies in the food processing industry during COVID-19. Supply Chain Management Review, 28(3), 89–102.
4. Galanakis, C. M. (2020). The food systems in the era of the coronavirus (COVID-19) pandemic crisis. Foods, 9(4), 523. DOI: doi.org/10.3390
5. Hailu, G. (2020). Economic thoughts on COVID-19 for Canadian food processors. Canadian Journal of Agricultural Economics, 68(2), 163–169. https://doi.org/10.1111/cjag.12241Wiley Online Library+4Wiley Online Library+4ResearchGate+4
6. Hassoun, A., Zhao, Y., & Wang, X. (2023). Long-term impacts of COVID-19 on global food supply chains: A review. Food Control, 142, 109276. https://doi.org/10.1016/j.foodcont.2023.109276
7. Hobbs, J. E. (2020). Food supply chains during the COVID-19 pandemic. Canadian Journal of Agricultural Economics, 68(2), 171–176. https://doi.org/10.1111/cjag.12237SCIRP

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

8. Nakat, Z., & Bou-Mitri, C. (2021). COVID-19 and the food industry: Readiness assessment. Food Control, 121, 107661. DOI: doi.org/10.1016/
9. Naseer, M., Ali, S., & Khan, T. (2023). Post-pandemic recovery and resilience in food supply chains: A systematic review. International Journal of Production Economics, 247, 108456. https://doi.org/10.1016/j.ijpe.2023.108456
10. Rinaldi, R., & Bottani, E. (2023). Enhancing resilience in food processing supply chains: Lessons from COVID-19 and beyond. Journal of Food Engineering, 350, 111234. https://doi.org/10.1016/j.jfoodeng.2023.111234
11. Thulasiraman, V., Kumar, S., & Rao, P. (2023). Challenges and opportunities in the Indian food processing sector during COVID-19. Journal of Food Science and Technology, 60(1), 12–25. https://doi.org/10.1007/s13197-022-05321-7
12. Timpanaro, G., Scuderi, A., & Foti, V. (2024). Geopolitical crises and their impact on agri-food supply chains: An Italian perspective. Agricultural Systems, 198, 103456. https://doi.org/10.1016/j.agsy.2024.103456
13. Vlachos, I. (2024). The COVID-19 pandemic impact on supply chains: a systematic literature review. International Journal of Logistics Systems and Management, 48(1), 17-66.
14. Zutshi, A., Mendy, J., Sharma, G. D., Thomas, A., & Sarker, T. (2021). From challenges to creativity: enhancing SMEs' resilience in the context of COVID-19. Sustainability, 13(12), 6542.

ESJ Social Sciences Peer-reviewed

The Intersection of Culture and Innovation in Georgian Business

Tinatin Zhorzholiani
Associate Professor, Grigol Robakidze University and David Aghmashenebeli National Defence Academy, Georgia

Doi:10.19044/esj.2025.v21n19p72

Submitted: 22 November 2024
Accepted: 29 July 2025
Published: 31 July 2025

Cite As:
Zhorzholiani, T. (2025). *The Intersection of Culture and Innovation in Georgian Business*. European Scientific Journal, ESJ, 21 (19), 72. https://doi.org/10.19044/esj.2025.v21n19p72

Abstract

This paper explores the intersection of culture and innovation within the context of Georgian business, examining how traditional cultural values and modern innovation practices coexist and influence business strategies. The primary aim is to analyze how Georgian businesses incorporate cultural norms while adopting innovative approaches to stay competitive in the global market. The objectives include identifying key cultural factors that shape innovation processes and assessing their impact on business performance. The research employs a mixed-method approach, combining qualitative interviews with business leaders and quantitative analysis of innovation performance metrics across various industries. Results indicate a strong relationship between cultural adaptability and innovative success, with businesses that embrace both traditional Georgian values and modern practices performing better in terms of growth and market adaptability. The findings suggest that cultural identity in Georgia plays a significant role in shaping innovation, providing a unique blend of creativity and tradition that enhances business success. The conclusion emphasizes the importance of balancing cultural heritage with the need for technological advancement to foster sustainable growth.

Keywords: Culture, Innovation, Georgian Business, Tradition, Competitiveness

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Introduction

The intersection of culture and innovation has emerged as a significant focus of research, particularly in regions where cultural traditions and modern business practices must coexist. In Georgia, a country rich in history and cultural heritage, this relationship plays a pivotal role in the business landscape. As globalization intensifies, businesses in Georgia face the dual challenge of remaining competitive while staying true to their cultural roots. Studies indicate that cultural values significantly influence business practices, organizational behavior, and leadership styles, thereby affecting a company's capacity to innovate (Hofstede, 2010; House et al., 2004).

Innovation is a key driver of economic growth, and its successful implementation is often shaped by the cultural environment in which it occurs (Roth, 2020). In Georgia, the balancing act between innovation and cultural tradition presents both opportunities and challenges for businesses. Research has shown that culture can act as both a barrier and a facilitator of innovation, depending on how it is managed within the organization (Tidd & Bessant, 2018). Georgian businesses, rooted in long-standing customs and practices, must navigate these dynamics carefully to harness the potential of innovation without alienating their cultural identity.

This study aims to explore how Georgian businesses manage the intersection of culture and innovation. The focus is on how cultural factors influence innovation strategies and, in turn, how innovation impacts business success in Georgia. By examining this relationship, the paper contributes to the ongoing discourse on culture and innovation, offering practical insights for business leaders and policymakers in Georgia and similar cultural contexts. This research is important not only for understanding the Georgian business environment but also for illustrating how cultural and innovative elements can be aligned for competitive advantage in the global marketplace (Smith & Peterson, 2022).

Literature Review

The relationship between culture and innovation has been the subject of extensive research across various disciplines, from sociology and anthropology to business and management studies. Scholars have long recognized that cultural contexts shape not only how innovation is perceived but also how it is implemented within organizations. This section synthesizes existing research on the intersection of culture and innovation, particularly focusing on its relevance to Georgian business.

One of the foundational studies in this area is Hofstede's (2010) work on cultural dimensions, which identifies key cultural factors - such as individualism vs. collectivism, power distance, and uncertainty avoidance - that influence organizational behavior and decision-making. Hofstede's

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

framework has been widely applied to understand how these cultural dimensions affect innovation. For instance, low power distance cultures, where hierarchical structures are flatter, tend to encourage more innovative behavior by fostering open communication and risk-taking (Hofstede, 2010). On the other hand, high uncertainty avoidance, as seen in many traditional societies like Georgia, may inhibit innovation because of a preference for stability and established practices (Shane, 1993). Another significant contribution to the literature is the GLOBE Study by House et al. (2004), which further refines the understanding of culture's role in leadership and innovation. This large-scale study emphasizes the importance of cultural values in shaping leadership behaviors that promote or hinder innovation. In Georgia, where collectivist and hierarchical tendencies prevail, innovation may be more challenging but not impossible. Research indicates that organizations can overcome these barriers by adopting hybrid approaches that integrate traditional values with modern, innovative strategies (House et al., 2004).

Innovation theories also emphasize the importance of the external environment, including cultural influences, in shaping the innovation process. Tidd and Bessant (2018) argue that innovation is not solely a technological phenomenon but also a social one, highly influenced by the surrounding cultural and institutional framework. According to their work, companies that succeed in innovation often do so by aligning their innovative efforts with the cultural values and social expectations of their target markets. In Georgia, businesses that respect cultural traditions while introducing new technologies or business practices tend to have more success in fostering innovation (Tidd & Bessant, 2018). Other researchers, such as Roth (2020), have explored how cultural adaptability - the ability to blend traditional values with modern innovation - can enhance business performance. Roth's study suggests that companies in culturally rich regions like Georgia are uniquely positioned to create a competitive advantage by using their cultural heritage as a foundation for innovation. This aligns with more recent work by Smith and Peterson (2022), who highlight the global trend toward "glocalization," where businesses localize their global strategies to fit cultural specifics, which is particularly relevant in Georgia's rapidly changing business environment.

In the specific context of Georgia, the interaction between culture and innovation has been understudied, though recent research has begun to fill this gap. Studies by Tsanava (2019) and Lekishvili (2021) examine how Georgian businesses integrate cultural identity with the need for innovation, particularly in sectors such as tourism, agriculture, and hospitality. Their findings indicate that Georgian businesses that respect and incorporate local cultural elements into their innovation processes tend to perform better than those that adopt a purely Western approach. Furthermore, research by Kvaratskhelia (2021)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

highlights the role of traditional Georgian values, such as respect for hierarchy and community, in shaping organizational dynamics. While these values may pose challenges to innovation, particularly in terms of risk aversion and resistance to change, they can also provide a stable foundation upon which innovative ideas can be built if managed correctly. This is particularly true in industries such as wine production, where Georgian businesses have successfully combined ancient practices with modern techniques to create unique products that resonate both locally and internationally.

The existing literature on the intersection of culture and innovation suggests that while culture can act as a constraint on innovation, it can also be a powerful enabler if leveraged appropriately. In the Georgian context, businesses that recognize and respect the importance of cultural identity while embracing innovative practices are better positioned for success. This literature review validates the need for further research on how Georgian businesses can balance tradition with modernity to foster innovation in a culturally sensitive manner. The findings of this study will contribute to this growing body of knowledge by providing empirical evidence from the Georgian business environment, particularly in terms of how cultural values influence innovation strategies and outcomes.

Methods

This study employed a mixed-method research design, combining both qualitative and quantitative approaches to explore the intersection of culture and innovation in Georgian business. The research was conducted in three phases: literature review, qualitative interviews, and quantitative analysis.

1. **Literature Review**: A comprehensive review of existing literature on culture and innovation was conducted to establish the theoretical framework. Peer-reviewed journal articles, books, and reports related to cultural dimensions, innovation theories, and Georgian business practices were analyzed. This provided the foundation for developing the research questions and hypotheses.
2. **Qualitative Interviews**: In the second phase, semi-structured interviews were conducted with 20 business leaders across different industries in Georgia, including hospitality, agriculture, and tourism. The interviewees were selected using purposive sampling to ensure diversity in company size, industry, and innovation strategies. The interviews focused on how cultural factors influence innovation processes, the challenges faced when integrating tradition with modern business practices, and strategies for overcoming these challenges. Each interview lasted approximately 45 minutes, and all interviews were recorded, transcribed, and analyzed thematically.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

3. **Quantitative Analysis**: In the third phase, a quantitative survey was distributed to 150 businesses across Georgia. The survey was designed to measure the extent to which cultural factors impact innovation performance, using Likert scales to assess variables such as cultural adherence, openness to change, and innovation outcomes. Statistical analysis was conducted using SPSS to identify correlations between cultural dimensions and innovation success, with regression analysis used to determine the strength of these relationships.

Regression Formula

To examine the relationship between cultural adaptability and innovation performance in Georgian businesses, the study employs the following multiple linear regression model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where:

- ✓ Y - Innovation Performance (measured by a composite index of product innovation, market expansion, and customer satisfaction)
- ✓ X_1 - Cultural Adaptability (degree to which businesses integrate traditional cultural values with modern innovation)
- ✓ X_2 - Power Distance (hierarchical structure within organizations)
- ✓ X_3 - Collectivism (extent of teamwork and group decision-making)
- ✓ X_4 - Tradition Orientation (business reliance on traditional practices)
- ✓ β_0 - Intercept
- ✓ $\beta_1, \beta_2, \beta_3, \beta_4$ - Coefficients representing the impact of each independent variable on innovation performance
- ✓ ε - Error term

Methodology

To analyze the intersection of culture and innovation in Georgian business, the study employs a mixed-method research design that combines qualitative and quantitative approaches.

1. **Data Collection**

Qualitative Data: Semi-structured interviews were conducted with 20 business leaders from diverse industries (hospitality, agriculture, tourism, and technology) to understand how cultural factors influence innovation strategies.
Quantitative Data: A survey was distributed to 150 businesses across Georgia, measuring key cultural dimensions and innovation outcomes. The survey used Likert-scale questions (1–5) to assess variables such as cultural adaptability, openness to change, and innovation performance.

2. **Statistical Analysis**

Descriptive Statistics: Mean, standard deviation, and frequency distributions were calculated for key variables.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Correlation Analysis: Pearson's correlation was used to assess the relationships between cultural dimensions and innovation performance.
Regression Analysis: A multiple linear regression model was applied using SPSS to determine the impact of cultural factors on innovation success. The model's significance was tested using the R^2 value, t-statistics, and p-values to evaluate the strength and validity of the relationships.

3. Key Findings from Regression Analysis

The model explained 34% of the variance in innovation performance (R^2 = 0.34).

Cultural Adaptability (X_1)had a positive and statistically significant effect on innovation performance ($\beta = 0.45$, $p < 0.01$), indicating that businesses integrating cultural values with modern innovation performed better.

Power Distance (X_2) and Collectivism (X_3) showed negative correlations with innovation performance ($\beta = -0.40$, $p < 0.05$ and $\beta = -0.32$, $p < 0.05$, respectively), suggesting that hierarchical structures and group decision-making may hinder rapid innovation.

Tradition Orientation (X_4) had a mild negative impact ($\beta = -0.28$, $p < 0.05$), indicating that excessive reliance on traditional methods could limit innovation potential.

The regression analysis highlights that cultural adaptability is a key driver of innovation performance in Georgian businesses. While hierarchical structures and strong collectivist tendencies may pose challenges, businesses that successfully balance cultural heritage with modern innovation strategies are better positioned for success.

This methodology ensures a rigorous and data-driven approach to understanding the complex relationship between culture and innovation in Georgia.

Results

The results of the qualitative and quantitative analyses provided insights into how culture and innovation intersect in the Georgian business environment.

1. **Qualitative Findings**: The thematic analysis of interview data revealed several recurring themes. Business leaders reported that Georgian culture, particularly its emphasis on hierarchy and collectivism, can sometimes inhibit innovation, as decision-making tends to be centralized and risk-averse. However, leaders who actively integrated cultural elements into their innovation strategies, such as incorporating traditional practices into product development or service delivery, reported more success in gaining customer trust and loyalty. These businesses were able to navigate cultural constraints by

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

fostering a balance between respect for tradition and openness to new ideas.

2. **Quantitative Results**: The quantitative analysis supported the qualitative findings. The survey data showed a significant positive correlation ($r = 0.58$, $p < 0.01$) between cultural adaptability and innovation performance. Businesses that rated themselves higher on cultural adaptability - measured by their ability to align innovation with local cultural values - reported better innovation outcomes, such as product innovation, market expansion, and customer satisfaction. Regression analysis indicated that cultural adaptability accounted for 34% of the variance in innovation success ($R^2 = 0.34$), suggesting that while culture plays a significant role, other factors also contribute to innovation performance.

Tables summarizing key correlations and regression results are available for further reference (Table 1: Correlation Between Cultural Factors and Innovation Performance; Table 2: Regression Analysis of Cultural Adaptability and Innovation Success).

Table 1: Correlation Between Cultural Factors and Innovation Performance

Cultural Factor	Correlation with Innovation Performance (r)	Significance (p-value)
Cultural Adaptability	0.58	<0.01
Collectivism	-0.32	<0.05
Power Distance	-0.4	<0.05
Tradition Orientation	-0.28	<0.05

Table 1: Correlation Between Cultural Factors and Innovation Performance shows the correlation coefficients (r) and significance levels (p-values) between various cultural factors and innovation performance.

Table 2: Regression Analysis of Cultural Adaptability and Innovation Success

Variable	Coefficient	Standard Error	t-Statistic	p-Value	RÂ²
Constant	0.2	0.08	2.5	<0.05	0.34
Cultural Adaptability	0.45	0.1	4.5	<0.01	

Table 2: Regression Analysis of Cultural Adaptability and Innovation Success presents the regression results, highlighting the coefficient for cultural adaptability, its statistical significance, and the proportion of variance in innovation success explained by the model (R^2).

Analysis of Culture in Georgian Business

The culture of a society plays a pivotal role in shaping business practices, influencing everything from leadership styles to decision-making processes. In the case of Georgia, a country with a rich historical and cultural heritage, this influence is particularly pronounced. Georgian businesses

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

operate in a unique cultural context characterized by collectivism, high power distance, and a strong respect for tradition (Hofstede, 2010). Understanding these cultural dimensions is essential for analyzing how businesses innovate and adapt to changing market demands.

Collectivism and Its Impact on Business Practices: Collectivism, a cultural dimension that emphasizes the importance of group harmony and social cohesion, is a dominant characteristic in Georgian society. Georgian businesses often place a strong emphasis on relationships, loyalty, and community values, which can influence how organizations are structured and how decisions are made. In a collectivist culture, decision-making tends to be more consultative, with significant weight given to the opinions of senior figures and the broader group (Triandis, 1995).

In Georgian businesses, this collectivist mindset fosters a close-knit organizational culture, where teamwork and collaboration are highly valued. However, it can also lead to challenges in innovation, as collectivism may inhibit individual risk-taking and creativity. Research suggests that innovation thrives in cultures where individual initiative and experimentation are encouraged (Shane, 1993). In Georgia, where cultural norms prioritize group consensus, there can be resistance to novel ideas that disrupt established ways of working. As a result, innovation may occur more incrementally rather than through radical shifts, as organizations are cautious about challenging the status quo.

Power Distance and Organizational Hierarchy: Georgian business culture is also shaped by a high degree of power distance, which refers to the acceptance of hierarchical structures and unequal distribution of power within organizations. Hofstede (2010) defines high power distance cultures as those where authority is concentrated at the top, and subordinates are less likely to challenge or question their leaders. In Georgia, this manifests in businesses that often have centralized decision-making, with senior leaders holding significant authority over strategic directions.

While high power distance can provide clear leadership and direction, it may also stifle innovation by discouraging open communication and feedback from lower-level employees (House et al., 2004). In such environments, employees may be reluctant to propose new ideas or challenge established practices for fear of disrupting the chain of command. This creates a cultural barrier to innovation, as organizations may miss out on valuable insights and creative solutions that could arise from a more egalitarian and open environment.

However, Georgian companies that have adapted their organizational structures to allow for more participative leadership and horizontal communication tend to be more successful in fostering innovation (Kvaratskhelia, 2021). These businesses encourage employees at all levels to

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

contribute ideas and engage in problem-solving, thereby creating a more dynamic and innovative work culture.

Tradition and Modernity in Georgian Business: One of the most significant challenges faced by Georgian businesses is the balancing act between tradition and modernity. Georgian culture places a high value on its historical heritage, and many businesses draw on traditional practices and values in their operations (Lekishvili, 2021). This is particularly evident in sectors such as hospitality, agriculture, and wine production, where businesses market their products and services based on their connection to Georgian traditions.

However, while tradition provides a strong cultural identity, it can also be a constraint on innovation. Businesses that are overly reliant on traditional methods may be slow to adopt new technologies or business practices that could enhance efficiency and competitiveness. Research shows that cultures with a strong attachment to tradition may experience more resistance to change, as innovation is often seen as a threat to cultural continuity (Tidd & Bessant, 2018).

Nevertheless, some Georgian businesses have successfully integrated tradition with innovation by creating unique products and services that appeal to both local and global markets. For example, the Georgian wine industry has embraced modern production techniques while maintaining traditional winemaking methods, such as the use of qvevri (large clay pots) for fermentation. This blend of tradition and modernity has allowed Georgian wine producers to differentiate themselves in the global market, demonstrating how cultural heritage can be leveraged as a competitive advantage (Tsanava, 2019).

Cultural Adaptability and Innovation: Cultural adaptability, or the ability to align innovation with cultural values, is a critical factor in the success of Georgian businesses. Businesses that respect and incorporate local cultural elements into their innovation strategies tend to perform better than those that adopt a purely Western approach (Roth, 2020). For instance, companies that tailor their products and services to reflect Georgian cultural preferences - such as emphasizing hospitality, community, and tradition - are more likely to gain customer trust and loyalty.

Moreover, businesses that promote cultural adaptability within their organizational cultures tend to be more agile and responsive to changing market conditions. These companies are able to navigate the tension between preserving cultural identity and embracing modernity, fostering an environment where innovation can thrive. As Kvaratskhelia (2021) notes, cultural adaptability is particularly important in the Georgian business context, where tradition and modernity often coexist in complex ways.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The analysis of culture in Georgian business reveals that cultural factors play a significant role in shaping business practices, particularly in relation to innovation. Collectivism and high power distance create both opportunities and challenges for businesses, while the tension between tradition and modernity requires careful management. Companies that successfully integrate cultural values into their innovation strategies are better positioned to thrive in the Georgian market. By understanding and navigating these cultural dynamics, Georgian businesses can create a competitive advantage that draws on both their rich cultural heritage and their ability to innovate.

Innovation Trends in Georgia

Innovation has become a key driver of economic growth in Georgia, with increasing efforts by both the government and private sector to create a dynamic, competitive business environment. In recent years, Georgia has witnessed a steady rise in innovative activities across various sectors, driven by globalization, technological advancement, and a growing entrepreneurial culture. This section explores the current trends in innovation in Georgia, highlighting the sectors where innovation is most prominent, the challenges faced by innovators, and the role of government policies in fostering innovation.

Growth of the Technology and Startup Ecosystem: One of the most significant innovation trends in Georgia is the rapid growth of its technology and startup ecosystem. The country's strategic location, well-developed IT infrastructure, and relatively low operational costs have attracted numerous tech startups and international companies. Tbilisi, in particular, has become a hub for tech innovation, hosting a growing number of incubators, accelerators, and co-working spaces that support startups in fields such as fintech, software development, and digital marketing (World Bank, 2021).

The startup culture in Georgia is largely driven by a young, well-educated workforce that is increasingly embracing entrepreneurial activities. Georgian universities and vocational institutions are also playing a critical role in nurturing talent in science, technology, engineering, and mathematics (STEM) fields. Initiatives such as Tbilisi Startup Bureau, Startup Grind Tbilisi, and the Georgian Innovation and Technology Agency (GITA) provide essential support in terms of funding, mentorship, and access to networks, further bolstering the country's startup ecosystem.

Furthermore, Georgia's strategic focus on digital transformation, including the development of e-government services and digital banking platforms, has positioned the country as a leader in the region for IT innovation. The introduction of blockchain technology into various sectors,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

such as land registration and financial services, has also opened new avenues for technological innovation (Kvaratskhelia, 2021).

Tourism and Hospitality Innovation: Innovation in Georgia's tourism and hospitality sectors is another key trend, driven by the country's rich cultural heritage and natural beauty. Georgian businesses are increasingly combining traditional tourism offerings with modern, sustainable, and tech-driven experiences to attract international visitors. For instance, several hotels and resorts are adopting digital solutions, such as mobile apps for booking and virtual reality (VR) tours, to enhance customer experiences (Lekishvili, 2021).

Another important trend is the rise of eco-tourism and responsible travel. Businesses in rural regions of Georgia are innovating by integrating local cultural elements into tourism experiences, such as wine tours in traditional qvevri wine cellars and cultural festivals. This blend of innovation and tradition not only adds value to the tourism sector but also promotes the preservation of Georgia's cultural identity. The push towards sustainable tourism aligns with global trends and responds to the growing demand for environmentally conscious travel experiences (Tsanava, 2019).

Agriculture and Agri-Tech Innovations: Georgia's agricultural sector has long been a cornerstone of its economy, but in recent years, innovation in agri-tech has begun transforming traditional farming practices. The use of precision agriculture, data analytics, and modern irrigation systems has increased productivity and efficiency in agriculture, helping Georgia's farmers compete in both domestic and international markets (Roth, 2020).

Innovations in the wine industry are particularly noteworthy. While Georgia is known for its ancient winemaking tradition, modern winemakers are incorporating new technologies, such as temperature-controlled fermentation and advanced grape cultivation techniques, to enhance the quality and variety of wines produced. The fusion of traditional qvevri methods with modern technology has helped Georgian wines gain recognition in global markets, demonstrating the sector's capacity for innovation (Kharatishvili & Meladze, 2022).

Additionally, smart farming solutions, such as the use of drones for crop monitoring and soil analysis, have been adopted by forward-thinking Georgian agricultural companies. These technologies enable farmers to optimize their yield and reduce environmental impact, aligning with global trends toward more sustainable agricultural practices.

Challenges to Innovation in Georgia: Despite the positive trends, Georgia still faces several challenges in fostering a robust innovation ecosystem. One of the major obstacles is limited access to financing for startups and small and medium-sized enterprises (SMEs). While government initiatives such as GITA provide grants and seed funding, there is still a lack

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

of venture capital investment, which hinders the scalability of many innovative businesses (World Bank, 2021).

Additionally, innovation in Georgia is constrained by the country's small market size. Many Georgian businesses must look beyond national borders to achieve growth, but this requires overcoming challenges such as limited access to international networks and the complexities of navigating global markets. As a result, export-driven innovation strategies are increasingly important for Georgian companies seeking to scale.

Cultural factors also play a role in shaping innovation trends. As noted in earlier sections, Georgia's collectivist culture and high power distance can create barriers to the free flow of ideas and hinder creative problem-solving. However, businesses that are able to strike a balance between tradition and modernity are better positioned to overcome these challenges and succeed in fostering innovation.

The Role of Government Policies in Promoting Innovation: The Georgian government has made significant strides in creating a supportive environment for innovation. Through initiatives such as the Innovation and Technology Agency and the "Startup Georgia" program, the government provides financial support, tax incentives, and infrastructure development to promote entrepreneurship and technological advancement. Furthermore, Georgia's business-friendly regulatory framework, ranked highly in global ease-of-doing-business indices, has encouraged both local and foreign investment in innovative sectors (World Bank, 2021).

Government efforts to promote digital literacy and STEM education are also critical to fostering innovation in the long term. By investing in human capital development and enhancing research and development (R&D) capacities, Georgia is positioning itself as a knowledge-based economy. Partnerships between academic institutions, the private sector, and international organizations are essential to supporting this growth.

Innovation in Georgia is advancing across multiple sectors, from technology and startups to tourism and agriculture. The country's evolving startup ecosystem, digital transformation initiatives, and sustainable tourism practices are at the forefront of this trend. However, challenges such as limited access to financing and the small domestic market continue to constrain the full potential of innovation in the country. To sustain this growth, ongoing support from the government, combined with efforts to integrate global best practices, will be essential. As Georgia continues to balance tradition and modernity, innovation will play a crucial role in shaping its economic future.

The Intersection of Culture and Innovation

The interaction between culture and innovation represents a complex and dynamic relationship, especially in countries like Georgia, where

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

historical and cultural identity play a central role in social and economic life. Understanding this intersection requires an exploration of how cultural factors can both support and limit innovation within businesses, and how companies can adapt to leverage culture as an asset rather than a constraint.

Cultural values deeply influence how organizations approach innovation. In collectivist societies, such as Georgia, there is a strong emphasis on group cohesion, respect for hierarchy, and maintaining traditional practices (Triandis, 1995). These values can lead to a conservative approach to change, where innovation is perceived as a disruption to established norms. For example, studies have shown that in high power distance cultures, employees are less likely to propose novel ideas or challenge existing practices, as these behaviors might be viewed as disrespectful to authority (Hofstede, 2010). However, these same cultural traits can foster a type of innovation that emphasizes incremental rather than radical changes, aligning new developments with existing practices to create a more cohesive approach to modernization. This form of "adaptive innovation" allows Georgian businesses to develop products and services that feel familiar to local consumers while integrating modern advancements.

Georgia's strong connection to its cultural heritage has inspired businesses to incorporate traditional elements into innovative practices, creating products and services that resonate with both local and international markets. This trend is particularly evident in the tourism and wine industries, where companies have successfully blended ancient methods with modern technology. In the wine sector, for instance, winemakers employ traditional qvevri fermentation techniques alongside contemporary production processes to create a distinctive product that appeals to consumers seeking authentic experiences (Kharatishvili & Meladze, 2022). This balance between tradition and innovation demonstrates how cultural heritage can serve as a foundation for differentiation in the global marketplace. Georgian companies are increasingly using their unique cultural identity as a competitive advantage, creating offerings that highlight their heritage while meeting modern quality standards and market expectations (Lekishvili, 2021).

Cultural adaptability - the ability of organizations to align innovation efforts with local cultural values - has emerged as a key driver of success for Georgian businesses. Companies that manage to balance respect for cultural traditions with openness to modern practices are better positioned to thrive in both local and global markets. Roth (2020) found that businesses with high cultural adaptability experienced better innovation outcomes, such as enhanced product development and customer satisfaction, as they could meet the diverse expectations of their clientele. For example, Georgian hospitality companies are incorporating advanced technology in customer service while preserving elements of traditional Georgian hospitality, which emphasizes

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

warm, personalized interactions. This blend of technology and cultural warmth enables these companies to cater to a global clientele while maintaining a distinctively Georgian service style (Tsanava, 2019).

Organizational culture - shaped by broader societal values - also influences innovation. In Georgia, where respect for authority and adherence to established norms are common, creating an organizational culture that supports innovation may require deliberate strategies to encourage open communication and experimentation. Businesses that actively promote a culture of inclusivity and feedback, where employees at all levels are encouraged to share ideas, are more likely to develop innovative solutions that address local market needs (Kvaratskhelia, 2021). Several companies in Georgia have implemented organizational changes that support a more innovative culture. These changes include adopting flatter organizational structures, encouraging cross-functional collaboration, and implementing incentive systems that reward creativity and problem-solving. By fostering a workplace culture that values both tradition and innovation, Georgian businesses are creating environments where employees feel empowered to contribute novel ideas without compromising cultural norms.

Despite the benefits, the intersection of culture and innovation also presents challenges. Businesses operating in high-context cultures like Georgia's may face difficulties in adopting rapid, disruptive innovations due to a preference for gradual change. Additionally, the hierarchical nature of many Georgian organizations can inhibit the free exchange of ideas, as employees may feel restricted in their ability to offer suggestions or voice concerns (House et al., 2004). Moreover, a strong adherence to tradition can make it challenging for companies to keep pace with global innovation trends, particularly in fast-evolving fields such as technology and digital services. To remain competitive, Georgian businesses must develop strategies that allow them to preserve cultural values while staying responsive to international advancements in their respective industries.

The intersection of culture and innovation in Georgian business reflects a nuanced relationship, where cultural values shape, influence, and sometimes challenge innovation processes. While cultural factors such as collectivism, power distance, and tradition can limit the pace of innovation, they also provide a unique platform for businesses to develop products and services that are both modern and culturally resonant. Companies that successfully integrate cultural values into their innovation strategies - demonstrating high cultural adaptability - are well-positioned to excel in the competitive landscape.

As Georgia continues to engage with the global economy, the ability of its businesses to leverage cultural identity as a foundation for innovation will be crucial. This intersection of tradition and modernity offers not only a

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

path for economic growth but also an opportunity for Georgian businesses to contribute distinctively to the global market by offering products and experiences that reflect their rich cultural heritage.

Discussion of Findings

The findings of this study reveal a complex and dynamic relationship between culture and innovation in the context of Georgian business. By examining the ways in which Georgian businesses integrate cultural values into their innovation strategies, several key insights emerge regarding the factors that enable or inhibit innovation, the role of cultural adaptability, and the unique challenges faced by companies operating in a culturally rich but rapidly evolving business environment.

One of the primary findings of this study is the significant positive correlation between cultural adaptability and innovation performance. Businesses that align their innovation efforts with cultural values - by embracing both traditional practices and modern approaches - tend to perform better in terms of product development, customer satisfaction, and market growth. This finding is consistent with existing literature, which suggests that cultural adaptability enhances an organization's ability to innovate in ways that resonate with local consumers (Roth, 2020; Kvaratskhelia, 2021). The role of cultural adaptability is particularly pronounced in industries where tradition holds strong, such as the wine and tourism sectors. For instance, Georgian wineries that blend ancient qvevri techniques with modern production methods have found success both domestically and internationally, leveraging cultural heritage as a source of competitive advantage. These businesses illustrate how cultural values can be an asset to innovation when managed effectively, allowing companies to create offerings that are both unique and authentic.

The study also highlights the impact of collectivist and high power distance cultural characteristics on innovation processes. Collectivism in Georgian business culture fosters a strong sense of loyalty, teamwork, and community, which can support collaboration and cohesion within organizations. However, the collectivist mindset may also limit individual risk-taking and creativity, as employees may prioritize group harmony over experimentation. This preference for consensus can make it challenging to introduce disruptive innovations that require a departure from established norms and practices (Triandis, 1995). High power distance, another prominent cultural trait, presents additional challenges. In many Georgian businesses, authority is concentrated at the top, and decision-making processes are often hierarchical. This structure can inhibit open communication and the free exchange of ideas, as employees at lower levels may feel reluctant to propose new ideas or challenge the status quo. High power distance can, therefore,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

hinder the development of a more dynamic and innovative organizational culture. However, some Georgian businesses have adopted flatter organizational structures or participative leadership styles, which enable more inclusive and open innovation processes (House et al., 2004).

Georgia's cultural emphasis on tradition presents a dual influence on innovation. On one hand, a strong attachment to cultural heritage can act as a constraint, creating resistance to rapid or radical changes. Many Georgian businesses, particularly those in industries closely tied to local customs, such as agriculture and hospitality, are cautious about adopting innovations that may disrupt established practices. This cautious approach can slow the pace of technological adoption and limit the exploration of uncharted territories. On the other hand, tradition can be a powerful asset when integrated thoughtfully into innovation strategies. Businesses that build on traditional elements while embracing modern practices create products and services that stand out in both local and international markets. The wine industry serves as a prominent example: by preserving ancient techniques and combining them with new technologies, Georgian winemakers have carved a niche in the global market, attracting consumers who value authenticity. This blend of tradition and innovation not only preserves cultural identity but also meets the demand for unique, culturally rich products.

The study also finds that organizational culture, shaped by broader societal values, plays a significant role in determining a company's innovation capacity. Georgian businesses that foster a workplace culture of inclusivity, trust, and open feedback are more likely to support innovative behaviors. By creating an environment that encourages employees to contribute ideas and take calculated risks, companies can overcome some of the constraints posed by traditional cultural values. Additionally, businesses that actively cultivate an organizational culture aligned with innovation are better positioned to attract talent that values both Georgian culture and forward-thinking practices. As Kvaratskhelia (2021) notes, businesses that blend tradition with modernity create a work environment that is both stable and dynamic, appealing to employees who wish to contribute to the company's innovative goals without sacrificing cultural values.

While the findings highlight the potential for cultural values to enhance innovation, they also underscore several challenges. The small domestic market in Georgia limits the scale at which businesses can innovate, prompting many companies to look to international markets for growth. However, competing globally requires additional resources and the ability to navigate diverse cultural contexts, which can be challenging for Georgian businesses that primarily operate in a culturally homogenous environment (Lekishvili, 2021). Furthermore, limited access to financing remains a significant barrier for small and medium-sized enterprises (SMEs) in Georgia. While

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

government initiatives like GITA provide support, there is a lack of venture capital and private investment, which restricts the ability of startups and SMEs to scale their innovative efforts. Addressing these challenges requires not only a supportive policy environment but also increased collaboration between the private sector, academia, and international organizations to build a sustainable innovation ecosystem (World Bank, 2021).

The study's findings have practical implications for Georgian business leaders and policymakers. For business leaders, fostering cultural adaptability within organizations can enhance innovation outcomes. This involves recognizing the value of cultural heritage while encouraging an openness to new ideas and practices. Developing organizational cultures that empower employees, reduce hierarchical barriers, and reward creativity is essential for sustaining innovation in Georgia. For policymakers, the findings suggest a need to strengthen support systems for innovation, particularly in terms of access to funding and talent development. Expanding initiatives that support STEM education, digital literacy, and entrepreneurship can help build a workforce equipped to drive innovation in the Georgian economy. Additionally, encouraging public-private partnerships can provide businesses with the resources needed to overcome structural barriers and scale their innovation efforts.

In conclusion, the intersection of culture and innovation in Georgian business reveals a nuanced relationship where cultural values serve as both enablers and constraints. Businesses that embrace cultural adaptability, leverage traditional practices in innovative ways, and foster inclusive organizational cultures are better positioned to succeed. While challenges such as limited market size and financing persist, a balanced approach that respects Georgia's cultural identity while fostering innovation holds significant promise for the country's economic future. The findings of this study underscore the importance of understanding and navigating cultural dynamics in innovation strategies, offering valuable insights for business leaders, scholars, and policymakers alike.

Conclusion

This study explored the intricate relationship between culture and innovation in Georgian business, highlighting how traditional cultural values interact with modern innovation practices. The findings reveal that while cultural factors such as collectivism, high power distance, and a strong respect for tradition can pose challenges to innovation, they also provide a unique foundation for businesses to develop culturally resonant products and services. Georgian companies that embrace cultural adaptability - blending respect for cultural identity with openness to modern practices - are better positioned to thrive in both local and international markets.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The concept of cultural adaptability emerged as a key driver of innovation success. Businesses that align their innovation strategies with local cultural values not only enhance their competitive edge but also foster stronger connections with customers and communities. This approach is particularly effective in sectors such as tourism, wine, and hospitality, where traditional Georgian elements serve as powerful differentiators in the global market. By using cultural heritage as a resource rather than a constraint, these businesses demonstrate that innovation and tradition can coexist harmoniously.

However, challenges remain. The limited scale of the domestic market, coupled with restricted access to financing, constrains the growth of Georgian startups and small businesses. These limitations underscore the importance of supportive policies that can strengthen Georgia's innovation ecosystem. Expanding public-private partnerships, enhancing access to venture capital, and fostering STEM education and digital literacy are essential steps for enabling sustainable, innovation-driven growth.

In conclusion, the intersection of culture and innovation in Georgian business offers both opportunities and challenges. By leveraging cultural values as a foundation for innovation, Georgian businesses have the potential to create distinctive offerings that honor tradition while embracing modernity. For policymakers and business leaders alike, fostering an environment that supports both cultural preservation and innovative thinking is key to driving Georgia's economic future. This balanced approach not only positions Georgia competitively in the global market but also strengthens its cultural identity in an era of rapid change.

Limitations of the Research

Despite the comprehensive approach taken in this study, certain limitations should be acknowledged.

- ✓ **Sample Size and Generalizability** – The study primarily focuses on Georgian businesses, with data collected from a limited number of companies. While the findings provide valuable insights into the intersection of culture and innovation, the results may not be fully generalizable to other cultural or economic contexts. Future research could expand the sample size and include comparative studies with businesses in other regions.
- ✓ **Qualitative Data Constraints** – The qualitative component of the research relies on interviews with business leaders, which, while insightful, may introduce subjective biases. The perspectives of employees at different organizational levels could further enrich the findings. Future studies may benefit from broader stakeholder engagement to capture a more diverse range of experiences.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- ✓ **Limited Time Frame** – The study analyzes the current state of innovation in Georgian businesses but does not account for long-term trends or historical changes. A longitudinal study could provide a more dynamic understanding of how cultural and innovation dynamics evolve over time.
- ✓ **Lack of Industry-Specific Analysis** – While the research covers multiple industries, it does not provide an in-depth analysis of how cultural and innovation factors differ across specific sectors. Future research could focus on sector-specific case studies to explore industry-specific challenges and opportunities in more detail.
- ✓ **Regression Model and Data Availability** – Although the study incorporates a quantitative approach, the availability and reliability of innovation performance metrics in Georgian businesses remain a challenge. The regression analysis is based on self-reported data, which may be subject to response bias. A more extensive dataset, including official innovation indices, could strengthen the study's empirical foundation.
- ✓ **Cultural Subjectivity** – The interpretation of cultural factors is inherently subjective, and while established theoretical frameworks such as Hofstede's cultural dimensions were used, cultural perceptions and their impact on business practices can vary significantly among individuals and organizations. Future research could incorporate experimental or ethnographic methods to deepen the cultural analysis.

These limitations highlight areas for further exploration and improvement, providing a foundation for future studies to build upon the findings of this research.

Conflict of Interest: The author reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

Funding Statement: The author did not obtain any funding for this research.

References:

1. Hofstede, G. (2010). *Cultures and Organizations: Software of the Mind.* McGraw-Hill Education.
2. House, R. J., Hanges, P. J., Javidan, M., Dorfman, P. W., & Gupta, V. (Eds.). (2004). *Culture, Leadership, and Organizations: The GLOBE Study of 62 Societies.* SAGE Publications.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

3. Kvaratskhelia, N. (2021). The impact of digital transformation on Georgian business. *Journal of Business and Technology, 12*(4), 102-120.
4. Kvaratskhelia, N. (2021). The role of cultural identity in Georgian business innovation. *Journal of Business and Economics, 15*(4), 135-152.
5. Kharatishvili, K., & Meladze, G. (2022). Innovations in Georgian winemaking: Tradition meets technology. *Journal of Wine Business Research, 35*(3), 45-58.
6. Lekishvili, T. (2021). Cultural traditions and innovation in Georgia: A study of the tourism sector. *Caucasus Business Review, 8*(2), 88-101.
7. Lekishvili, T. (2021). Cultural innovation in the Georgian tourism sector. *Tourism and Hospitality Research, 11*(2), 76-90.
8. Roth, L. (2020). The impact of cultural dimensions on innovation processes in global markets. *Journal of Innovation Management, 8*(3), 56-78.
9. Shane, S. (1993). Cultural influences on national rates of innovation. *Journal of Business Venturing, 8*(1), 59-73.
10. Smith, P. B., & Peterson, M. F. (2022). *Cross-Cultural Leadership and Innovation: Global Challenges in a Dynamic World.* Routledge.
11. Triandis, H. C. (1995). *Individualism & Collectivism.* Westview Press.
12. Tsanava, D. (2019). The impact of cultural identity on innovation in Georgian businesses. *International Journal of Innovation and Management, 6*(1), 45-60.
13. Tsanava, D. (2019). The role of culture and innovation in Georgian business growth. *International Journal of Innovation and Business Development, 7*(1), 41-56.
14. Tidd, J., & Bessant, J. (2018). *Managing Innovation: Integrating Technological, Market and Organizational Change* (6th ed.). Wiley.
15. World Bank. (2021). *Innovation and technology development in Georgia: A policy review.* World Bank Group.

ESJ Social Sciences Peer-reviewed

Supply Chain Resilience: The Role of Total Quality Management on the Performance of Kenya Medical Supplies Authority

Ndungu Wahome John
Stephen Makau Muathe
School of Business, Economics and Tourism,
Kenyatta University, Kenya

Doi:10.19044/esj.2025.v21n19p92

Submitted: 05 June 2025
Accepted: 22 July 2025
Published: 31 July 2025

Cite As:
Ndungu, W.J. & Muathe, S.M. (2025). *Supply Chain Resilience: The Role of Total Quality Management on the Performance of Kenya Medical Supplies Authority*. European Scientific Journal, ESJ, 21 (19), 92. https://doi.org/10.19044/esj.2025.v21n19p92

Abstract

Managers are empowered to improve the quality of services and products by incorporating key total quality management principles. However, the Kenya Medical Supplies Authority (KEMSA) has faced scrutiny due to inefficiencies, which are hindering access to essential healthcare services. This aims to assess the Kenya Medical Supplies Authority's performance in the application of the four Total Quality Management principles. These are fact-based decisions, process-centric approaches, relationship management, and employee engagement. The study is grounded in four theoretical foundations: resource-based view, dynamic capabilities, stakeholder theories, and Deming's theory of quality management. A descriptive research design was used. The target population was 330 employees; however, a sample of 181 respondents was selected using proportionate stratified and simple random sampling techniques. Structured questionnaires were used to collect data, which was analyzed quantitatively using both descriptive and regression analysis, and SPSS version 25 was used to aid the data analysis. The findings indicate that the independent variables explain 58.5% of variables in the dependent variable, that is, the performance of KEMSA. Fact-based decisions had the highest impact and positive correlation with performance (B = 0.372, t = 5.239), followed by employee engagement (B = 0.348, t = 4.640), process-

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

centric approach (B = 0.319, t = 4.691), and relationship management (B = 0.257, t = 3.134 all at p<0.01. The findings point to the importance of continuous staff training, participatory leadership, and integrated data systems to enhance performance. Additionally, the study recommends mentorship for junior staff, regular assessment of all resources, and a supportive organizational culture that sustains quality improvements.

Keywords: Fact-Based Decisions, Process Approach, Relationship Management, Healthcare Supply Chain

Introduction

Healthcare can be described as a dynamic field that requires crucial delivery of high-quality services. This is because it influences not only the health of patients but also the health of the general public. Healthcare agencies involved in the medical supply chain undertake a critical role in ensuring the availability of essential healthcare supplies, drugs, and medical equipment (Ajmal et al., 2020). Achieving high-quality and consistent supply chain performance across these agencies remains a problem globally, especially among developing countries such as Kenya (Shukla et al., 2018).

Solving these limitations requires clear frameworks within management, such as efficiency enhancement, waste reduction, and service delivery standards. TQM has therefore emerged as one of the most effective approaches for improving performance within organizations across different sectors. TQM is viewed as a holistic philosophy of management that stresses continuous improvement (Kaizen), customer satisfaction, employee involvement, and process augmentation (Talib *et al.,* 2023).

TQM within the healthcare sector promotes service quality through systematic identification and elimination of supply chain inefficiencies as well as ensuring that medical practitioners acquire the necessary resources for delivering quality healthcare (Firdaus & Irfan, 2023). According to Tenji and Foley (2019), adopting TQM practices leads to substantial improvements in operational efficacy, cost-effectiveness, and patient satisfaction. Customer needs and preferences are highly dynamic, thus requiring organizations to generate products and operations that meet higher quality standards and surpass customer expectations. Hence, the health sector is no exception. By delivering better products and operations, organizations position themselves competitively despite facing extreme uncertainty. Therefore, the desire for quality products and services contributes to the increased acceptance and recognition of the TQM concept (Ross, 2017). Total Quality Management currently enjoys wide awareness among scholars, particularly within the strategic management arena. According to Jaca and Psomas (2015), TQM as a practice today aims at continuous improvement, which contributes to the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

performance of firms. One of the key drivers of performance in an organization is quality, especially in a globalized economy.

Organizational performance can be observed as a multidimensional facet measurable using both financial and non-financial metrics. Within an organization, key financial metrics include return on investment, return on assets, liquidity level, market share, and earnings per share. The non-financial metrics, on the other hand, include employee productivity, customer retention levels, employee satisfaction, new product design, and customer satisfaction (Gutterman, 2023).

Performance in the context of KEMSA as a healthcare authority can be described as efficiency, effectiveness, and quality of service delivery. Effective performance management requires that agencies in the healthcare sector consistently meet required service delivery standards, manage resources efficiently, and ensure high levels of satisfaction among both customers and patients (Githuku, 2015). Integrating practices aligned with quality management, such as those found in TQM, can significantly improve organizational performance through indicators such as customer satisfaction, efficiency, and cost management (Joseph *et al.*, 2024).

Performance metrics critical to healthcare supply chains include service quality, lead time, and inventory management (Alfina et al., 2024). In healthcare agencies, especially within supply chains, performance is also reflected by the organization's capacity to respond to the dynamic needs of patients. An efficient supply chain in the healthcare industry is vital for ensuring the availability of drugs, equipment, and technologies (Gatiti et al., 2021). According to Agarwal et al. (2018), healthcare logistics performance is tied to efficient procurement processes, distribution systems, and the warehousing concept - all of which are interdependent. Performance challenges at KEMSA often stem from inefficiencies at the manufacturing sites, operational processes, inventory management, and logistics bottlenecks, all of which hinder service delivery objectives. Inefficiencies within KEMSA contribute not only to financial loss but also lead to the unavailability of essential medical supplies, highlighting the need for total quality management. In the current study, performance indicators include productivity and operational efficiency. Productivity is the ability to maximize output, such as the distribution of medical supplies, while minimizing inputs such as resources and cost. Operational efficiency at KEMSA focuses on streamlining processes to deliver high-quality services at a minimized cost.

Total Quality Management is a framework of quality improvement methodologies that are service-oriented and customer-centered (Nigam, 2005). TQM originated in Japan before gaining widespread popularity. It is described as an organization-wide, logical method for the continuous improvement of processes, outputs, and services by focusing on customer

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

satisfaction, employee involvement, and data-based decision-making. It further emphasizes specific concepts like kaizen, customer focus, fact-based decisions, employee participation, and process orientation. Fact-based decisions involve the accurate use of data in assisting the organization's decision-making processes (Otieno et al., 2021). Although decision-making is placed in the hands of management, managers often face pressure and make decisions based on incomplete information. An overload of information may confront managers, compelling them to make decisions that are difficult to evaluate and may lack relevance in the organizational context (White et al., 2024). The process-centric approach refers to clearly emphasized and well-defined processes aimed at achieving consistency and effectiveness (Dogan, 2023).

Relationship management can be described as the quality of interactions with various stakeholders, aiming to draw them towards the organization and work towards a shared goal (Talib *et al.,* 2023). It is what an organization needs to do to foster strong connections with stakeholders, including suppliers, customers, and internal departments. According to Omore (2022), this is a win-win connection where both the organization and its stakeholders benefit. Building trust and encouraging effective communication with stakeholders is central to relationship management (Omore, 2022). Clarity and consistency in communication ensure that suppliers are updated and informed about procurement requirements, delivery schedules, and quality standards (Kiarie et al., 2024). Transparent leads to effective collaboration and supply chain efficiency. Top management's commitment - reflected through effective relationship management and proper communication - positively influences organizational performance (Kiarie et al., 2024). Relationship management indicators in this study include communication and suppliers' trust. Employee engagement plays a critical role in healthcare worker retention. It is widely recognized as a key management technique across institutions for addressing employees' needs (Gabra, Yousuf & Abood, 2019). TQM helps in identifying the target group before implementing changes to systems or processes, ensuring satisfaction (Li *et al.,* 2019).

The Kenya Medical Supplies Authority (KEMSA) is a government corporation established under the KEMSA Act (2013) within the Ministry of Health. Its functions include procurement, storage, and distribution of essential medical supplies for public healthcare. It also partners with county governments to create frameworks for service delivery, warehousing, and drug distribution. Since 1901, KEMSA has undergone several changes aimed at improving service delivery. Its goal is to ensure the consistent and timely supply of high-quality healthcare products, supporting Kenya's Universal Health Coverage (UHC) objectives.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

KEMSA faces deficiencies associated with TQM, such as procurement inefficiencies, inadequate inventory management, and distribution delays. These issues have resulted in the wastage of medical supplies, undermining KEMSA's mission to guarantee quality products to health facilities. According to Transparency International (2020), inefficiencies at KEMSA underscore the urgent need for improved TQM practices.

Statement of the Problem

The Kenya Medical Supplies Authority (KEMSA) plays a pivotal role in ensuring the efficient procurement, storage, and distribution of medical supplies across Kenya's healthcare system (Wakuthii, 2019). As a cornerstone of the nation's healthcare infrastructure, KEMSA is mandated to fulfill legislative obligations that guarantee the continuous availability of essential medical commodities in public health facilities (Kanyangi, 2018). Despite having this critical mandate, KEMSA has recently encountered persistent operational inefficiencies that have significantly hindered its performance (Kurgat & Deya, 2023). Reports of mismanagement, poor service delivery, and logistical challenges have repeatedly emerged, undermining access to essential healthcare services and eroding public confidence in the agency's ability to meet its core objectives (Salil et al., 2024). Although various reforms and structural adjustments have been implemented, these problems remain largely unresolved, signaling the need for a more holistic and sustainable performance management framework (Min & Oh, 2020).

This institutional underperformance has attracted extensive scrutiny from government bodies, including the Ministry of Health, the office of the President, and oversight task forces. External assessments by health development partners such as USAID, the Global Fund, and UNFPA have further exposed systemic weaknesses compromising KEMSA's ability to fulfill its statutory duties (UNFPA, 2021; Wamoto et al., 2023).

Although numerous studies have been conducted on the usefulness of Total Quality Management (TQM), these have primarily focused on the agriculture, manufacturing, hospitality, and education sectors, neglecting a critical area of TQM application in the medical supply chain. For example, Kithinji (2019) examined TQM management strategies but limited the scope to employee performance. The study also overlooked TQM principles such as fact-based decisions and process-centric approaches within referral hospitals, thereby leaving a gap in understanding how TQM influences such institutions. While KEMSA is not a healthcare institution per se, it functions as a vital conduit that supplies essential resources to healthcare facilities (Kurgat & Deya, 2023).

Nding'uri (2019), a study on strategic change management and KEMSA's performance, identified change management practices theorized as

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

strategic leadership, legal framework, and resource management. The study suggested that a broader study to determine the extent to which KEMSA's performance is influenced by the application of such management practices to be carried out. Therefore, the impact of Total Quality Management (TQM) on performance represents a critical area of inquiry, highlighting a significant gap that this study seeks to address.

Specific Objectives

This study sought to:

i. Establish the effect of fact-based decision on the performance of the Kenya Medical Supplies Authority.
ii. Determine the effect of a process-centric approach on the performance of the Kenya Medical Supplies Authority.
iii. Examine the effect of relationship management on the performance of the Kenya Medical Supplies Authority.
iv. Establish the effect of employee engagement on the performance of the Kenya Medical Supplies Authority.

Review of Literature

Theoretical Review

This study is grounded on four theories: the Resource-Based View (RBV), the Dynamic Capabilities Theory, the Stakeholder Theory, and Deming's Theory of Total Quality Management.

Resource-Based View

The Resource-based view (RBV) theory, initially developed by Penrose (2009), posits that differences in firm competitiveness stem from the heterogeneous distribution of resources among organizations operating within the same industry. According to recent RBV, resources - both tangible and intangible - are viewed as strategic assets that firms leverage to formulate and execute strategies suited to their internal capabilities and external conditions (Utami & Alamanos, 2025).

Moreover, Madhani (2010) conceptualizes two basic assumptions forming the basis of RBV: assets and capacities, which are under firm control and ownership. The diversity of resources holds the premise that various firms within an industry possess different resource capabilities, which can be either tangible or intangible. According to Barney (2007), the mobility of resources assumes that resources possessed within diverse entities are challenging to generate and relocate within the industry. Both the resource heterogeneity and mobility assumptions highlight firms' ability to organize, exploit, synchronize, and manage their properties to develop an edge over competitors and comparatively achieve improved outcomes (Halawi *et al.,* 2005).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Additionally, Kinyua, Muathe, and Kilika (2015) emphasize that, across several sectors, enterprise achievement in a competitive environment - characterized by constantly evolving business conditions - is dependent upon strategy formulation and execution that make a firm distinguishable from its competitors. Nevertheless, value and delivery-based creation of strategic options should be conceived in a way that allows for amendments, ensuring there is constant fit with the firm's changing conditions (Madhani, 2010). RBV postulates that resource identification and acquisition foster a firm's capacity to generate and reserve organizational performance, edging out competitors (Alghamdi & Agag, 2024). Furthermore, it is observed that a firm distinguishes itself from its rivals when it possesses resources that are unique, valuable, and difficult to replace or replicate, hence shaping its competitive posture (Madhani et al., 2012). Various studies have incorporated RBV in diverse contexts (Njuguna & Muathe, 2020; Nyaboga & Muathe, 2024; Wandie & Muathe, 2022). The postulates of RBV underpin the competitiveness and performance of the authority.

Dynamic Capabilities Theory

The dynamic concept, as applied in this context, refers to the potential to revitalize capabilities for the sole purpose of achieving alignment with a regularly changing business environment (Teece et al., 1997). Accordingly, Chowdhury and Quaddus (2017) assert that the notion of dynamic capabilities refers to how a firm or an organization gains the ability to adapt, reconfigure, and integrate both intrinsic and extrinsic capabilities, provisions, and core skills in alignment with constantly evolving environmental prerequisites.

The focus of Dynamic Capabilities Theory is on capabilities within management, supported by resource distinctiveness from current fields such as process development, product innovation, human resources, and organizational learning. Jiang *et al.* (2018) advocate that Dynamic Capabilities Theory is explained by Resource-based theory, focusing on a specific subset of capabilities - otherwise known as competencies - that empower organizations to produce high-quality and innovative products and processes in response to evolving market conditions. Nevertheless, Gupta *et al.* (2014) argue that when Dynamic Capabilities Theory is used in conjunction with RBV, the former receives criticism due to limitations in determining whether either theory - individually or collectively - can consistently lead to operational performance and, ultimately, a competitive edge.

In the current study, Dynamic Capabilities Theory is adopted as it underscores the necessity of prioritizing internal capabilities within an organization and ultimately enhancing organizational performance. Furthermore, the theory assists in arguing how the Kenya Medical Supplies Authority allocates its resources toward advanced technology and innovation.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The theory suggests that organizations possessing scarce resources encounter limited capability in adopting modern technology and innovation, supporting the process-centric approach and fact-based decision variables, as it emphasizes the organization's ability to seize and transform opportunities through process and data leveraging.

Stakeholder Theory

Stakeholder Theory remains influential in highlighting the role of stakeholder participation in organizational success. Stakeholders are described as entities or individuals affected in various ways by decisions formulated by an organization. Stakeholders are critical, especially when examining organizations at their peak performance or during emerging negative trends; their role is, therefore, geared toward contributing significantly to organizational success. Essential processes upheld by management include key stakeholder identification, engagement, and strategies for fostering their alignment with the organization.

Stakeholder theory recommends strong stakeholder engagement, involvement, and continuous communication to align them with the organization (Bridoux & Stoelhorst, 2022). Organizational stakeholders often express their concerns, whether consciously or unconsciously, and ignoring their influence is not feasible. Management should, therefore, ensure that stakeholders are consolidated, engaged, and encouraged to support the organization's objectives and goals (Ezeh et al., 2024). According to Foster and Jonker (2003), once a stakeholder gains comfort with an organization's processes, they are more likely to offer support, thereby increasing the likelihood of success, compared to when stakeholders refuse to support similar processes.

Employee involvement and customer focus remain key Total Quality Management (TQM) principles that significantly determine TQM effectiveness in enhancing a firm's performance. Employees and customers are among the major stakeholders who play a central role in achieving organizational success. Effective stakeholder consultation and involvement in matters concerning the organization are fundamental to enhancing firm performance, as projected by Stakeholder Theory (Oakley, 2011).

In the context of this study, Stakeholder Theory was useful in explaining the role of TQM in promoting operational performance through employee involvement and customer focus. Employees and customers are key stakeholders who must be actively engaged. Thus, the theory supports employee management and relationship management as independent variables.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Deming Theory of Total Quality Management

The Deming Theory was first developed by Deming (1982), considering the quality of a product as a vital indicator of an organization's performance, thereby strengthening organizational competitiveness. Deming's theory is widely used to emphasize the importance of quality as a means of improving effectiveness and performance. Deming's theory of quality management supports the role of Total Quality Management (TQM) in organizational success by proposing that quality reduces operational costs through the minimization of errors, defects, and waste, and by promoting efficient resource utilization and reduced delays. Deming emphasizes the necessity for employees to work closely with management to enhance output quality and eventually sustainable and collective organizational performance. This theory is relevant to the current study as it supports performance as a dependent variable, while fact-based decisions and the process-centric approach are considered independent variables. It underscores the importance of aligning internal processes, management, and employees toward a unified strategic direction by promoting a systems-based approach, data-driven decision-making, and continuous process improvement.

Empirical Review

Fact-Based Decisions and Performance

Bungei (2022) conducted a study examining the relevance of fact-based decision-making approaches on the operational performance of large manufacturing firms in Nairobi City County. The primary objective was to evaluate the extent to which these firms integrate data-driven strategies into their decision-making processes and the subsequent impact on organizational performance. The study revealed a significant positive relationship between the use of fact-based decisions and improved operational performance. However, this study focused on large manufacturing firms within Nairobi City County, implying that the results' generalizability does not extend to other sectors, such as the health sector, and institutions like KEMSA. Findings from Mkongoh and Kyalo (2023) indicated that poor system integration hinders the performance of public agencies. However, the study did not explicitly explore how fact-based decision impacts performance in specialized organizations like KEMSA, thereby indicating a contextual gap. The study also presents a conceptual gap in that it links management information systems with the performance of public agencies but fails to analyze fact-based decisions as a unique concept. Furthermore, the study lacks theoretical grounding, illustrating an empirical gap. Additionally, Mochanga (2020) pointed out that increased competition and improvements in real-time decision-making resulted from growing interdependence among management information systems. The need to enhance customer satisfaction and improve service

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

delivery timeliness led most organizations to adopt MIS dynamism in their operations. However, the study did not provide or differentiate the specific aspects of fact-based decisions relevant to organizations such as KEMSA.

H_{01} Fact-based decisions have no significant effect on the Performance of the Kenya Medical Supplies Authority

Process-Approach and Performance

Gombe *et al.,* (2024) investigated the effects of process analysis on the performance of Kenyan Huduma Centres. The study focused on various objectives, including resource utilization, cycle time, process-centric decision-making, and strategic alignment. It was grounded in organizational change theory, the balanced scorecard, goal-setting theory, and innovation theory. However, the study failed to adopt Deming's Theory of Quality Management, which is vital in such investigations. The data used in this study were derived from Huduma Centres, implying that the findings may not apply to the healthcare sector, particularly KEMSA. Mohammed (2022) examined large manufacturing firms in Kenya, focusing on the standardization of business processes and operational performance. Mohammed investigated the impact of process-centered approaches on businesses and the extent to which they affect performance within Kenyan manufacturing firms. Various theories provided the foundation for the study, including dynamic capabilities theory, resource-based view, and constraint theory. The research adopted a cross-sectional descriptive research design and collected primary data using semi-structured questionnaires. Stratified random sampling was employed, and descriptive statistics were used for data analysis. The study found that businesses need to identify the specific procedures that enable them to continually add value to customers and shareholders. However, the study explored process standardization without delving into the process-centric approach in the context of Total Quality Management (TQM).

H_{02} Process-centric approach has no significant effect on the Performance of the Kenya Medical Supplies Authority

Relationship Management and Performance

A study by Kiriinya (2021) investigated practices related to the impact of supply chain relationship management on the performance of Kenyan pharmaceutical firms. The study considered process alignment, transparency, collaborative planning, and resilience building. It was grounded in stakeholder theory, systems and network theory, and dynamic capabilities theory. Building future customer relationships is facilitated by attentively considering customer feedback to improve the customer experience. However, the study focused on supply chain relationships within pharmaceutical firms rather than on public health authorities such as KEMSA. The theories used in the study did not

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

explicitly integrate TQM principles, which are essential in managing supply chain relationships. The study also applied descriptive statistics, correlation coefficients, and regression analysis to illustrate a causal connection between relationship management and organizational performance. Oduro et al. (2020) examined the relationship management of suppliers and hospital performance in Ghana, an emerging economy. The study sought to integrate resource dependency theory and social exchange theory to examine dimensions of relationship management and the performance of both public and private hospitals. Establishing mutually beneficial partnerships with strategic supplier partners is crucial for achieving higher-level innovations and gaining a competitive edge. Collaboration with suppliers to enhance processes is essential, and they should be consistently involved in new product development.

H_{03}: Relationship Management has no significant effect on the performance of the Kenya Medical Supplies Authority

Employee Engagement and Performance

Koech and Cheboi (2018) examined the relationship between employee engagement and the performance of technical institutions in Kenya based on an empirical analysis. The study adopted regression analysis to illustrate the connection between variables, using a longitudinal approach. Findings from the study revealed a positive and significant relationship between employee engagement and performance. However, the study focused specifically on technical institutions, which differ significantly from the healthcare sector; hence, the findings cannot be replicated in the current study. Additionally, the study failed to incorporate both quantitative and qualitative approaches to understanding how different job categories evolve. It would have been beneficial if the researchers had introduced a mediating variable, as they focused only on one variable. A moderating variable, such as leadership style, could have been appropriate.

Ibua (2021) examined the impact of employee engagement on the performance of small and medium-sized enterprises (SMEs) in Mombasa County, Kenya. Ibua emphasized that employee engagement is a process that keeps employees involved in an organization and is fundamental to organizational competitiveness. The theoretical underpinnings of the study were the Resource-Based View (RBV) and Hertzberg's Two-Factor Theory of Motivation. The research design was descriptive, incorporating stratified random sampling. Primary data was collected through questionnaires, and hypothesis testing was conducted using Pearson's product-moment correlation. The study found that most SMEs have not yet embraced the concept of employee engagement. Recommendations from the study emphasized the need for thoughtful planning by management to improve

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

employee engagement. However, the research was centered on SMEs in Mombasa County, limiting the generalizability of its findings to other sectors such as healthcare. A conceptual gap also exists, as the study was anchored on only two theories - RBV and Hertzberg's - while neglecting other relevant frameworks such as Deming's Theory of Quality Management. Moreover, the study did not incorporate other regression models or inferential models to explain causality.

Abbas (2020) investigated the impact of TQM on organizational longevity in small and medium-sized enterprises in Pakistan. The study surveyed managers using questionnaires and applied a descriptive approach. Abbas found that TQM was pivotal in augmenting organizational longevity. The study concluded that elements such as information sharing are crucial in supporting TQM, enhancing its contribution to organizational sustainability. However, since the study was conducted in a foreign country, its findings are less applicable in the Kenyan context due to differing cultural, economic, and institutional frameworks. Additionally, the study focused primarily on TQM longevity and did not delve deeply into employee engagement as a key variable. The study also lacked the inclusion of a moderating variable, such as firm size, despite applying a descriptive approach and failing to compare findings with those from another country.

H_{04}: Employee engagement has no significant effect on the Performance of the Kenya Medical Supplies Authority

Methods

Research designs can be categorized as exploratory, descriptive, and explanatory (Saunders et al., 2019; Bell et al., 2015; Muathe, 2010; Creswell & Creswell, 2018). This study adopted a descriptive research design to examine how the implementation of TQM and organizational performance at KEMSA are related. The design was appropriate as it allowed for the quantitative assessment of perceptions and practices within the organization. Additionally, it enabled the generalization of findings across the target population while providing a structured framework that helps in current practices and performance analysis. Descriptive design is appropriate in research because it presents the current state of affairs and identifies areas that require improvement in the public sector. (Saunders et al., 2019).

The target population for this study comprised different levels of management from KEMSA headquarters in Nairobi City County. Management levels included top-level management - comprising the Chief Executive Officer, Directors in various departments, and board members - middle-level management comprising departmental managers, assistant managers, and senior officers, and operational-level officers, including those

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

in finance, logistics, IT, procurement, warehouse, and quality assurance departments.

Proportionate stratified and random sampling techniques were employed to ensure that key subgroups within the target population were proportionately represented in the sample. This approach is particularly appropriate when the population is heterogeneous, as it enhances the precision of estimates by ensuring that diverse characteristics - such as roles, experience levels, or departments - are adequately captured (Makwana, *et al.,* 2023). The population was divided into mutually exclusive strata, and random samples were drawn from each stratum based on their relative size. This method improves the representativeness and reliability of the sample compared to simple random sampling.

To determine the appropriate sample size, Yamane's (1967) formula was applied, which is suitable for large populations and when a known margin of error is considered. The formula is expressed as:

$$n= N/ [1+N (e) 2]$$
$$n= 330/ [1+330 (0.05)2]$$
$$330/ (1+330 (0.0025)$$
$$330/1.825$$
$$n= 181$$

The procedure for collecting data began with obtaining an authority and a research permit from Kenyatta University and the National Commission for Science, Technology and Innovation (NACOSTI), respectively. Primary data was collected using structured questionnaires.

The collected data was first cleaned and coded in Excel. Data analysis was conducted quantitatively, incorporating both descriptive statistical approaches (mean, median, mode, and standard deviation) and inferential statistical methods, including correlation and regression analysis, using SPSS version 25. The regression analysis aimed to illustrate the effect of TQM dimensions on performance, as outlined in the Model.

To ensure clarity in operationalization, the study used a structured questionnaire based on established literature. Each Total Quality Management (TQM) principle was represented by a set of five Likert-scale items adapted from empirical studies as presented in Appendix A. The questionnaire was validated through expert review and a pilot test conducted with 15 respondents from KEMSA, who were not included in the final sample. Reliability analysis was performed, and all constructs met the acceptable Cronbach's alpha threshold of 0.70.

The raw scores from individual items for each variable (e.g., X1 = Fact-Based Decisions) were averaged to generate a composite score, which was then used in inferential statistical analyses. These variables were then

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

entered into a multiple linear regression model to determine their effect on organizational performance (Y).

$$Y=\beta0+\beta1X1+\beta2X2+\beta3X3+\beta4X4+\varepsilon\ldots\ldots\ldots\text{Model}$$

Where:

Y = Organizational performance (dependent variable)
X1 = Fact-based decisions
X2 = Process-centric approach
X3 = Relationship management
X4 = Employee engagement
β0, β1, β2, β3, β4 = Beta Coefficients
ε = Error term

Research Findings and Discussion

A total of 181 questionnaires were presented to the respondents. Out of these, 140 questionnaires were duly filled and returned, yielding a response rate of 77.3%, which was deemed sufficient for analysis, as per Mugenda and Mugenda (2019), who recommend a response rate of 70% and above.

Demographic Characteristics of Respondents

Understanding the demographic characteristics of respondents is essential in contextualizing the research findings and interpreting how personal and professional attributes may influence perceptions and behaviors regarding TQM practices. This section presents a summary of key demographic variables, including respondents' age, level of education, work experience, and management level. These characteristics help identify trends, draw comparisons, and explain variations in responses related to organizational performance. The demographic profile also ensures that the data collected is representative of the population under study, thereby enhancing the reliability and relevance of the research outcomes (Saunders, Lewis, & Thornhill, 2019).

Age distribution data was collected to assess how generational differences may influence perceptions and engagement with Total Quality Management (TQM) practices at KEMSA. Respondents were categorized into relevant age brackets to facilitate comparative analysis across different age groups. This variable, presented in Table 1, is important for understanding how factors such as experience, maturity, adaptability to change, and familiarity with digital systems might influence the adoption and effectiveness of quality management initiatives.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 1. Age Distribution

Years	**Frequency**	**Percent**
18-30	16	11.4
31-40 years	64	45.7
41-50 years	49	35.0
>50	11	7.9
Total	**140**	**100.0**

Source: Survey data, 2025

The study established that the majority of respondents were between 31-40 years (45.7%), followed by those aged 41-50 years (35.0%), 18-30 years (11.4%), and 50 years and above (7.9%). This indicates that most respondents were within the mature working-age bracket, indicating a workforce with potentially significant experience and responsibility levels. The study further outlined the age distribution of respondents by gender, offering additional context to demographic patterns across KEMSA.

Gender Distribution by Educational Level

An analysis of the educational qualifications of KEMSA staff by gender reveals both parity and variation in access to higher education between male and female employees. These insights are presented in Table 2.

Table 2. Gender Distribution by Educational Level

		Education				**Total**
		Certificate	Diploma	Degree	Masters	
Gender	Male	11	16	30	13	70
	Female	3	17	36	14	70
Total		14	33	66	27	140

Source: Survey data, 2025

Among male respondents, the highest proportion held a bachelor's degree (n = 30; 42.9%), followed by those with a diploma (n = 16; 22.9%) and a master's degree (n = 13; 18.6%). A smaller number had certificate-level qualifications (n = 11; 15.7%). Similarly, among female respondents, the largest group also held a bachelor's degree (n = 36; 51.4%), followed by diploma holders (n = 17; 24.3%) and those with a master's degree (n = 14; 20%). Only three female respondents (4.3%) possessed certificate-level qualifications, significantly fewer than their male counterparts. This distribution suggests a generally higher academic qualification among female employees, particularly at the degree level, where females outnumber males (36 vs. 30). Furthermore, the near parity in the number of master's degree holders (14 females vs. 13 males) reflects gender balance at the postgraduate level.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Inferential Statistics

Inferential statistics was employed to infer the wider population based on the sample data in alignment with the study's objectives. Specifically, correlation analysis and regression analysis were conducted to determine the strength, direction, and significance of relationships among the study variables.

Correlation Analysis

In the context of public health supply chain organizations such as KEMSA, understanding the interplay between internal management practices and performance outcomes is crucial for institutional sustainability and the effectiveness of service delivery. Recent empirical studies emphasize that organizational performance is increasingly shaped by soft factors, including employee engagement, structured processes, data-informed decision-making, and relational dynamics (Mabey et al., 2023).

Table 3. Correlation Analysis

		1	2	3	4	5
Fact-Based Decisions	Pearson Correlation	1				
Process-Centric Approach	Pearson Correlation	.713**	1			
Relationship Management	Pearson Correlation	.399**	.465**	1		
Employee Engagement	Pearson Correlation	.454**	.558**	.451**	1	
Performance	Pearson Correlation	0.114	0.160	0.000	.169*	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Source: Survey data, 2025

The correlation results in Table 3 highlight the relationships among the five key constructs within KEMSA. A strong, positive, and statistically significant correlation exists between Fact-Based Decisions and Process-Centric Approach ($r = .713$, $p < .01$), indicating that institutions relying on data-driven strategies are more likely to streamline their internal processes for efficiency. Similarly, Employee Engagement demonstrated moderate-to-strong positive correlations with both Process-Centric Approach ($r = .558$, $p < .01$) and Relationship Management ($r = .451$, $p < .01$). These findings suggest that higher levels of employee involvement are associated with improved collaboration and stronger adherence to structured procedures.

Interestingly, Employee Engagement is the only variable showing a statistically significant correlation with Organizational Performance ($r = .169$, $p = .046$), though the strength of this relationship is weak. This implies that employee morale and participation may have a modest but meaningful influence on organizational outcomes. On the other hand, Fact-Based Decisions ($r = .114$, $p = .182$) and Process-Centric Approach ($r = .160$, $p = .059$) exhibit positive but statistically insignificant correlations with

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

performance. This suggests that while these practices are crucial to institutional operations, their direct impact on performance may be mediated by other factors such as leadership dynamics, resource allocation, or external regulatory influences.

Surprisingly, Relationship Management showed no significant correlation with performance ($r = .000$, $p = .996$). This result implies that stakeholder relationships are not perceived to have a direct impact on organizational performance from the internal perspective of KEMSA staff. This finding contrasts with prior literature, such as Nguyen et al. (2023), which emphasized the importance of stakeholder engagement in public sector performance. Overall, these results underscore the importance of strengthening the performance linkages of strategic practices, particularly by leveraging employee engagement as a critical driver of institutional success.

Regression Analysis

To establish the effect of the independent variables on the dependent variable, multiple linear regression analysis was used to test the four hypotheses. The results are presented in Tables 4, 5, and 6 below.

Table 4 presents the model summary, which includes the four independent variables collectively explaining approximately 58.5% of the variance in organizational performance ($R^2 = 0.585$, Adjusted $R^2 = 0.572$), suggesting a strong model fit. The standard error of the estimate was relatively low at 0.458, reflecting a consistent and reliable prediction of performance outcomes based on the included TQM dimensions. The finding reinforces the model's robustness in explaining organizational performance within a public healthcare supply chain context, such as KEMSA

Table 4. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.765	0.585	0.572	0.458

Source: Survey data, 2025

ANOVA Results

This analysis was significant in testing whether the combined effect of the independent variables on the dependent variable is statistically significant, as presented in Table 5.

Table 5. Anova

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	46.210	4	11.553	55.036	0.000
Residual	32.790	135	0.243		
Total	79.000	139			

Source: Survey data, 2025

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The Sum of Squares for the regression (46.210) reflects the variation in performance explained by the four independent variables, while the Residual Sum of Squares (32.790) represents the variation that remains unexplained by the model. The Total Sum of Squares (79.000) captures the total variability in the dependent variable. The high F-statistic value and low significance level indicate a strong model fit, reinforcing the findings from the model summary, which demonstrated that the model accounts for approximately 58.5% of the variance in performance. This further supports the reliability of the identified predictors in explaining organizational performance. The significant results confirm that the combined effect of the predictors is meaningful, providing a robust foundation for strategic decision-making within the organization.

Table 6. Regression Coefficients

Variable	Unstandardized Coefficients (B)	Std. Error	Beta	T	Sig.
(Constant)	1.003	0.302		3.322	0.001
Fact-Based Decisions	0.372	0.071	0.338	5.239	0.000
Process-Centric Approach	0.319	0.068	0.298	4.691	0.000
Relationship Management	0.257	0.082	0.223	3.134	0.002
Employee Engagement	0.348	0.075	0.305	4.640	0.000

Source Survey Data, 2025

The following hypotheses, which were conceptualized in chapter two, were tested:

- H_{01} Fact-based decision has no significant effect on the Performance of the Kenya Medical Supplies Authority.
- H_{02} Process-centric approach has no significant effect on the Performance of the Kenya Medical Supplies Authority.
- H_{03} Relationship management has no significant effect on the performance of the Kenya Medical Supplies Authority.
- H_{04} Employee engagement has no significant effect on the Performance of the Kenya Medical Supplies Authority

The regression analysis results in Table 6 provide empirical evidence of how different Total Quality Management (TQM) practices influence organizational performance at KEMSA. The model shows that fact-based decisions significantly predicts performance outcomes ($B = 0.372$, $\beta = 0.338$, $p < 0.001$). This finding suggests that data-driven decisions enhance efficiency and strategic alignment - a result consistent with other studies that emphasize the integration of data into decision-making as a driver of organizational effectiveness (AlKetbi et al., 2020; Kopeć et al., 2022). These findings further

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

corroborate Bungei's (2022) conclusion that adopting a data-driven approach enhances operational performance in manufacturing firms. Additionally, Mkongoh and Kyalo (2023) found that poor data system integration hindered public agency performance, indirectly highlighting the need for a structured data-use system. However, their failure to isolate fact-based decisions introduces a conceptual gap, which the present study bridges by isolating and quantifying its contribution. Mochanga (2020) also emphasized real-time decision-making enabled by MIS, further supporting the significance of factual/data-based decisions in boosting organizational effectiveness and performance.

The results show that the process-centric approach also had a strong positive effect (B = 0.319, β = 0.298, $p < 0.001$). This underlines the importance of standardized, well-documented procedures in ensuring consistency and minimizing operational inefficiencies - an observation supported by Nguyen & Mohamed's (2021) study, which highlighted how process optimization leads to better service quality and operational resilience in public institutions. The findings also confirm Mohammed's (2022) conclusions that process standardization boosts client value and performance. Gombe et al. (2024) similarly reported that process-centric decisions and cycle time optimization improve public service delivery, aligning well with KEMSA's operational objectives. This study's findings demonstrate, within a healthcare distribution context, how TQM's process focus can significantly influence institutional performance.

Findings on employee engagement (B = 0.348, β = 0.305, $p < 0.001$) also emerged as another key predictor of performance. Organizations that promote participatory leadership and empower staff report higher performance levels, as employees are often motivated, productive, and committed to their work (Memon et al., 2020). This aligns with the study of Zaman et al. (2023), which indicated that engaged workforces drive innovation and adaptability, especially in dynamic environments. Other previous studies - Koech and Cheboi (2018) - also pointed to positive relationships in technical institutions and highlighted that engaged employees are critical to SME competitiveness, respectively.

Relationship management also significantly influenced performance (B = 0.257, β = 0.223, $p = 0.002$), confirming that strong collaborations with suppliers, partners, and stakeholders are essential for effective public service delivery. This finding echoes recent empirical research that links strategic stakeholder engagement with improved institutional trust and performance (Chen et al., 2022). The findings also support Kiriinya's (2021) study, which established a positive link between supply chain collaboration and firm performance in the pharmaceutical sector. Similarly, Oduro et al. (2020)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

confirmed that effective supplier relationships are essential for innovation and competitiveness.

The results indicate that all four TQM constructs considerably influence organizational performance at KEMSA. While correlation analysis suggested weak or non-significant relationships between some constructs and performance, regression analysis revealed their unique predictive contributions when controlling for other variables. This contrast illustrates the complex nature of organizational performance, which may be shaped by multiple interacting factors. Notably, the strong beta weights for fact-based decisions and employee engagement suggest these two areas are the most immediate levers for improving performance outcomes. The absence of a strong bivariate correlation for relationship management may imply that its influence is indirect, possibly mediated by process efficiency or moderated by internal culture.

Conclusion

Fact-based decisions significantly influence organizational performance. The study revealed that employees at KEMSA appreciate the use of data to guide operational and strategic decisions, reflecting a strong understanding of the value of accurate information in optimizing resource allocation, reducing errors, and improving service quality. This alignment with data-driven decisions supports greater accountability and transparency within the organization, which are essential for achieving operational excellence. The process-centric approach was found to be positively impacting performance by promoting consistency and reducing operational variability.

Clearly defined and standardized processes contribute to efficient workflows, improved resource utilization, and enhanced service quality. However, the study identified a need for targeted training and mentorship, particularly for junior and less experienced staff, to bridge the knowledge gap and ensure organization-wide adherence to these best practices. Relationship management emerged as a crucial element in enhancing organizational cohesion and productivity. Effective communication, collaboration, and trust among staff members were associated with better team dynamics and a supportive work environment. However, the findings indicated that senior staff benefit more from these interpersonal relationships, suggesting a need for more inclusive relationship-building efforts across all organizational levels.

Employee engagement was confirmed as a significant driver of performance. Actively involving employees in decision-making and recognizing their contributions as well as their qualifications fosters commitment, motivation, and job satisfaction, ultimately leading to higher organizational performance. However, the study highlighted the need for more inclusive engagement practices to address the concerns of junior staff who

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

may feel less involved in decision-making. The study confirms that TQM practices collectively contribute to enhanced organizational performance. To sustain these improvements, KEMSA must continue to champion a quality-driven culture, promote participatory leadership, and invest in ongoing staff development.

Policy Recommendations

Based on the study's objectives, several recommendations are proposed to enhance the performance of the Kenya Medical Supplies Authority (KEMSA) through the effective implementation of Total Quality Management (TQM) practices. Regarding fact-based decisions, it is recommended that KEMSA leadership establish a structured framework for TQM training across all levels of the organization. This framework should incorporate regular refresher courses to reinforce employees' understanding of quality management tools and data-driven decisions. Furthermore, departmental heads should integrate quality targets into annual performance evaluations to ensure accountability, track improvements, and support a culture that embraces data-informed decisions.

Concerning the process-centric approach**,** middle-level managers and process supervisors should ensure that processes are consistently communicated and reinforced through structured workshops and on-the-job training. Special attention should be given to onboarding and supporting junior staff through routine orientation and training programs that emphasize the organization's process standards. Additionally, regular capacity-building sessions should be held to promote standardized workflows and continuous improvement across departments.

Regarding relationship management**,** senior management should initiate mentorship programs that foster participatory leadership. These programs should be designed to enhance collaboration between senior and junior staff, facilitating knowledge transfer, team cohesion, and improved communication across the organization. Furthermore, the Human Resource Department should formalize coaching programs by pairing experienced staff with new or junior employees, enabling smoother integration and consistent relationship building within teams.

Lastly, in terms of employee engagement**,** the organization should conduct frequent evaluations of human resource utilization. This will help in identifying challenges in optimizing the utilization of human capital, finances, and operational resources, thereby enhancing employee motivation and institutional performance. Job enrichment and enlargement should align with academic and professional qualifications and roles to ensure that employees feel valued, thereby improving the organization's performance. Collectively, these recommendations, if implemented effectively, are expected to

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

significantly improve service delivery and align KEMSA's operations and core values with public health priorities.

Limitations and Future Research Direction

While the study achieved a strong response rate and used a validated questionnaire, several limitations persist. The cross-sectional design restricts causal inference, and the use of self-reported data may introduce bias. Construct validity was not tested through factor analysis.

Methodologically, the study did not include diagnostic tests for multicollinearity or endogeneity, nor did it control for relevant background variables. These omissions limit the robustness of the regression model. Future research should apply more rigorous econometric techniques, including control variables, diagnostic testing, and longitudinal designs, to enhance the reliability and generalizability of findings.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

Funding Statement: The authors did not obtain any funding for this research.

Declaration for Human Participants: This research followed the guidelines for research and ethics involving human subjects underscored by the Kenyan Ministry of Education and the National Commission for Science, Technology and Innovation. The research was approved by the Graduate School Board of Kenyatta University, Kenya.

References:

1. Abbas, J. (2020). Impact of total quality management on corporate sustainability through the mediating effect of knowledge management. *Journal of Cleaner Production, 244,* 118806.
2. Agarwal, A., Shankar, R., & Tiwari, M. K. (2018). Enhancing healthcare logistics performance through efficient procurement, distribution, and warehousing: An integrated approach. Journal of Supply Chain Management, 54(2), 135–150. https://doi.org/10.1002/jscm.2018.54.2.135
3. Ajmal, M., Isha, A. S. N., Nordin, S. M., Kanwal, N., Al-Mekhlafi, A. B. A., & Naji, G. M. A. (2020). A conceptual framework for the determinants of organizational agility: Does safety commitment matter? *Solid State Technol*, *63*(6), 4112-4119.
4. Alfina, K. N., Ratnayake, R. C., Wibisono, D., Basri, M. H., & Mulyono, N. B. (2024). Prioritizing Performance Indicators for the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Circular Economy Transition in Healthcare Supply Chains. *Circular Economy and Sustainability*, 1-46.

5. Alghamdi, Omar A., & Agag, G. (2024). Competitive advantage: A longitudinal analysis of the roles of data-driven innovation capabilities, marketing agility, and market turbulence. *Journal of Retailing and Consumer Services*, *76*, 103547. https://doi.org/10.1016/j.jretconser.2023.103547
6. AlKetbi, L. M., Al Shamsi, A., & Ajmal, M. (2020). The role of data analytics in decision-making and organizational performance. *International Journal of Business Excellence*, 21(3), 325–342.
7. Bell, E., Bryman, A., & Harley, B. (2015). Business Research Methods (6th Ed.). Oxford University Press.
8. Bridoux, F. & Stoelhorst, J. W. (2022). Stakeholder theory, strategy, and organization: Past, present, and future. Strategic Organization, 20(4), 797-809.
9. Bungei, H. (2022). *Decision-Making Approaches and Operational Performance of Large Manufacturing Firms in Nairobi County* (Doctoral dissertation, University of Nairobi).
10. Chen, J., Xu, L., & Zhang, W. (2022). Strategic relationship management and public sector performance: Evidence from supply chain partners. *Public Management Review*, 24(6), 919–938.
11. Chowdhury, M. M. H. & Quaddus, M. (2017). Supply chain resilience: Conceptualization and scale development using dynamic capability theory. *International journal of production economics, 188,* 185-204.
12. Creswell, J. W. & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (5th Ed.). SAGE Publications.
13. Deming, W. E. (1982). Out of crisis. Cambridge, MA: Massachusetts Institute of Technology, Centre for Advanced Engineering Study.
14. Dogan, O. (2023). Process-centric performance management in a call center. *Applied Intelligence*, 53(3), 3304-3317.
15. Ezeh, M. O., Ogbu, A. D., Ikevuje, A. H., & George, E. P.-E. (2024). Stakeholder engagement and influence: Strategies for successful energy projects. *International Journal of Management & Entrepreneurship Research*, *6*(7), 2375–2395. https://doi.org/10.51594/ijmer.v6i7.1330
16. Firdaus, R. H. & Irfan, A. (2023). From Compliance to Excellence: The TQM Story in Indonesian Health Service Providers. In *International Conference on Business Management and Accounting* (Vol. 2, No. 1, pp. 9-17).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

17. Foster, D. & Jonker, J. (2003). Third generation quality management: the role of stakeholders in integrating business into society. *Managerial Auditing Journal, 18*(4), 323-328.
18. Gabra, S., Yousef, H., & Abood, S. A. (2019). Relationship between Empowerment and Motivation among Staff Nurses in Minia University Hospital. *Journal of Nursing and Health Science 8*(2), 57-64.
19. Gatiti, P., Ndirangu, E., Mwangi, J., Mwanzu, A., & Ramadhani, T. (2021). Enhancing healthcare quality in hospitals through electronic health records: a systematic review. *Libraries*.
20. Githuku, M. W. (2015). *Total quality management in Kenyan healthcare industry* (Doctoral dissertation, University of Nairobi).
21. Gombe, C. A., Wasike, S., & Abraham, K. A. D. K. (2024). Influence of process analysis on organizational performance of Huduma centers in Kenya. *Cuea Journal of Business and Economics*, *2*(1).
22. Gupta, C. & Belokar, R. M. (2014). Applications of total quality management in the Indian airline industry. *International Journal of Science and Research*, *3*(5), 1077-1081. Applications of total quality management in the Indian airline industry
23. Gutterman, A. S. (2023). Organizational performance and effectiveness. Available at SSRN 4532570.
24. Halawi, L., Aronson, J., & McCarthy, R. (2005). Resource-Based View of Knowledge Management for Competitive Advantage. The Electronic Journal of Knowledge Management, 3(2): 75-86.
25. Ibua, M. P. (2021). Effect of employee engagement on the performance of small and medium-sized enterprises in Mombasa County, Kenya. *Multidisciplinary Journal of Technical University of Mombasa, 1*(2), 5-17.
26. Jaca, C. & Psomas, E. (2015). Total quality management practices and performance outcomes in Spanish service companies. *Total Quality Management & Business Excellence*, *26*(9-10), 958-970.
27. Jiang, W., Chai, H., Shao, J., & Feng, T. (2018). Green entrepreneurial orientation for enhancing firm performance: A dynamic capability perspective. Journal of Cleaner Production, 198, 1311-1323.
28. Joseph, K. N., Mwenda, L., & Wachira, A. (2024). Role of Employee Commitment in Total Quality Management on Performance of Institutions of Higher Learning in Kenya. *East African Journal of Education Studies, 7(2), 19-28.*
29. Kanyangi, F. (2018). *Distribution Strategies and Performance of Kenya Medical Supplies Authority* (Doctoral dissertation, University of Nairobi).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

30. Kinyua, M. G., Muathe, S. M., & Kilika, M. J. (2015). Influence of Knowledge Transfer and Knowledge Conversion on Performance of Commercial Banks in Kenya. Science Journal of Business and Management, 3(6): 228-234.
31. Kiriinya, A. E. (2021). *Supply Chain Relationship Management Practices and Performance of Pharmaceutical Firms in Kenya* (Doctoral dissertation, JKUAT-COHRED).
32. Kithinji, V. M. (2019). Total Quality Management Strategies and Employee Performance in Referral Hospitals in Kenya: A Case of Kenyatta National Hospital (Doctoral dissertation, Kenyatta University).
33. Koech, C. J. S. & Cheboi, J. (2018). An empirical analysis of employee engagement on employee performance in technical institutions in Kenya. *International Journal of Advances in Management and Economics*. https://managementjournal.info/index.php/IJAME/article/view/99
34. Kopeć, K., Kędzior, M., & Kowalski, A. M. (2022). Evidence-based decision making and digital transformation in public administration. *Sustainability*, 14(2), 687.
35. Kurgat, G. K. & Deya, J. (2023). Data forecasting strategies and competitive advantage of savings and credit cooperative societies in Nairobi City County, Kenya. *International Journal of Social Sciences Management and Entrepreneurship (IJSSME)*, *7*(2).
36. Li, W., Pomegne, W. W. K., Dogbe, C. S. K., & Novixoxo, J. D. (2019). Employees' customer orientation and customer satisfaction in the public utility sector: The mediating role of service quality. *African Journal of Economic and Management Studies 5(*3), 23-31
37. Mabey, C., Ramirez, M., & Lewin, D. (2023). *Strategic human resource management and performance in the public sector: New evidence and emerging insights*. Public Management Review, 25(5), 823–840. https://doi.org/10.1080/14719037.2022.2108695
38. Madhani, P. M. (2010). Resource-Based View (RBV) of Competitive Advantage. An Overview. The Icfai University Press, 1-22.
39. Makwana, D., Engineer, P., Dabhi, A., & Chudasama, H. (2023). Sampling methods in research: a review. Int. J. Trend Sci. Res. Dev. 7, 762–768
40. Memon, M. A., Salleh, R., Baharom, M. N. R., & Ting, H. (2020). Linking participative leadership to employee engagement: The role of organizational culture. *Global Business Review*, 21(3), 652–667.
41. Min, B. H. & Oh, Y. (2020). How do performance gaps affect improvement in organizational performance? Exploring the mediating

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

roles of proactive activities. *Public Performance & Management Review*, *43*(4), 766-789.

42. Mkongoh, R. M. & Kyalo, J. (2023). Adoption of management information systems and performance of public agencies in Mombasa County, Kenya. *The Strategic Journal of Business & Change Management*, *10*(4), 811-828.
43. Mochanga, J. A. (2020). *Management information systems dynamics and performance of Mtongwe base of the Kenya Navy* (Doctoral dissertation, Kenyatta University).
44. Mohammed, H. A. (2022). *Business Process Standardization and Operational Performance of Large Manufacturing Firms in Kenya* (Doctoral dissertation, University of Nairobi).
45. Muathe, S.M.A. (2010). The Determinants of Adoption of Information and Communication Technology by Small and Medium Enterprises within the Health Sector in Nairobi, Kenya. Unpublished PhD Thesis, Kenyatta University
46. Mugenda, O. M. & Mugenda, A. G. (2019). Research methods: Quantitative and Qualitative Approaches, Acts Press, Nairobi-Kenya.
47. Nding'uri, D. M. (2019). *Strategic change management practices and performance of Kenya Medical Supplies Authority in Nairobi City County, Kenya* (Doctoral dissertation, Kenyatta University).
48. Nguyen, T. M., Simkin, L., & Canhoto, A. I. (2023). *Stakeholder orientation and performance in public sector organizations: A strategic management perspective.* Journal of Public Administration Research and Theory, 33(1), 112–130. https://doi.org/10.1093/jopart/muac012
49. Nguyen, T. T. & Mohamed, S. (2021). The role of process standardization in improving service delivery in public sector institutions. *Government Information Quarterly*, 38(2), 101574.
50. Nigam, S. (2005). *Total quality management: an integrated approach.* Excel Books India.
51. Njuguna, M. W. & Muathe, S. (2020). Strategic Choice and Performance: Empirical Evidence from Mission Hospitals in Kiambu County, Kenya. *European Scientific Journal, 16*, 16.
52. Nyaboga, J. M. & Muathe, S. M. (2024). Understanding performance of public hospitals: Operational strategies approach in Kajiado County, Kenya. *International Journal of Research in Business and Social Science, 13*(4), 134-146.
53. Oakley, M. A. R. K. (2011). Organizing design activities. *The Handbook of Design Management, 2nd ed. London: Bloomsbury Academic*, 74-86.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

54. Oduro, S., Nyarku, K. M., & Gbadeyan, R. A. (2020). Supplier relationship management and organizational performance of hospitals in an emerging economy context: A comparative study. *Journal of Modelling in Management*, *15*(4), 1451-1478
55. Omore, J. A. (2022).*Effect of Total Quality Management (TQM) Practices on Service Delivery in the Health Sector in Nairobi County, Kenya* (Doctoral dissertation, KCA University).
56. Otieno, N. A., Malik, F. A., Nganga, S. W., Wairimu, W. N., Ouma, D. O., Bigingo, G. M., …& Omer, S. B. (2021). The decision-making process for the introduction of maternal vaccines in Kenya, 2017-2018. *Implementation Science, 16*, 1-15.
57. Penrose, E. (1959). Contributions of the Resource-Based View of Strategic Management, *Journal of Management Studies, 41*(1), 183-191.
58. Ross, J. E. (2017). *Total quality management: Text, cases, and readings*. Routledge.
59. Salil, C., Musau, E., & Kurere, C. (2024). Ethical procurement practices, lead-time variation, and organizational performance: evidence from Kenya Medical Supplies Authority (KEMSA). *International Academic Journal of Procurement and Supply Chain Management, 3 (2)*, 356-367.
60. Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students* (8th Ed.). Pearson Education.
61. Shukla, R. K., Garg, D., & Agarwal, A. (2018). Modeling supply chain coordination for performance improvement using an analytical network process-based approach. *International Journal of Business Excellence*, *14*(1), 18-48.
62. Talib, N. A. C., Abd Razak, N., & Mahmud, N. (2023). Enhancing Small and Medium Enterprise Performance through Supply Chain Integration: A Case Study of Malaysia. *Information Management and Business Review*, *15*(3 (I)), 405-417.
63. Teece, D. J. (1997). Dynamic capabilities and (digital) platform lifecycles. In Entrepreneurship, innovation, and platforms. Emerald Publishing Limited.
64. Tenji, T. & Foley, A. (2019). Testing the readiness of an organizational culture profile for a TQM implementation. *The TQM Journal*, *31*(3), 400-416.
65. Utami, H.& Alamanos, E. (2025) Resource-Based Theory: A review. In S. Papagiannidis (Ed.), Theory Hub Book. Available at https://open.ncl.ac.uk / ISBN: 9781739604400
66. Wakuthii, R. N. (2019). Factors influencing procurement of materials in parastatals, a case study of Kenya Medical Supplies Agency,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

KEMSA. Retrieved from https://ir.gretsauniversity.ac.ke/bitstream/handle/20.500.12736/1894/BUS-4-2276-17%

67. Wamoto, E., Kwasira, J., & Ndolo, J. (2023). Relationship between Demand Forecasting and Operational Performance of Stores Function in Commercial State Corporations in Kenya. *The International Journal of Business Management and Technology*, *7*(1), 561-569.
68. Wandie, R. W. & Muathe, S.M. (2022). What enhances service delivery in public hospitals in Kenya? The role of total quality management practices. *International Journal of Research in Business & Social Science 11*(7).
69. White, K. M., Dudley-Brown, S., & Terhaar, M. F. (Eds.). (2024). *Translation of evidence into nursing and healthcare*. Springer Publishing Company.
70. Zaman, U., Elahi, M., & Nisar, Q. A. (2023). Engaged and agile: Linking employee engagement to organizational agility in healthcare logistics. *Journal of Health Management*, 25(1), 10–25.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Appendix A: Survey Instrument Summary Table

This table summarizes the questionnaire items used to measure the independent and dependent variables in the study

Each item was measured using a 5-point Likert scale: (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Variable	Code	Sample Item (1 out 5)	No. of Items	Source/Adapted From
Fact-Based Decisions	X1	Decisions in my department are based on verified data.	5	Otieno et al. (2021); Bungei (2022)
Process-Centric Approach	X2	Our procedures are well documented and standardized.	5	Dogan (2023); Gombe et al. (2024)
Relationship Management	X3	We have strong, collaborative relationships with our suppliers.	5	Kiarie et al. (2024); Oduro et al. (2020)
Employee Engagement	X4	I feel involved in decision-making in my department."	5	Gabra et al. (2019); Li et al. (2019)
Organizational Performance	Y	Service delivery targets are consistently met.	5	Joseph et al. (2024); Gutterman (2023)

Each construct was measured by computing the average score across its respective items.

These composite variables (X1, X2, X3, X4, Y) were then used in regression and correlation analysis.

ESJ Social Sciences Peer-reviewed

Determinants of Competitiveness Among Georgian Commercial Banks in the Financial Market

Natia Gadelia
Grigol Robakidze University, Georgia

Doi:10.19044/esj.2025.v21n19p121

Submitted: 22 November 2024
Accepted: 15 July 2025
Published: 31 July 2025

Cite As:
Gadelia, N. (2025). *Determinants of Competitiveness Among Georgian Commercial Banks in the Financial Market.* European Scientific Journal, ESJ, 21 (19), 121.
https://doi.org/10.19044/esj.2025.v21n19p121

Abstract

This study investigates the competitiveness of Georgian commercial banks by examining their financial performance, market positioning, and the role of innovation in achieving and maintaining market leadership. A stable and efficient banking sector is fundamental to a country's economic health, as commercial banks facilitate the allocation of financial resources and support sustainable growth. However, bank failures can pose systemic risks and undermine public trust. The research employs a mixed-method approach, combining quantitative analysis of key financial indicators with qualitative assessment through structured interviews with banking professionals. The financial data was collected from annual reports and official statistics of leading Georgian banks, while interviews provided insights into strategic management practices and innovation-driven competitiveness. The results indicate that JSC TBC Bank and JSC Bank of Georgia have maintained strong market positions through diversified financial services, customer-centric innovations, and strategic segmentation. Furthermore, banks like JSC ProCredit Bank and JSC Credo Bank have established niche competitiveness by focusing on SME lending and inclusive finance models. The findings highlight that technological adaptation, effective risk management, and customer satisfaction are critical determinants of competitiveness in the Georgian banking sector. In conclusion, the study reveals that both financial robustness and non-financial capabilities, such as innovation and managerial efficiency, contribute significantly to the sustained competitiveness of

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Georgian commercial banks in an increasingly dynamic and globalized financial market.

Keywords: Georgian commercial banks, competitiveness, financial performance, market positioning, innovation, banking sector, risk management, financial stability, customer satisfaction, investor confidence, qualitative and quantitative analysis

Introduction

The problem of the issue: The problem addressed in this research is the challenge faced by Georgian commercial banks in maintaining and strengthening their competitiveness in an increasingly dynamic and globalized financial environment. Despite growth in the banking sector, many banks struggle to integrate financial innovations, optimize management structures, and effectively assess risks, which can hinder their ability to lead the market. Understanding the key factors affecting the competitiveness of Georgian commercial banks is crucial for ensuring their long-term sustainability and their contribution to the country's economic stability.

Relevance of the Topic: A well-functioning banking sector is a key prerequisite for a country's financial stability. If commercial banks are able to efficiently perform their intermediary function, they will facilitate the flow of finances within society and the economy as a whole, saving time and resources for both savers and borrowers. On the other hand, the bankruptcy of a bank could cause serious harm not only to its clients but also to the entire financial sector and the national economy. Therefore, it is essential to study the factors and indicators that determine the competitiveness of Georgian commercial banks, as well as the methods they use to achieve and maintain their position in the financial market. The banking sector in Georgia has undergone significant development since the 19th century, and today, commercial banks offer a wide range of services to customers. A strong banking system promotes the advancement of all sectors and individuals, having a direct impact on every participant in a market economy. Currently, the National Bank of Georgia supervises commercial banks and the entire financial sector, with its status defined by the country's Constitution. It is equally important for commercial banks to consistently assess the market accurately and position themselves in a way that ensures competitiveness.

Research Objective: The aim of the research is to evaluate the competitiveness of Georgian commercial banks, identify which banks hold leading positions in the financial market, and determine the factors contributing to their leadership.

Based on the research objective, the following tasks have been set to assess the key areas of market positioning:

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

✓ Analyze the competitiveness of commercial banks in the Georgian financial market from two perspectives: that of the customer and the investor. In the first case, the focus is on the diversity and quality of services offered, marketing activities, and technological innovations. From the investor's perspective, the focus shifts to financial indicators such as Return on Equity (ROE), Return on Assets (ROA), net profit, loan and deposit volumes, and market share in the banking sector.

✓ Additionally, for both groups, it is important to consider the bank's international rating and image. It is also worth exploring the appeal of Credo Bank and Liberty Bank. From the perspective of an employee of ProCredit Bank, it was interesting to analyze and compare the competitiveness of commercial banks. The ability to attract capital through representation on international stock exchanges also contributes to the competitiveness of commercial banks. Moreover, another task is to define the role of sound banking management and organizational structure, assess various types of risks, and choose a management strategy for them by the relevant department.

✓ Finally, the role of innovation as a tool for competitiveness will be evaluated. In recent years, the banking sector has undergone changes in this area. The paper will review modern trends in the banking system globally and in Georgia, as well as the concept of direct banking and its global development.

Research Hypothesis: Georgian commercial banks that effectively combine financial innovations and strategic risk management practices achieve higher competitiveness in the financial market, which is reflected in superior financial indicators, increased market share, and trust from both clients and investors.

Research Subject: The subject of this research is the assessment of the competitive dynamics of Georgian commercial banks through financial indicators, the adoption of innovations, and strategic market positioning.

Research Object: The object of this research is Georgian commercial banks and their financial indicators.

Literature Review

The concept of competitiveness within the banking sector has been the subject of extensive theoretical and empirical inquiry. Scholars generally agree that competitiveness is a multidimensional phenomenon shaped by both financial and non-financial factors, including productivity, innovation, market positioning, and strategic governance (Abuselidze & Mamaladze, 2020; Porter, as cited in Chakaberidze, 2016). In the context of a rapidly evolving global financial environment, the ability of commercial banks to adapt and innovate determines their resilience and long-term success.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

According to Abuselidze and Slobodianyk (2021), productivity is a key determinant of national competitiveness, and by extension, of sectoral performance. A competitive banking sector should exhibit high productivity in terms of capital utilization, service delivery, and innovation. In Georgia, however, structural limitations within the financial system - particularly in the areas of innovation, market size, and venture capital - have constrained competitiveness. The World Economic Forum ranks Georgia relatively low in these categories, reflecting systemic issues in financial infrastructure (Chakaberidze, 2016).

Michael Porter's theory of competitive advantage is particularly relevant in assessing sector-specific dynamics. He argues that competitiveness is largely developed through localized conditions such as institutional quality, business environment, and historical market development. In Georgia, the competitiveness of commercial banks is closely linked to regulatory frameworks, the role of the National Bank of Georgia, and banks' ability to respond to market shifts (Chuthlashvili & Barbakadze, 2016).

Literature also highlights the critical importance of **strategic management and corporate governance**. Effective decision-making, planning systems, and the implementation of risk management strategies are considered foundational to achieving sustained competitiveness. As Beridze (2016) and the Bank of Georgia (2021) note, competitiveness is not only a matter of offering diverse services, but also of aligning operational capabilities with long-term strategic goals. SWOT analysis and strategic indicators such as Return on Assets (ROA) and Return on Equity (ROE) are commonly used in both academic and practical frameworks to assess performance and direction.

Another critical component in the literature is the role of **technological innovation**. Jayakumar et al. (2019) argue that digital transformation is both a challenge and an opportunity for the banking sector. In Georgia, banks such as TBC Bank and Bank of Georgia have leveraged mobile and internet banking as tools for differentiation. However, legacy systems, low digital literacy among older populations, and insufficient customer engagement strategies continue to limit the broader adoption of innovation-driven competitiveness (Liberty Bank, 2021; Chakaberidze, 2016).

Marketing and customer perception also feature prominently in the literature. Marketing activities contribute not only to brand strength but also to customer trust and loyalty, which are intangible yet essential elements of competitiveness. According to the National Bank of Georgia (2020), the use of multi-channel marketing platforms by leading banks has become a strategic advantage, especially in a highly saturated market where price and quality differentiation is minimal.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

From an investor perspective, financial indicators remain central. Studies agree that indicators such as net profit, asset volume, loan portfolio, ROA, and ROE are reliable measures of a bank's financial health and potential for growth (van der Vleugel et al., 2020). These metrics are increasingly complemented by environmental, social, and governance (ESG) factors, although Georgian banks are still in the early stages of integrating such considerations into their strategic reporting.

In summary, the reviewed literature supports the view that **competitiveness in the banking sector is a result of cumulative factors**, including effective financial management, strategic foresight, market responsiveness, technological innovation, and regulatory adaptability. While Georgian commercial banks have made substantial progress in key areas, particularly digitalization and customer service diversification, academic and policy discourse continues to highlight the need for structural reforms, long-term investment in innovation, and stronger alignment with international banking standards.

Competitiveness in the financial sector and its theoretical aspects

The necessity of a sound and rationally operating financial sector has been amply illustrated by the current financial crisis. Accurate risk assessment of all kinds is crucial when allocating resources from individuals, businesses, and international institutions to high-yield investment or entrepreneurial enterprises. This is where an efficient financial sector comes in. To enhance productivity, it is essential to have a high-quality financial market that provides access to: loans from a sound banking sector, securities from a well-regulated stock exchange, venture capital, and other financial products. Financial markets have the responsibility to develop protective mechanisms for investors and business sector representatives during crisis situations(Chakaberidze, 2016, 65).

Competitiveness has long been a subject of debate. Researchers examine the competitiveness of a country, a nation, an industry, and a sector. According to Michael Porter, Highly localized processes are used to establish and maintain competitive advantage. Differences in national values, culture, economic conditions, and structure, as well as existing companies and their development history, all contribute to the process of gaining competitive advantage. Since a country cannot be competitive in all or even most industries, the competitive structure of each country is highly differentiated. A country achieves success in a particular sector when, during a certain period, its domestic conditions and factors prove to be better, more dynamic, and more promising compared to others(Abuselidze & Mamaladze, 2020, p. 453).

No country can be competitive in all sectors. Ideally, the limited human and other resources of a specific country should be distributed in such

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

a way that they are used with maximum efficiency. In countries with a high standard of living, there may be many sectors where their local companies are not competitive. Scholars consider productivity to be the key concept of competitiveness(Abuselidze & Slobodianyk, 2021, p. 718). The ability of domestic enterprises to attain high levels of production determines the standard of living in a given nation. The quantity of production generated per unit of capital or material resource used over a specific amount of time is known as productivity(Abuselidze, 2021, p. 19). It is the main determinant of long-term living standards and the primary source of national income.

Georgia has achieved its lowest results in terms of innovation, market size, and the financial system, while it has ranked highest in healthcare, macroeconomic stability, and qualification. Out of the four main components, Georgia's indicators have worsened in two areas – the economic environment and markets, while improving in the innovation ecosystem and human capital(Abuselidze & Slobodianyk, 2020, p. 150).

According to the World Economic Forum's calculations, the quality of financial system development (91st position out of 141) includes several indicators. Georgia recorded its poorest results in terms of venture capital availability (109th position), the percentage of market capitalization relative to gross domestic product (119th position), and the size of insurance premiums relative to GDP (112th position)(Chakaberidze, 2016, 65). The highest assessment in terms of financial markets was achieved in the size of non-performing loans relative to total loans (47th position) and the volume of loans issued to individuals relative to GDP (57th position).

Bank management and its importance in the process of gaining competitiveness

The modern dynamic economy, under the conditions of globalization and a changing environment, has made it crucial to select the right strategy and to continuously seek new avenues, rather than merely maintaining previously achieved results. Generally, management involves decision-making, where a decision is the correct choice among alternatives. The quality and implementation of this choice depend on how effectively management information and planning systems operate. This is characteristic of any organization but is particularly relevant in commercial banks(Abuselidze & Beridze, 2018, p. 29). The decision-making process in a commercial bank is primarily expressed in the form of strategic planning.

In any model of strategic planning, it is essential to have documented detailed procedures outlining how, on what principles, within what timeframes, and at what hierarchy the planning is developed, followed by performance control and evaluation. A well-functioning mechanism for planning and subsequent control indicates the existence of effective and

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

modern corporate governance in a commercial bank. Different practices of strategic planning may exist within individual commercial banks, and it is crucial to align strategic and operational plans properly(Bank of Georgia, 2021, p. 1). The development of a strategic plan consists of several stages (Beridze, 2016, p. 18):

In the first stage, during the bank's establishment process, the bank's mission, or slogan, is formulated. The bank's mission encapsulates the formulation of the main task, clearly defining the purpose of the commercial bank's existence and its corporate culture. It represents the philosophical idea of the fundamental objectives for which the bank is created. Despite changes in various circumstances, the bank's mission and the core values stated within it should remain unchanged. Although infrequently, changes to the mission may occur, usually related to changes in the composition of shareholders(Bank of Georgia, n.d., p. 25).

The second stage of strategic planning involves defining target indicators. Target indicators can be based on key directions such as commercial, financial, technological, human resources, marketing, security, and risk management. The third stage of strategic planning involves describing the current state of the bank, commonly known as a SWOT analysis. The factors of SWOT analysis are(Bank of Georgia, n.d.):

S - for strengths standing out as strong points.
W - for weaknesses,
O- stands for opportunities
T - for threats.

Positive (strengths and opportunities) and negative (weaknesses and threats) aspects and events that are present now or are expected in the near future are both discovered and assessed during the SWOT analysis. In the final stage, specific pathways for achieving target qualitative indicators are determined. The strategic plan outlines the following qualitative performance measures (Return on Assets - ROA, Return on Equity - ROE, Cost to Income Ratio, Net Interest Margin, among others)(Chuthlashvili & Barbakadze, 2016, 35). The strategic plan should also document the projected figures for various mandatory indicators (liquidity, capital, investments, open currency positions, etc.)(Chakaberidze, 2016, p. 55).

During the process of drafting the operational plan and budget, the balance indicators are detailed: by credit portfolio products, securities portfolios, fixed assets, and so forth, along with revenues and expenditures.

To achieve competitiveness, it is crucial for the bank to consider the aforementioned factors because, regardless of the quality and diversity of the services offered, if a proper strategy is not defined, the development of the company is practically impossible.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Evaluation of financial indicators and competitiveness of Georgian commercial banks

General indicators of competitiveness are well-known, including price, quality, and service. However, the specific characteristics of the banking sector must also be taken into account. Below, we will discuss the financial indicators of Georgian commercial banks and the factors influencing their competitiveness. In our view, the competitiveness of commercial banks should be considered from two perspectives: that of consumers and investors(Legislative Herald of Georgia, 2021, p. 36).

For investors, important factors when making choices include the bank's net profit, market share, asset volume, size of issued loans, deposit volume, return on assets (ROA), return on equity (ROE), alignment with ecological standards, and market power(Chuthlashvili & Barbakadze, 2016, 35). From the consumers' perspective, other decisive factors come into play, such as price, variety of services, service quality, accessibility of remote services, and the significant role of the bank’s marketing strategy in the decision-making process. There may also be intersections between these two groups, such as a commercial bank's international ranking and reputation(National Bank of Georgia, 2020, p. 45).

Among the factors listed, aside from price and quality, we should examine the competitiveness indicators of Georgian banks through specific examples. The reason we do not characterize banks solely by price and quality indicators is due to the complexity of comparing several companies(National Bank of Georgia, 2020, p. 19). Prices for various banking services among Georgian commercial banks are constantly changing and are almost identical (with minor differences). Regarding quality, it is difficult to assess it for each type of service due to the diversity of available offerings.

Key indicators for evaluating a bank’s competitiveness from investors' perspectives include return on equity and return on assets ratios. The return on equity (ROE) is a profitability ratio that indicates a company’s ability to generate profit from investments made by its founders(van der Vleugel, Breeden, & Gautheron, 2020, 123). ROE is also an indicator of how effectively management uses capital contributions to finance operations and support beneficiary growth. A high ROE is generally preferable to a low one; however, this coefficient should be compared to the performance of other companies within the same sector. Since each sector has different sizes and types of investments and revenues, ROE cannot be directly compared across different industries(National Bank of Georgia, 2020, p.78).

Return on equity (ROE) is calculated as net profit divided by the equity held by shareholders. Return on assets (ROA), also known as return on total assets, is a profitability metric that assesses the net income generated from total assets during a specific timeframe, by comparing it to the average total

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

assets(van der Vleugel, Breeden, & Gautheron, 2020, 123). ROA indicates how effectively a bank can generate profit using its assets over a certain period. A high coefficient suggests better performance, as it indicates that the beneficiary is managing assets more efficiently and achieving higher net income. A positive ROA coefficient generally indicates an upward trend in profitability(van der Vleugel, Breeden, & Gautheron, 2020, p. 98).

Marketing campaigns run by companies significantly influence the decision-making process of individuals. Currently, representatives of the banking sector in Georgia actively utilize almost all communication channels for marketing activities. However, specific expenses directed towards marketing are not delineated in the financial reports presented by the banks.

The role of innovation in the modern banking system

Commercial banks operating under banking licenses employ a variety of management technologies, enabling them to create better consumer demand and experiences. In the modern era, where innovation is a necessity, banks strive to keep pace with technological advancements. The geographical zones in which commercial banks operate have also expanded, making it essential for all transactions to be recorded in real time, regardless of when they are completed. A client may be in a completely different time zone, but this should not hinder their ability to receive services(Chakaberidze, 2016, 68).

Instead of integrating these updates into antiquated systems, financial institutions have started to create additional technological frameworks to support every new offering, channel, functionality, and regional presence. For example, because of the original setup of the product and customer management systems in banks, a new client cannot obtain a mortgage or utilize a card without first establishing a current account. This limitation is so entrenched that clients rarely think about asking for an adjustment(Liberty Bank, 2021).

In the case of traditional banks, the allocation of additional resources for technological modernization is driven by several factors, such as the costs of outdated technology and the time required for processing, which always exceed the costs associated with operations performed using digital technologies. Resources that are excessively allocated could otherwise be used to enhance customer service and innovate products. Traditional banking services, such as executing transfers in a branch, hinder the ability to provide real-time customer service or conduct direct transactions, as clients must incur additional time costs for visiting the branch(Chakaberidze, 2016, 69).

Inefficient systems, which are difficult to update, create opportunities for increased competition in the market from small and new companies that leverage new technologies in the service process. Every year, outdated systems hinder banks and impede achieving desirable ratios, such as cost-to-

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

income, return on equity, and return on assets(Jayakumar, Pradhan, Chatterjee, Sarangi, & Dash, 2019, p. 275).

To achieve full customer engagement in the digital world, a systematic approach to financial and human resource allocation in this direction is necessary over several years. Depending on the various types of customers, banks must exert corresponding effort and labor. For example, elderly customers may manage their finances very well but utilize digital technologies less, while younger clients are inclined to use modern channels but require guidance regarding various banking products.

Banks need to determine the number of customers whose irritation may result from stringent approaches, potentially leading to their loss. In interactions with such categories, branch and contact center staff play a crucial role, as the information they provide should be delivered in a manner that prevents dissatisfied clients from leaving the bank and encourages them to start using remote channels.

Online Research: Modern Banking Services in Georgia

We were interested in understanding the public's attitude towards the services offered by commercial banks in Georgia and their level of satisfaction. Additionally, we explored how well they have adapted to innovations proposed by the banks.

We surveyed 102 people, and the findings were as follows:

The majority use banking services, with 59.1% utilizing services from multiple banks.

- 88.3% try to avoid cash payments and maximize the use of plastic cards.
- 94.9% use internet/mobile banking.

Only a small portion of respondents (4.1%) believe that internet banking is not secure, while 47.8% consider it somewhat risky but accept this risk for convenience. In contrast, 48.1% believe their accounts are completely secure when using remote services.

68.8% perform all types of transactions through internet/mobile banking, 24% use it partially and still visit branches for certain transactions, and the rest either do not use internet banking or find it functionally inadequate, preferring to visit branches.

Regarding the simplicity of the internet/mobile banking menu and design, 53.9% rated it 5 out of 5, 34.7% gave it 4 points, 6.3% gave it 3 points, 0.3% gave it 2 points, 0.6% rated it 1 point, and 4.1% do not use these services at all.

When asked which bank's internet/mobile banking they liked most, the top five were as follows (respondents could select multiple banks):

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- TBC Bank – 65 votes
- Bank of Georgia – 15 votes
- ProCredit Bank – 20 votes
- VTB Bank – 5 votes
- Liberty Bank – 5 votes.

Most respondents, 68.3%, stated that they had not opened a bank account remotely. 20.2% had opened an account using TBC Bank's Space app, 11.9% through the Bank of Georgia, 1.6% via ProCredit Bank, and 1.6% through Pasha Bank (Rebank).

Of the 102 respondents, 55.5% are aged 26-40, 26.8% are 41-60, 15.8% are 18-25, and the remaining 1.9% are either under 18 or over 61.

- 89.6% hold higher education degrees.
- 77.5% are employed, and 9.5% are self-employed.

As the survey indicated, the majority use remote channels and are satisfied with the service quality. The dominance of JSC TBC Bank and JSC Bank of Georgia in the market is reinforced by their use of modern technologies, as many respondents both use and appreciate the mobile/internet banking services provided by these two banks. Despite the rise in cyberattacks in recent years, nearly half of the respondents believe that their internet/mobile banking is fully secure, while 47.8% perceive some risks but accept them for the convenience offered.

Finally, while most respondents have not yet opened bank accounts remotely, the active promotion and marketing efforts by leading banks in recent times are likely to change this trend in the near future.

Research Methodology

Research Design

This study employed a quantitative research design based on a structured online survey to examine public attitudes toward modern banking services in Georgia. The approach was chosen to collect standardized, comparable, and generalizable data from a diverse group of respondents.

Target Population and Sampling

The target population included Georgian residents aged 18 and above who have access to banking services. A non-probability convenience sampling method was applied, whereby participants were recruited through online channels. Although this method may limit generalizability, it is effective for exploratory studies and gathering rapid feedback from a digital-literate population.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Data Collection Method

Data were collected using a self-administered online questionnaire distributed via social media platforms, primarily Facebook and Instagram. The survey was active for one week in May 2025 and received 102 valid responses. Participants were assured of anonymity and voluntary participation. The questionnaire included both closed-ended (multiple-choice) questions and Likert-scale items to measure satisfaction, usage frequency, and perceptions of digital banking.

Survey Instrument

The questionnaire was developed specifically for this study, informed by previous research on digital banking adoption and customer satisfaction. It consisted of four sections:

- Demographic Information (e.g., age, education, employment status)
- Bank Usage Patterns (e.g., number of banks used, preferred channels)
- Digital Banking Engagement (e.g., frequency of internet/mobile banking use)
- Perceptions of Security and Ease of Use
- The Likert-scale questions ranged from 1 (strongly disagree) to 5 (strongly agree) or from 1 (very poor) to 5 (excellent), depending on the item.

Data Analysis Techniques

Descriptive statistical methods were used to analyze the data, including frequency distributions, percentages, and comparative rankings. Microsoft Excel and SPSS were utilized to organize and interpret the results. These methods allowed for clear identification of trends in user behavior, satisfaction levels, and security perceptions.

Ethical Considerations

Participation in the study was fully voluntary, and no personal identifiers were collected. Respondents were informed about the purpose of the research and consented to take part in the survey anonymously. The study adhered to standard ethical guidelines for social research.

Research Results and Analysis

This chapter presents the findings of the quantitative survey conducted to assess public attitudes toward modern banking services in Georgia. The analysis focuses on service usage, digital banking preferences, security perceptions, and the overall competitiveness of leading commercial banks.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

1. **Use of Banking Services and Channel Preferences**

Out of 102 respondents, 59.1% reported using services from multiple banks, indicating a competitive and diversified banking market. A strong majority - 88.3% - prefer non-cash transactions, actively using plastic cards for daily financial operations. This suggests a shift toward digital payment behavior among Georgian customers.

Additionally, 94.9% of participants reported using internet or mobile banking services, reflecting high digital penetration and general customer readiness to engage with modern banking technologies. However, a small segment (5.1%) either does not use or is dissatisfied with these channels, which still leaves room for improving functionality and accessibility.

2. **Perception of Security in Internet/Mobile Banking**

Security remains a relevant concern in digital banking adoption. According to the results:

- 4.1% of respondents believe internet/mobile banking is not secure,
- 47.8% consider it somewhat risky but use it for convenience, and
- 48.1% feel fully secure when using digital services.

This nearly equal division between perceived risk and security highlights the importance of trust-building and cybersecurity communication strategies among banks.

3. **Functional Assessment of Digital Banking Interfaces**

Respondents were asked to evaluate the usability and simplicity of internet/mobile banking platforms:

- 53.9% gave a full score of 5 out of 5,
- 34.7% rated it 4,
- 6.3% rated it 3 or below,
- 4.1% stated they do not use digital banking at all.

This suggests that while most users are satisfied, a notable minority still encounter functional barriers, potentially impacting overall customer satisfaction and retention.

4. **Preferred Digital Banking Platforms**

When asked which bank's internet/mobile banking application they preferred (multiple answers allowed), the responses were as follows:

- TBC Bank – 65 votes
- ProCredit Bank – 20 votes
- Bank of Georgia – 15 votes
- VTB Bank – 5 votes
- Liberty Bank – 5 votes

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

TBC Bank clearly leads in customer preference for digital banking, highlighting its technological edge and user-friendly platform design.

5. **Remote Account Opening Behavior**

A significant portion of the population (68.3%) has never opened a bank account remotely. Among those who have:

- 20.2% used TBC Bank's Space app,
- 11.9% used Bank of Georgia's digital channel,
- 1.6% used ProCredit Bank,
- 1.6% used Pasha Bank (Rebank).

These figures illustrate the early stages of digital onboarding adoption and the need for enhanced promotion and trust-building measures to expand usage.

6. **Demographic Insights**

Age Distribution: 55.5% of respondents were aged 26–40; 26.8% were 41–60; 15.8% were 18–25; 1.9% were either under 18 or over 61.

- Education Level: 89.6% held higher education degrees.
- Employment: 77.5% were employed, 9.5% self-employed.

This indicates that the majority of participants are young, educated, and professionally active - traits strongly correlated with higher digital banking adoption rates.

Summary of Key Findings

Digital Banking Penetration is high, with 94.9% of respondents actively using online or mobile banking services.

Perceived Security is evenly split: nearly half feel fully secure, while the other half remain cautious.

TBC Bank has a clear advantage in terms of user preference for digital banking services.

Remote Onboarding is still emerging; despite digital capabilities, most respondents prefer traditional methods for account opening.

Customer Satisfaction with functionality and design is relatively high, but there is still room for optimization for non-tech-savvy users.

Conclusion

Competitiveness is a multifaceted and context-dependent concept, especially in the banking sector, where various internal and external factors contribute to a bank's ability to gain a market advantage. In the case of Georgian commercial banks, competitiveness refers to their capacity to deliver superior results, attract and retain diverse customer segments, adapt to

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

technological advancements, and sustain financial resilience in a rapidly evolving economic landscape.

This study set out to analyze the core determinants of competitiveness in Georgia's financial sector, using both financial indicators and qualitative insights to assess the relative performance of leading banks. The research confirmed that JSC TBC Bank and JSC Bank of Georgia occupy dominant positions in the market. TBC Bank leads in terms of net profit, asset volume, and net loans, while Bank of Georgia surpasses in deposit volume. Collectively, these two institutions account for nearly 80% of the market share, reflecting not only their financial strength but also their effective strategic and operational practices.

Several key attributes define the competitive edge of these banks:

- Strong capitalization and asset base, enabling them to serve all market segments efficiently;
- Wide coverage and diversified service portfolio, including consumer lending, credit/debit cards, mobile/internet banking, corporate financing, business loans, and trade guarantees;
- Inclusive customer targeting, from pensioners and students to SMEs and high-net-worth individuals;
- Balanced revenue streams, where higher margins from individual clients are offset by stable, lower-margin services for larger corporate clients.

The analysis revealed that a bank's ability to maintain a competitive position is heavily dependent on sound management, effective strategic planning, robust internal control mechanisms, and a well-functioning risk management system. This includes identifying key risk categories, evaluating their impact, and implementing dynamic mitigation strategies across departments.

Another critical component identified in the study is the role of marketing. Both TBC Bank and Bank of Georgia have demonstrated superior marketing outreach through diverse channels including television, digital platforms, social media, direct marketing, SMS campaigns, and personalized phone outreach. These efforts not only increase brand visibility but also reinforce customer loyalty and perception of innovation.

From a consumer perspective, competitiveness is no longer solely defined by price and service quality. Modern customers demand accessibility, innovation, and digital convenience. This was confirmed by the survey data, where over 94% of respondents reported using internet or mobile banking services, and a significant proportion expressed trust in the security of these platforms. However, despite the increasing reliance on digital channels, a considerable segment of users - especially older individuals - still prefers in-

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

branch banking, which underscores the continued importance of maintaining traditional service models alongside technological innovation.

From an investor perspective, key indicators such as ROE, ROA, net profit, loan and deposit volumes, and market reputation serve as critical markers of a bank's viability and future growth potential. In this regard, both leading banks exhibit robust financial profiles, further strengthened by international ratings and transparent reporting practices.

The research also addressed the evolving role of innovation. While most commercial banks have introduced digital tools and platforms, innovation in Georgia's banking system has not yet fully matured into a decisive competitive instrument. The gap between technological capability and public readiness remains a challenge, particularly for digital-only banks that lack the hybrid service models offered by traditional institutions. The study suggests that over time, generational shifts may increase the adoption of fully remote banking solutions, but in the present environment, a dual strategy - combining digital innovation with traditional branch services - is essential for maintaining market relevance and customer satisfaction.

In conclusion, the study finds that the competitiveness of Georgian commercial banks is a result of synergistic factors: financial strength, strategic diversification, technological adaptability, inclusive service provision, and consistent customer engagement. While leading banks have demonstrated clear advantages, continued investment in innovation, improved financial literacy, and customer-centric planning will be essential for ensuring long-term competitiveness in a fast-changing financial environment.

Conflict of Interest: The author reported no conflict of interest.

Data Availability: All relevant data generated or analyzed during this study are included within the content of the manuscript. No additional datasets were generated or used.

Funding Statement: The author did not obtain any funding for this research.

Declaration for Human Participants: This study was conducted in accordance with the ethical standards of the Grigol Robakidze University and the principles outlined in the Helsinki Declaration. The research involved voluntary participation through an anonymous online survey. No personally identifiable information was collected. Prior to participation, all respondents were informed about the purpose of the study and provided their consent.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

References:

1. Abuselidze, G. (2021). The influence of Covid-19 on the public debt growth and default risk: A fiscal sustainability analysis. In Proceedings of the International Scientific and Practical Conference on Sustainable Development of Regional Infrastructure (ISSDRI 2021). SciTePress.
2. Abuselidze, G., & Beridze, L. (2018). Proceedings of the 4th International Conference on European Integration (ICEI) (pp. 29–41).
3. Abuselidze, G., & Mamaladze, L. (2020). Lecture Notes in Computer Science, 12253, 453–467. Springer, Cham. https://doi.org/10.1007/978-3-030-58814-4_32
4. Abuselidze, G., & Slobodianyk, A. (2019). Economic Science for Rural Development, 52, 203–221.
5. Abuselidze, G., & Slobodianyk, A. (2020). E3S Web of Conferences, 210, 15016. https://doi.org/10.1051/e3sconf/202021015016
6. Abuselidze, G., & Slobodianyk, A. (2021). Advances in Intelligent Systems and Computing, 1258, 718–728. Springer, Cham. https://doi.org/10.1007/978-3-030-57450-5_61
7. Bank of Georgia. (2021). Financing. http://bankofgeorgia.ge/en/retail/loans
8. Bank of Georgia. (n.d.). Electronic banking. Retrieved October 10, 2024, from https://bankofgeorgia.ge/ka/retail/digital-bank
9. Bank of Georgia. (n.d.). Retrieved October 10, 2024, from https://bankofgeorgia.ge/
10. Beridze, L. (2016). Proceedings of the International Scientific Conference Challenges of Globalization in Economics and Business. Tbilisi.
11. Chakaberidze, D. (2016). Specifics of banking competition in Georgia: Abstract of dissertation submitted for the degree of Doctor of Finance. Tbilisi.
12. Chuthlashvili, A., & Barbakadze, K. (2016). Financial institutions and markets. Tbilisi.
13. Dincer, H. (2019). Financial innovation and competitiveness in the banking sector. Kybernetes, 48(6), 1195–1215. https://doi.org/10.1108/K-02-2018-0055
14. Jayakumar, M., Pradhan, R. P., Chatterjee, D., Sarangi, A. K., & Dash, S. (2019). Digital transformation in banking: Challenges and opportunities. In Advances in analytics and applications (pp. 275–297). Springer, Singapore. https://doi.org/10.1007/978-981-13-1208-3_21
15. Legislative Herald of Georgia. (2021). Law of Georgia on Competition. http://matsne.gov.ge/en/document/view/1659450?publication=9

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

16. Liberty Bank. (2021). Financing and loans. http://libertybank.ge/en/produqtebi/chemi-biznesistvis/biznes-sesxi
17. Liberty Bank. (2021). Term deposits. http://www.libertybank.ge/ka/produqtebi/chemtvis/anabrebi-da-sertipikatebi/vadiani
18. National Bank of Georgia. (2020). Annual report 2016–2019. http://www.nbg.gov.ge/uploads/publications/annualreport/2019/annual_2018.pdf
19. National Bank of Georgia. (2020). Annual reports of Georgian commercial banks 2016–2019.
20. National Bank of Georgia. (2020). Financial stability 2016–2019 years data. http://www.nbg.gov.ge/index.php?m=404
21. National Bank of Georgia. (2020). New regulations. http://www.nbg.gov.ge/index.php?m=340&newsid=3545
22. van der Vleugel, M., Breeden, S., & Gautheron, P. (2020). For banks, modernizing technology has become a perpetual challenge.

ESJ Social Sciences Peer-reviewed

Conceptual Formation of Curvature in the Logic of Art: An Educational Mathematical Approach

Vassileios Petrakis, MA
Laboratory of Interdisciplinary Semantic Interconnected Symbiotic Education Environments, Electrical and Computer Engineering Department, Faculty of Engineering, University of Peloponnese, Greece
Lambrini Seremeti, PhD
Department of Regional & Economic Development, Agricultural University of Athens & Laboratory of Interdisciplinary Semantic Interconnected Symbiotic Education Environments, Electrical and Computer Engineering Department, Faculty of Engineering, University of Peloponnese, Greece
Ioannis Kougias, PhD
Laboratory of Interdisciplinary Semantic Interconnected Symbiotic Education Environments, Electrical and Computer Engineering Department, Faculty of Engineering, University of Peloponnese, Greece

Doi:10.19044/esj.2025.v21n19p139

Submitted: 04 June 2025
Accepted: 10 July 2025
Published: 31 July 2025

Cite As:
Petrakis, V., Seremeti, L. & Kougias, I. (2025). *Conceptual Formation of Curvature in the Logic of Art: An Educational Mathematical Approach.* European Scientific Journal, ESJ, 21 (19), 139. https://doi.org/10.19044/esj.2025.v21n19p139

Abstract

This article investigates how curvature, commonly examined in differential geometry, functions as a conceptual and visual bridge between mathematics and the arts. Focusing on its presence in both abstract artworks (e.g., Kandinsky, Pollock) and architectural design (e.g., Gaudí), the study analyzes how mathematical curves such as parabolas, sinusoids, and exponential spirals are embedded in artistic compositions. Rather than treating curvature as a purely technical metric, the study presents it as a perceptual and compositional tool that structures form, evokes emotion, and communicates symbolic meaning. The paper introduces readers to core geometric principles underpinning curvature and their visual and compositional applications in art, aiming to make these concepts accessible to non-specialist readers. Employing case studies of historical and contemporary artworks, it highlights how

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

mathematical patterns manifest intuitively in artistic practice. Key implications include the potential for curvature to foster interdisciplinary education, particularly through STEAM learning models that integrate science, technology, engineering, the arts, and mathematics. This approach encourages enriched classroom engagement, deeper visual literacy, and a broader appreciation of form as both analytic structure and expressive language.

Keywords: Curvature, Art, Differential Geometry, Aesthetic, STEAM education

Introduction

Curvature is not only a foundational concept in mathematics but also a powerful, often intuitive, force in artistic creation. From the sinuous parabolic arches of Antoni Gaudí's Sagrada Família (Middleton & Petruzzello, 2024) to the fractal-like splatter compositions of Jackson Pollock (Taylor, et al., 2008; Taylor, et al., 2011), curved forms actively shape our visual and emotional engagement with art and architecture. These manifestations of curvature are far from incidental, since they structure space, evoke emotion, and encode symbolic meaning across cultures and historical periods.

Mathematically, curvature is rigorously defined using the tools of differential geometry to describe how a space bends or deviates from flatness. In contrast, artists often employ curvature intuitively to convey rhythm, harmony, dynamism, or spiritual resonance. Gaudí's designs, for instance, utilize parabolas and catenary curves to combine structural efficiency with biomorphic beauty, while Pollock's chaotic yet patterned drips echo the self-similarity of natural fractals, offering a raw visual expression of motion and energy. These examples demonstrate how mathematical principles of curvature are not limited to theoretical domains but are deeply embedded in creative visual practices.

This study adopts a didactic and exploratory lens, introducing non-specialist readers - particularly educators, artists, and students - to the conceptual foundations of curvature and their expressive applications in art. Simplified geometric forms such as parabolas, sinusoids, and spirals are used not only as visual motifs but also as conceptual bridges between disciplines. In this way, the paper expands on prior works that link visual perception and geometry (Hoffman & Richards, 1984; Arnheim, 1974), emphasizing the expressive, perceptual, and symbolic potency of curvature across domains.

While previous literature has explored mathematical models in art (McRobie, 2017; Devlin, 2011; Henderson & Taimina, 2001), there remains a notable gap in explicitly pedagogical approaches that integrate curvature as

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

both a compositional and cognitive tool within STEAM (Science, Technology, Engineering, Art, Mathematics) education. Few studies provide concrete case-based frameworks for teaching curvature as a shared visual language between mathematics and the arts. Moreover, current curricula often treat geometry as a purely technical subject, underemphasizing its aesthetic and interpretive dimensions (Sinclair & Watson, 2017; Schoevers, et al., 2019).
This article seeks to address these gaps by offering:

- Visually grounded examples that demonstrate how curvature functions within both historical and modern artworks.
- A conceptual and accessible mathematical framework to understand curvature intuitively.
- A rationale for embedding curvature-focused content into cross-disciplinary learning environments.
- A call for greater attention to the perceptual and symbolic resonance of geometric forms within visual culture and education.

In doing so, the study contributes to the broader movement toward STEAM education, where interdisciplinary thinking is fostered through connections between abstract reasoning and creative inquiry (UNESCO, 2015; Lisi & Nagappan, 2024). By treating curvature not merely as a technical metric but as an expressive and interpretive device, we unlock its potential to engage learners more deeply, foster visual literacy, and encourage collaborative approaches between sciences and the arts.

The rest of the paper proceeds as follows. It firstly explores how curvature evokes spatial harmony, symbolic meaning, and emotional resonance in visual art. Secondly, a foundational mathematical exposition of curvature using accessible terms is provided. Thirdly, illustrative case studies from visual art and architecture, including works by Kandinsky, Gaudí, and Pollock are presented. Fourthly, the potential of integrating curvature into STEAM education, enhancing visual literacy and interdisciplinary thinking in both arts and sciences, is highlighted. Next, the discussion explores how this interdisciplinary framework fosters collaboration between artists and mathematicians and proposes broader applications in pedagogy and research. Finally, the conclusion summarizes the key findings and reflects on future directions for research and curriculum development involving curvature across art and mathematics.

Curvature in the Logic of Art: A Conceptual Analysis

Curvature is a fundamental geometric notion and, in tandem, a powerful aesthetic device. In mathematics, curvature quantifies the deviation of a line or surface from flatness. In art, it guides the viewer's eye, evokes emotion, and structures visual meaning. Thus, curvature is far more than a

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

geometrical measure. It is a conceptual tool that artists use to shape form, guide perception, convey meaning, and structure visual logic. By understanding its morphological, perceptual, semiotic, and formal aspects, we gain insight into why curved forms have had so deeply in art and design. Understanding the technical, emotional, and semantic value of curvature in the arts is a complex task, and many theories have been developed, such as perception and visual aesthetics theories (McRobie, 2017; Ruta, et al., 2023).

The notion of Curvature in art can symbolize various themes, from the dynamism of motion to the calmness of symmetry. Artistic expressions frequently employ curvature to guide the viewer's gaze, suggest volume, or evoke certain emotions. In many classical compositions, curved lines lead viewers into the scene, creating a sense of flow or natural rhythm. Additionally, curvature in sculptures and architecture contributes to balance and aesthetic harmony (Gombrich, 1960; Friedman & Carter, 1991).

The "logic of art" here refers to the guiding principles or semiotics used in art to communicate with viewers. This logic often employs curvature to convey meanings that transcend literal forms. For instance, abstract art by artists such as Wassily Kandinsky explore "spiritual" meanings through curved shapes that lack representational content but are rich in emotional resonance (Kandinsky, 1947). In Renaissance art, curved lines often guide the viewer's eye, creating harmony and balance. This intentional use of curvature is seen in Leonardo da Vinci's "The Last Supper," where curved arches frame the scene, leading attention toward central figures (Grieve, 2018).

A Naive Mathematical Approach to Curvature in Art

In this section, we introduce an accessible mathematical framework that can be used by artists or theorists without extensive backgrounds in mathematics (Smith, 1958). Rather than employing rigorous proofs, we rely on intuitive descriptions of curvature:

1. **Curved Lines and Emotional Tone:** Artists use simple curves (such as parabolic or sinusoidal shapes) to create tension or release in compositions.

Example: The parabolic curve often represents balance and stability, seen in works by artists like Leonardo da Vinci (Livio, 2002). The curves in da Vinci's compositions resemble parabolic shapes, i.e., shapes like U (e.g., arches in classical architecture) and are defined by the equation:

$$y = ax^2 + bx + c$$

2. **Curvature as Flow:** The flow of curvature, where a line or shape smoothly transitions, can be represented by simple sine functions, which show how wave height and spacing vary with respect to the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

parameters. For instance, a sinusoidal curve, i.e., a sine wave graph, is defined by:

$$f(x) = a\sin(bx + c),$$

where

- a affects amplitude, impacting visual intensity,
- b affects frequency, determining rhythm or tension,
- c adjusts phase influencing movement and positioning.

Example: In landscape art, curved hills and flowing rivers can be approximated with sinusoidal waves, creating a sense of organic movement and continuity.

3. **Curvature as Symbolism:** In abstract art, curvature often symbolizes movement or growth, an element that is reflected mathematically in exponential growth functions of the form:

$$f(x) = e^{kx},$$

where k dictates the curve's growth rate, analogous to a spiral or expanding form in art.

Examples: (a) Kandinsky uses abstract curved shapes to express emotional and spiritual energy. (b) Da Vinci frames central figures using soft arches (e.g., *The Last Supper*).

Mathematical Framework of Curvature

In mathematics, curvature can be classified as the degree to which a curve deviates from being a straight line or a surface from being a plane. This concept is often analyzed in differential geometry, where curvature provides a tool to study properties of surfaces (Pressley, 2001). For instance, Gaussian curvature helps describe surfaces by measuring their intrinsic curvature, while mean curvature gives insight into surface behavior in three-dimensional space (Kreyszig, 1991).

Curvature of Curves

For a planar curve C, the curvature κ at any point is defined as the rate of change of the curve's tangent angle with respect to arc length, given by:

$$\kappa = \frac{|y''|}{[1 + (y')^2]^{3/2}},$$

where y' and y'' represent the first and second derivatives of the curve function, respectively.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

If the curve is represented parametrically as $r(t) = (x(t), y(t))$, then:

$$\kappa = \frac{|x'y'' - y'x''|}{[(x')^2 + (y')^2]^{3/2}}.$$

Example Calculation

For a circle of radius R, parameterized as $r(t) = (R\cos t, R\sin t)$, i.e. $x(t) = R\cos t \quad y(t) = R\sin t$ and thus $x'(t) = -R\sin t$, $x''(t) = -R\cos t$, $y'(t) = R\cos t$, $y''(t) = -R\sin t$, from where we derive:

$$\kappa = \frac{|-R\sin t \cdot (-R\sin t) - R\cos t \cdot (-R\cos t)|}{(R^2\cos^2 t + R^2\sin^2 t)^{3/2}} = \frac{1}{R}.$$

This constant curvature is characteristic of circles, aligning with the uniform balance and symmetry often found in classical art.

By the Pythagorean identity $\sin^2 t + \cos^2 t = 1$, we get the result.

Calculating $(x')^2 + (y')^2$, we find:

$(x')^2 + (y')^2 = (-R\sin t)^2 + (R\cos t)^2 = R^2\sin^2 t + R^2\cos^2 t = R^2$.

Now substitute these values back into the curvature formula:

$$\kappa = \frac{R^2}{(R^2)^{3/2}} = \frac{R^2}{R^3} = \frac{1}{R}.$$

The result $\kappa = 1/R$ means that the curvature of a circle of radius R is constant at every point on the circle and is inversely proportional to the radius. A smaller circle (with a smaller R) will have a higher curvature (more "bent"), while a larger circle (with a larger R) will have a lower curvature (flatter).

This result is unique to circles, i.e., for any point on a circle, the curvature remains the same.

A *Gaussian curvature* K (Kühnel, 2006) is the product of the principal curvatures, κ_1 and κ_2, at each point on a surface:

$$K = \kappa_1 \cdot \kappa_2.$$

Positive K (e.g., on a sphere): Both principal curvatures curve in the same direction.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Negative K (e.g., on a saddle): The curvatures bend in opposite directions, creating a shape with unique geometric and aesthetic properties.

To enhance accessibility for non-specialist readers, in particular students and artists, simplified visual representations of mathematical curves are essential. Illustrating parabolas, sinusoids, and exponential spirals as intuitive shapes - rather than abstract equations - can demystify their artistic relevance. For instance, the gentle rise and fall of a sine wave can evoke calmness, while the dramatic sweep of an exponential spiral may suggest movement or transformation. Such forms influence perception by guiding the viewer's gaze, establishing rhythm, and producing emotional responses like serenity, dynamism, or tension. Neuroaesthetic studies have shown that viewers often prefer curved over angular forms, linking mathematical smoothness with psychological comfort. By integrating diagrams and symbolic interpretations, visual aids act as cognitive bridges between analytical logic and artistic intuition. This approach not only supports comprehension but also invites interpretive engagement, allowing learners to perceive curvature not merely as a geometric property but as an expressive language embedded in visual experience.

Visual Aids

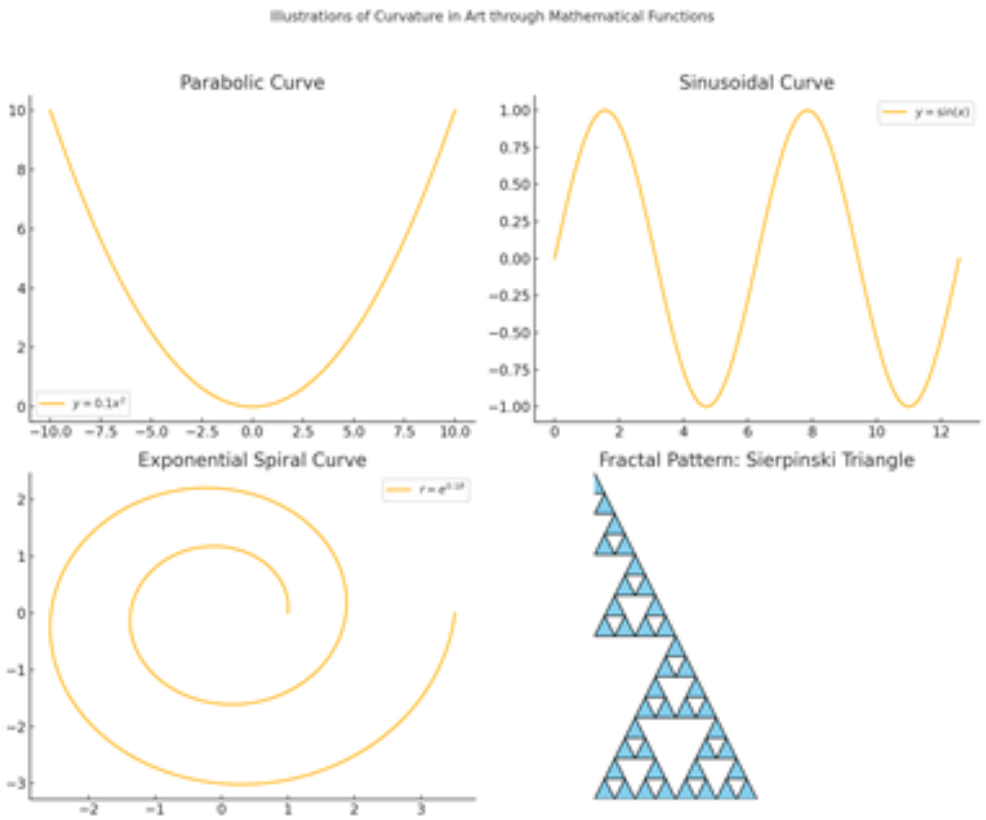
Fractal patterns have been present in art for centuries, carrying aesthetic and spiritual significance across diverse cultures - for instance, Leonardo da Vinci's representations of trees reflect these underlying mathematical principles (Gao & Newberry, 2024).

Fractal Analysis of Pollock's Curves: Show log-log plots of Pollock's patterns (Taylor et al., 2008).

Below, four graphical illustrations based on the discussed mathematical concepts are shown:

- **Parabolic Curve**: The graph shows a simple parabolic curve, $y = 0.1x^2$. This shape, often used in architecture and classical compositions, provides stability and balance.
- **Sinusoidal Curve**: The sine wave, $y = \sin(x)$, represents natural rhythm and flow, commonly found in landscapes and abstract art to convey a sense of continuity.
- **Exponential Spiral**: The spiral, $r = e^{0.1\theta}$, displays exponential growth, symbolizing movement, growth, and continuity, often seen in natural forms and abstract art.
- **Fractal Pattern**: The Sierpinski Triangle (Kempkes et al., 2019) is a recursive pattern representing a fractal. Fractals, like those in Jackson Pollock's art, display self-similarity across scales, showing how complexity can be created through repetition.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

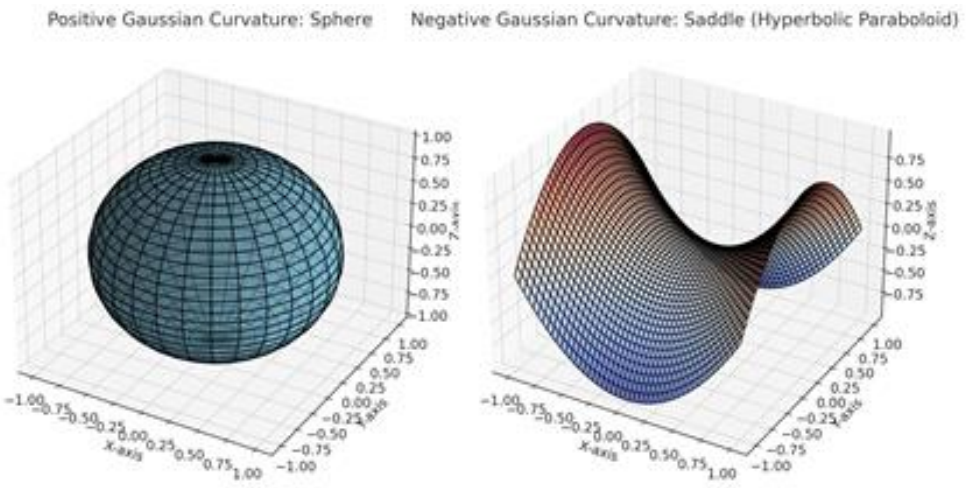


Fractal Pattern: Sierpinski Triangle

Curved Fractal Patterns in Nature and Art: Comparisons of fractal patterns in Pollock's work and natural fractals (e.g., tree branches, river networks). Below are two additional visualizations illustrating Gaussian curvature on 3D surfaces, showing the difference between positive and negative curvature:

- **Positive Gaussian Curvature (Sphere)**: The surface of a sphere has positive Gaussian curvature, where each point curves uniformly in all directions. This characteristic is common in rounded, balanced structures, such as domes or certain sculptural forms in art, conveying harmony and completeness.
- **Negative Gaussian Curvature (Saddle or Hyperbolic Paraboloid)**: The hyperbolic paraboloid (saddle shape) has negative Gaussian curvature, curving in opposite directions along each axis. This shape is frequently seen in modern architecture, abstract sculptures, and surrealist compositions, suggesting dynamic, tension-filled forms.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431



Negative Gaussian Curvature: Saddle (Hyperbolic Paraboloid)

These visualizations give an inside view of how simple mathematical curves can inspire or be identified within artistic compositions. The curvature types not only define surface geometry but also play significant roles in the visual impact of forms in art and architecture.

Case Studies in Art

Architecture: The Parabolic Arches of Antoni Gaudí

Antoni Gaudí's architectural masterpieces, particularly the iconic Sagrada Familia in Barcelona, beautifully exemplify the use of curvature in design (Middleton & Petruzzello, 2024). Gaudí employed parabolic arches - curves shaped by mathematical precision - to achieve both structural efficiency and artistic elegance. These arches distribute weight naturally, minimizing stress on supporting materials and enhancing stability without sacrificing beauty. Beyond functionality, the organic shapes evoke natural forms such as trees, caves, and waves, creating a sense of harmony between the built environment and the natural world. Gaudí's innovative use of curvature reflects his deep understanding of geometry and his desire to integrate mathematical logic into a spiritually inspired aesthetic. His work continues to influence modern architecture, serving as a bridge between scientific reasoning and artistic vision.

Abstract Art: Jackson Pollock's Dynamic Curves

Jackson Pollock's abstract expressionist paintings are known for their intense energy, marked by sweeping lines, splatters, and fluid drips. While they may appear chaotic at first glance, Pollock's artworks often display recurring patterns that can be examined through mathematical frameworks, especially fractal geometry and chaos theory (Taylor et al., 2011). The

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

"curvature" in his work emerges not from traditional arcs or spirals but from the rhythmic density and directional flow of paint across the canvas. His drip technique produces intricate layers and textures, forming complex visual systems that resemble natural phenomena such as turbulence or branching patterns. Scholars have even used fractal analysis to measure self-similarity within his works. Pollock's method thus opens fascinating intersections between abstract art and mathematics, suggesting that even seemingly spontaneous creativity can follow underlying mathematical rules. His paintings challenge conventional definitions of curvature while inviting a deeper, analytical appreciation of form and movement.

Educational Implications and Benefits

The interdisciplinary methodology outlined in this article presents numerous educational benefits, particularly for educators and learners engaged in both the mathematical sciences and the visual arts. By treating curvature as a conceptual bridge, the study fosters a more holistic understanding of spatial and symbolic relationships. For students, particularly those with limited formal training in mathematics, anchoring abstract concepts in artistic examples provides an intuitive and visually compelling pathway to learning (Sylviani et al., 2024). This method promotes cognitive engagement, critical thinking, and creativity, encouraging learners to explore beyond traditional disciplinary boundaries.

Practical Teaching Strategies

- Mathematical Drawing Projects: Students can recreate classic artworks or architectural motifs using mathematical functions. For example, using graphing tools (e.g., Desmos, GeoGebra), they can plot parabolas to model Gaudí's arches or sinusoidal waves to reconstruct rhythm in landscape art.
- Gallery Walks with Analytical Tasks: In an interdisciplinary classroom, students walk through a curated exhibit (real or virtual) of artworks known for curved structures (e.g., Kandinsky, Pollock, Gaudí). Using guided worksheets, students may identify mathematical properties in the visual compositions, including curvature, symmetry, and transformation.
- STEAM Integrated Lesson Plans: For instance, a cross-curricular unit could have math students derive and plot exponential spirals while art students create sculptures or digital illustrations based on those plots. This echoes the success of programs such as *Mathematics in Art* by ArtsEdge and documented STEAM projects (Henriksen et al., 2016). (For details on ArtsEdge, visit the Kennedy Center: https://www.kennedy-center.org/education/resources-for-educators/classroom-resources/),

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- Reverse Engineering Artistic Forms: Learners are given abstract artworks and asked to model the curves using basic functions (e.g., sine, exponential, parametric equations). This analytical reconstruction encourages active exploration and higher-order thinking.
- 3D Modeling with Curvature: Using accessible tools like Tinkercad or Fusion 360 (for more details visit: https://www.tinkercad.com and https://www.autodesk.com/eu/products/fusion-360/overview), students design sculptures or architectural components that incorporate curvature principles, translating mathematical theory into tangible design. This method was tested with notable results in "STEAM Fabrication Labs" in secondary schools (Boaler, 2016).
- Neuroaesthetic Response Activities: Drawing on evidence (Ruta et al., 2023; Taylor et al., 2011), students can engage in reflection exercises comparing their emotional and perceptual responses to curved vs angular designs. These reflections can be coupled with writing prompts or data analysis exercises.

Curriculum Examples

- Middle School Geometry: Integrate basic curve types into the study of conic sections, encouraging students to find or draw artistic representations for each case.
- High School Calculus: Use Pollock's fractals to explain limits and self-similarity; students estimate dimensionality using simplified box-counting methods.
- Visual Arts Courses: Include short modules on how mathematical curves inform design in architecture, abstract art, and sculpture.
- Computer Science/Digital Media: Teach vector graphics with parametric equations for curves, merging algorithmic thinking with visual creativity.

Empirical Evidence and Case Studies

- Fierro-Newton (2024) demonstrated that students show significantly higher engagement and retention when learning geometry through curvature in natural and artistic forms, reinforcing cognitive links between aesthetics and mathematical reasoning.
- Henriksen et al. (2016) found that integrated STEAM classrooms increased students' creative confidence and problem-solving skills, especially when abstract math was connected to sensory and visual experiences.
- Boaler (2016) documented that when students engaged in artistic expression of math concepts, including curvature, they developed more positive attitudes toward mathematics and demonstrated deeper conceptual understanding.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- Amanova et al. (2025) reviewed 60+ STEAM initiatives and found that visual arts integration significantly enhanced learning outcomes in geometry and trigonometry, particularly when using tools like tessellations, parabolas, and spirals as instructional anchors.

Broader Learning Benefits

The integration of artistic frameworks into mathematical instruction improves visual literacy, supports multiple learning modalities, and reflects Universal Design for Learning (UDL) principles (Cast, 2018; Rose & Meyer, 2002). It also validates diverse cognitive styles and fosters meaningful dialogue between the analytic and artistic, reinforcing the need for educational models that celebrate complexity, ambiguity, and interconnection.

Finally, the emphasis on emotional tone and compositional balance in artworks highlights that mathematical forms are not purely technical but also expressive and interpretive. As research in neuroaesthetics suggests, curvature activates effective and cognitive processes in the brain that contribute to deeper emotional and intellectual engagement with learning materials (Silva & Barona, 2009; Ruta et al., 2023).

Discussion and Implications for Cross-Disciplinary Studies

The case studies of Antoni Gaudí and Jackson Pollock offer rich, grounded illustrations of how curvature operates not only as a mathematical abstraction but also as a powerful artistic and communicative force. These examples substantiate the proposition that curvature serves as a shared conceptual and visual language capable of bridging disciplinary divides.

In the case of **Gaudí's Sagrada Familia**, parabolic arches are not merely structural optimizations - they encode a biomorphic aesthetic that resonates with spiritual and ecological metaphors. Students encountering these forms in a geometry classroom may initially perceive them as static equations, but when recontextualized through Gaudí's architectural vision, the parabola becomes a dynamic agent of meaning, representing gravity, organicism, and transcendence (Middleton & Petruzzello, 2024). Teaching curvature through such a lens can invigorate mathematical learning by inviting interpretive, affective, and design-oriented thinking. However, this requires educators to translate architectural context into accessible pedagogy, an interdisciplinary fluency that is not yet widely supported by curriculum or teacher training programs.

Similarly, **Jackson Pollock's use of fractal-like curves**, though visually chaotic, reflects deep structures of self-similarity and complexity. His works exemplify how curvature may escape conventional parametric representation yet still align with mathematical models of turbulence and fractal geometry (Taylor et al., 2008; Taylor et al., 2011). This juxtaposition, between perceived disorder and latent order, invites learners to appreciate

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

curvature not only in smooth parabolas but also in stochastic, recursive forms. Integrating such abstract expressionist art into the mathematics classroom demands an openness to ambiguity and process over finality. This may challenge traditional educational models that emphasize procedural clarity and deterministic outcomes.

A central challenge in interdisciplinary teaching lies in reconciling *epistemic differences* between the disciplines, since mathematics often prizes precision and proof, while art values ambiguity, affect, and interpretation (Andrés & Franco, 2021; Boaler, 2016). For instance, a mathematics educator might be concerned with deriving curvature from first principles, while an art teacher might emphasize how curvature conveys motion or emotion, e.g., in a Kandinsky painting. When interdisciplinary content is introduced without careful scaffolding, it can risk becoming superficial or tokenistic, which in Henriksen et al. (2016) is described as "disciplinary silos with decorative bridges".

Moreover, student comprehension is not always symmetrical across domains. Learners with strong visual and emotional intelligence may intuit the aesthetic power of a curved form but, at the same time, struggle with its formal mathematical derivation. Conversely, mathematically inclined students may plot sinusoidal curves, yet fail to connect them to symbolic or expressive content in an artwork. Effective cross-disciplinary pedagogy must therefore include metacognitive strategies that help students reflect on how they think and learn across different representational systems (Rose & Meyer, 2002; Sousa, 2016).

Despite these challenges, the mutual reinforcement of perception and analysis that emerges from cross-disciplinary approaches can yield transformative outcomes. For example, when students use digital tools to model Gaudí's catenary arches or simulate Pollock's drip patterns with fractal algorithms, they are not only developing computational fluency but also engaging in aesthetic judgment, spatial reasoning, and interpretive critique. These integrated competencies align with the goals of STEAM education, which aims to cultivate learners who are both analytically precise and creatively agile (UNESCO, 2015; Amanova et al., 2025).

In this regard, the pedagogy of curvature becomes a test case for broader efforts to harmonize analytic rigor with expressive insight. Gaudí and Pollock, though operating in distinct traditions, each demonstrate how formal structures - whether parabolic or fractal - can embody affective depth and cultural resonance. By foregrounding such examples in their curriculum, educators can model how disciplinary fluency is not diluted through integration but expanded through dialogue.

To facilitate this, future research should explore collaborative teaching models that bring together mathematicians, artists, and educators to co-design

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

curriculum and assess learning outcomes (Sylviani et al., 2024). These efforts may benefit from the establishment of interdisciplinary learning hubs, where tools such as 3D modeling, generative design software, and neural interface studies, inspired by neuroaesthetics research (Ruta et al., 2023), are deployed to examine curvature not only as a static form but as a dynamic perceptual experience. In this way, curvature moves from being a symbol of form to a vehicle of transformation across disciplines, cultures, and minds.

Conclusion

This article has presented an interdisciplinary inquiry into the role of curvature as a bridge between mathematical reasoning and artistic expression. By examining parabolic, sinusoidal, and exponential forms through both visual and analytical lenses, we have demonstrated how curvature can function not only as a structural or aesthetic element but also as a metaphorical and interpretive device.

The study's core proposition - that even simplified mathematical frameworks can deepen our understanding of visual composition and artistic logic - has implications for both academic research and classroom practice. Whether through educational design, visual storytelling, or the structuring of spatial perception, the integration of mathematical concepts into art enriches both fields, fostering creativity, engagement, and cross-disciplinary literacy.

Future research might explore the application of more sophisticated mathematical models - such as topological transformations, fractal dynamics, or machine learning-based image analysis - in understanding artistic forms. Similarly, further qualitative and quantitative studies could investigate how students and educators respond to interdisciplinary approaches involving curvature. As we continue to bridge disciplinary boundaries, the study of curvature exemplifies how conceptual elegance and artistic vision can converge to inspire new forms of inquiry and innovation.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

Funding Statement: The authors did not obtain any funding for this research.

References:

1. Amanova, A. K., Butabayeva, L. A., Abayeva, G. A., Umirbekova, A. N., Abildina, S. K., & Makhmetova, A. A. (2025). A systematic review of the implementation of STEAM education in schools. Eurasia Journal of Mathematics, Science and Technology Education, 21(1), em2568. https://doi.org/10.29333/ejmste/15894

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

2. Andrés F. A-A. & Franco, C. A. (2021). The Creative Act in the Dialogue between Art and Mathematics, Mathematics, MDPI, 9(13), 1517, 1-26. https://doi.org/10.3390/math9131517
3. Arnheim, R. (1974). Art and Visual Perception: A Psychology of the Creative Eye. University of California Press.
4. Boaler, J. (2016). Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages, and innovative teaching. Jossey-Bass/Wiley.
5. Cast (2018). UDL Guidelines 3.0. http://udlguidelines.cast.org
6. Devlin, K. (2011). Mathematics education for a new era: Video games as a medium for learning. 1st Edition, A K Peters/CRC Press. https://doi.org/10.1201/b10816
7. Fierro-Newton, P. (2024). The Emotional Impact of Curved vs. Angular Designs. https://neurotectura.com/2024/12/31/the-emotional-impact-of-curved-vs-angular-designs/?utm_source=chatgpt.com
8. Friedman, M. & Carter, M. (1991). Curvature in Art and Nature. Journal of Aesthetic Education, 25(3), 85-96.
9. Gao, J. and Newberry, M. (2024). Fractal Scaling and the Aesthetics of Trees, Physics and Society, arXiv:2402.13520 [physics.soc-ph]. https://doi.org/10.48550/arXiv.2402.13520
10. Gombrich, E. H. (1960). Art and Illusion: A Study in the Psychology of Pictorial Representation. Princeton University Press.
11. Grieve, A. (2018). The Scientific Narrative of Leonardo's Last Supper, Jour. of Excellence in Integrated Writing at Wright State University, Vol. 5(1).
12. Henderson, D. W. & Taimina, D. (2001). Crocheting the hyperbolic plane. The Mathematical Intelligencer **23**, 17–28. https://doi.org/10.1007/BF03026623
13. Henriksen, D., Mishra, P. & Fisser, P. (2016). Infusing creativity and technology in 21st-century education: A systemic view for change. Educational Technology & Society, 19(3), 27–37. https://www.researchgate.net/publication/311670214
14. Hoffman, D. D. & Richards, W. (1984). Parts of recognition. Cognition, 18(1-3), 65-96. https://doi.org/10.1016/0010-0277(84)90022-2
15. Kandinsky, W. (1947). Concerning the Spiritual in Art. Wittenborn, Schultz, Inc.
16. Kempkes, S. N., Slot, M. R., Freeney, S. E., Zevenhuizen, S. J. M., Vanmaekelbergh, D., Swart, I., & Morais Smith, C. (2019). Design and characterization of electrons in a fractal geometry. Nat. Phys. 15, 127–131. https://doi.org/10.1038/s41567-018-0328-0
17. Kreyszig, E. (1991). Differential Geometry. Dover Publications.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

18. Kühnel, W. (2006). Differential Geometry: Curves, Surfaces, Manifolds. American Mathematical Society. ISBN 0-8218-3988-8.
19. Lisi & Nagappan, R. (2024). Exploring the Interconnections and Practical Applications of Art within a STEAM Education Curriculum. International Journal of Education and Humanities. 16(2), 193-197. https://doi:10.54097/xs0n7598
20. Livio, M. (2002). The Golden Ratio: The Story of Phi, the World's Most Astonishing Number. Broadway Books.
21. McRobie, A. (2017). The Seduction of Curves: The Lines of Beauty that Connect Mathematics, Art and the Nude. Princeton University Press. ISBN: 9780691175331.
22. Middleton, J. & Petruzzello, M. (2024). "Sagrada Família". Encyclopedia Britannica, 3 Oct. 2024, https://www.britannica.com/topic/Sagrada-Familia
23. Pressley, A. (2001). Elementary Differential Geometry. Springer.
24. Rose, D. H., & Meyer, A. (2002). Teaching every student in the digital age: Universal design for learning. Association for Supervision and Curriculum Development (ASCD). ISBN: ISBN-0-87120-599-8.
25. Ruta, N., Vano, J., Peppereli, R., Corradi, G. B., Chuquichambi, E. G., Rey, C. & Munar, E. (2023). Preference for paintings is also affected by curvature. Psychology of Aesthetics, Creativity, and the Arts, 17(3), 307-321. https://doi.org/10.1037/aca0000395
26. Schoevers, E. M., Leseman, P. P. M. & Kroesbergen, E. H. (2019). Enriching Mathematics Education with Visual Arts: Effects on Elementary School Students' Ability in Geometry and Visual Arts. International Journal of Science and Mathematics Education, 18, 1613–1634. https://doi.org/10.1007/s10763-019-10018-z
27. Silva, P. J. & Barona, C. M. (2009). Do People Prefer Curved Objects? Angularity, Expertise, and Aesthetic Preference, Empirical Studies of Arts, 27(1), 25-42. https://doi:10.2190/EM.27.1.b
28. Sinclair, N., & Watson, A. (2001). The aesthetic is relevant. For the Learning of Mathematics, 21(1), 25–32. https://eric.ed.gov/?id=EJ627148
29. Smith, D. E. (1958). History of Mathematics, Vol. 2. New York, NY: Dover Publications.
30. Sousa, D. A. (2016). How the brain learns (5th ed.). Corwin Press. https://www.amazon.com/How-Brain-Learns-David-Sousa/dp/1506346308
31. Sylviani, S., Permana, F. C. & Azizan, A. T. (2024). Enhancing Mathematical Interest through Visual Arts Integration: A Systematic Literature Review, International Journal of Education in Mathematics,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Science and Technology, 12(5), 1217-1235. https://doi.org/10.46328/ijemst.4118

32. Taylor, R. P., Spehar, B., Clifford, C. W. G., & Newell, B. R. (2008). The Visual Complexity of Pollock's Dripped Fractals. In: Minai, A.A., Bar-Yam, Y. (eds.) Unifying Themes in Complex Systems IV, 175–182. Springer, Heidelberg.
33. Taylor, R. P., Spehar, B., Van Donkelaar, P., & Hagerhall, C. M. (2011). Perceptual and physiological responses to Jackson Pollock's fractals. Frontiers in Human Neuroscience, Vol. 5, Article 60, 1-13. doi:10.3389/fnhum.2011.00060
34. UNESCO. (2015). Cracking the code: Girls' and women's education in science, technology, engineering and mathematics (STEM). United Nations Educational, Scientific and Cultural Organization. https://unesdoc.unesco.org/ark:/48223/pf0000253479

ESJ Social Sciences Peer-reviewed

Understanding of stoichiometry by learners from Form Four to final year of general secondary education in Cameroon

Jeremie Awomo Ateba, PhD
Senior Lecturer, ENS-University of Yaounde 1, Cameroon
Josephine Nita Tematio Woukeng, MA
FSE-University of Yaounde 1, Cameroon
Lawrence Ntam Nchia, PhD
Senior Lecturer, ENS-University of Yaounde 1, Cameroon
Ayina Bouni, PhD
Associate professor, ENS-University of Yaounde 1, Cameroon

Doi:10.19044/esj.2025.v21n19p156

Submitted: 23 May 2025
Accepted: 15 July 2025
Published: 31 July 2025

Cite As:
Ateba, J.A., Woukeng, J.N.T., Nchia, L.N. & Bouni, A. (2025). *Understanding of stoichiometry by learners from Form Four to final year of general secondary education in Cameroon.* European Scientific Journal, ESJ, 21 (19), 156.
https://doi.org/10.19044/esj.2025.v21n19p156

Abstract

The aim of the present research is to determine the conceptions of learners from Form Four to Upper Sixth (13-19 years) of general secondary education in Cameroon about the concept of stoichiometry. A preliminary analysis of the didactic transposition of the concept of chemical reaction in the Form Four textbook, combined with an epistemological study of the concept of stoichiometry, enabled us to design an 8-item paper-and-pencil questionnaire. The questionnaire was administered to 239 learners ranging from four to Upper Sixth students of five general secondary schools. The data collected were analyzed using Dehon's (2018) significance level model. The results show that many students assign irrelevant meanings to the concepts within the conceptual network of stoichiometry. For instance, 54.4% of students conceive of the stoichiometric coefficient at the macroscopic level as a quantity of matter. Furthermore, only 20.4% of students correctly determine the number of molecules (or atoms) of one reactant needed to react completely with a known number of molecules (or atoms) of another reactant, and 36.8% correctly determine the quantity of matter of one reactant required to react

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

completely with a precise quantity of another reactant. It appears that stoichiometry is better conceptualized by students at the macroscopic level than at the microscopic level.

Keywords: Chemical reaction, stoichiometry, levels of knowledge, stoichiometric coefficient, conceptions

Introduction

A chemical reaction is a fundamental concept in chemistry that poses enormous learning difficulties. Its complexity lies in the fact that it encompasses other concepts, and its understanding requires a shift between the macroscopic and microscopic levels. To explain a chemical reaction, we need to understand not only the structure of the reactants and products, but also the proportions in which they react. At the microscopic level, a chemical reaction can be interpreted as a rearrangement of atoms from well-identified chemical species to other, new species with different natures and organizations, often described for the first time in the case of new compounds (Barlet & Plouin, 1994). The result of this chemical effect can be represented by a simple formula which, like all algebraic formulas, is nothing more than reasoning put into tight form (Fourcroy & Vauquelin, 1797). This is the reaction equation, an integrating concept (Barlet & Plouin, 1994) introduced into Cameroonian general secondary education in Form Three (12-15 years) under the name of “literal equation”.

Balanced equation is a topic of study in Form Four onwards and is used as the preferred tool for quantitative study in chemistry (Barlet & Plouin, 1994). To speak of a quantitative study in chemistry is to speak of stoichiometry. According to Zumdahl (2002), stoichiometry is a chemical concept based on mathematical principles that makes it possible to determine the quantity of product that will be formed from a specific amount of reagent. And determining the amount of product to be formed from a given amount of reactant is the task regularly assigned to students in chemistry exercises. Students' difficulties in solving these exercises form the basis of many studies in chemistry education research (Çelikkiran, 2020; Frazer & Servant, 1986; Gauchon, 2008; Gauchon & Méheut, 2007; Laugier & Dumon, 2000).

Some research highlights the difficulties learners face in understanding stoichiometry (Frazer & Servant, 1986; Gauchon, 2008; Gauchon & Méheut, 2007; Laugier & Dumon, 2000). In this regard, Laugier & Dumon (2000) show that over 75% of form five students believe that none of the copper and hydroxide ions will remain after mixing a copper sulfate solution and a sodium hydroxide solution, whatever the initial proportions. In addition, Gauchon & Méheut (2007) show that for learners, when the reagents are in different physical states, the solid reagent is entirely consumed whatever the case, while

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

the liquid reagent remains in excess. Moreover, when students become aware of the proportionality relationship between the reagents, they encounter another difficulty, that of determining the proportional quantities. Thus, the quantities concentration, mass and volume are often used instead of the quantity of substance (Frazer & Servant, 1986; Laugier & Dumon, 2000).

Çelikkiran (2020) has shown that the idea of conservation of elements during a chemical reaction is not understood by grade 11 learners. Furthermore, they do not understand that stoichiometric coefficients represent stoichiometric ratios rather than simple numbers used to balance equations.

However, in the Cameroonian context, the concept of stoichiometry is not prescribed in the official curriculum. It is addressed implicitly in the study of the concept of chemical reaction. The objectives of this study are: to define the concepts of chemical reaction, reactants, products, balance equation; to state the law of conservation of matter; to write and balance a reaction balance equation; to exploit a reaction balance equation. Stoichiometry evolves in the shadow of the balance equation. Our empirical observation is that, in classroom situations, teachers insist on the algorithmic balancing of equations, to the detriment of the construction of relevant meanings for the signs contained in the equation. We are thus witnessing an overemphasis on algorithmic techniques in teaching stoichiometry, which may explain students' struggles with novel problems, especially in the transition from symbols, theories and models to the macroscopic aspects of chemical reactions, and in the construction of the meaning of the symbols contained in the reaction balance equation (BouJaoude & Barakat, 2003; Çelikkiran, 2020; Dehon, 2018; Dehon & Snauwaert, 2015; Ducamp & Rabier, 2005; Nakhleh & Mitchell, 1993; Nurrenbern & Pickering, 1987; Stamovlasis et al., 2005).

Generally speaking, stoichiometry is not just about moles, balancing reaction equations, or even stoichiometric coefficients. Stoichiometry has many aspects that are not necessarily linked to a purely algorithmic idea. These concepts make up the conceptual network. Cedran et al. (2022) have shown that the conceptual network of stoichiometry includes: the conservation of matter, the symbolism of atoms and molecules, the concept of the mole, the proportions between reactant quantities of matter, and the constant composition of compounds.

The teaching of stoichiometry, as it is carried out in the Cameroonian context, leads us to predict that learners, once taught, will have mostly irrelevant meanings of the concept of stoichiometry by Form Four. What precisely are these meanings, and how do they evolve as learners progress through the curriculum?

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Theoretical framework

According to Johnstone (2000), the difficulties encountered by learners in chemistry can be explained by its multi-representational nature. He defines three levels of thought according to which knowledge in chemistry can be structured: a macroscopic level, a submicroscopic level and a symbolic level. The various representations (symbols, icons, etc.) at the symbolic level enable us to communicate about chemical experiments at the macroscopic level and models at the submicroscopic level. These representations constitute what Talanquer (2011) and Dehon (2018) have called "visualizations". In the Cameroonian context, visualizations are central to teaching/learning, as they are the starting point (Awomo Ateba, 2022). They are a set of dynamic and static visual signs, symbols and icons, which enable the elaboration and communication of qualitative and quantitative relationships relating to experiences and models (Dehon, 2018). Dehon has thus proposed a framework for addressing the question of the meanings that students lend to elements of language used in the popularization of knowledge in chemistry. In this framework, the learner can, on the basis of a visualization, construct meanings at three distinct levels:

- The macroscopic level of meaning: the student refers to the observable by citing empirical observations (colour change, disappearance during a chemical reaction, etc.); by using macroscopic concepts such as substance, metal, solid, etc.; or even describes certain properties of the substance under consideration (states of matter, brightness, etc.). Empirical observations also fall within this same level of meaning.
- The microscopic level of meaning: students refer to the constituent entities of matter (molecules, atoms, and ions), molecular geometry, microscopic properties or subatomic particles (electrons, protons, neutrons).
- The level of symbolic meaning: the student is limited to reading the sign(s) as a signifier (association of letters, position in a combination of symbols, number in a mathematical equation, etc.). At this level, the student can also give the visualization a meaning outside the strict framework of chemistry.

Methods

The present research explores the conceptualizations made by learners taught about the "notion of chemical reaction" and their understanding of the concepts within the conceptual network of stoichiometry. It is therefore descriptive in nature (Thouin, 2014). Given that the notion of chemical reaction (in which most of the concepts of the conceptual network of stoichiometry are addressed) constitutes a topic of study in Form Four in Cameroon's official curriculum, and that these concepts are used as tools for

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

quantitative analysis as early as in form five, this study seeks to examine the meanings that learners from Form Four to Upper Sixth lend to the concepts of the conceptual network of stoichiometry. This would make it possible to assess the impact of manipulating these concepts on the meaning that students attribute to them. The data collection tool is a questionnaire consisting of 8 open and semi-open questions. This questionnaire was validated with 35 learners from Form Four to Upper Sixth, who did not belong to our sample. It was then administered to 239 students from 5 schools in the cities of Yaoundé and Bafoussam and their suburbs, including 105 in Form Four, 40 in Form Five, 56 in Lower Sixth and 38 in the Upper Sixth. The test was administered by the teachers of the respective classes, during class time and in the presence of the researcher, for an average of 45 minutes.

Results and Discussion

Balancing reaction equations: symbolic meanings of the stoichiometric coefficient

The first question assesses learners' ability to balance reaction equations. It is divided into two cases as follows: Balance each of the following equations:

a. $\ldots\ldots H_2 + \ldots\ldots Cl_2 \rightarrow \ldots\ldots HCl$

b.$\ldots\ldots Al + \ldots\ldots CO_2 \rightarrow \ldots\ldots Al_2O_3 + \ldots.. C$

The respective results are shown in the following tables:

Table 1: Learners' significance of the stoichiometric coefficient at the symbolic level, case a

Category name	Frequencies				General percentage
	3ième/105	2nde/40	1ière/56	Tle/38	
1- Simple coefficients	52,4%	50,0%	50,0%	76,3%	55,2%
2- Multiple coefficients	16,2%	25,0%	39,3%	13,2%	22,6%
3- Using of rational stoichiometric coefficients	0,0%	7,5%	1,8%	7,9%	2,9%
4- Failure to master the rule	18,1%	10,0%	7,1%	2,6%	11,7%
5- Erroneous conception of the index	10,5%	2,5%	1,8%	0,0%	5,4%
6- No answer	2,9%	5,0%	0,0%	0,0%	2,1%

Table 2: Learners' significance of the stoichiometric coefficient at the symbolic level case b

Category name	Frequencies				General percentage
	3ième/105	2nde/40	1ière/56	Tle/38	
1- Simple coefficients	47,6%	55,0%	76,8%	68,4%	59,0%
2- Multiple coefficients	0,0%	0,0%	1,8%	2,6%	0,8%
3- Using of rational stoichiometric coefficients	1,9%	15,0%	5,4%	7,9%	5,9%
4-Failure to master the rule	41,6%	27,5%	14,3%	21,1%	33,2%
5- No answer	2,9%	2,5%	1,8%	0,0%	2,1%

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

On average, 80.8% of learners at all levels were able to balance the first reaction equation correctly. However, 55.2% of learners use the simplest integer coefficients, i.e., the triplet (1, 1 and 2) (from left to right respectively) to balance the equation. They seem to have constructed the idea of a stoichiometric coefficient as a 'proportion'. 22.6% of learners used multiples of the previous coefficients, namely (2, 2 and 4) and even (3, 3 and 6). For these students, the most important thing is to balance the equation, whatever the 'numbers' used. For them, balancing a reaction equation has no meaning in the context of chemistry, but remains a mathematical game. In addition, 2.9% of learners use rational stoichiometric coefficients. These are certainly relevant at the macroscopic and symbolic levels, but not at the microscopic level.

Furthermore, 5.4% of the students between the third and first grades thought they were balancing the equation using the triplet (2, 2, 2). They have an erroneous conception of the index and lead us to believe that when simple pure bodies of the same valency react to form a single product, the students disregard their indices when balancing the balance equation. Finally, 11.7% of learners were unable to balance the balance equation, probably because of their poor grasp of the balancing 'rules'.

The rate of correct answers recorded in the first case rises to 65.7% in the second. This suggests that the learners' ability to balance the reaction equations depends on the case in question.

Constant composition of compounds: role of the index at the symbolic level

The second item is designed to check that the students have assimilated the unique identity of compounds, which translates into a constant composition at the symbolic level. The question, in the form of a MCQ, is worded as follows: Hydrogen sulphide (H_2S) reacts with sulphur dioxide (SO_2) to form water (H_2O) and sulphur (S). The balanced chemical equation for the reaction is as follows:

a. $2H_2S + SO_2 \rightarrow 2H_2O + S_3$
b. $2H_2S + SO_2 \rightarrow 2H_2O + 3S$
c. $H_2S + SO_2 \rightarrow H_2O_2 + 2S$
d. $H_2S + SO_2 \rightarrow H_2O + S$
e. other

Although equations a and c are balanced, they do not retain the formulae of the compounds mentioned in the text. Equation b corresponds to the balanced reaction equation and to the unbalanced equation. The results obtained are shown in Table 3.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Table 3: Learners' meanings of the composition of the compounds when writing the reaction balance equation

Category name	Frequencies				General percentage
	3ième/105	2nde/40	1ière/56	Tle/38	
1- Preserving compound identity	41,9%	37,5%	64,3%	68,4%	50,6%
2- Modification of compound identity and preservation of elements	36,2%	37,5%	26,8%	19,1%	31,8%
3- Preservation of identity but not of elements	17,1%	22,5%	7,1%	10,5%	14,6%
4- Others	2,9%	2,5%	1,8%	0,0%	2,1%
5- No answer	1,9%	0,0%	0,0%	0,0%	0,8%

Table 3 shows that 50.6% of the students correctly identified the balanced reaction equation. They were aware of the constant composition of the compounds. We can assume that they have constructed relevant meanings for the index and the stoichiometric coefficient at the symbolic level. 14.6% opted for a not balanced equation in which the identity of the compounds was preserved. They have therefore constructed a symbolically relevant meaning for the notion of index, but not for that of stoichiometric coefficient. Finally, 31.8% retained the number of elements, but not the identity of the compounds. They have constructed a relevant meaning for the notion of stoichiometric coefficient at the symbolic level, but not for the index. However, this poor conceptualisation of the index at the symbolic level tends to disappear as the learners progress through their course.

Meaning of the stoichiometric coefficient at the macroscopic level

The third question in the questionnaire aims to bring out the meanings attributed to the stoichiometric coefficient at the macroscopic level, in particular, its relationship with the initial quantity of matter of the reagents introduced. The question is worded as follows: Three moles of nitrogen (N_2) and two moles of hydrogen (H_2) are reacted to form ammonia (NH_3). Write down the balance equation for the reaction to form ammonia. The results are shown in Table 4.

Table 4: Learners' meanings of the stoichiometric coefficient at mthe acroscopic level

Category name	Frequencies				General percentage
	3ième/105	2nde/40	1ière/56	Tle/38	
1- $N_2 + 3H_2 \rightarrow 2NH_3$ $N_2 + H_2 \rightarrow NH_3$ $N_2 + \frac{1}{2}H_2 \rightarrow 2NH_3$	47,6%	30,0%	41,05%	42,2%	42,2%
2- $3N_2 + 2H_2 \rightarrow NH_3$ $3N_2 + 2H_2 \rightarrow 6NH_3$ $3N_2 + 2H_2 \rightarrow 2N_2H_3$ $3N_2 + 9H_2 \rightarrow 6NH_3$	21,9%	40,0%	35,7%	39,5%	33,9%

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

3- Failure to identify reactants and products	23,8%	20,0%	10,7%	13,2%	18,5%
4- No answer	6,7%	10,0%	1,8%	2,6%	5,4%

Table 4 shows that 42.2% knew that the initial quantities of matter of the reactants are not taken into account when writing a reaction balance equation. They therefore constructed relevant meanings for the stoichiometric coefficient at the macroscopic level. Only 26.4% (of the total sample) wrote a balanced reaction equation. They also constructed relevant meanings for the stoichiometric coefficient at the symbolic level. 12.5% did not balance the equation. They are aware that the initial quantities of matter of the reactants do not appear in the balanced reaction equation, but have not constructed a relevant meaning for the stoichiometric coefficient at the symbolic level. Finally, 3.3% of learners had difficulty balancing the reaction equation.

In addition, 33.9% of the students confused the stoichiometric coefficient with the initial quantity of reactant. They had constructed an irrelevant meaning for the stoichiometric coefficient at the macroscopic level. However, 3% of them seem to have constructed a relevant meaning for the stoichiometric coefficient at the symbolic level. Although they initially positioned the initial quantities of the reactants in place of the stoichiometric coefficients, they then readjusted the equation to ensure the conservation of the elements.

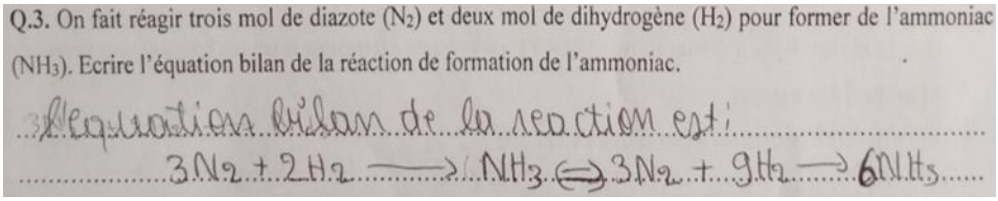


Figure 1: Irrelevant significance of the stoichiometric coefficient at the macroscopic level of a learner

Strangely enough, this misconception seems to increase as students' progress through the curriculum. Finally, 18.5% of learners have difficulty correctly identifying the reactants and products of a reaction described at the macroscopic level.

Conservation of elements during a chemical reaction

The fourth question assesses the students' understanding of the conservation of elements during a chemical reaction at the microscopic level. The aim is to recognise that no new elements are created during a chemical reaction, but that the elements that make up the reactants are rearranged. The question is formulated as follows: The combustion of a substance A in the oxygen (O_2) in the air produces carbon dioxide (CO_2) and water (H_2O). Where

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

do the carbon and hydrogen elements in the products come from? The results obtained are shown in Table 5.

Table 5 : Learners' understanding of the conservation of elements during a chemical reaction

Category name	Frequencies				General percentage
	3ième/105	2nde/40	1ière/56	Tle/38	
1- Substance A	2,9%	0,0%	23,2%	29,0%	11,3%
2- Chemical reaction	26,7%	50,0%	32,1%	23,7%	31,4%
3- Writing of an equation	0,0%	0,0%	1,8%	7,9%	1,7%
4- Products	8,6%	5,0%	3,6%	0,0%	5,4%
5- Reactants	8,6%	0,0%	7,1%	2,6%	5,9%
6- Answers out of context	13,3%	32,5%	14,3%	10,5%	16,3%
7- No answer	40,0%	12,5%	17,9%	26,3%	28,0%

Table 5 shows that only 11.3% of learners think that the elements carbon and hydrogen come from substance A. This proportion of students seems to have constructed relevant meanings of the conservation of elements during a chemical reaction at the microscopic level. Compared to the high rate of learners who correctly balance the balance equations obtained in the first question (65.7 to 80.8%), we can deduce that many learners have difficulty moving from the symbolic level to the microscopic level. We share the idea (Dehon, 2018) that learners' ability to balance reaction balance equations is not synonymous with constructing relevant meanings of the underlying concepts. The high non-response rate obtained in Table 5 (28%) confirms this idea.

Furthermore, 31.4% of learners thought that chemical reactions produce chemical elements. The formulations used by these learners were as follows: *"*the elements carbon and hydrogen come from the complete combustion of body A in the oxygen in the air", "... from the combustion of the reactants", "... from the combustion of carbon and hydrogen". They did not construct a relevant meaning of the concept of chemical reaction at the microscopic level.

5.9% of learners think that the elements carbon and hydrogen come from the reactants, but are unable to identify the reactant in question precisely. They simply recited the rule from the 3rd year textbook, which states that "the atoms present in the reactants are all combined differently in the products obtained". A formulation used by some of them is: "the elements carbon and hydrogen come from body A and O_2". They were not aware that O_2 contained neither carbon nor hydrogen.

5.4% of the students thought that the carbon and hydrogen elements present in the products came from the products themselves. Their answer was based solely on the raw formulae of the products, in which they identified the letters C and H. They therefore remained at the level of symbolic meaning.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

16.3% of the pupils gave answers outside the context of the situation described, such as "a black deposit and escaping water", "hydrolysis", "methane". These are at the level of symbolic meaning (Dehon, 2018).

Stoichiometric mixing at macroscopic level

The fifth question in the questionnaire aims to determine what learners mean by stoichiometric mixing at the macroscopic level. The aim is to recognise that the quantity involved in a stoichiometric relationship is the quantity of matter and not the mass or volume. It can be stated as follows: Consider the chemical reaction symbolised by the following balance equation: $C + O_2 \rightarrow CO_2$. At the initial instant, one gram of carbon (C) and one gram of oxygen (O_2) are mixed. Are the reactants in stoichiometric proportions? Justify this.

Table 6: Learners' meanings of stoichiometric proportions

Category name	Frequencies				General percentage
	3ième/105	2nde/40	1ière/56	Tle/38	
1- yes	41,9%	55,0%	42,9%	36,8%	43,5%
2- No	9,5%	25,0%	37,5%	44,7%	24,3%
3- No answer	48,6%	20,0%	19,6%	18,4%	32,2%

Table 6 shows that this question had a considerable rate of non-responses (32.2%). Of those who answered the question, very few (24.3%) thought that the reactants were not in stoichiometric proportions. Of these, only 1.7%, exclusively in first and final year classes, justified that the reactants are in stoichiometric proportions if the ratios of their initial quantities of matter by their respective stoichiometric coefficients are equal. They have constructed a relevant meaning of the notion of stoichiometric mixture at the macroscopic level. In addition, 15% think that the reactants are in stoichiometric proportions if their initial quantities are equal. These learners have relevant meanings of the particle counting unit at the macroscopic level. However, the fact that they did not mention the stoichiometric coefficients suggests that they have not constructed relevant meanings of the proportions in which the reactants react.

On the other hand, 43.5% think that the reactants are in stoichiometric proportions. In this category, 10.9% justified that the reactants were in stoichiometric proportions because the equation was balanced. Some backed up their statements by saying that "the stoichiometric coefficients are equal to the masses". These students, therefore, carry around the erroneous meaning mentioned above: the stoichiometric coefficient represents the initial quantity of reactants. They do not understand that mixtures of different amounts of the same reactants can obey the same equation. In addition, 7.5% thought that the reactants were in stoichiometric proportions because "the mass of the reactants is equal to that of the products". This justification, which is used in a context

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

where the mass of the products has not been given, is based on a recitation of Lavoisier's law of conservation of mass studied in class.

Finally, 5.4% of learners thought that the reactants were in stoichiometric proportions if their coefficients were equal.

Meaning of the concept of stoichiometry at the macroscopic level

The sixth question probes the meanings associated with stoichiometry at the macroscopic level. The aim is to determine from a balance equation the quantity of a reagent that can react completely with a known quantity of the other reagent. The reaction of iron with oxygen is modelled by the following balance equation. What quantity of oxygen (O_2) is needed to completely react 2 moles of iron (Fe)? The results obtained are given in Table 7.

Table 7: Learners' meanings of stoichiometry at macroscopic level

Category name	Frequencies				General percentage
	3ième/105	2nde/40	1ière/56	Tle/38	
1- Correct use of the proportionality relation at the macroscopic level	4,8%	40,0%	62,5%	84,2%	36,8%
2- Poor conceptualisation of the amount of substance	18,1%	0,0%	7,1%	5,3%	10,5%
3- Poor use of the rule of 3	1,9%	2,5%	0,0%	0,0%	1,3%
4- Random/unjustified answers	10,5%	12,5%	3,4%	2,6%	8,0%
5- Using of m/M	33,3%	17,5%	9,0%	2,6%	20,1%
6- Using of the Avogadro number	3,8%	2,5%	0,0%	2,6%	2,5%
7- No answer	27,6%	25,0%	17,9%	2,6%	20,9%

Overall, 36.8% of the students questioned were able to determine the quantity of a reagent needed to react completely with a precise quantity of another reagent. They seem to have constructed relevant meanings for the proportionality relationship between reactants at macroscopic level. However, the fact that the rate of correct answers increased with the level of study indicates that this correct application of the relationship of proportionality between reagents is due more to its frequent use than to an understanding of stoichiometry.

Furthermore, 20.1% of the students (mostly in the third year) used the relationship to determine the quantity of O_2. Almost all of these students assigned arbitrary values to the different variables in the relationship in order to obtain a result. This relationship therefore, remains constructed at a symbolic level. In addition, 8% of the learners questioned had a poor conceptualisation of the quantity of matter. They sometimes equated it with the stoichiometric coefficient, sometimes with the molar mass. 2.5% of students used the relationship between the number of moles and Avogadro's number, this time confusing the number of atoms with the quantity of matter.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Finally, 8% gave haphazard answers, without any justification, and 1.3% of the students misused the rule of 3 to answer the question.

Meaning of the concept of stoichiometry at the microscopic level

The seventh question explores the meanings associated with stoichiometry at the microscopic level. It involves determining from a balance equation the number of molecules (or atoms) of one reactant that can react completely with a known number of molecules (or atoms) of the other reactant. It is formulated as follows: the reaction of iron with oxygen is modelled by the following balance equation: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$. How many molecules of oxygen (O_2) are needed to react completely with 8 atoms of iron (Fe)? The results obtained are shown in Table 8.

Table 8: Learners' meanings of stoichiometry at the microscopic level

Category name	Frequencies				General percentage
	3ème/105	2nde/40	1ère /50	Tle/38	
1- Correct use of the proportionality relation at the microscopic level	1,0%	0,0%	8,0%	2,4%	3,1%
2- Multiplying the stoichiometric coefficients of the equation	1,0%	25,6%	34,0%	26,8%	17,3%
3- Poor use of the Avogadro's number	6,2%	9,3%	12,0%	14,6%	9,5%
4- Poor use of the proportionality relation at the macroscopic level	0,0%	16,3%	10,0%	12,2%	7,4%
5- Inappropriate use of the formula n=m/M	7,2%	0,0%	0,0%	2,4%	3,5%
6- Incorrect answers without justification	27,8%	16,3%	12,0%	14,6%	19,9%
7- No answer	56,8%	32,6%	22,0%	24,4%	39,0%

Table 8 shows that (20.4%) of learners correctly determined the number of molecules (or atoms) of one reagent needed to react completely with a known number of molecules (or atoms) of the other reagent. This rate of correct answers increases with the level of study. However, the fact that the rate of correct answers was higher in the first year of secondary school than in the final year is cause for concern. Of these, 3.1% correctly applied the relationship of proportionality between reagents at the microscopic level. They seem to have constructed a relevant meaning of stoichiometry at the microscopic level. 17.3% chose to multiply the stoichiometric coefficients of the balance equation by two. These students constructed a relevant meaning for the stoichiometric coefficient at the microscopic level as the number of molecules (atoms) of reactants that react.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Comparing this percentage of correct answers (20.4%) with that for question 6 (36.8%), it appears that stoichiometry is better conceptualised by the learners at the macroscopic level than at the microscopic level. The high rate of non-response (39%) and of unjustified wrong answers (19.9%) supports this idea.

Furthermore, 9.5% of the learners used the relationship n = $\frac{N}{N_A}$ (where n represents the quantity of matter, N the number of molecules and NA the Avogadro number). They do not take into account the balance equation. They have therefore constructed an irrelevant significance of stoichiometry at the microscopic level. 10.9% of learners calculate the quantity of matter instead. 7.4% used the proportionality relation and 3.5% used the relationship $n = \frac{m}{M}$. They remain at the macroscopic level.

Determining the quantity of product formed from a non-stoichiometric mixture

The eighth question tests the students' ability to determine the quantity of product formed from a non-stoichiometric mixture. In particular, we want to check whether the students, given the initial quantities of two reagents, take the trouble to find the limiting reagent before looking for the quantity of product formed. This will enable us to highlight the meanings they have constructed around the concept of the limiting reagent. The question is formulated as follows: 5 moles of oxygen (O_2) and 3 moles of iron (Fe) are mixed. The reaction that occurs is modelled by the following balance equation: $4Fe + 3O_2 \rightarrow 2Fe_2O_3$. The quantity of iron oxide III (formed at the end of the reaction is: (circle the letter corresponding to the correct answer):

a. 4 mol
b. 2 mol
c. 1,5 mol
d. 3,33 mol
e. Other

The answers are given in Table 9.

Table 9: Learners' understanding of the concept of limiting reagent

Category name		Frequencies				General %
		3e/105	2nde /40	1ière/56	Tle/38	
1- Correct application of the proportionality relation after determining the limiting reagent		0,0%	0,0%	4,0%	12,1%	3,0%
2- Correct application of the proportionality relation without	Use of the limiting reagent	4,1%	12,2%	22,0%	19,5%	12,2%

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

determining the limiting reagent	Using excess reagent	1,0%	4,9%	4,0%	4,9%	3,1%
	Uncertainty between reagents	0,0%	0,0%	6,0%	4,9%	2,2%
3- Incorrect application of the proportionality relation		0,0%	2,4%	4,0%	7,3%	2,6%
4- Stoichiometric coefficient		13,4%	39,0%	26,0%	12,2%	20,5%
5- Multiplying the index and the stoichiometric coefficient		21,7%	0,0%	4,0%	7,3%	11,4%
6- Unjustified answers		37,4%	34,1%	16,0%	17,1%	28,8%
7- No answer		21,6%	7,3%	14,0%	14,7%	16,2%

Table 10 shows that only 3% of learners found the limiting reagent and correctly determined the quantity of product formed. They had constructed a relevant meaning for the limiting reagent at macroscopic level.

On the other hand, 17.5% of the learners, although correctly applying the relationship of proportionality between the quantities of reagent consumed and product formed, did not determine the limiting reagent beforehand. They had constructed an irrelevant meaning for the notion of limiting reagent. The fact that 2.2% of learners determined two values for the quantity of the product from the quantities of the two reagents supports this idea*:* "if you use oxygen, you get 3.33 moles and if you use iron, you get 1.5 moles". The use of the limiting reagent (without prior determination) by 12.2% of learners could be explained by the position of the two reagents in the balance equation. In fact, they would have spontaneously used the first reagent to appear in the equation.

In addition, 20.5% of the learners confused the quantity of iron (III) dioxide formed with its stoichiometric coefficient. They have an irrelevant meaning for the notion of stoichiometric coefficient at the macroscopic level. The same applies to the 11.4% who multiply the stoichiometric coefficient of the product by the index of the element iron. They also have a poor conceptualisation of the role of the index.

Conclusions

We have surveyed learners' conceptions of the concepts in the stoichiometry conceptual network using a test consisting of eight open-ended and semi-open-ended questions. The data were analysed using Dehon's (2018) significance level model. The results showed that, although learners had little difficulty in balancing chemical equations, they constructed meanings for the concepts in the stoichiometry conceptual network that were largely irrelevant. In fact, the stoichiometric coefficient is better constructed at the symbolic (number that enables the balance equation to be balanced) and microscopic (number of reactant molecules that react) levels than at the macroscopic level, where it is considered as the quantity of reactant introduced or the quantity of

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

product formed. Furthermore, learners who manage to balance chemical equations have difficulties moving between the symbolic and microscopic levels. Specifically, the idea of atoms being rearranged during a chemical reaction is poorly understood by learners, most of whom think that the chemical reaction itself produces chemical elements.

Finally, the concept of stoichiometry is better constructed at the macroscopic level than at the microscopic level. Furthermore, it is unfortunate that the other concepts in the conceptual network of stoichiometry (stoichiometry, limiting reagent, stoichiometric coefficient) are not given much space in current secondary education in Cameroon, in favour of the balancing of reaction equations. A better construction of these concepts in classroom situations would allow a better conceptualisation of this integrating concept. In the future, we will test this working hypothesis by proposing a learning sequence that includes the different concepts of the stoichiometry conceptual network.

Conflict of Interest: The authors declare that they have no direct or indirect conflicts of interest in relation to the research presented in this article. Each author has made a significant contribution to the design, production and writing of this work. The order of authors' names has been established by mutual agreement, reflecting each author's contribution. This work is the collective intellectual property of the research team and is not linked to any external company or shareholder, thus guaranteeing its independence and integrity.

Data Availability: All data are included in the content of the paper.

Funding Statement: This study received no external funding. All costs related to the research design, data collection, analysis, and writing were covered by the authors. While academic research allowances in Cameroon supported the broader research environment, they did not directly fund this project.

Declaration for Human Participants: This study involved students from the fourth to final year of secondary school and was conducted in accordance with established ethical standards in the humanities and social sciences. Given the involvement of minors, special attention was paid to protecting participants' rights and well-being. Prior to data collection, written authorizations were obtained from school authorities. Clear information was provided to students and their parents or legal guardians about the study’s purpose, data confidentiality, and their right to refuse or withdraw at any time without consequences. Informed consent was obtained from all participants; for

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

minors, consent was also obtained from parents or legal guardians. All data collected has been treated anonymously and confidentially, ensuring that no information can be used to identify individual participants. The data has been stored securely and will only be used for research purposes.

References:

1. Awomo Ateba, J. (2022). Difficultés des élèves dans l'apprentissage du concept d'équilibre chimique au secondaire camerounais. Contribution à une épistémologie appliquée à la construction curriculaire. [Thèse de doctorat], Université de Yaoundé 1, Yaoundé. DOI: 10.13140/RG.2.2.26695.06561
2. Barlet, R., & Plouin, D. (1994). L'équation-bilan en chimie. Un concept intégrateur source de difficultés persistantes. Aster: Recherches En Didactique Des Sciences Expérimentales, 18(1), 27–56.
3. BouJaoude, S., & Barakat, H. (2003). Students' problem solving strategies in stoichiometry and their relationships to conceptual understanding and learning approaches. The Electronic Journal for Research in Science & Mathematics Education.
4. Cedran, D. P., da Costa Cedran, J., & Kiouranis, N. M. M. (2022). Panorama histórico da construção do campo conceitual da estequiometria. Revista Dynamis, 28(2), 152–170.
5. Çelikkiran, A. T. (2020). Examination of Secondary School Students' Ability to Transform among Chemistry Representation Levels Related to Stoichiometry. International Journal of Progressive Education, 16(2), 42–55.
6. Dehon, J. (2018). L'équation chimique, un sujet d'étude pour diagnostiquer les difficultés d'apprentissage de la langue symbolique des chimistes dans l'enseignement secondaire belge, développement d'une séquence de leçons en s' appuyant sur un modèle des niveaux de signification. Namur: PUN.
7. Dehon, J., & Snauwaert, P. (2015). L'équation de réaction: une équation à plusieurs inconnues. Étude de productions d'élèves de 16-17 ans (grade 11) en Belgique francophone. RDST. Recherches En Didactique Des Sciences et Des Technologies, 12, 209–235.
8. Ducamp, C., & Rabier, A. (2005). L'avancement de réaction en classe de première scientifique. 4iemes Rencontres Scientifiques de l'ARDIST.
9. Fourcroy, A.-F.;Vauquelin, L.-N. (1797). De l'action spontannée de l'acide sulfurique concentré sur les substances végétales et animales. Annales de Chimie, 194–195.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

10. Frazer, M. J., & Servant, D. (1986). Aspects of stoichiometry titration calculations. Education in Chemistry, 23(2), 54–56.
11. Gauchon, L. (2008). *Comprendre les titrages-Représentations d'élèves de première et terminale scientifiques et effets de quelques variables*. Université Paris-Diderot-Paris VII.
12. Gauchon, L., & Méheut, M. (2007). Learning about stoichiometry: from students' preconceptions to the concept of limiting reactant. *Chemistry Education Research and Practice*, *8*(4), 362–375.
13. ohnstone, A. H. (2000). Teaching of chemistry-logical or psychological? *Chemistry Education Research and Practice*, *1*(1), 9–15.
14. Laugier, A., & Dumon, A. (2000). Travaux pratiques en chimie et representation de la reaction chimique par l'equation-bilan dans les registres macroscopique et microscopique: Une etude en classe de seconde (15-16 ans). *Chemistry Education Research and Practice*, *1*(1), 61–75.
15. Nakhleh, M. B., & Mitchell, R. C. (1993). *Concept learning versus problem solving: There is a difference*. ACS Publications.
16. Nurrenbern, S. C., & Pickering, M. (1987). Concept learning versus problem solving: Is there a difference? *Journal of Chemical Education*, *64*(6), 508.
17. Stamovlasis, D., Tsaparlis, G., Kamilatos, C., Papaoikonomou, D., & Zarotiadou, E. (2005). Conceptual understanding versus algorithmic problem solving: Further evidence from a national chemistry examination. *Chemistry Education Research and Practice*, *6*(2), 104–118.
18. Talanquer, V. (2011). Macro, submicro, and symbolic: The many faces of the chemistry "triplet." *International Journal of Science Education*, *33*(2), 179–195.
19. Thouin, M. (2014). *Réaliser une recherche en didactique*. Éditions MultiMondes.
20. Zumdahl, S. S. (2002). *Chemical Principles: Steven S. Zumdahl*. Boston, MA: Houghton Mifflin.

ESJ Social Sciences Peer-reviewed

Identification des risques comme moyen d'amelioration des performances des projets de developpement rural au Cameroun

Bessi Aboganina Hubert
Benjamín Otto Ortega Morales
Université Internationale Ibéro-Américaine – UNINI, México

Doi:10.19044/esj.2025.v21n19p173

Submitted: 19 May 2025
Accepted: 08 July 2025
Published: 31 July 2025

Cite As:
Bessi Aboganina, H. & Ortega Morales, B.O. (2025). *Identification des risques comme moyen d'amelioration des performances des projets de developpement rural au Cameroun*. European Scientific Journal, ESJ, 21 (19), 173. https://doi.org/10.19044/esj.2025.v21n19p173

Résumé

Cet article relatif à l'influence des risques sur la performance des projets de développement rural au Cameroun repose sur une approche méthodique d'identification et d'atténuation des risques. Son objectif principal est de contribuer à l'amélioration de la performance des projets de développement rural. L'étude a été menée sur trois projets financés par différents bailleurs de fonds, à travers des entretiens semi-directifs, l'analyse de documents et l'observation. Elle a identifié vingt-deux (22) risques majeurs liés aux projets, dont 68 % sont exogènes et 32 % endogènes. Onze (11) d'entre eux sont fréquents ; seize (16) ont un impact significatif sur le respect des délais ; quatorze (14) influencent fortement l'exécution budgétaire et onze (11) ont un impact notable sur la qualité des livrables prévus. L'étude révèle que les mesures de gestion des risques sont généralement mises en œuvre dès qu'elles se manifestent et ont déjà eu un impact négatif sur la chaîne de résultats. Elle présente également un modèle de criticité des risques que les équipes de projet peuvent utiliser pour prendre des décisions de gestion. De plus, l'étude souligne la nécessité de renforcer les compétences des équipes de projet en matière de gestion des risques afin d'assurer la performance des projets de développement rural.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Mots clés : Projet de développement rural, influence, risque de projet, performance, succès

Risk identification as a means of improving the performance of rural development projects in Cameroon

Bessi Aboganina Hubert
Benjamín Otto Ortega Morales
Université Internationale Ibéro-Américaine – UNINI, México

Abstract

This paper concerning the influence of risks on rural development project performance in Cameroon is based on a methodical approach to risk identification and mitigation. Its main objective is to contribute to the improvement of the performance of rural development projects. The study was conducted on three projects funded by various donors, through semi-structured interviews, document analysis, and observation. It identified twenty-two (22) major project risks, of which 68% are exogenous and 32% endogenous. Eleven (11) of them occur frequently; sixteen (16) have a significant impact on meeting deadlines; fourteen (14) greatly influence budget execution, and eleven (11) have a notable impact on the quality of the planned deliverables. The study reveals that risk management measures are generally implemented once they manifest and have already had a negative impact on the outcome chain. It also presents a risk criticality model that project teams can use to make management decisions. Furthermore, the study highlights the need to strengthen the risk management skills of project teams in order to ensure the performance of rural development projects.

Keywords: Rural development project, influence, project risk, performance, success

Introduction

Afin de concrétiser sa vision 2035, le gouvernement camerounais a établi, en 2020, la Stratégie nationale de développement (SND30). La SND30 combine des stratégies sectorielles, dont le développement rural et le Plan national d'investissement agricole, pour atteindre les Objectifs du Millénaire pour le développement. Le gouvernement a mis l'accent sur le développement rural comme essence du développement national, favorisant ainsi la modernisation tout en contribuant au développement local.

Le Cameroun s'appuie sur l'aide publique au développement (APD) pour mettre en œuvre ses diverses stratégies de développement grâce aux

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

partenaires techniques et financiers (PTF) multilatérales ou bilatérales qui représentent respectivement 17,37 % et 5,35 % de l'APD reçue. Entre 2009 et 2018, 18 PTF se sont engagées dans le développement rural, avec 83 projets à travers le pays. Cependant, la plupart des projets de développement rural n'atteignent pas leurs objectifs, la pauvreté urbaine diminuant de 12,2 % à 10,8 % et la pauvreté rurale augmentant de 55 % à 59,5 %.

Selon les estimations de la Société Financière Internationale (SFI), un projet sur deux échoue. Un autre aspect notable de la gestion actuelle des projets de développement rural au Cameroun est la tendance aux prorogations, illustrant l'incapacité du projet à réaliser ses objectifs dans le temps imparti. Les problèmes de gestion des projets d'aide au développement dans les pays en développement sont légion (Ika, 2011). Awe Baina et al. (2020) signalent une performance généralement insatisfaisante des projets de développement rural au Cameroun. On attribue fréquemment cette sous-performance à une prise en compte insuffisante des risques de projet. C'est pourquoi cette étude se préoccupe de l'influence des risques sur la performance des projets de développement rural. Face à cette situation, il convient de se demander en quoi les risques de projet entravent la bonne performance des projets de développement au Cameroun. À cette question principale se rajoutent deux questions supplémentaires. Quels sont les risques qui pourraient influencer la gestion des projets de développement ? Quels sont leurs impacts sur les résultats escomptés des projets de développement ? Cet article se structure autour des sections suivantes : introduction, méthodologie, résultats et discussions, et enfin conclusion.

Méthodologique

L'approche méthodologique de cette étude s'appuie sur la revue de la littérature et l'observation participative. La revue de la littérature a constitué la fondation de base pour nos divers travaux, permettant non seulement de saisir le contexte et les défis du secteur rural camerounais, mais également d'acquérir une compréhension approfondie de l'évaluation de la performance, de l'identification des risques dans les projets de développement, ainsi que des principaux arguments des auteurs qui les ont mis en pratique ou étudiés. Quant à l'observation participative, elle a facilité notre immersion dans le secteur du management des projets de développement rural au Cameroun pour examiner les comportements, les interactions et les approches d'évaluation de la performance utilisées dans ce type de projet. La technique d'échantillonnage probabiliste utilisée nous a permis d'en sélectionner les trois projets suivants :

- Le PADFA financé par le fonds international pour le développement agricole (FIDA) ;
- Le PD-COBIE financé par la banque islamique de développement (BID) ;

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

- PCP-ACEFA financé par l'agence française de développement (AFD).

Dans chacun de ces projets, tous les individus occupant des postes de responsabilité (cadres) ont été sélectionnés pour constituer la taille de notre échantillon. Ces individus étaient composés des chargés de projets pays, des coordonnateurs nationaux, des responsables administratifs et financiers, des chefs de composantes et des responsables des unités régionales. Sur un effectif de départ de 83 individus, 73 ont réellement été interrogés, ce qui correspond à un taux de participation de 88 %.

Sur la base de la revue documentaire, le respect des budgets, le respect de la qualité et le respect des délais constituent nos trois variables dépendantes qui affectent la performance d'un projet de développement (triangle de la performance). Les mauvais scores de ces trois variables dépendantes au sein d'un projet de développement affectent négativement la chaîne des résultats. Toutefois, notre étude a identifié plusieurs risques de projet (variables indépendantes) qui proviennent de l'environnement interne ou externe du projet.

Ce faisant, en employant ces deux méthodes qualitatives dans le contexte de notre recherche, nous ne visons pas à manipuler ces différentes variables, mais plutôt à comprendre leur interrelation. L'objectif est d'apporter une contribution à l'amélioration des performances des projets de développement rural au Cameroun, en suggérant une approche de gestion qui tient compte des risques.

Resultats

Evaluation de la performance des projets de développement

La théorie des organisations constitue le fondement théorique des études sur la performance des projets et programmes de développement. Initialement, la gestion des projets était axée sur le temps, le coût et la portée, également appelé « triangle de fer » (Jugdev & Müller, 2005). La littérature actuelle distingue la performance d'un projet de sa réussite en raison de l'évolution de ses concepts. L'approche de Baccarini (as cited Khang & Mae, 2008) suggère que la performance d'un projet peut être évaluée progressivement tout au long de des phases de cycle de projet, en se concentrant sur la qualité des produits financiers générés et l'obtention des résultats escomptés. La réussite d'un projet est évaluée à sa fin selon différents critères, basés sur son impact, sa durabilité et son acceptation par les parties prenantes et la communauté du développement (Khang & Mae, 2008).

La performance d'un projet est mesurée à l'aide de divers indicateurs, notamment quantitatifs (coût, temps, qualité) et qualitatifs (satisfaction des bénéficiaires, impact social, développement durable), qui permettent de suivre

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

la progression vers les objectifs fixés et d'évaluer son impact sur la base des valeurs cibles contenues dans le cadre de mesure des résultats (CMR).

Un projet de développement rural est une initiative temporaire qui combine des ressources financières, humaines et matérielles pour améliorer le bien-être économique, social ou environnemental des populations rurales (Saidou, 2015). Il représente le principal moyen de dissémination de l'APD en Afrique depuis 1960. Cependant, malgré la multiplication des projets de développement rural en Afrique, notamment au Cameroun, leurs performances restent mitigées (Assontia Djoudji et al., 2022) . Awe Baina et al. (2020) rapportent que 70 % de ces projets ont une performance insuffisante et peu satisfaisante, tandis que 30 % ont une performance satisfaisante et très satisfaisante.

Risques de projet, incertitudes et complexité : caractéristiques implicites des projets de développement rural

Selon Khan & Zahid (2013), les projets de développement sont généralement des organisations à faible maturité, car leurs systèmes de gestion, relativement nouvelles, ne parviennent pas à gérer les risques en raisons de diverses contraintes. C'est pour cette raison que l'externalisation, aussi appelée « faire faire », est fréquemment utilisée pour exécuter la plupart des activités planifiées. Cette stratégie vise à garantir la solidité institutionnelle et à renforcer les compétences des acteurs locaux en matière de services de développement socio-économique. Cependant, cette approche engendre une incertitude relative à la variabilité de la qualité des services rendus, en raison de l'absence ou de l'indisponibilité de l'expertise locale.

Selon le PMI (2017), le risque de projet est « un évènement ou une condition incertaine dont la concrétisation aurait un effet positif ou négatif sur un ou plusieurs objectifs du projet, tels que le contenu, l'échéancier ou la qualité ». Pour Wysocki (2014), l'incertitude et le risque sont deux concepts indissociables. Plus un projet est complexe, plus son degré d'incertitude est élevé. Kreye & Balangalibun (2015) précisent que l'incertitude entourant les objectifs d'un projet est principalement associée aux indicateurs de performance (coût, délai ou qualité) et à la variabilité des projections. La complexité peut être définie comme un système composé de nombreuses parties interagissant de manière compliqué, les tâches et les relations étant des sources majeures de complexité (Simon, 1965).

Identification des risques dans les projets de développement rural au Cameroun

L'identification des risques de projet consiste à détecter et à documenter tous les risques potentiels qui pourraient influencer la performance d'un projet. D'après le corpus des connaissances en management

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

de projet (PMBOK), c'est le deuxième processus de la gestion des risques qui permet de comprendre les menaces et de prendre les mesures d'atténuation adéquates.

L'analyse des données issues de la phase terrain de notre recherche a permis d'identifier et de classifier selon la typologie des risques de Ray (2015), vingt-deux (22) principaux risques de projet. Leurs impacts sur le projet ont également été déterminés.

Tableau 1: Classification des risques selon la typologie de Ray

Risques Endogènes	**Impact sur le projet**
Conflit entre les membres de l'équipe de projet	- Diminution de la productivité ; - Baisse du moral ; - Qualité du travail compromise ; - Retards dans l'exécution ; - Risque de départ des membres clés.
Démissions imprévues des membres du projet	- Perturbation des activités ; - Perte de compétences et de connaissances ; - Augmentation de la charge de travail ; - Coûts additionnels de recrutement ; - Diminution de l'engagement de l'équipe.
Dysfonctionnement des procédures de passation de marché	- Retards dans l'exécution des activités ; - Dépassement budgétaire ; - Qualité des fournitures et services compromise ; - Risques juridiques ; - Perte de confiance des parties prenantes.
Fraudes et corruption au sein du projet	- Perte des ressources financières ; - Détérioration de la qualité des livrables ; - Atteinte à la réputation - Retards et complications juridiques ; - Érosion de la confiance des bénéficiaires.
Incompétence de certains membres de l'équipe de projet	- Baisse de la qualité des livrables ; - Retards dans l'exécution ; - augmentation de la charge de travail ; - Coûts additionnels ; - Détérioration de la cohésion d'équipe.
Mauvaise gestion des paiements par le service administratif et financier du projet	- Retards dans l'exécution des activités ; - Perte de confiance des fournisseurs ; - Dépassement budgétaire ; - Problèmes de conformité ; - Détérioration du moral de l'équipe.
Obsolescence des capacités techniques du personnel d'encadrement des bénéficiaires	- Diminution de la qualité de l'encadrement ; - retards dans l'exécution des activités ; - Résistance au changement ; - Impact sur la durabilité des résultats ; - Coûts additionnels de formation.
Risque Exogènes	
Absence de soutien de la part de la tutelle	- Retards dans l'exécution ; - Manque de ressources ;

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

	- Difficultés de coordination ; - Perte de crédibilité.
Ajout des activités non-prévues dans le PTBA émanant de la ratification de nouvelle convention avec d'autres projets ou institutions	- Surcharge de travail ; - Retards dans l'exécution ; - Dépassement budgétaire ; - Complexité de la gestion ; - Détérioration de la qualité des résultats.
Apparition d'une pandémie (coronavirus)	- Retards dans l'exécution des activités ; - Perturbations logistiques ; - Augmentation des coûts ; - Impact sur la santé des équipes ; - Changements dans les besoins des bénéficiaires.
Détournement de l'objet des appuis du projet par les bénéficiaires	- Perte de ressources ; - Diminution de l'impact du projet ; - Conflits avec les parties prenantes ; - Mauvaise réputation ; - Difficultés de suivi et d'évaluation.
Faible capacité de mobilisation de l'apport personnel par les bénéficiaires	- Réduction de l'efficacité ; - Dépendance aux ressources externes ; - Baisse de l'engagement ; - Difficultés de suivi et d'évaluation ; - impact négatif sur la durabilité.
Faible maitrise des procédures techniques, administratives et financières du projet par les parties prenantes	- Erreurs dans l'exécution des activités ; - Retards dans les délais ; - Dépassements budgétaires ; - Conflits entre parties prenantes ; - Impact sur la durabilité des résultats.
Inflation ou volatilité des prix des intrants sur le marché	- Dépassements budgétaires ; - Retards dans l'exécution ; - Réduction de la qualité ; - Impact sur la durabilité.
Insécurité dans les zones d'intervention du projet	- Retards dans l'exécution des activités ; - Insécurité des équipes ; - Diminution de l'engagement des bénéficiaires ; - Perturbations logistiques ; - Dégradation de la réputation du projet.
Lenteur dans la mise à disposition des ressources financières au projet	- Retards dans l'exécution des activités ; - Perturbation des relations avec les partenaires ; - Dépassements budgétaires ; - Impact sur le moral de l'équipe ; - Diminution de la qualité des résultats.
Mauvaise exécution des activités confiées aux prestataires techniques externes de mise en œuvre du projet	- Baisse de la qualité des livrables ; - Retards dans l'avancement du projet ; - Dépassements budgétaires ; - Impact sur la réputation ; - Conflits et tensions.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Mauvaise relation entre le coordonnateur du projet et le bailleur de fonds	- Retards dans le financement ; - Manque de soutien ; - Difficultés de communication ; - Dégradation de la réputation ; - Conflits de priorités.
Non-respect des engagements des partenaires stratégiques dans l'exécution des activités programmées	- Retards dans l'exécution des activités ; - Perturbation des relations partenariales ; - Diminution de la qualité des résultats - Dépassements budgétaires ; - Durabilité des résultats.
Retard dans l'obtention des avis non objection	- Retards dans l'exécution des activités ; - Perturbation du budget ; - Diminution de la motivation de l'équipe ; - Nuisance des relations avec les parties prenantes ; - Non-conformité des résultats ou livrables ;
Retards ou difficultés dans la mobilisation des fonds de contrepartie	- Retards dans l'exécution des activités ; - Perturbation du budget ; - Diminution de la confiance des partenaires ; - Impact sur la qualité des résultats ; - Augmentation des non-conformités.
Sècheresse ou inondation dans les zones d'intervention du projet	- Perturbation des activités agricoles ; - Dommages sur les infrastructures ; - Insécurité alimentaire ; - Retards dans l'exécution du projet.

Source : Auteurs

L'étude identifie 15 risques exogènes, tandis que 7 sont endogènes, indiquant que les projets sont significativement impactés par les risques exogènes. Ces risques sont principalement liés à la gestion de projet, à la communication, à l'ambiguïté des objectifs et aux erreurs de planification. 71 % des risques endogènes sont liés à la ressource humaine, tandis que 29 % sont liés aux procédures. Les risques exogènes, également appelés risques externes, peuvent avoir un impact négatif sur un projet en raison de leur nature imprévisible.

Les risques identifiés ont été catégorisés suivant la classification du PMBOK : risques opérationnels, risques stratégiques à court terme et risques stratégiques à long terme.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Tableau 2: Classification des risques selon le PMBOK.

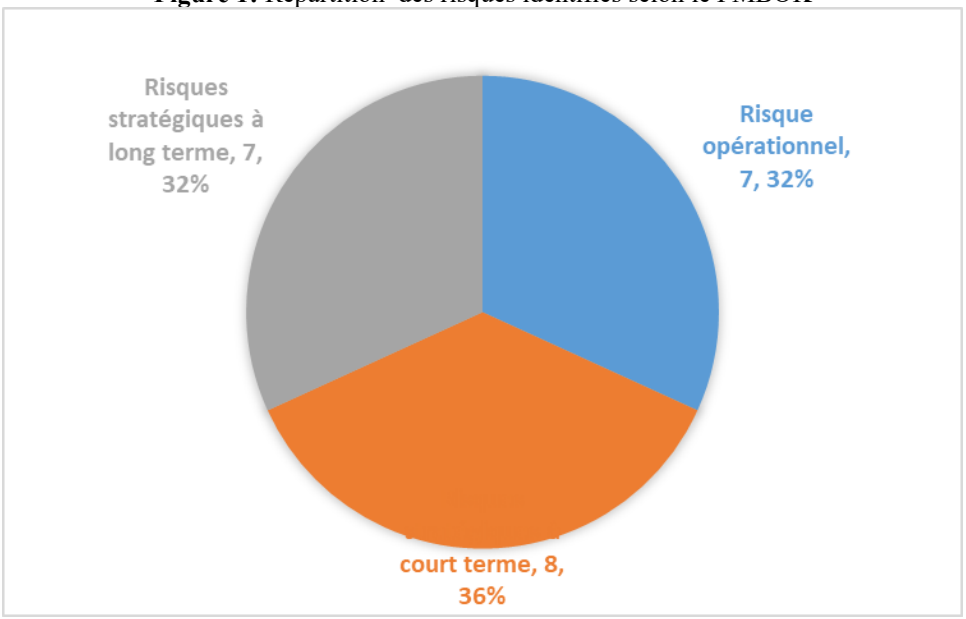
Catégorie	Risque identifié
Risques opérationnel	Conflit entre les membres de l'équipe de projet
	Démissions imprévues des membres du projet
	Fraudes et corruption au sein du projet
	Retard dans l'obtention des avis non objection
	Obsolescence des capacités techniques du personnel d'encadrement des bénéficiaires
	Incompétence de certains membres de l'équipe de projet
	Mauvaise relation entre le Coordonnateur du projet et le Bailleur de fonds
Risques stratégiques à court terme	Dysfonctionnement des procédures de passation de marché
	Mauvaise gestion des paiements par le service administratif et financier du projet
	Faible maitrise des procédures techniques, administratives et financières du projet par les parties prenantes
	Lenteur dans la mise à disposition des ressources financières au projet
	Mauvaise exécution des activités confiées aux prestataires techniques externes de mise en œuvre du projet
	Retards ou difficultés dans la mobilisation des fonds de contrepartie
	Non-respect des engagements des partenaires stratégiques dans l'exécution des activités programmées
	Ajout des activités non-prévues dans le PTBA émanant de la ratification de nouvelle convention avec d'autres projets ou institutions
Risques stratégiques à long terme	Absence de soutien de la part de la tutelle
	Apparition d'une pandémie
	Détournement de l'objet des appuis du projet par les bénéficiaires
	Sècheresse ou inondation dans les zones d'intervention du projet
	Insécurité dans les zones d'intervention du projet
	Faible capacité de mobilisation de l'apport personnel par les bénéficiaires
	Inflation ou volatilité des prix des intrants sur le marché

Source : Auteurs

Cette catégorisation a permis de ressortir leur répartition contenue dans la figure1.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Figure 1: Répartition des risques identifiés selon le PMBOK



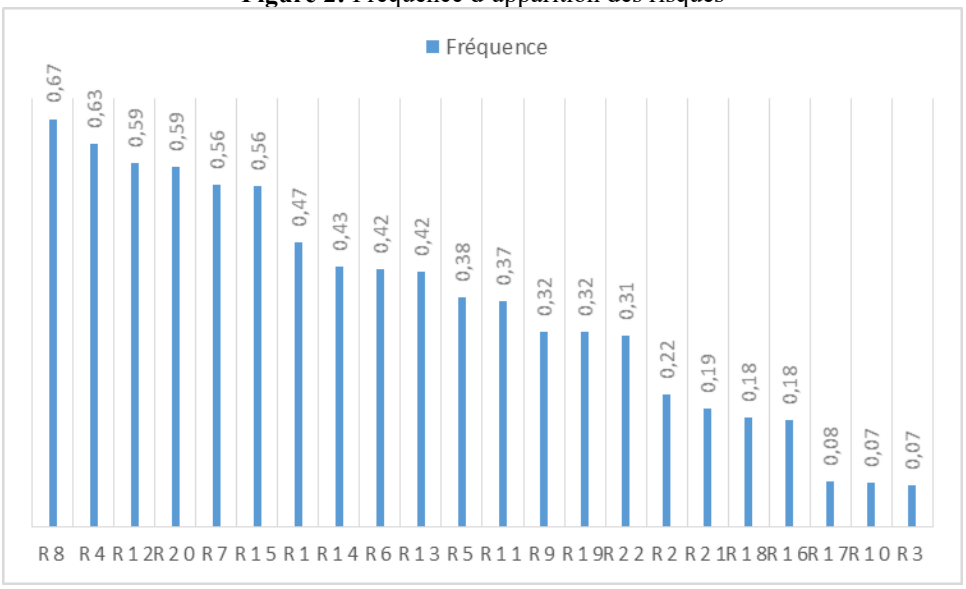
Source : Auteurs

Cette catégorisation indique que les risques stratégiques à court terme sont plus fréquents que les risques opérationnels et à long terme, ce qui rend cruciales des mesures proactives et organisées. Il est essentiel de surveiller et d'évaluer chaque risque, d'élaborer des plans d'action spécifiques et de mettre en œuvre des stratégies de réduction, d'évitement ou de transfert. Cette approche permet aux équipes de relever efficacement les défis existants tout en restant attentives aux enjeux à long terme, garantissant ainsi la continuité des opérations.

La figure 2 illustre la fréquence moyenne à laquelle chaque risque identifié se présente lors de l'exécution d'un projet de développement rural.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Figure 2: Fréquence d'apparition des risques



Source : Auteurs

L'illustration met en évidence les risques élevés liés à l'incompétence du groupe de projet, à l'inflation, aux fluctuations du marché, au manque de contrôle, à la fraude, à la corruption, aux contributions personnelles limitées et à la gestion inefficace des paiements. Elle souligne l'importance d'une analyse approfondie, de stratégies d'atténuation efficaces et d'un suivi rigoureux, de l'identification des causes profondes, de la priorisation des risques, de l'élaboration de plans d'action et du suivi de leur mise en œuvre (PMI, 2017).

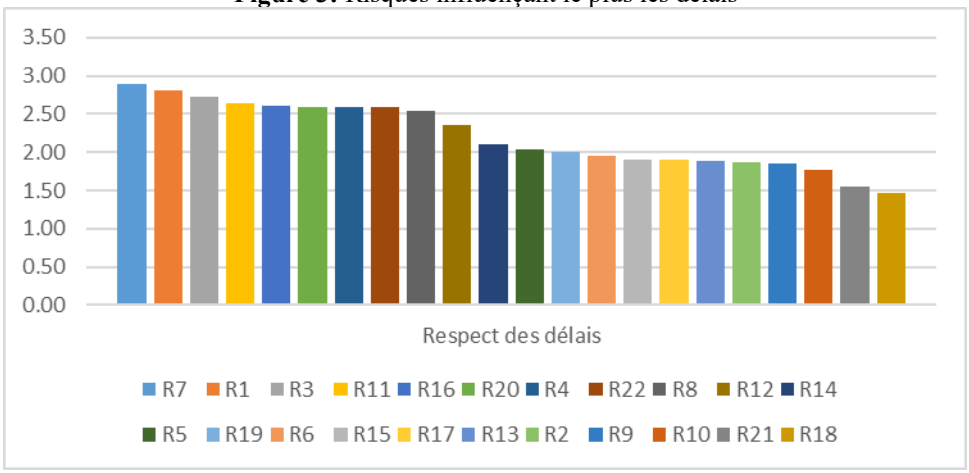
L'identification des risques, leur classification et la détermination de leur fréquence d'apparition sur les cas étudiés, nous ont permis d'analyser leurs influences sur la performance des projets de développement rural.

Influence des risques identifiés sur la performance des projets de développement

L'évaluation de l'impact des risques identifiés sur les trois variables de la performance (temps, coût et qualité) a été réalisée en déterminant la moyenne des notes attribuées par chaque interviewé.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Figure 3: Risques influençant le plus les délais



Source : Auteurs

Tous les risques identifiés impactent négativement le respect des délais de mise en œuvre d'un PDR. Toutefois, l'occurrence de l'un de ces seize (16) risques cités, classés par ordre d'influence, engendre des incidences élevées sur le respect des échéanciers :

- R7_Faible capacité de mobilisation de l'apport personnel par les bénéficiaires ;
- R1_Insécurité dans les zones d'intervention du projet ;
- R3_Apparition de pandémie ;
- R11_Dysfonctionnement des procédures de passation de marché ;
- R16_Conflit entre les membres de l'équipe de projet ;
- R20_Mauvaise exécution des activités confiées aux prestataires techniques externes de mise en œuvre du projet ;
- R4_Inflation ou volatilité des prix des intrants sur le marché ;
- R22_Retard dans l'obtention des avis non objection ;
- R8_Incompétence de certains membres de l'équipe de projet ;
- R12_Faible maitrise des procédures techniques, administratives et financières du projet par les parties prenantes ;
- R14_Lenteur dans la mise à disposition des ressources financières au projet ;
- R5_Fraudes et corruption au sein du projet ;
- R19_Non-respect des engagements des partenaires stratégiques dans l'exécution des activités programmées ;
- R6_Détournement de l'objet des appuis du projet par les bénéficiaires ;
- R15_Mauvaise gestion des paiements par le service administratif et financier du projet ;
- R17_Mauvaise relation entre le coordonnateur du projet et le bailleur de fonds.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Ces risques se manifestent durant la mise en œuvre des activités d'un PDR par :

- Les retards dans l'accomplissement des activités, les livraisons, ou les étapes clés du projet, pouvant induire un effet boule de neige sur tout l'ensemble du plan de travail et de budget annuel (PTBA) ;
- Les dépassements budgétaires qui requièrent l'allocation de ressources additionnelles, en particulier financières, pour récupérer le retard ou pour pallier les effets des retards ;
- Une dégradation de la qualité des livrables attendues, puisque les équipes pourraient être forcées d'accélérer leur rythme de travail ou de renoncer à certaines spécifications afin de se conformer aux délais ;
- Des litiges entre les parties, surtout si les contrats prévoient des sanctions en cas de non-conformité aux échéances ;
- Un impact négatif sur la réputation l'équipe de projet si elle ne parvient pas à respecter les échéances prévues pour les projets.

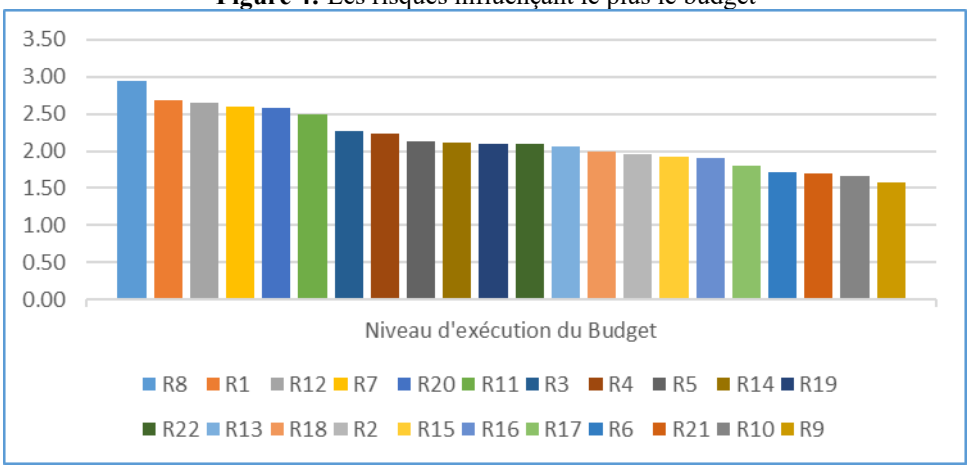
A titre de préventif, il faut agir rapidement et proactivement, en déterminant les risques affectant les délais, en évaluant les retards et les tâches potentiels à l'aide de diagrammes de Gantt ou d'analyses critiques, et en mettant en œuvre des mesures préventives.

Si le risque s'est déjà produit les actions correctives suivantes peuvent être entreprises :

- Déterminer les actions spécifiques pour réduire le retard, en ajustant la planification si besoin ;
- Si possible, affecter des ressources supplémentaires aux activités les plus critiques pour attraper le retard ;
- Informer les parties impliquées de la situation et des actions entreprises pour résoudre le problème.
- En cas de risque potentiel, les mesures préventives suivantes sont préconisées:
- Établir des actions visant à diminuer la possibilité que le risque survienne ou à en minimiser les conséquences si jamais il se matérialise ;
- Établir des plans de réponse pour chaque risque identifié ;
- Surveiller fréquemment l'évolution des risques et instituer des indicateurs clés de performance (KPI) pour mesurer l'efficacité des mesures préventives.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Figure 4: Les risques influençant le plus le budget



Source : Auteurs

Les quatorze (14) risques identifiés ci-après peuvent entraîner des conséquences négatives importantes sur la mise en œuvre du budget prévu :

- R8_Incompétence de certains membres de l'équipe de projet ;
- R1_Insécurité dans les zones d'intervention du projet ;
- R12_Faible maitrise des procédures techniques, administratives et financières du projet par les parties prenantes
- R7_Faible capacité de mobilisation de l'apport personnel par les bénéficiaires ;
- R20_Mauvaise exécution des activités confiées aux prestataires techniques externes de mise en œuvre du projet ;
- R11 _Dysfonctionnement des procédures de passation de marché ;
- R3_Apparition de pandémie (coronavirus) ;
- R4_Inflation ou volatilité des prix des intrants sur le marché ;
- R5_Fraudes et corruption au sein du projet ;
- R14_Lenteur dans la mise à disposition des ressources financières au projet ;
- R19_Non-respect des engagements des partenaires stratégiques dans l'exécution des activités programmées ;
- R22_Retard dans l'obtention des avis non objection ;
- R13_Retards ou difficultés dans la mobilisation des fonds de contrepartie ;
- R18_Absence de soutien de la part de la Tutelle.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

L'apparition de l'un de ces risques se manifeste sur le budget d'un PDR de plusieurs manières, notamment :

- Les dépassements des coûts pouvant entrainer des changements non prévus sur les spécifications ou sur les exigences du projet et induire des retards. Ces retards, causés par des aléas ou une mauvaise mise en œuvre des activités, peuvent engendrer des coûts supplémentaires suite à l'allongement des ressources et des dépenses opérationnelles induits. Des budgets trop rigides peuvent également poser des problèmes d'adaptation aux modifications inattendues et engendrer des dépassements de coûts ;
- La mauvaise qualité des livrables qui peut être liée à la compression des ressources financières en raison du souci de respect des budgets, compromettant ainsi la réalisation des objectifs du projet ;
- Une motivation insuffisante des employés affectant leur productivité, avec une incidence sur les coûts.

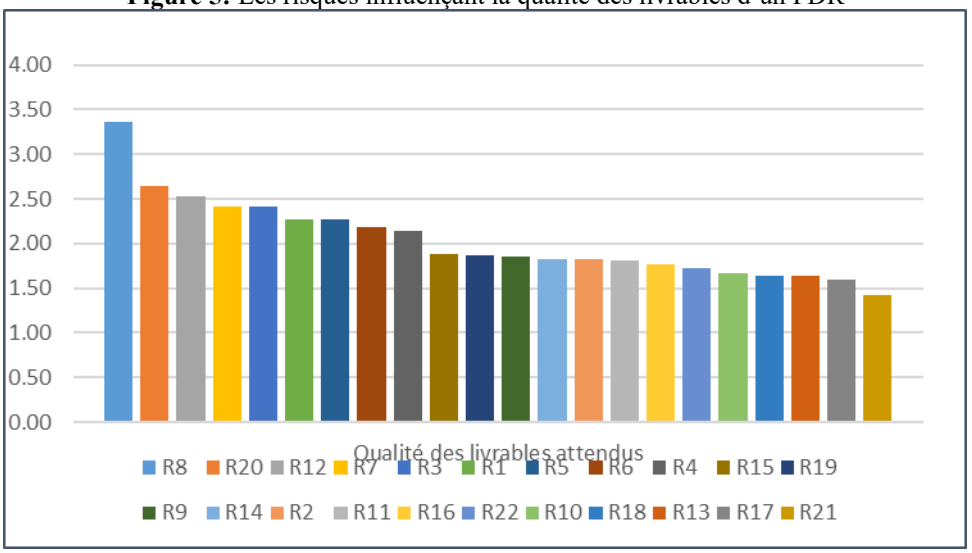
Les dispositions générales en matière de gestion de risque pour éviter ou réduire l'impact négatif des risques sur les budgets prévus nécessitent la mise en œuvre des étapes successives suivantes :

- Identification et analyse des risques. Ici, on cherche à identifier les raisons du dépassement budgétaire (comme un retard de livraison d'un prestataire, une hausse inattendue des coûts des intrants ou équipements, etc.). Par la suite, il convient d'examiner l'importance du dépassement budgétaire et son incidence sur les autres dimensions du de la performance (délais et qualité) ;
- Mettre en place des plans d'atténuation. Il s'agit dans un premier temps d'identifier les actions possibles pour réduire l'impact du risque (par exemple, négocier avec le fournisseur, optimiser les ressources, etc.). Ensuite, choisir les mesures les plus efficaces pour réduire le risque. Finalement, s'assurer que les ressources requises (financières, temporelles, humaines) disponibles pour l'application des plans d'atténuation ;
- Suivre et ajuster les plans. Cela consiste à mettre en œuvre les actions planifiées pour réduire le risque, surveiller l'évolution des circonstances et déterminer si les dispositions prises sont performantes, et au besoin, ajuster les stratégies d'atténuation afin de mieux traiter les risques.

Lors des phases de planification et de maturation de projet, un budget de contingence peut être introduit dans le budget global afin de prévoir une marge de sécurité pour faire face à ce type de risque ou aux dépenses imprévues.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Figure 5: Les risques influençant la qualité des livrables d'un PDR



Source : Auteurs

Il ressort de l'examen de cette figure que douze risques influencent le plus la qualité des livrables attendus. Par ordre de grandeur, il s'agit de :

- R8_Incompétence de certains membres de l'équipe de projet ;
- R20_Mauvaise exécution des activités confiées aux prestataires techniques externes de mise en œuvre du projet ;
- R12_Faible maitrise des procédures techniques, administratives et financières du projet par les parties prenantes ;
- R7_Faible capacité de mobilisation de l'apport personnel par les bénéficiaires ;
- R3_Apparition de pandémie ;
- R1_Insécurité dans les zones d'intervention du projet ;
- R5_Fraudes et corruption au sein du projet ;
- R6_Détournement de l'objet des appuis du projet par les bénéficiaires ;
- R4_Inflation ou volatilité des prix des intrants sur le marché ;
- R15_Mauvaise gestion des paiements par le service administratif et financier du projet ;
- R19_Non-respect des engagements des partenaires stratégiques dans l'exécution des activités programmées ;
- R9_Obsolescence des capacités techniques du personnel d'encadrement des bénéficiaires.

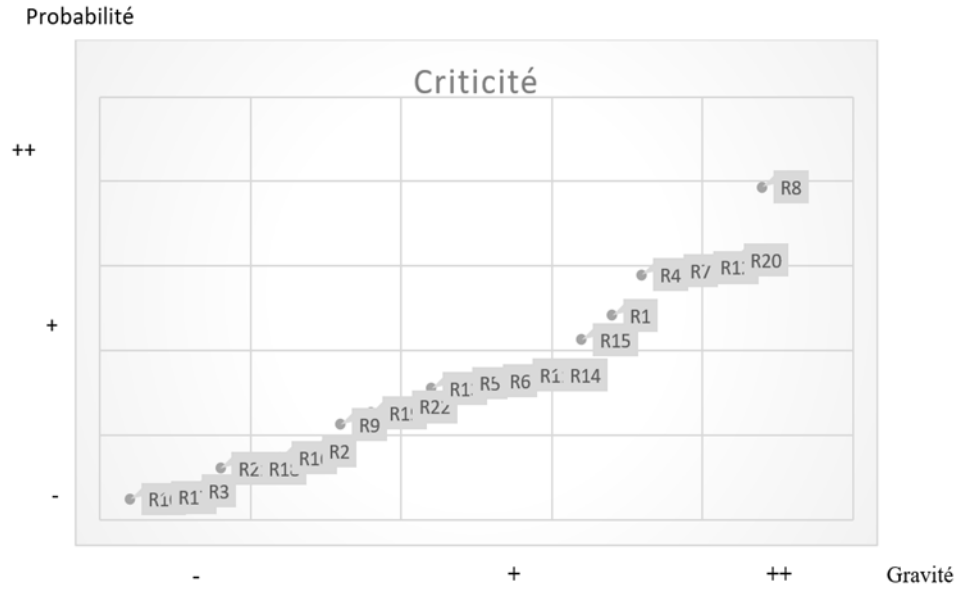
 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

L'occurrence de ce type de risque se manifeste généralement par :

- La récurrence des non-conformités. Les livrables attendus ne répondent pas aux spécifications ou aux attentes des parties prenantes ;
- Les retards dans l'exécution des activités du projet. Les défauts présentés par les livrables nécessitent peuvent exiger des retouches ou des améliorations, entraînant des délais supplémentaires ;
- L'augmentation des coûts. Les corrections et les modifications augmentent le budget initial ;
- L'insatisfaction des parties prenantes. Les différentes parties prenantes du projet, peuvent être insatisfaits si les livrables ne répondent pas à leurs besoins ou attentes.

Les cas étudiés nous ont conduits à établir une matrice de criticité des risques sur laquelle l'équipe de projet peut se baser pour prendre des décisions de gestion afin de contrôler les risques.

Figure 6: Matrice de criticité des risques



Source : Auteurs

Les décisions de gestion proposées sont contenues dans le tableau 3.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Tableau 3: Décision de maîtrise des risques

Code	Probabilité	Gravité	Criticité	Décision
R10	0,07	1,70	0,12	Risque négligeable
R17	0,08	1,77	0,13	Risque à suivre
R3	0,07	2,47	0,17	Risque à suivre
R21	0,19	1,56	0,30	Risque à suivre
R18	0,18	1,70	0,30	Risque à suivre
R16	0,18	2,09	0,37	Risque à suivre
R2	0,22	1,88	0,41	Risque à suivre
R9	0,32	1,76	0,56	Risque à suivre
R19	0,32	1,99	0,63	Risque à suivre
R22	0,31	2,14	0,67	Risque à suivre
R13	0,42	1,86	0,77	Risque à suivre
R5	0,38	2,15	0,81	Risque à suivre
R6	0,42	1,96	0,82	Risque à suivre
R11	0,37	2,32	0,85	Risque à suivre
R14	0,43	2,01	0,85	Risque à suivre
R15	0,56	1,90	1,06	Risque à traiter
R1	0,47	2,59	1,21	Risque à traiter
R4	0,63	2,32	1,45	Risque à traiter
R7	0,56	2,63	1,47	Risque à traiter
R12	0,59	2,51	1,49	Risque à traiter
R20	0,59	2,61	1,54	Risque à traiter
R8	0,67	2,95	1,97	Risque à traiter

Source : Auteurs

Cette matrice nous permet de comprendre que l'incompétence (R8 ; 1,97) et la mauvaise exécution des activités confiées aux prestataires techniques externes (R20 ; 1,54) sont des risques qui nécessitent une attention particulière. Il est clair que si ces risques se manifestent régulièrement durant la phase de mise en œuvre, les objectifs escomptés du projet ne seront jamais atteints. Pour éviter cette situation, un point d'honneur doit être accordé au casting de l'équipe de projet ainsi qu'aux processus de passation des marchés.

La matrice de gravité des risques offre non seulement une prévision des impacts négatifs liés à la survenue des risques, mais elle facilite également l'optimisation des ressources et des efforts pour maitriser les risques les plus critiques. Ces différents résultats permettent de classer, de hiérarchiser, d'établir des priorités et de concevoir des plans d'action pour réduire l'impact des risques sur la performance attendue. Cette démarche permet garantit une contribution significative du projet aux objectifs de développement pour lesquels il a été créé.

L'analyse des informations recueillies auprès de nos interlocuteurs et nos constatations dans le secteur du développement de projets mettent en lumière le fait que les démarches de gestion des risques ne sont mises en œuvre qu'une fois que ceux-ci ont déjà provoqué des dommages sur les résultats

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

escomptés ou gênent l'exécution des tâches prévues, confirmant ainsi nos hypothèses de recherche. Il est donc essentiel que les acteurs clés du projet possèdent des compétences en gestion des risques afin d'éviter les impacts négatifs et de garantir les améliorations souhaitées suite à une action de développement.

Discussion

Ndiaye (2017) identifie 19 facteurs de risque affectant la gestion des projets de développement international au Sénégal. Les facteurs de risque sont des causes potentielles de risques, tandis que les risques liés aux projets sont des événements ayant des impacts négatifs potentiels. Cette précision est capitale dans la mesure où elle permet de faire une distinction entre les concepts et de lever les ambiguïtés. L'auteur indiquent que sans intervention, 55 % des projets au Sénégal accusent des retards, 42 % ne respectent pas les spécifications techniques et 37 % dépassent les coûts. Les facteurs de risque les plus importants comprennent l'expertise de l'équipe projet, les relations entre les bailleurs de fonds et les coordinateurs, et la non-gestion des aspects administratifs.

Bouchard (2008), quant à lui, examine les facteurs de risque internes et externes et leur impact sur la perception du succès par des acteurs clés dans les projets de développement en Afrique, en Europe, en Asie et en Afrique. Il classe les facteurs de risque en six catégories et conseille aux équipes du projet de se concentrer sur la gestion des risques externes, tels que les litiges contractuels, les actions de justice et les changements de composition d'équipe.

Les sections ci-dessus démontrent que l'occurrence d'un risque (variable indépendante) durant la phase de mise en œuvre du projet influence au moins deux variables de la performance, impactant de facto le succès d'un projet de développement rural. L'apparition d'un risque en phase d'exécution peut avoir plusieurs conséquences, qui peuvent varier en fonction de la nature du risque et de la manière dont il est géré. La figure 7 ci-dessous présente les liens de causalité des risques sur le succès d'un projet de développement.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Figure 7: Impact des risques sur le succès d'une intervention de développement

Source : Auteurs

Les risques de projet peuvent être financiers, techniques, externes, de planification, de ressources, de réputation, de qualité, liés aux fournisseurs, liés à la santé et à la sécurité. Les impacts indésirables sur les performances du projet comprennent les retards, l'augmentation des coûts, la diminution de la qualité et l'insatisfaction des parties prenantes. S'ils ne sont pas gérés efficacement, ces risques peuvent avoir un impact significatif sur la performance des projets de développement rural. Ceci soutient nos deux hypothèses de recherche : H1 (l'absence de dispositif d'identification, d'analyse et de réponses aux risques influence la performance d'un projet de développement rural) et H2 (la non-maitrise des risques impacte négativement le succès d'un projet de développement rural).

La gestion des risques proactive est donc cruciale pour minimiser les conséquences sur un projet en anticipant les risques et en mettant en œuvre des stratégies d'atténuation. Lorsque les risques de projet surviennent fréquemment, les mesures de prévention et d'atténuation sont essentielles. Cela implique de revoir les origines, d'élaborer des stratégies de gestion des risques, de mettre en œuvre des procédures de surveillance et de contrôle et de maintenir une communication efficace avec toutes les parties impliquées.

Conclusion

Les risques de projets peuvent gravement affecter la performance des projets de développement rural en entraînant des retards, des coûts supplémentaires et une qualité de résultats compromise. Nos résultats ont permis d'identifier et de classer les risques de projet en fonction de leur influence sur les trois variables de la performance d'un PDR. De manière

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

générale, l'occurrence d'un risque influence beaucoup plus le respect des délais de mise en œuvre des activités avec un effet d'entrainement sur le respect du budget et la qualité des livrables. Nos résultats ont également permis de ressortir la fréquence d'apparition de chaque risque de projet identifié, aboutissant ainsi à la détermination de leur niveau de criticité et à la proposition des stratégies d'atténuation.

La contribution à l'amélioration de la performance des initiatives de développement rural au Cameroun grâce à l'identification des risques de projet est essentielle et peut se décliner en plusieurs axes : i) renforcement de la planification stratégique ; ii) amélioration de la gestion des ressources ; iii) augmentation de la qualité des interventions, iv) renforcement de l'engagement des parties prenantes ; v) résilience face aux risques et vi) apprentissage et capitalisation des expériences. L'identification des risques de projet est un levier crucial pour améliorer la performance des initiatives de développement. En renforçant la planification, en optimisant les ressources et en augmentant la qualité des interventions, les projets de développement peuvent devenir plus efficaces et durables, apportant ainsi des bénéfices significatifs aux communautés rurales.

En somme, cet article relève la nécessité de mettre en place une gestion proactive des risques au cours de l'exécution d'un projet de développement. En effet, la gestion des risques de projet est essentielle pour maximiser la performance des projets de développement rural. Elle permet d'anticiper les problèmes, d'améliorer la planification, d'optimiser les ressources et d'assurer la qualité des résultats. Investir dans une gestion des risques solide est donc un élément clé du succès des interventions de développement dans le secteur rural.

Conflit d'intérêts : Les auteurs n'ont signalé aucun conflit d'intérêts.

Disponibilité des données : Toutes les données sont incluses dans le contenu de l'article.

Déclaration de financement : Les auteurs n'ont obtenu aucun financement pour cette recherche.

References:

1. Ahizi, D. (2019a). *Évaluation de la performance de projets d'aide internationale au développement : Exemple de trois projets exécutés en Côte d'Ivoire*. Conservatoire national des arts et métiers.
2. Alaoui, M., & Bahri, M. (2018). *Défis et opportunités de développement rural en Afrique subsaharienne*. Institut Royal des Etudes Stratégiques.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

3. Arndt, C., Jones, S., & Tarp, F. (2010). Aid, growth, and development : Have we come full circle? *Journal of Globalization and Development*. https://www.researchgate.net/publication/227378549_Aid_Growth_and_Development_Have_We_Come_Full_Circle
4. Arndt, C., Jones, S., & Tarp, F. (2015). Assessing foreign aid's long-run contribution to growth and development. *Journal of Globalization and Development*.
5. Assontia Djoudji, Kolokosso à Bediang, R., & Begnikin, J. J. (2022). El método MACTOR para analizar los procesos de gestión de los proyectos y programas de desarrollo en África. *Project, Design and Management,4(1), -. doi: 10.35992/pdm.4vi1.835*. https://www.mlsjournals.com/Project-Design-Management/article/view/835/1455
6. Awe Baina, M., Manu, I. N., Esso Ondoa, A. M., Tiwan, G., & Daiwe BainaSeraphin. (2020). Evaluation des performances des projets et programmes de développement rural au Cameroun. *International Journal of Innovation and Applied Studies*.
7. Bauer, P. (1972). *Dissent on development.* (Cambridge, Mass: Harvard University Press).
8. Benhadji, W. (2014). *Risque projet et méthodes de management des risques projet : Quelle approche pour une contribution a une meilleure planification d'un projet de construction?* [Mémoire, University of Tlemcen]. http://dspace.univ-tlemcen.dz/bitstream/112/6236/2/PFE-BENHADJI-2014.pdf
9. Boone, P. (1995). *Politics and the effectiveness of foreign aid* (Vol. 40). European Economic Review. https://www.sciencedirect.com/science/article/abs/pii/0014292195001271
10. Bouchard, M. (2008). *Les facteurs de risque des projets de développement international : Une analyse empirique de la perception des coordonnateurs*. Université du Québec.
11. Burside, C., & Dollar, D. (2004). *Aid, policies, and growth : Revisiting the evidence*.
12. Chambers, R. (2013). *Rural Development : Putting the Last First* (Pearson Education Limited). Pearson Education Limited.
13. Charnoz, O., & Severino, J.-M. (2007). *L'aide publique au développement*. https://www.cairn.info/l-aide-publique-au-developpement--9782707146571-page-3.htm
14. Commission Européenne. (2001). *Manuel Gestion du Cycle de Projet*.
15. Cooke-Davies, T. (2002). The real success factors on projets. *International Journal of Project Management, 20(n°1)*, 185-190.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

16. Courtot, hervé. (1998). *La Gestion des Risques dans les Projets*. Economica.
17. Diallo, A., & Thuillier, D. (2005). *Une analyse de la perception des coordonnateurs de projets de développement en Afrique*.
18. DSCE. (2010). *Document de Stratégie pour la Croissance et l'Emploi*.
19. Easterly, W. (2003). Can Foreign Aid Buy Growth? *Journal of economic perpectives*. https://www.aeaweb.org/articles?id=10.1257/089533003769204344
20. Ezratty, V. (2012). *Dévelopement d'une nouvelle approche pour la performance durable des projets d'une organisation* [Ecole Centrale]. https://tel.archives-ouvertes.fr/tel-00680991/document
21. FIDA. (2018). *Investir dans les populations rurales au Cameroun*. www.ifad.org
22. FIDA. (2019). *Projet d'Appui au Développement des Filières Agricoles—Phase II Document de Conception de Projet*.
23. Gomanee, K., Morrissey, O., Mosley, P., & Verschoor, A. (2005). Aid, government expenditure, and aggregate welfare. *World Development*. https://www.sciencedirect.com/science/article/abs/pii/S0305750X04001998#!
24. Hirano, Y., & Otsubo, S. (2014). *Aid is good for the poor*. World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/19397/WPS6998.pdf?sequence=1&isAllowed=y
25. Ignou. (2019). *Block-2 Rural Development—Concept, Strategies and Experience*. http://egyankosh.ac.in//handle/123456789/52946
26. IKA, L. (2011). *Les facteurs clés du succès des projets d'aide au développement* [Université du Québec]. https://archipel.uqam.ca/3953/1/D2133.pdf
27. Jacquet, P. (2006). *Les enjeux de l'aide publique au développement.* 941-954.
28. Jugdev, K., & Müller, R. (2005). A retrospective look at our evolving understanding of project success. *Project Management Journal*, 36(4),19-31.
29. Khan, & Zahid. (2013). *Adaptive project risk management in low maturity organizations*. PMI® Global Congress 2013, North America, New Orleans, LA. Newtown Square, PA: Project Management Institute.
30. Khang, D. B., & Mae, T. L. (2008). Success criteria and factors for international development projects. *Project Management Journal, 39(1)*, 72-84.
31. Kwak, Y. H., & Dewan, S. (2001). *Risk management in international development projects*. Paper presented at Project Management

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Institute Annual Seminars & Symposium, Nashville, TN. Newtown Square, PA: Project Management Institute.

32. Landoni, P., & Corti, B. (2011). The management of international development projects moving toward a standard approach or differentiation? *Project Management Journal, 42(3)*, 45-61.
33. Maders, H.-P., & Masselin, J.-L. (2009). *Piloter les risques d'un projet* (Éditions d'Organisation). Eyrolles.
34. Mahembe, E., & M. Odhiambo, P. N. (2019). *Foreign aid and poverty reduction : A review of international literature*. https://www.tandfonline.com/doi/citedby/10.1080/23311886.2019.1625741?scroll=top&needAccess=true
35. Mark, G. (2013). *Project Risk Management Guidance for WSDOT Projects*. Washington State Department of Transportation.
36. Masud, N., & Yontcheva, B. (2005). *Does Foreign Aid Reduce Poverty ? Empirical Evidence from Nongovernmental and Bilateral Aid*.
37. MINADER-MINEPIA. (2016). *ACEFA 3 : Programme de Consolidation et de Perennisation du Dispositif de Conseil Technico-Economique du Cameroun*.
38. MINEPIA-ISBD/ PD-COBIE. (2020). *Manuel de Suivi-Evaluation*.
39. Moyo, D. (2009). *Dead of Aid : Why Aid Makes Things Worse and How There is Another Way for Africa* (New York: Farrar, Straus and Giroux).
40. Ndiaye, M. (2017). *Facteurs de risque dans la gestion des projets de développement international* (ems).
41. OCDE. (2020). *Des critères améliorés pour des évaluations meilleures*. https://www.oecd.org/fr/cad/evaluation/criteres-d-evaluation-brochure-2020.pdf
42. PMI. (2017). *Guide du corpus des connaissances en management des projets* (Sixième).
43. Popa, M. G., Grasu, S., Cadis, A., & Popp, M. (2024). Investigating rural development : Conceptual framework and factors for promoting it. *The Bucharest University of Economic Studies, Bucharest, Romania*.
44. Project Management Institute. (2019). *Le standard pour la gestion des risques des portefeuilles, des programmes et des projets* (Project Management Institutes, Inc.).
45. Rashid Solagberu, A. (2012). *Rural Development in the Twenty-First Century as a Global Necessity*. http://www.intechopen.com/books/rural-development-contemporary-issuesand-

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

practices/introductory_chapter_rural_development_in_the_twenty_first_century_as_a_global_necessity

46. Ray, J. (2015). *De la gestion des risques au management des risques. Pourquoi ? Comment ?* Afnor.
47. Riddell, R. (2008). *Does foreign aid really work?* (New York : Oxford University Press).
48. Royer, P. S. (2000). Risk Management : The Undiscovered Dimension of Project Management. *Project Management Journal, 31(1)*, 6-13.
49. Saidou, S. (2015). *Projets de développement rural : Attention au foncier !* http://www.foncier-developpement.fr/publication/projets-developpement-rural-attention-au-foncier/
50. UNEG. (2016). *Normes et règles d'évaluation*. New York : UNEG. http://www.unevaluation.org/2016-Norms-and-Standards.
51. World Bank. (1998). *Assessing Aid : What Works, What Doesn't, and Why*. Oxford University.
52. Youker, R. (2015). Managing International Development Projects : Lessons Learned. *PM World Journal*. https://pdfs.semanticscholar.org/71a3/ec7bfdd2670ac6028fdb21645743ecb4b93a.pdf

ESJ Social Sciences Peer-reviewed

Evaluation de la rentabilité de la production de la banane plantain dans le village Mansende au Kongo central en République Démocratique du Congo

Mireille Kimanda Asha
Désiré Bisimwa Byamungu
Alphonse Roger Ntoto M'Vubu, PhD
Département d'économie agricole, Faculté des Sciences Agronomiques, Université de Kinshasa, Kinshasa XI, République Démocratique du Congo

Doi:10.19044/esj.2025.v21n19p198

Submitted: 15 May 2025
Accepted: 10 July 2025
Published: 31 July 2025

Cite As:
Asha, M.K., Byamungu, D.B. & M'Vubu, A.R.N. (2025). *Evaluation de la rentabilité de la production de la banane plantain dans le village Mansende au Kongo central en République Démocratique du Congo.* European Scientific Journal, ESJ, 21 (19), 198. https://doi.org/10.19044/esj.2025.v21n19p198

Résumé

Le plantain joue un rôle essentiel dans la sécurité alimentaire et constitue une source importante des revenus pour les acteurs de la filière. Bien qu'elle soit surtout cultivée pour l'autoconsommation des ménages, certains consacrent une partie de leur récolte à la vente. L'objectif de cette étude est d'évaluer la rentabilité d'une bananeraie d'un hectare. Spécifiquement, seront déterminés (1) différents indicateurs comptables (2) ratios de productivité brute et du capital investi (3) les facteurs déterminants de la rentabilité. Pour y arriver, 30 exploitants ont été sélectionnés de façon aléatoire pour les enquêtes. Après analyses statistiques et économétriques, voici les résultats : la culture de banane est pratiquée presque exclusivement par des hommes (96,7%) dont près de la moitié a un âge compris entre 25-35 ans, sur de petites surfaces (968,958±2241,650 m^2), parmi lesquels 50% sont propriétaires terriens, pour un rendement moyen de 7200 Kg/ha. En outre, cette culture est moyennement rentable avec un ratio de productivité brute (0,97) et un ratio de productivité du capital investi (1,0223), disons l'exploitation dégage des revenus presque juste pour couvrir le coût d'intrants utilisés pour la production. De tous les prédicteurs estimés, trois sont significatifs au seuil de 10% : la superficie du champ (sig = 0,078), le nombre d'actifs agricoles dans

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

le ménage (sig = 0,092) et la distance du marché (sig = 0,093). Ils déterminent positivement la rentabilité de cette culture au regard de leurs *odds ratio* respectifs. D'où, l'exploitation de plus d'un hectare, l'amélioration de condition d'accès au marché et la disponibilité des actifs agricoles permettraient d'accroître la rentabilité de cette culture.

Mots-clés : Rentabilité, déterminants, production, banane plantain, village Mansende

Evaluation of the Plantain Production Profitability in Mansende Village in Central Kongo in D.R. Congo

Mireille Kimanda Asha
Désiré Bisimwa Byamungu
Alphonse Roger Ntoto M'Vubu, PhD
Département d'économie agricole, Faculté des Sciences Agronomiques, Université de Kinshasa, Kinshasa XI, République Démocratique du Congo

Abstract

Plantain plays an essential role in food security and constitutes an important source of income for stakeholders in the sector. Although it is mainly grown for household self-consumption, some devote part of their harvest to sale. The objective of this study is to evaluate the profitability of a one-hectare banana plantation. Specifically, (1) different accounting indicators, (2) ratios of gross productivity and invested capital will be determined. To achieve this, surveys were carried out among 30 randomly selected farmers. After statistical and econometrics analyses, the following results were found: Banana production is practiced almost exclusively by men (96.7%), almost half of whom are aged between 25 & 35 years, in small areas (968.958±2,241.650 m^2), among whom 50% are landowners, for an average yield of 7,200 kg/ha. Banana cultivation is moderately profitable with a productivity ratio (0.97) and the productivity ratio of invested capital (1.0223), that is to say, farming generates income almost just to cover the cost of inputs used in production. In addition, of all the estimated predictors, three are significant at the 10% level: the area of the field (sig = 0.078), the number of agricultural workers in the household (sig = 0.092) and the distance from the market (sig = 0.093). They positively determine the profitability of the crop with regard to their respective odds ratios. To finish, the farming of more than one hectare, the improvement of market access conditions, and the availability of agricultural workers would make it possible to increase the profitability of this crop.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Keywords: Profitability, determinants, production, plantain banana, Mansende village

Introduction

Les bananes plantain figurent indéniablement parmi les fruits tropicaux les plus essentiels (Rasoatarafambola, 2007), l'une des principales sources d'alimentation des populations d'Afrique centrale (Cohan, et al., 2003 ; Hedegla, 2022) et joue un rôle vital en ce qui concerne la sécurité alimentaire et en procurant revenus substantiels pour les acteurs de cette filière (Folefack, 2018).

Le bananier est une culture de diversification dans les zones de production de rente comme le cacao ou le café. Il est cultivé particulièrement dans de petites structures de production et dans des associations de cultures diverses qui varient selon les régions (Kwa & Temple, 2019). D'après Briki et al., (2021), le bananier constitue le quatrième produit agricole en termes de production mondiale après le riz, le blé et le maïs. Dans l'ensemble (bananes et plantains), la banane est la troisième culture fruitière tropicale en quantité produite, environ 85 % de la production est autoconsommée et/ou vendue localement dans différents pays notamment en Afrique (Kwa & Temple, 2019).

En République Démocratique du Congo (RDC), le plantain constitue de nos jours, le troisième produit vivrier après le manioc et le maïs, par contre les bananes douces représentent les fruits les plus importants du pays, soit 1/3 de la production fruitière totale du pays (Bangata et al., 2018). En 2016, relativement aux productions attendues pour les quatre principales cultures évaluées (riz, manioc, maïs et plantain), il s'est avèré que seul le bananier plantain a atteint le seuil minimum de la production attendue. A cet effet, entre 2015 et 2016, la production de banane est passée de 4.076.704 à 4.097.589,61 tonnes, soit une augmentation de 0,51% (MINAGRI, 2017). Dans le village Mansende, la culture du bananier se fait dans de petites parcelles non loin du village et de jardins de case autour du village, où trois à sept variétés des bananiers et bananiers plantains sont cultivées ensemble. Les cultivars de plantains cultivés dans ce village, ont été choisis pour des raisons commerciales, car elles donnent beaucoup de rendements, mais aussi elles ont bon goût et sont plus appréciées par les commerçants acheteurs (Bangata et al., 2018).

Dans le cas de la plantation pluriannuelle, la production est dispersée dans le temps et par conséquent très variable pendant l'année (IICA, 2012), ce qui fait que la banane soit récoltée durant toute l'année (Mpanzu, 2007) et procure ainsi revenu au fil de l'année aux ménages producteurs.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Quant aux rendements, ceux-ci varient entre 3 et 5 tonnes l'hectare en milieu traditionnel. Un peu plus tard, suite à la mise en place des innovations variétales et de nouvelles itinéraires techniques, les rendements moyens à l'hectare varient de 7 à 18 Tonnes/hectare selon les zones de production et selon les variétés et du type de sol. Le rendement du plantain est légèrement plus é1evé que celui de la banane douce (Daderu, 1987 ; IICA, 2012).

Bien qu'elle soit surtout cultivée pour l'autoconsommation des ménages, certains consacrent une partie de leur récolte à la vente (Van Damme, 2008 ; Bézard, 2017). L'exploitant constitue l'acteur principal qui détermine même l'existence des autres catégories d'acteurs car, c'est à lui de produire et mettre dans le circuit de commercialisation la banane plantain (Fongang et al., 2019). La vente de plantains génère des revenus permettant à une franche de la population de survivre (Ntacobasima et al., 2019). De manière générale, les bananes plantains font l'objet d'un commerce local pour approvisionner les villes. La plupart des transactions s'effectuent sur les petits marchés locaux qui peuvent être à peu près permanents et se tiennent à jour fixe dans les villages (Djomo & Melin,1972). Les revenus générés par le commerce de la banane plantain sont très attractifs (Boureima, 2019), néanmoins, l'absence de structure organisée au sein des producteurs encourage une mainmise des commerçants urbains sur la formation des prix, qui après négociation finissent par imposer leur prix, au détriment des producteurs (IICA, 2012).

Ainsi, l'objectif de la tenue d'une bananeraie est une production de bananes durable, rentable pour le producteur. En se basant sur les différents enjeux liés aux exploitations agricoles, il est judicieux d'analyser la performance économique (rentabilité) des petites exploitations de banane (Kimwanga, 2021). La banane étant essentiellement cultivée de manière informelle par des petits agriculteurs (FAO, 2020), la connaissance de la rentabilité reste une question. Quelle est alors la rentabilité de la culture de banane dans le village Mansende ? La rentabilité représente la capacité du capital investi de produire un revenu, exprimé en termes financiers (Hamadou & Bouyer, 2005). La littérature sur la culture de bananes a mis en évidence la rentabilité de cette culture en affirmant que la production et la vente des bananes et plantains sont des activités rentables et engendrent de revenus (Mpanzu, 2012 ; MINAGRI, 2017 ; Folefack, 2018 ; Briki et al., 2021).

Globalement, cette étude a pour objectif d'évaluer la rentabilité d'une bananeraie d'un hectare de superficie. Spécifiquement, il sera question de (1) déterminer différents indicateurs comptables (2) déterminer les ratios de productivité brute et du capital investi pour déterminer la rentabilité financière (3) identifier, par une approche économétrique, les déterminants de rentabilité. Cette étude permettra de mettre à la disposition, d'une part, des exploitants, une référence sur la rentabilité de la culture de banane et d'autre part, des

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

partenaires socio-économiques, une référence en matière de production de banane et de difficultés que rencontrent les exploitants dans ce coin du pays.

Milieu d'étude et Méthode

Milieu d'étude

Mansende est un village se trouvant dans le district de Cataracte dans le Kongo central, province située à l'Ouest de la RDC, des coordonnées 5° 39′ de latitude Sud, 14°46′30″ de longitude Est et 442 m d'altitude. Quant à ce qui est du climat, aucune donnée n'est disponible pour ce village, il sera à cet effet question de se référer au travail de Muku et al. (2020) travail réalisé sur le village M'vuazi, à une vingtaine de Km. Suivant la classification de Köppen, le climat est de type Aw4 (climat tropical avec 4 mois de saison sèche) avec deux saisons, une saison pluvieuse de 7 mois (mi-octobre à mi-mai) et une saison sèche de 5 mois (mi-mai à mi-octobre) (Onotamba, 2007). La saison culturale A commencé en octobre et se clôture en février tandis que la saison culturale B couvre la période allant de mars à mai. La pluviométrie moyenne annuelle varie entre 1 400 et 1 600 mm, avec des températures moyennes annuelles de ±28 °. Selon Denisoff & Devred (1954) cité par Muku et al., (2020) il s'agit des sols alluvionnaires formés sur l'esquisse géologique d'argile résiduelle et présentant de bonnes propriétés (fertilité et résistance à l'érosion). La végétation est du type guinéo-congolais, avec une prédominance de savane boisée parsemée par endroit de galeries forestières vu la présence de plusieurs cours d'eau qui traversent le milieu (Pongi, 2021).

Méthodologie

Collecte et traitement de données

L'évaluation et l'estimation de déterminants de la rentabilité de la production de banane fait de cet article une étude quantitative. Généralement la banane est essentiellement cultivée de manière informelle par des petits agriculteurs, il est donc difficile d'obtenir des chiffres précis sur sa production (FAO, 2020). Outre l'approche documentaire qui a permis de réaliser la partie théorique de ce travail, l'approche enquête auprès de 30 ménages sélectionnés de manière aléatoire, dans un village de 152 ménages a permis la collecte de données, selon la disponibilité de la population dans le village. Pour cette étude, les données ont été collectées au moyen du questionnaire, en deux phases entre 2018 et 2020, actualisées et complétées en 2023. Pour les analyses, nous avons utilisé trois méthodes : la statistique descriptive qui a permis de ressortir les tendances centrales et de dispersion (Moloba et al., 2019), la comptabilité analytique pour la détermination de la rentabilité ainsi que l'économétrie pour déterminer les différents prédicteurs de rentabilité. Successivement seront déterminées les coûts de production et de commercialisation de bananes, les recettes ainsi que les deux ratios de

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

rentabilité. Pour l'ensemble des calculs effectués, toutes les données ont été ramenées à une moyenne annuelle dans le but de permettre la comparaison. Les logiciels tels que EpiData 3.1, Excel 10, SPSS 20, ont été utilisés pour les analyses.

Calcul du coût d'exploitation

Le coût total de production (CP) est la valeur de toutes les ressources et tous les services utilisés dans le processus de production. Dans lequel on retrouve tous les coûts variables (CVT) qui est la somme des intrants et la main d'œuvre, ainsi que tous les coûts fixes (CFT) qui est la somme de la valeur des amortissements et du coût de la terre (Maniriho, et al., 2021). La méthodologie prévoit que les tâches de la main-d'œuvre familiale soient rémunérées au taux d'activité moyen de la main-d'œuvre salariée extérieure (Boulet & Lebel, 2005). La plupart des enquêtés sont des propriétaires terriens, soit par droit coutumier pour tout autochtone du village, soit par titre foncier.

CVT= Achat rejets + Main d'œuvre pour les différentes activités de la production (de la préparation du terrain au transport de productions récoltées) ; *CFT : Valeur de l'amortissement,* D'où CP=CVT+CFT

Calcul du coût hors production lié au système de commercialisation

Le commerce local est pratiqué souvent par les producteurs eux-mêmes. Le marché le plus proche et le plus fréquenté se trouve à 5 Km, dans le village Luvaka, où se rencontrent les commerçants venant de Kinshasa. Les grandes quantités de bananes sont souvent vendues sur place au village, vu que celui-ci se trouve sur le chemin de Luvaka. Ce marché se tient tous les jeudis. En milieu rural, le prix varie entre 2 et 5$. Cette variation de prix est fonction de la grosseur des fruits, la période de récolte et de la demande. Une moyenne de 3,5$/régime de ±10 Kg sera utilisée. Par estimation, les exploitants ont renseigné avoir récolté plus ou moins 720 régimes par an, récolte répartie au fil de l'année.

Ainsi donc, le coût hors production est la somme des toutes les charges liées au transport (du champ au village, du village aux lieux de vente et pour le retour au village), taxes, et des frais divers (manutention, étalage, séjours), etc.

Détermination de la rentabilité financière

La détermination de la rentabilité financière d'une exploitation agricole revient à analyser les coûts et de recettes issus des activités de production et de vente (Yabi, 2010). Ainsi, dans le cadre de ce travail, nous allons, d'une manière simple, déterminer la rentabilité des exploitations agricoles à l'aide de la comptabilité analytique (Altukhova-Nys et al., 2017).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Les deux ratios suivants sont utilisés pour évaluer la rentabilité de la production de banane à Mansende :

Le ratio de productivité brute : le rapport entre la somme des coûts totaux (CT) sur le revenu agricole brut (RAB) : $\frac{CT}{RAB}$. Il exprime la capacité de production d'un groupe d'intrants à l'intérieur d'une période de temps donnée. L'exploitation est rentable lors que le ratio est < 1 (Hamadou & Bouyer, 2005 ; DA Silva & Santugini, 2009) ;

Le ratio de la productivité du capital investi : le rapport Marge brute et Coût de production. Ce ratio indique ce que rapporte 1.00 $USD investi dans une exploitation : $\frac{MB}{CP}$ (Kimwanga, 2021). Il indique la quantité de biens en valeur monétaire que peut produire une exploitation à l'aide d'un dollar de capital investi. L'exploitation est rentable lors que le ration est >1. Le calcul de ces différents ratios suppose la détermination des indicateurs ci-dessous (Penot, 2009). Il s'agit de :

- Marge brute (MB)= produit brut (PB) - coût de production (CP)
- Produit brut (PB)= Valeur des productions finales (vendues et/ou auto-consommée).
- Valeur ajoutée brute (VAB) = Produit brut – Consommations intermédiaires CI (consommations de biens de durée annuelle). Elle permet de traduire une richesse créée.
- Valeur ajoutée nette (VAN) = Valeur ajoutée brute – Amortissements économiques (consommation de biens et services de durée pluriannuelle).
- Revenu agricole brut (RAB)= VAN– Salaires versés à la main d'œuvre extérieure (MO) – Fermages et/ou Métayages – Intérêts des emprunts – Impôts et taxes foncières + Subvention. Pour notre cas, il n'y a ni Fermages et/ou Métayages (terrain donné gratuitement), Intérêts des emprunts, Impôts et taxes foncières ni Subvention. Il devient alors : RAB=VAN-MO

Déterminants de rentabilité de la culture de banane

Au regard de l'importance de la question de rentabilité pour les exploitations agricoles rurales, il est pertinent d'identifier les facteurs déterminants leur rentabilité. Plusieurs études ont été menées et la plupart se sont focalisées sur les facteurs socio-économiques comme facteurs déterminants de la rentabilité des exploitations agricoles (Malla & Yabi, 2023). Ainsi, 5 facteurs ont été identifiés, tels que la superficie exploitée, la variété de bananes cultivées, du mode d'acquisition de terres, l'ancienneté dans le domaine et nombre d'actifs agricoles dans le ménage. Cette approche méthodologique que nous utilisons permet d'identifier les facteurs pouvant impacter la rentabilité tout en déterminant le niveau de leur impact (Yabi,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

2010), au travers un modèle économétrique empirique de régression logistique suivante :

$$Logit\,[P\,(RENT_i = 1\,|X = NOACT,\ TENUR,\ EXPE,\ SUPER,\ VAR)] = \beta_0 + \beta_1 NOACT_i + \beta_2 TENUR_i + \beta_3 EXPE_i + \beta_4 SUPER_i + \beta_5 VAR + \mathcal{E}_i$$

Où, RENTi est une variable aléatoire binaire qui prend la valeur 0 en cas de non rentabilité d'une exploitation et la valeur 1 si occurrence. Elle est la variable dépendante.

Les variables indépendantes sont : $NOACT_i$ est une variable quantitative qui représente le nombre d'actifs agricoles dans le ménage i enquêté. Pour cette variable, un nombre élevé d'actifs agricoles accroitrait la productivité. TENUR est une variable qualitative désignant le mode d'acquisition de terre pour chaque exploitation i représentée par le ménage enquêté. Elle impacte la rentabilité dans le sens où le non droit sur la propriété exploitée pourrait inciter à produire assez. EXPE variable quantitative et représente le nombre d'années d'expérience acquis dans l'exercice des différentes activités. Il est supposé que plus l'exploitant a une longue ancienneté dans la culture, plus il est performant. SUPER désigne la taille de l'exploitation i enquêtée. On suppose que plus la taille du champ est grande, plus l'exploitation est rentable. VAR : désigne la variété cultivée, on estime un impact positif sur la rentabilité, car il est en lien direct avec le rendement. β_0 à β_5 : paramètres à estimer. Ils donnent le niveau d'impact des facteurs qui leur sont relatifs sur la rentabilité économique et ε_i : terme d'erreur qui représente l'erreur que l'on commet en utilisant la droite de régression pour prédire la rentabilité à partir de différents facteurs la déterminant (Fouzai & Bachta, 2008 ;Yabi et al., 2016).

Résultats

Dans cette partie sont présentés, outre les résultats concernant le profil du répondant, d'une part les différents coûts d'exploitation et recettes, et d'autre part les différents indicateurs ainsi que les différents ratios et déterminants de rentabilité.

Caractéristiques sociodémographiques des enquêtés

Il sera question de présenter les résultats permettant de segmenter les exploitants en raison de leur sexe, leur âge, leur statut matrimonial, le sexe du chef de ménage, leur niveau d'instruction et la taille de leur ménage.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Tableau 1 : Caractéristiques socio-démographiques des enquêtés

Variables	Modalités	Effectif	Pourcentage
Sexe du répondant	Homme	21	70,0
	Femme	9	30,0
	Total	30	100,0
Statut marital du répondant	Marié	28	93,3
	Divorcé	1	3,3
	Célibataire	1	3,3
	Total	30	100,0
Sexe du chef de ménage	Homme	29	96,7
	Femme	1	3,3
	Total	30	100,0
Niveau d'instruction du chef de ménage	Sans instruction	2	6,6
	Primaire	6	20,0
	Secondaire	22	73,4
	Total	30	100,0
Tranche d'âge du répondant	Moins de 25 ans	1	3,3
	25 - 35 ans	12	40,0
	36-45 ans	7	23,3
	46-55 ans	7	23,3
	Plus de 55 ans	3	10,0
	Total	30	100,0
Taille des ménages	Moins de 3 personnes	2	6,7
	De 3 à 6 personnes	20	66,7
	De 7 à 10 personnes	7	23,3
	Plus de 10 personnes	1	3,3
	Total	30	100,0

Source : données des enquêtes 2018 actualisé en 2023

Il ressort de ce tableau 1 que, notre échantillon est constitué de 30% des femmes et 70% des hommes, représentant chacun un ménage dont 96,7% des chefs de ménages sont des hommes. Il ressort en plus que, 93,3% des répondants sont mariés et plus de 86,3% ont un âge variant entre 25 et 55 ans avec une moyenne d'âge de 40,4±11,248 ans ; 73,4% ont un niveau d'étude secondaire, moins de 7% de non instruits. Environ 66,7% de ménages ont 3 à 6 personnes et 26,6 % des ménages ont plus de 7 personnes, un nombre moyen des 3 actifs agricoles par ménage moyen de 6±2 personnes.

Coût total de production

Il s'agit de représenter toutes les activités associées à la production et à la vente de banane. Avant cela, quelques paramètres seront déterminés à savoir le nombre de personnes exploitant la banane, le mode d'acquisition de la terre, la superficie exploitée, l'ancienneté dans le domaine ainsi que le système de vente.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Tableau 2. Mode d'acquisition de la terre, superficie emblavée pour la culture du bananier et ancienneté dans la culture (en %, N=24)

Variables	Modalités	Age de répondant					Total
		Moins de 25 ans	25 - 35 ans	36-45 ans	46-55 ans	Plus de 55 ans	
Culture de bananes	Yes	4,17	45,83	20,83	20,83	8,33	100
Total		4,17	45,83	20,83	20,83	8,33	100
Mode d'acquisition du terrain	Propriété familiale	20	40	-	40	-	20,8
	Propriété époux(se)	-	33,33	50	16,67	-	25
	Donné	-	66,67	16,67	16 ,67	-	25
	Acheter	-	-	-	-	100	4,2
	Bien communautaire	-	50	16,67	16,67	16,67	25
Total		4,17	45,83	20,83	20,83	8,33	100
Superficie emblavée	Moins de 1000 m2	-	52,40	19,05	19,05	9,52	87,5
	De 1000 à 3000 m2	100	-	-	-	-	4,2
	De 3001 à 6000 m2	-	-	100	-	-	4,2
	Plus de 6000 m2	-	-	-	100	-	4,2
Total		4,17	45,83	20,83	20,83	8,33	100
Ancienneté dans la culture	Moins de 3 ans	-	61,54	23,08	15,41	-	54,2
	De 3 à 6 ans	50	-	-	50	-	8,3
	De 7 à 9 ans	-	50	50	-	-	8,3
	Plus de 9 ans	-	28,57	14,29	28,57	28,57	29,2
Total		4,17	45,83	20,83	20,83	9,5	100

Source : données des enquêtes 2018 actualisé en 2023

De ce tableau 2, la tranche d'âge la plus active est celle comprise entre 25 – 35 ans. A cet effet, l sied de signaler que, 80,0% d'enquêtés cultivent la banane, dont 50% sont d'une façon ou d'une autre propriétaire de la terre exploitée, appartenant soit à la famille, soit aux conjoints ou soit acheté, mais de ce groupe, 42,0% est constitué d'exploitants ayant un âge compris ente 25-55 ans. Outre les propriétaires, 50% d'exploitant cultivent la banane sur des terrains offerts par le chef du village. Quant à l'ancienneté dans la culture, de l'ensemble des exploitants, 54,2% est constitué de nouveaux exploitants parmi lequel 61,5 % ont un âge compris entre 25-35 ans tandis que près d'un tier (29,2%) d'âges confondu pratique la culture depuis plus de 9 ans. En plus, notre échantillon est constitué de 87,5% de petits planteurs cultivant la banane sur des petites parcelles ayant une superficie inférieure à 1000 m^2 pour une superficie moyenne de 965,958±2241,650 m^2.

Système de commercialisation de banane

Seront caractérisés les différents paramètres en rapport avec la vente ainsi que les personnes impliquées ; les coûts engagés pour la

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

commercialisation de bananes, enfin les recettes pour une récolte en plantains de ±720 régimes de ±10 Kg l'an (±7200 Kg), répartie au cours de l'année.

Tableau 3 : La commercialisation de banane plantain au niveau local (en %, N=24)

Variables	Modalité	Niveau d'éducation du chef de ménage			Total	Valeur et Signification de Khi carré au seuil de 0,05
		Pas d'éducation	Niveau primaire	Niveau secondaire		
La personne qui s'occupe de la vente	Papa	-	20	80	20,8	4,291 (0,891)
	Maman	7,14	28,57	64,29	58,33	
	Enfant	-	-	100	16,67	
	En groupe	14,29	14,29	71,43	29,17	
Total		8,33	16,67	75	100	
Moyen de transport utilisé pour se rendre au marché	Pied	8,33	20,83	70,83	100	4,353 (0,629)
	Véhicules	-	10	90	41,67	
	Moto	4,76	19,05	76,19	87,5	
Total		8,33	20,83	70,83	100	
Lieu de vente	Luvaka	4,35	17,39	78,26	95,83	22,373 (0,034)
	Ntungwa	-	-	100	12,25	
	Kwuilu ngongo	10	30	60	41,67	
	Kinshasa	-	-	100	16,67	
	Sur place au village	13,33	20	66,67	62,5	
Total		8,33	12,5	79,17	100	
Déterminants du prix de vente	Grosseur de fruits	4,76	19,05	76,19	87,5	3,294 (0,348)
	Période de récolte	33,33	-	66,67	12,5	
Total		8,33	16,67	75	100	
Mode d'accès à l'information sur le prix de vente	Voisins	10	20	70	83,33	2,725 (0,842)
	Correspondants	7,69	23,08	69,23	54,17	
	Commerçants	9,09	13,34	77,27	91,67	
Total		8,33	16,67	75	100	

Source : données des enquêtes 2018 actualisé en 2023

La vente de banane fait intervenir tous les membres du ménage ayant à 75,0% un niveau secondaire. Généralement (58,33%) les mamans interviennent plus pour la vente dans les marchés locaux les plus proches, tandis que les hommes interviennent quand il faut vendre des grandes quantités soit sur place au village (62,5%) soit dans les marchés plus éloignés (Ntungwa 12,25% ou Kwilu-ngongo 41,7%) ou à Kinshasa (16,7%). Parfois les exploitants s'organisent en groupe (29,2%), délèguent une ou deux personnes. Les moyens de transport les plus utilisés pour la vente locale sont les pieds (100%) et la moto (87,5%). Le marché local le plus fréquenté est Luvaka, où 95,83% d'exploitants se rendent pour écouler leurs productions et faire des approvisionnements. Il arrive que les paysans vendent sur place au village. Pour fixer le prix de vente de banane, les exploitants se renseignent soit auprès des commerçants venus de Kinshasa (91,67%), soit auprès de leur voisin (83,33%), ou auprès de leur correspondant (54,2%). Le prix du régime

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

est déterminé généralement par la grosseur des fruits (87,5%). Le test d'indépendance de χ^2 au seuil de 5%, dans ce tableau 3 montre que seul le choix du lieu de vente (sign=0,034) est influencé à 22,373% par le niveau d'instruction de l'exploitant, tandis que les autres variables n'ont aucune dépendance.

Tableau 4 : Synthèse du coût total d'exploitation en $/an

Rubriques	Coût total	% sur le coût total
Coût variables		
1. Consommation intermédiaires (CI)		
Achat rejet + transport	600	
Total CI	600	33,53
2. Main d'œuvre (HJ)		
Préparation du sol (défrichage et labour)	125	6,99
Trouaison	150	8,38
Plantation	125	6,99
Sarclage	85	4,75
Œilletonnage et tuteurage	40	2,24
Récolte	40	2,24
Transport de récoltes du champ au village	50	2,79
Total MO	615	34,37
3.Coût de commercialisation (CC)		
Transport du village au lieu de vente (Moto)	544,66	30,44
Taxe	0,34	0,02
Frais transport pour le retour au village	1,28	0,07
Autres frais et charges (droit d'étalage)	1,2	0,07
Frais de séjours	1,7	0,10
Total CC	549,18	30,69
Total coût variable= CI + MO + CC (1)	1764,18	98,60
Coûts fixes		
Houe	5,25	0,29
Pèle	3	0,17
Machette	16,75	0,94
Total coût fixe (2)	25	1,40
Total coût de production= (1) +(2)	1789,18	100,00

Source : données des enquêtes 2018, actualisées et Calculées en 2023

Dans ce tableau 4, est calculé le coût total de production. Les coûts variables sont très importants, ils représentent 98,6% du coût de production dont 34,4% est constitué du coût de la main d'œuvre. Le coût fixe ne représente rien sur le coût de production, car les producteurs, dans le système de production traditionnel, consent très peu d'investissements dans leurs parcelles, par conséquent ils ne possèdent que quelques houes, machettes, pèles, etc.

Quant aux charges liées à la commercialisation des bananes, le transport représente près du tier du coût total de production. L'exploitant

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

dépense en moyenne 2,75$ pour produire et mettre sur le marché rural un régime de plantain de ± 10 Kg.

Rentabilité financière et déterminants de rentabilité de la culture du bananier

Tableau 5: Tableau synthèse de l'analyse de la rentabilité pour un hectare (les valeurs sont évaluées en $)

Rubriques	Valeur totale	Valeur unitaire
Recette après-vente	2274,3	
Coût de production	1240	1,72
Coût total d'exploitation	1789,18	2,75
Marge bénéficiaire	485,12	0,75
Recette brute	2520	
Marge brute	1280	1,78
Valeur Ajoutée Brute	1920	2,67
Valeur Ajoutée Nette	1895	2,63
Revenu agricole brut	1280	1,78
Ratio de productivité brute	0,97	
Ratio de la productivité du capital investi	1,03	

Calcul personnel 2023

Pour la rentabilité de banane, il ressort de ce tableau 5 les résultats suivants : L'exploitation crée une valeur ajoutée brute de 1920$ et des recettes après-vente de 2274,3$ pour un coût total de production de 1789,18$. L'exploitation produit alors une marge bénéficiaire de 485,12$ sur ces recettes soit 21,3%. Le ratio de productivité brute est de 0,97. Il renseigne que la consommation d'une unité d'un groupe d'intrants et d'équipements de 2,75$ engendre 1,78$ de revenu agricole brut. Le ratio marge de la productivité du capital investi montre que chaque 1 dollar investi dans la production de banane produit 0,72$ de recette.

Tableau 6 : Déterminants de la rentabilité de la culture de banane à Mansende

Variables dans l'équation						
Déterminant	A	E.S.	Wald	ddl	Sig.	Exp(B)
Distance du marché	,268	,160	2,822	1	,093	1,307
Nombre d'actifs agricoles	2,173	1,290	2,837	1	,092	8,789
Ancienneté dans la culture	-1,269	,681	3,467	1	,063	,281
Superficie exploitée	,002	,001	3,106	1	,078	1,002
Mode d'acquisition de terres	-6,441	4,503	2,046	1	,153	,002
Variétés cultivées	,288	10,328	,001	1	,978	1,333
Constante	-11,916	12,573	,898	1	,343	,000

Valeur de α=0.05

Quant aux facteurs influençant la rentabilité de la culture du bananier à Mansende, le modèle est globalement significatif au seuil de 5 % et est expliqué à 79,2% par les variables introduites dans le modèle. En plus, la log-vraisemblance est de 12,983, le R^2 Negelkerke 0,752 et le Chi-deux de 19,618

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

pour un seuil de signification inférieur à 1%. Les résultats ce tableau 6 montrent que, bien que le nombre d'actif agricole dans le ménage (β = 2,173), les variétés cultivées (β = 0,288), la distance du marché (β = 0,268) et la taille du champ (β = 0,002) aient un effet marginal positif sur la rentabilité, seulement la taille du champ (sign = 0,078), nombre d'actif agricole (sig = 0,092), la distance su marché (sign = 0 093) déterminent significativement la rentabilité (au seuil α = 0,10) avec un rapport de cotes respectivement Exp (β) = 1,002, 8,799 et 1,307. Tandis que l'expérience dans la culture (β = -1,269) la tenure de la terre (β = - 6,441) n'ont aucun effet marginal sur la rentabilité.

Discussions

L'agriculture vivrière constitue la source principale de revenu des paysans du village Mansende et la production de la banane contribue à hauteur de 35% aux revenus des exploitants. La production de banane est le domaine presque exclusif des hommes (96,7%) à cause de la lourdeur des travaux de production, comme cela a été aussi démontré par Briki *et al.* (2021) dans l'étude menée dans la réserve de Luki. L'âge moyen des répondants est de 40,4±11,248 ans résultat supérieur à la moyenne de la province qui se situe à 53% selon INS direction provinciale (2015). La taille moyenne du ménage agricole est de 6±2 personnes en raison d'une moyenne de 3 actifs agricoles. Près d'un tiers (29,2%) d'exploitants d'âge confondu cultivent la banane depuis plus de 9 ans mais les jeunes producteurs représentent plus de la moitié (54,4%) de notre échantillon, attiré par les différents avantages de ladite culture. Communément appelé champ de cases, la taille moyenne de l'exploitation est de 968,958±2241,650 m^2 et 87,5% de paysans cultivent sur des petites parcelles ayant une superficie inférieure à 1000 m^2, résultat conforme à celui de Mpanzu (2012) dans sa thèse sur la commercialisation des produits vivriers paysans dans le Bas-Congo.

La banane est cultivée par 80,0% d'enquêtés dont 50% sont d'une façon ou d'une autre propriétaire de la terre exploitée, résultat différent de la réalité de la réserve de Luki où plus de 98% est prioritaire. Cette différence est d'autant plus que 25% de la population de Mansende est migrant, pour leurs survies, le chef du village, vue l'abondance de terre, met à leur disposition des terrains gratuits. Quant à l'ancienneté dans la culture, 54,2% est constitué de nouveaux exploitants tandis que près d'un tiers (29,2%) d'âges confondu pratique la culture depuis plus de 9 ans.

La commercialisation de banane fait intervenir généralement (58,33%) les mamans pour la vente dans les marchés locaux les plus proches à pied en transportant la production sur la tête. Pour fixer le prix de vente de banane, les exploitants se renseignent souvent auprès des commerçants venus de Kinshasa, prix du régime qui est déterminé généralement par la grosseur des fruits. De par le test d'indépendance entre le choix du lieu de vente et le niveau

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

d'instruction, le χ^2 significatif (sign=0,034) au seuil de 5% montre que seul le choix du lieu est influencé à 22,373% par le niveau d'instruction de l'exploitant car, le choix du lieu de vente étant généralement fonction du prix offert dans le marché (la recherche de bénéfice). Quant au coût total d'exploitation, le rendement trouvé est ±7200 Kg à l'hectare, ce qui coïncide avec la littérature (IICA, 2012), qui stipule que suite à la mise en place des innovations variétales et de nouvelles itinéraires techniques, les rendements moyens à l'hectare varient de 7 à 18 Tonnes/hectare selon les lieux de production et les variétés. L'exploitant engage un coût de production de 1789,18$ pour produire un hectare et mettre sur les marchés ruraux les bananes, duquel résulte 2520$ de recettes brutes et 2274,3$ des recettes après-vente pour une valeur ajoutée brute de 1820$. Ceci montre que l'exploitation est capable de créer de richesse plus que son coût de production et dégagé une marge bénéficiaire de 21,3%, résultat supérieur à ce que Briki et al. (2021) ont trouvé (13%). Cela s'expliquerait par la différence de structure des coûts pour les deux études mais aussi des recettes. Le ratio de productivité brute est de 0,97. Il renseigne que la consommation d'une unité d'un groupe d'intrants et d'équipements de 2,75$ engendre 1,78$ de revenu agricole brut. Le ratio de la marge de la productivité du capital investi montre que chaque 1 dollar investi dans la production de banane produit 1,03$ de recettes.

Tous les ratios étant proche de 1, il convient d'expliquer que la production de banane dans le village Mansende est passablement avantageux, à cause du bas prix négocié dans les milieux ruraux, car les agriculteurs sont souvent contraints de vendre leur production à des prix dérisoires vue qu'à 91,7% ce sont les commerçants urbains qui imposent leur prix au détriment des producteurs. Ce résultat va dans le même sens que celui trouvé par Fongang et al. (2019) qui ont signifié que de tous les acteurs du système de commercialisation, le producteur est celui qui bénéficie la plus petite et le moins rémunéré de tous. La détérioration très avancée des voies de communication en est la principale cause.

Quant aux facteurs déterminant la rentabilité de la culture du bananier à Mansende, les résultats montrent que le modèle est globalement significatif au seuil de 5 % et que 79,2% des variations de la rentabilité sont expliquées par les variables indépendantes introduites dans le modèle. Il découle en plus des analyses que la log-vraisemblance de 12,983, le R^2 Negelkerke de 0,752 et le Chi deux de 19,618 pour un seuil de signification inférieur à 1 %, implique que le modèle global est ajusté et les variables explicatives utilisés dans le modèle ont permis d'expliquer collectivement la variable expliquée. En outre, de tous les prédicteurs estimés, trois sont significatifs au seuil de 10% : la superficie du champ (sig = 0,078), le nombre d'actifs agricoles (sig = 0,092) et la distance du marché (sig = 0,093). Leurs *odds ratio* montrent que l'accroissement de superficie exploitée d'une unité se traduit par un

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

accroissement de la rentabilité estimée de 1,012, tandis que l'accroissement de la main d'œuvre familiale d'une personne se traduirait par un accroissement de rentabilité estimée de 8,799. En outre, le non effet marginal sur la rentabilité de l'expérience de l'exploitant peut être expliqué par la présence de beaucoup de nouveaux exploitants motivés pour la reprise de ladite culture puisque les anciens, victimes autrefois de la maladie de BBTD dans le village, auraient du mal à décoller avec des grandes superficies. De même que le mode d'acquisition n'a aucun effet marginal sur la rentabilité puisque la terre à cultiver est quasi gratuite dans ce village et accessible par tout le monde.

Conclusion

L'objectif de cette étude était d'évaluer la rentabilité d'une bananeraie d'un hectare de superficie car, la production de bananes constitue la principale culture pour 80% des paysans enquêtés dans le village Mansende. Cette culture se pratique dans de petites parcelles non loin du village et de jardins de case autour du village.

A l'issue des analyses, il a été démontré que les deux ratios de productivité sont approximativement proches de 1 et une marge bénéficiaire de 21,3%, ce qui signifie que dans le village Mansende, la production de banane est passablement rentable. En outre, au seuil de 10%, la superficie du champ, le nombre d'actifs agricoles et la distance du marché déterminent positivement la rentabilité de la culture au regard de leurs *odds ratio* respectifs.

Au regard des constats faits sur les contraintes de la production agricole dans ce coin du pays, il a été remarqué que le mauvais état des infrastructures routières, augmentant le temps du transport tout en réduisant la qualité du produit proposé sur les marchés de consommation, constitue la principale cause de faible production et des bas prix négociés en milieux ruraux, surtout en période pluvieuse. Aux autorités tant nationales que provinciales, d'aménager les routes secondaires et de dessertes agricoles afin de permettre une bonne circulation des personnes et des marchandises. Ce qui fera de cette culture, une activité d'appoint et génératrice de revenus pour subvenir aux besoins ponctuels des ménages producteurs.

Au regard des facteurs qui déterminent la rentabilité de la banane dans ce coin, il convient de que la superficie du champ, le nombre d'actifs agricoles et la distance du marché constituent de facteurs sur lesquels les paysans tout comme les chercheurs et politique devraient se concentrer pour une amélioration positive de la performance de cette culture et accorder moins d'effort sur ceux n'ayant aucun impact.

Conflit d'intérêts : Les auteurs n'ont signalé aucun conflit d'intérêts.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Disponibilité des données : Toutes les données sont incluses dans le contenu de l'article.

Déclaration de financement : Les auteurs n'ont obtenu aucun financement pour cette recherche.

Déclaration pour les participants humains : Cette étude a été approuvée par le département d'économie agricole, Faculté de Science Agronomiques et Environnement, Université de Kinshasa et les principes de la Déclaration d'Helsinki ont été suivis.

References:

1. Altukhova-Nys Y., Bascourret J-M., Ory J-F. & Petitjean J-L. (2017) : Mesurer la compétitivité des exploitations agricoles en transition vers l'agroécologie : un état des lieux des problématiques comptables. *La Revue des Sciences de Gestion, 3*(285-286), 41-50. DOI 10.3917/rsg.285.0041, ISSN 1160-7742.
2. Bangata B. N. M., Mobambo K. N., Shungu D., Vuvu K., Vangu P., Omondi A. & Staver, C. (2018) : Évaluation du potentiel prolifératif de six cultivars de bananier (cv. AAB, ABB, et AAA) par macropropagation en République Démocratique du Congo. *Journal of Applied Biosciences,* 127. 12785-12793. https://dx.doi.org/10.4314/jab.v127i1.3.
3. Bézard M. (2017) : *Caractérisation de la culture de bananes plantain en Guadeloupe : diversité des pratiques, performance écologique & Référencement technico-économique* (Mémoire de master, SAADS – RESAD, Montpellier SupAgro) Belgique.
4. Boulet S. & Lebel M. (2005) ; *Étude sur le coût de production du bison en 2003 au Québec*. Consulté le 23/12/2023. https://www.agrireseau.net/grandsgibiers/documents/rapport%20final%20cdp%20bison.pdf .
5. Boureima T., (2019) : Introduction de la culture de la banane plantain au Burkina Faso. *In CTA. Innovation et promotion des chaines de valeurs de produits agricoles locaux en Afrique*. URI : https://hdl.handle.net/10568/101548. 4p
6. Briki M. M., Vangu Paka G., Vuvu K. E., Shungu D. A., Nsimba Y. J., Lukuta N. G., Biba M. et Loma F. D., (2021) : Analyse socioéconomique de la culture de bananier plantain (Musa paradisiaca) dans la Réserve de Biosphère de Luki en République Démocratique du Congo. *Revue Africaine d'Environnement et d'Agriculture* ; 4(4), 60-66 http://www.rafea-congo.com ISSN (Print) : 2708-7743 ISSN : 2708-5422 Dépôt légal : JL 3.01807-5725.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

7. Cohan P., Abadie C., Tomekpé K. & Tchango J. (2003) : Performances agronomiques et résistance à la maladie des raies noires de l'hybride 'CRBP-39' J. *Infomusa,* 12(1), 29-32.
8. Da Silva L. & Santugini M. (2009) : Qu'est-ce que la productivité. Document du travail du Centre sur la productivité et la prospérité au Québec. Consulté le 18/07/2023 sur http://www.hec.ca/cpp.
9. Daderu (1987) : Département de l'Agriculture et du Développement Rural : Production et commercialisation de la banane au Zaïre. *Bureau d'Analyse Economique*., 78p.
10. Djomo E. & Melin Ph. (1972) : Importance économique de la banane plantain au Cameroun. *Fruits,* 27(4), 251-254.
11. FAO (2020): The State of Food Security and Nutrition in the World: Examen du Marché de la banana. Consulté le 25/12/2023 sur https://openknowledge.fao.org.
12. Folefack P. D. (2018) : Evaluation financière de la production d'un hectare de banane plantain. CARBAP, https://www.researchgate.net/publication/327418537, DO I : 10.13140/RG.2.2.21544.21764
13. Fongang F.G. H., Bikoi A., Folefack D. P., Tieche I. & Noupandja P. (2019) : Analyse socioéconomique du système de commercialisation de la banane plantain dans la région de l'Ouest Cameroun. Int. *J. Biol. Chem. Sci.* 13(4) : 2259-2274 DOI : https://dx.doi.org/10.4314/ijbcs.v13i4.30.
14. Fouzai A. & Bachta M, S. (2008) : Les Déterminants de l'adoption des techniques d'économie d'eau d'irrigation en Tunisie. Etude de cas du périmètre de Fej Rouissat – Kairouan. Article consulté le 26/05/2023 sur https://www.iwra.org/congress/2008/resource/authors/abs484article.pdf
15. Hamadou S. & Bouyer J. (2005) : Calcul de la rentabilité des fermes : Production laitière en zone périurbaine. La fiche sur la synthèse méthodologique sur Production animale en Afrique de l'Ouest, Consulté le 25/12/2023 sur www.cirdes.org.
16. Hedegla, A. N. A. M. (2022) : *Analyse des systèmes de production et des besoins en formation des producteurs pour le développement durable de la filière banane plantain au Benin.* (Mémoire Master Ecole supérieure de gestion et de technologie du Bénin) Bénin.
17. IICA (2012) : Institut Interaméricain de Coopération pour l'Agriculture : HAITI : Etude de la filière banane. Rapport de consultation produit par le groupe CJ-Consultants. Consulté le 12/11/2023, http://www.agriculture.gouv.ht.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

18. Kimwanga S. P., Kabuita M. L., Lusi S. L. J-P, Nzawele D. B. & Mussa I. M. (2021) : Rentabilité et obstacles à l'adoption des variétés améliorées du Manioc (*Manihot esculenta Cranz*) chez les paysans en RD Congo. *Rev. Mar. Sci. Agron. Vét.* 9(2) 286-292. DOI : remav_9-2_kimwanga, p-ISSN : 2028-991X.
19. Kwa M. & Temple L. (2019) : Importance des bananiers et des plantains. In M. Kwa et L. Temple (Eds.), *Le bananier plantain, Enjeux socio-économiques et techniques, expériences en Afrique intertropicale (pp.13-19)*. Gembloux, *les Presses agronomiques de Gembloux, Quæ et CTA*.
20. Malla I. A. & Yabi A. J. (2023) : Les déterminants de la rentabilité économique des entreprises paysannes en milieu rural dans le Borgou au Bénin. *African Scientific Journal*, 03(16), 022 – 049. DOI : 10.5281/zenodo.7567768, ISSN : 2658-9311
21. Maniriho A., Berti F., Musabanganji E. & Lebailly P. (2021) : La rentabilité de la production de pomme de terre dans la région des sols de laves au Rwanda. *Tropicultura*, 39(4), 1-29, DOI : 10.25518/2295-8010.1909
22. MINAGRI (2017) : Ministère de l'agriculture : Evaluation de la campagne agricole, de la sécurité alimentaire et du risque phytosanitaire en relation avec les zones attaquées par la chenille légionnaire d'automne"Spodoptera frugiperda" en République Démocratique du Congo. Rapport de Mission Septembre 2017.
23. Moloba L. Y., Mobula M. V., Ntoto M. R. et Mahungu N. M. ; (2019) : Dynamique Socio-économique de L'adoption de la Transformation Améliorée de la Farine Fermentée du Manioc en République Démocratique du Congo (RDC). *European Scientific Journal*, Vol.15, No.27, ISSN : 1857 – 7881 (Print) e - ISSN 1857- 7431. 17p
24. Mpanzu B. P., (2012) : *Commercialisation des produits vivriers paysans dans le Bas-Congo (R.D. Congo) : contraintes et stratégies des acteurs* (Thèse de doctorat, Université de Liège) Gembloux, Belgique, 213 p.
25. Mpanzu, B. P. (2007). *Approvisionnement de la ville de Kinshasa en banane dessert et banane plantain* (Mémoire de master Université de Liège) Belgique.
26. Muku M. T, Mbungu M., P. et Nkulukuta B. E., (2020) : Effets de différents modes de labour sur le rendement et la rentabilité de la culture du manioc (Manihot esculanta Crantz) à M'vuazi, RD Congo. *Int. J. Biol. Chem. Sci.* 14(6) : 2112-2119. DOI : https://dx.doi.org/10.4314/ijbcs.v14i6.14,
27. Ntacobasima C. C., Murhula M. M., et Bengehya Z. J-D., (2019) : La vente de bananes dessert, douces et plantains sur les marchés et sites

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

de vente dans la commune d'Ibanda, ville de Bukavu. *International Journal of Innovation and Applied Studies*, Vol. 28 No. 1, pp. 32-58. ISSN 2028-9324, http://www.ijias.issr-journals.org/

28. Onotamba K. P., (2007) : *topographie et cartographie de différents type de végétation des inventaires du bloc UH 48 de la reserve biosphère de Luki/Bas-congo/RDC*. (Mémoire de licence, Unikin/Facagro) RDC.
29. Penot E. (2009) : *Calculs économiques avec le logiciel Olympe dans le cadre des réseaux de fermes de références et définitions pour le projet PAMPA*. Document du travail de ce projet au Madagascar. Consulté le 13/6/2023 sur https://agritrop.cirad.fr/563699/.
30. Pongi K.G. (2021) : *Etude et modélisation de la productivité des systèmes de culture de basés sur le semis direct sous couvert végétal dans la savane du Sud-Ouest de la République Démocratique du Congo : cas de M'vuazi*, (thèse de doctorat, Université Pédagogique Nationale, Kinshasa) RDC.
31. Rasoatarafambola J. L. (2007) ; *Projet de création d'une entreprise de fabrication de farines de banane infantile à Mananjary.* (Mémoire de fin d'études, université d'Antananarivo) Madagascar.
32. Van Damme J. (2008) : *Analyse systémique des contraintes en culture bananière au Rwanda*. (Mémoire de master UCL) Belgique.
33. Yabi A. J. (2010) : Analyse des déterminants de la rentabilité économique des activités menées par les femmes rurales dans la commune de Gogounou au Nord-Bénin. *Annales des Sciences Agronomiques,* 14(2), 221-239, ISSN 1659-5009.
34. Yabi A. J., Bachabi F. X., Labiyi I. A., Ode C. A. & Ayena R. L. (2016) : Déterminants socio-économiques de l'adoption des pratiques culturales de gestion de la fertilité des sols utilisées dans la commune de Ouaké au Nord-Ouest du Bénin. *International Journal of Biological and Chemical Sciences*, 10(2), 779-792.

ESJ Social Sciences Peer-reviewed

Évolution de la pauvreté et des inégalités en Guinée de 2007 à 2019

M.D. Dilé Diallo
Direction de la Population, Ministère du Plan et du Développement Économique, Conakry, Guinée

Doi:10.19044/esj.2025.v21n19p218

Submitted: 11 April 2025
Accepted: 28 June 2025
Published: 31 July 2025

Cite As:
Diallo, M.D.D. (2025). *Évolution de la pauvreté et des inégalités en Guinée de 2007 à 2019*. European Scientific Journal, ESJ, 21 (19), 218.
https://doi.org/10.19044/esj.2025.v21n19p218

Résumé

Le présent article examine l'évolution de la pauvreté en Guinée entre 2007 et 2019, une période marquée par une croissance économique faible de 2007 à 2012, suivie d'une forte expansion à partir de 2016, principalement grâce à l'essor du secteur minier et à l'augmentation de la production énergétique. Le produit intérieur brut (PIB) du pays a ainsi connu une progression notable, passant de 6 280 millions de francs guinéens en 2007 à 13 514 millions de francs guinéens en 2019, soit une augmentation de plus du double en l'espace de cette période. L'étude est faite à partir des données des trois enquêtes nationales sur les conditions de vie des ménages, réalisées en Guinée en 2007, 2012 et 2019. La taille des échantillons de ces enquêtes varie de 7 552 ménages à l'ELEP 2007, 7 501 à l'ELEP 2012 et 8 240 à l'EHCVM 2019. Pour analyser l'évolution de la pauvreté, les indicateurs de Foster, Greer et Thorbecke (incidence, profondeur et sévérité) ont été utilisés en comparant les intervalles de confiance, les courbes de Lorenz et ainsi que les indices de Gini aux différentes enquêtes. Les résultats de l'analyse révèlent une stabilité de la pauvreté en milieu urbain et une aggravation en milieu rural. En effet, entre 2007 et 2019, la proportion de personnes vivant dans la pauvreté est passée de 53% à 58%, avec des tendances similaires tant en milieux urbain que rural. En milieu urbain, environ un tiers des ménages sont pauvres, tandis qu'en milieu rural, plus des deux tiers des ménages sont touchés. Toutefois, les intervalles de confiance se chevauchant, cette augmentation ne peut être considérée comme significative. La profondeur de la pauvreté, mesurée par

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

l'écart des dépenses des pauvres par rapport au seuil de pauvreté a légèrement progressé entre 2012 et 2019, mais cette amélioration demeure insuffisante pour être jugée significative. L'indice de Gini qui évalue les inégalités de revenus, a diminué de manière marginale, passant de 0,31 en 2007 à 0,27 en 2019. Cette baisse a été plus marquée en milieu rural (de 0,29 en 2007 à 0,25 en 2019), tandis qu'en milieu urbain, l'indice de Gini est resté stable. L'analyse des inégalités de revenu révèle une inégalité globale modérée (l'indice de Gini varie entre 0,27 et 0,31). Les résultats des trois enquêtes montrent de façon constante que les inégalités internes aux milieux de résidence (urbain/rural) expliquent plus de 90% des disparités totales, tandis que les inégalités entre ces milieux restent marginales (environ 7 à 9%). La répartition par quintiles de revenu met en évidence une forte concentration de la richesse au sommet de la distribution. Suivant le quintile de revenu, il apparait qu'environ les trois quarts (73%) de l'inégalité globale proviennent des différences entre les quintiles de revenu, ce qui montre que la majeure partie des inégalités est due à la structure de la distribution des revenus. Cette étude apporte une contribution à la compréhension de l'évolution de la pauvreté en Guinée, en mettant en évidence les tendances et les disparités urbaines-rurales. Elle souligne également l'importance d'une estimation précise du niveau de pauvreté et des facteurs qui y sont associés, afin de mettre en place des politiques efficaces pour lutter contre ce fléau.

Mots clés : Guinée, pauvreté, inégalités, croissance économique

Trends in Poverty and Inequality in Guinea from 2007 to 2019

M.D. Dilé Diallo
Direction de la Population, Ministère du Plan et du Développement Économique, Conakry, Guinée

Abstract

This article examines the evolution of poverty in Guinea between 2007 and 2019, a period marked by weak economic growth from 2007 to 2012, followed by strong expansion beginning in 2016, primarily driven by the boom in the mining sector and increased energy production. The country's gross domestic product (GDP) rose significantly, from 6,280 billion Guinean francs in 2007 to 13,514 billion in 2019, more than doubling over the period. The study is based on data from three national household living conditions surveys conducted in Guinea in 2007, 2012, and 2019. The sample sizes varied from 7,552 households in the 2007 ELEP, 7,501 in the 2012 ELEP, and 8,240 in the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

2019 EHCVM. To analyze poverty trends, the Foster, Greer, and Thorbecke indicators (headcount ratio, poverty gap, and severity) were used, along with comparisons of confidence intervals, Lorenz curves, and Gini indices across the different surveys. The results reveal stability in urban poverty and worsening conditions in rural areas. Between 2007 and 2019, the proportion of people living in poverty rose from 53% to 58%, with similar trends observed in both urban and rural settings. In urban areas, about one-third of households are poor, while in rural areas, more than two-thirds are affected. However, due to overlapping confidence intervals, this increase is not statistically significant. The poverty gap, which measures the shortfall in poor people's expenditures relative to the poverty line, increased slightly between 2012 and 2019, but the change is not significant. The Gini index, which measures income inequality, decreased marginally from 0.31 in 2007 to 0.27 in 2019. This decline was more pronounced in rural areas (from 0.29 in 2007 to 0.25 in 2019), while the urban Gini index remained stable. Income inequality analysis reveals a moderate overall inequality (Gini index ranging between 0.27 and 0.31). The three surveys consistently show that intra-area inequalities (within urban/rural areas) account for more than 90% of total disparities, whereas inter-area inequalities (between urban and rural areas) remain marginal (around 7–9%). Income quintile distribution highlights a strong concentration of wealth at the top of the distribution. Analysis by income quintiles shows that about 73% of overall inequality stems from differences between income groups, indicating that most inequality results from the structure of income distribution. This study makes a valuable contribution to understanding the evolution of poverty in Guinea by highlighting urban-rural trends and disparities. It also underscores the importance of accurately estimating poverty levels and associated factors to design effective policies for combating poverty.

Keywords: Guinea, poverty, inequalities, economic growth

Introduction

La réduction de la pauvreté continue d'être un défi politique et économique en Afrique subsaharienne. Selon la Banque Mondiale, la proportion des Africains vivant dans l'extrême pauvreté a baissé, passant de 54% en 1990 à 35% en 2019 (Christiaensen, 2019). Entre 1990 et 2014, le monde (principalement, l'Asie du Sud-Est) a réalisé des progrès remarquables dans la réduction de la pauvreté, avec plus d'un milliard de personnes qui sont sorties de cette situation (ONU, 2020). Les résultats des enquêtes sur les conditions de vie des ménages réalisées dans plusieurs pays africains confirment cette baisse. Au Sénégal, le taux de pauvreté monétaire est passé de 43% en 2010 à 38% en 2019, tandis qu'au Mali, il est passé de 49% (2010)

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

à 47% (2019). En Guinée, le taux de pauvreté est passé de 53% en 2007, à 55% en 2012 pour atteindre 44% en 2019 (INS, 2019). Toutefois, selon les Nations Unies, le rythme de réduction de la pauvreté s'est ralenti dans le monde depuis 2015, aggravée en cela par la crise du COVID-19 (ONU, 2020). La réduction de la pauvreté s'est accompagnée d'une augmentation des inégalités ces dernières décennies. Les inégalités de revenu se sont creusées dans de nombreux pays riches (pays de l'OCDE). Dans les années 80, le revenu moyen des 10% les plus riches dans ces pays était environ sept fois plus élevé que celui des 10% les plus pauvres ; aujourd'hui, il est environ neuf fois et demie plus élevé. En Asie, les inégalités se sont creusées dans certains des pays qui sont les moteurs économiques de la région (Chine, Inde et Indonésie). Elles ont également progressé en Afrique subsaharienne, mais ont reculé dans de nombreux pays sud-américains. Cette diminution des inégalités s'explique par un renforcement de la protection sociale et une intensification des mesures de redistribution dans ces pays (Keely, 2015).

Parmi les stratégies de lutte contre la pauvreté, l'accélération de la croissance économique et la redistribution des richesses occupent une place centrale (Kabore, 2004). Sous l'impulsion de la Banque Mondiale et du Fonds Monétaire International (FMI), la majorité des pays africains ont élaboré et exécuté des Stratégies de réduction de la pauvreté (SRP) et des Plans Nationaux de Développement (PND) pour impulser le développement de leur pays. Entre 2001 et 2016, la Guinée a élaboré trois documents de Stratégie de Réduction de la Pauvreté (SRP) et un Plan National de Développement Économique et Social (PNDES). Ces stratégies prônent toutes, une amélioration du bien-être de la population basée sur une croissance économique forte.

Sur la période 2007-2012, la croissance de l'économie a été très faible en Guinée. Le PIB s'est accru, en moyenne, de 2,1% contre un taux de croissance démographique de 3%. La période 2011-2012 a été marquée par une relance de la croissance économique (5% en 2012) et de réduction de l'inflation de 19% à 13% (MPDE, 2017). Le pays n'a connu une croissance importante qu'entre 2016 et 2017 (respectivement 10,8%, 10,3%), suivie d'un repli à 6,2% en 2018, et 5,6% 2019 (INS, 2022). La forte croissance enregistrée en 2016 et 2017 a été tirée par le secteur des mines qui a enregistré une hausse exceptionnelle des investissements directs étrangers de 48% en 2016 et de 52% en 2017. Le produit intérieur brut (PIB) du pays est passé de 6 280 millions en 2007 à 7 640 millions en 2012 pour atteindre 13 514 millions de dollars en 2019 (Banque mondiale, 2024).

L'économie guinéenne se caractérise par la prépondérance des secteurs primaire et tertiaire dans la création des richesses. Le secteur primaire concentre la moitié des emplois du pays, en particulier dans l'agriculture. Le secteur secondaire (28,7% du PIB), est dominé par les activités minières. Le

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

secteur tertiaire représente près de 50% du PIB. Il est tiré principalement par le secteur informel, le commerce et les services marchands (MPDE, 2017). Le faible poids du secteur secondaire dans le PIB (environ un quart dont 6,8% pour le secteur manufacturier) démontre que c'est une économie très peu transformatrice et très peu industrialisée.

En dépit de cette embellie économique, les conditions de vie des populations guinéennes restent précaires. La pauvreté touche un peu plus d'un ménage sur deux principalement en milieu rural (65% en 2012 et 55% en 2019). L'accès à l'eau potable (65%), à l'électricité (45%) et à des toilettes améliorées (52%) reste moyen. En 2018, le taux de mortalité infantile était de 66 décès pour 1 000 enfants nés vivants. Environ 22% de la population était en insécurité alimentaire contre 30% en 2012 (INS & PAM, 2018). La malnutrition chronique touchait 30% des enfants de moins de 5 ans, et l'insuffisance pondérale près d'un sixième des enfants (16%) (INS & ICF, 2019).

Entre 2007 et 2019, la Guinée a connu une croissance économique notable. Mais cette croissance a-t-elle permis une réduction significative de la pauvreté des ménages ? Pour répondre à cette question, cet article s'appuie sur les données de trois enquêtes sur la pauvreté réalisées en Guinée en 2007, 2012 et 2018. Il est structuré en trois parties. La première partie présente les données et les méthodes d'analyse. La deuxième partie examine les résultats de l'analyse comparée de l'évolution des principaux indicateurs de pauvreté. Enfin, la troisième partie est consacrée à la discussion et à la conclusion.

Données et méthodes

La mesure de l'impact des stratégies de réduction de la pauvreté demeure un défi scientifique en Afrique subsaharienne en raison du manque de données pertinentes, exhaustives, fiables et actualisées sur les revenus et la consommation des ménages (Banque mondiale, 2014). En outre, la comparaison des niveaux de pauvreté dans le temps et l'espace est tributaire du seuil de pauvreté choisi, des échelles d'équivalence ainsi que des indices de pauvreté (Bonzik, 2004).

Données

Entre 2007 et 2018, la Guinée a réalisé trois enquêtes nationales sur les conditions de vie des ménages (ELEP 2007, ELEP 2012, EHCVM 2019) pour évaluer la pauvreté. Ces enquêtes ont été conçues pour collecter des informations sur les caractéristiques sociodémographiques des ménages, les caractéristiques physiques des logements, l'état de santé, le niveau d'instruction, la situation d'emploi, les activités économiques, l'accès aux infrastructures de base, le revenu total et la consommation des membres du ménage etc.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

L'Enquête Légère pour l'Évaluation de la Pauvreté (ELEP) réalisée en 2007 et 2012 est une enquête à passage unique. Elle avait pour objectif principal de fournir des informations pour le suivi-évaluation de la stratégie de réduction de la pauvreté et des objectifs du millénaire pour le développement.

L'Enquête Harmonisée sur les Conditions de Vie des Ménages (EHCVM) est une enquête réalisée dans les huit pays membres de l'UEMOA, la Guinée et le Tchad avec l'appui technique et financier de la Banque Mondiale. L'objectif principal de cette enquête est de fournir des indicateurs sur les conditions de vie des ménages et la pauvreté fiables, comparables entre les pays mais aussi dans le temps. La collecte des données a été réalisée en deux vagues.

Les fichiers de données ménages et individus issues de ces enquêtes de 2007, 2012 et 2019 seront exploités pour cette étude.

Taille des échantillons

Les échantillons de ces trois enquêtes nationales sont des échantillons probabilistes. Ils sont conçus pour être représentatifs de la population avec des niveaux de précision acceptables pour les indicateurs clés. La taille des échantillons de ces enquêtes varie entre 7 552 ménages à l'ELEP 2007, 7 501 à l'ELEP 2012 et 8 240 à l'EHCVM 2019. Ces tailles sont suffisamment grandes pour produire des estimations robustes et comparables pour la plupart des indicateurs.

Le plan de sondage utilisé dans chacune de ces enquêtes, est un sondage complexe comportant deux degrés de tirage. Au premier degré, une sélection des unités primaires de sondage (grappes) est faite en utilisant des probabilités proportionnelles à la taille de la population. Au deuxième degré, un tirage systématique d'un nombre prédéfini de ménages est effectué dans chaque unité primaire.

Méthodes

Pour mesurer les niveaux de pauvreté et évaluer les tendances au fil du temps, trois outils sont utilisés. Le premier est l'indicateur de bien-être des ménages, qui totalise la consommation d'un ménage afin de la comparer à celle d'autres ménages. Le deuxième est le seuil de pauvreté, défini comme étant la valeur de l'indicateur de bien-être en dessous de laquelle un ménage est considéré comme pauvre. Le troisième est un ensemble d'indicateurs de pauvreté permettant d'évaluer le niveau de bien-être de chaque ménage et de le comparer au seuil de pauvreté. Toutefois, pour assurer la cohérence des indicateurs de pauvreté à travers les différentes périodes, l'indicateur de bien-être et le seuil de pauvreté doivent rester similaires dans les différentes enquêtes (Backiny-Yetna, 2010) (Banque mondiale, 2014).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

En Guinée, la comparaison des niveaux de pauvreté entre 2012 et 2019 est complexe en raison des changements méthodologiques et des différences dans les paniers de consommation utilisés lors des enquêtes. Les données des enquêtes ELEP de 2007 et 2012 ont été collectées en un seul passage, tandis que pour l'EHVCM de 2018, la collecte a été réalisée en deux passages.

De plus, le panier de consommation alimentaire a évolué. En 2007 et 2012, le panier utilisé était celui de l'EIBEP 2002/2003, comprenant 30 biens alimentaires couvrant environ 80 % de la consommation alimentaire des ménages, avec une couverture énergétique estimée de 2 100 kilocalories par jour. En 2019, un nouveau panier de 48 biens alimentaires a été introduit, visant à couvrir 2 300 kilocalories par jour et représentant 90 % de la consommation alimentaire des ménages situés entre le 3ème et le 8ème décile. Ce changement exclut les ménages très pauvres (deux premiers déciles) et les plus aisés (deux derniers déciles) de la constitution du panier.

Il est important de préciser que le taux de pauvreté et l'intensité de la pauvreté sont directement liés au seuil de pauvreté. Par conséquent, une modification du panier de consommation peut entraîner une réévaluation de ces indicateurs, ce qui complique les comparaisons entre différentes populations ou périodes (Coulibaly, 2008) (Banque mondiale, 2014).

Indicateurs de pauvreté

Les principaux indicateurs de pauvreté calculés dans les enquêtes sur les conditions de vie des ménages sont les indicateurs de Foster, Greer et Thorbecke (FGT). Il s'agit de l'incidence de la pauvreté (P_0) qui fournit la proportion des pauvres parmi la population totale ; la profondeur de la pauvreté (P_1), qui mesure l'écart entre le revenu moyen des pauvres et le seuil de pauvreté ; et la sévérité de la pauvreté (P_2), qui estime le degré d'inégalité de consommation parmi les pauvres.

La formule générale s'écrit : $P_\alpha = \frac{1}{N}\sum_{i=1}^{N} \left(\frac{Z-Yi}{Z}\right)^\alpha \mathrm{I}(Yi \leq Z)$

Où :

Z est le seuil de pauvreté,

Y_i la consommation annuelle (par tête) de l'individu numéro i de la population ;

I ($Y_i \leqslant Z$) est une fonction indicatrice valant 1 si $Y_i \leqslant Z_{yi} \leqslant Z$ et 0 sinon.

Si α=0, $P_0 = \frac{Q}{N}$, Q = nombre de pauvres, N= population totale

Si α=1, $P_1 = \frac{1}{N}\sum_{i=1}^{N} \left(\frac{Z-Yi}{Z}\right)$

Si α=2, $P_2 = \frac{1}{N}\sum_{i=1}^{N} \left(\frac{Z-Yi}{Z}\right)^2$

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Évolution de la pauvreté en Guinée

Dans cette étude, l'analyse de l'évolution de la pauvreté en Guinée sur la période 2007–2019 repose sur l'utilisation des seuils de pauvreté internationaux spécifiques à chacune des enquêtes disponibles. Afin de garantir la robustesse des comparaisons dans le temps, les intervalles de confiance associés aux principaux indicateurs sont examinés. En complément, des courbes de dominance stochastique sont construites pour chacune des trois enquêtes, offrant une évaluation comparative plus fine des dynamiques de pauvreté.

Toutefois, il convient de souligner que les comparaisons intertemporelles des niveaux de pauvreté peuvent être affectées par des changements dans les méthodes d'enquête. En effet, des modifications substantielles de la méthodologie peuvent induire des variations artificielles des taux de pauvreté, indépendamment de l'évolution réelle des conditions de vie. Pour remédier à ces biais, la meilleure pratique consiste à procéder à des révisions rétrospectives des estimations antérieures, afin d'harmoniser les séries dans le temps. Cette approche a été adoptée dans plusieurs pays confrontés à des défis similaires, notamment au Sénégal (2011), au Niger (2013) et au Rwanda (2015) (Porte, 2021).

Intervalles de confiance

Les intervalles de confiance sont des outils essentiels en statistique pour évaluer l'incertitude associée aux estimations. Pour interpréter les résultats, les intervalles de confiance de l'indicateur d'une enquête sont comparés à ceux de l'enquête précédente. Si les intervalles de confiance entre deux périodes se chevauchent, cela indique qu'il n'y a pas de changement statistiquement significatif dans le taux de pauvreté. En revanche, si les intervalles de confiance ne chevauchent pas, ou chevauchent de manière marginale, cela suggère une différence statistiquement significative entre les groupes (Besançon, 2017).

Soit p, la proportion de ménages pauvres et $\hat{p}$ la proportion observée dans l'échantillon), l'équation est la suivante :

IC = $\hat{p} \pm Z[\sqrt{\hat{p}\,(1-\hat{p}\,)/n}$

- $\hat{p}$ est la proportion observée dans l'échantillon.
- Z est la valeur critique de la distribution normale.
- n est la taille de l'échantillon.

Courbe de Lorenz et Indice de Gini

La courbe de Lorenz (ou courbe de concentration) est une représentation graphique qui permet de visualiser le degré de concentration d'une variable statistique, par exemple le revenu des ménages. Pour la construire, il faut classer les ménages ou les individus en fonction de leur

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

revenu par ordre croissant. En abscisse du graphique, va être indiquée la fréquence cumulée de la population. Le point d'abscisse 10 correspond ainsi aux 10% disposant des plus bas revenus, le point d'abscisse 60 aux 60% aux plus bas revenus. Pour déterminer la valeur de l'ordonnée des points, il faut calculer pour chaque groupe considéré (par exemple, le groupe des 20% aux plus bas revenus) la part du revenu global détenu par les membres du groupe. La diagonale (bissectrice) représente la droite d'équirépartition, illustrant une répartition parfaitement égalitaire de la variable, chaque groupe disposant d'une part du revenu équivalent à son poids démographique. Plus la courbe de Lorenz s'éloigne de cette droite, plus le degré d'inégalité dans la répartition est élevé.

Si l'on considère deux courbes de Lorenz des revenus correspondant à deux pays différents, le fait que la courbe d'un pays soit toujours en dessous de la courbe de l'autre signifie que le premier est plus inégalitaire que le second (critère de Lorenz).

Le critère de Lorenz, fondé sur la position relative des courbes de Lorenz, ne permet pas de classer toutes les distributions entre elles. En effet, lorsque deux courbes de Lorenz se croisent, il devient impossible de déterminer de manière univoque laquelle des deux distributions est la plus égalitaire. Dans ce cas, on dit que le critère de Lorenz est incomplet pour l'évaluation des inégalités, car il ne permet pas toujours d'établir une hiérarchie claire entre les distributions (Navarro, 2022).

L'indice de Gini est l'un des indicateurs les plus couramment utilisés pour mesurer les inégalités de revenu ou de richesse au sein d'une population. Il permet de résumer en une seule valeur le degré de concentration ou de dispersion d'une distribution. Dans le cas d'une distribution discrète, il est défini par l'équation suivante :

$$G = \frac{1}{2n^2\mu}\sum_{i=1}^{n}\sum_{j=1}^{n}|yi - yj|$$

Où :

n est la taille de la population,

y_i et y_j sont les revenus des individus i et j,

μ est le revenu moyen.

L'indice de Gini (G) varie entre 0 (égalité parfaite, où tous les individus ont un revenu identique) et 1 (inégalité maximale, où un seul individu détient la totalité des ressources). Il repose sur une représentation graphique, la courbe de Lorenz, qui compare la part cumulée des revenus détenue par une fraction de la population avec la part cumulée de cette dernière. Plus l'écart entre cette courbe et la diagonale d'égalité parfaite est marqué, plus les inégalités sont prononcées.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

L'un des principaux avantages de cet indicateur synthétique est qu'il prend en compte l'ensemble de la distribution des revenus, allant des plus pauvres aux plus riches. Toutefois, il présente certaines limites. Il est, par exemple, peu sensible aux variations affectant de petits effectifs ou aux changements localisés dans les extrémités de la distribution, précisément là où les inégalités tendent à se concentrer (Navarro, 2022).

De plus, l'indice de Gini souffre d'une limitation structurelle majeure : il ne permet pas une décomposition additive rigoureuse des inégalités en composantes intra-groupes (au sein de sous-populations) et inter-groupes (entre ces sous-populations). Cette lacune restreint l'analyse des disparités selon des critères comme le lieu de résidence, la région, le sexe, le niveau d'instruction ou encore le quintile de richesse.

Pour pallier cette contrainte, des extensions méthodologiques ont été proposées. Parmi elles, la décomposition multidimensionnelle de l'indice de Gini permet d'intégrer des dimensions non monétaires telles que l'accès à l'éducation, aux soins de santé, aux services de base, offrant ainsi une vision plus complète des inégalités multidimensionnelles. Ces avancées contribuent à une meilleure évaluation de l'impact différencié des politiques publiques et à l'élaboration de stratégies ciblées visant à réduire les écarts structurels au sein de la population (Heikkuri, 2024).

Courbe de dominance stochastique,

Une des principales critiques adressées aux indices de Foster, Greer et Thorbecke réside dans leur dépendance à une ligne de pauvreté, dont la définition est intrinsèquement ‘‘arbitraire’’. Cette dépendance soulève des questions sur la robustesse des indices face au choix du niveau de pauvreté (Lubrano, 2008). Plutôt que de considérer un simple indice P_0 comme une valeur fixe, certains auteurs suggèrent de le traiter comme une fonction de Z, avec Z variant à l'intérieur d'un intervalle prédéfini. Ainsi, comparer deux situations revient à comparer deux fonctions de répartitions (courbes), plutôt que deux points. Les courbes de dominance offrent la possibilité d'ordonner des distributions de revenu ou des indicateurs de niveau de vie sans qu'il ne soit nécessaire de fixer un seuil de pauvreté unique (Coulibaly, 2008). La technique de dominance stochastique généralise les indices de pauvreté FGT en permettant au seuil de pauvreté de varier sur tout le segment de population considéré.

Cette technique consiste à tracer des fonctions de répartition de la consommation par tête pour chaque année. Ces fonctions de répartition affichent, sur l'axe des abscisses, les niveaux de consommation par tête, et sur l'axe des ordonnées, le pourcentage de personnes vivant dans des ménages dont la consommation est inférieure à ce niveau. Une fois un seuil de pauvreté défini sur l'axe des abscisses, le taux de pauvreté correspondant peut être

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

directement lu sur l'axe des ordonnées. Ainsi, si une courbe A se situe entièrement en dessous d'une courbe B, cela signifie que les niveaux de pauvreté associés à la courbe A sont systématiquement inférieurs à ceux de la courbe B (Lachaud, 1999) (INS, 2012).

En effet, soient $F(x_i)$ et $G(x_i)$ les fonctions de distribution cumulative (CDF) de deux distributions discrètes, où x_i représente les différents niveaux de revenu ou de consommation. La distribution F domine stochastiquement la distribution G au premier ordre si, pour tout x_i :

$$F(x_i) \leq G(x_i)$$

Cela signifie qu'à chaque niveau de revenu x_i, la probabilité cumulative d'avoir un revenu inférieur ou égal à x_i est toujours inférieure (ou égale) pour F que pour G.

En ce qui concerne la dominance stochastique du second ordre, on utilise les sommes cumulées des CDF discrètes. La distribution F domine stochastiquement la distribution G au second ordre si, pour tout x_i :

$$\sum_{j=1}^{i} F(xj) \leq \sum_{j=1}^{i} G(xj)$$

Où la somme est prise sur les niveaux de revenu x_j allant de la plus petite valeur jusqu'à xi.

Cette condition implique que l'aire sous la courbe de Lorenz associée à la distribution F est toujours inférieure ou égale à celle de G, pour toutes les proportions cumulées de la population.

Ces critères de dominance permettent de comparer les distributions de revenus ou de pauvreté de manière robuste, en s'affranchissant des limitations liées au choix de seuils arbitraires.

En particulier, la dominance stochastique du second ordre est davantage appropriée pour l'analyse des inégalités, car elle prend en compte non seulement la position relative des individus dans la distribution, mais aussi la dispersion des revenus.

Résultats et discussion

Les trois indices de pauvreté : l'incidence (P_0), la profondeur (P_1) et la sévérité (P_2) ont été calculés pour chacune des trois enquêtes. Les valeurs obtenues ont été vérifiées et jugées cohérentes avec celles publiées dans les rapports de l'Institut national de la statistique (INS, 2021). En complément, les erreurs types et les intervalles de confiance à 95% ont été générés pour chaque indicateur, en tenant compte de l'effet du plan de sondage complexe à deux degrés, à l'aide du logiciel Stata.

Une comparaison des intervalles de confiance a été réalisée pour chaque paire d'estimations : 2007–2012 et 2012–2019, tant au niveau national qu'au niveau des milieux de résidence. Cette comparaison s'est appuyée sur

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

une procédure simple visant à évaluer la significativité statistique des écarts entre estimations.
La règle suivante a été appliquée :

- Si la borne supérieure de l'intervalle de confiance pour l'ELEP 2007 chevauche la borne inférieure de celui de l'ELEP 2012, aucune différence significative ne peut être conclue.
- De même, si la borne supérieure de l'intervalle de confiance de l'ELEP 2012 chevauche la borne inférieure de celui de l'EHCVM 2019, l'hypothèse nulle de stabilité ne peut être rejetée.
- À l'inverse, si la borne inférieure de l'intervalle de confiance de l'EHCVM 2019 chevauche la borne supérieure de celui de l'ELEP 2012, aucune différence significative ne peut non plus être affirmée.

Dans tous les autres cas, les estimations sont considérées comme statistiquement différentes au seuil de confiance de 95%.

Par ailleurs, s'agissant de la comparaison des niveaux d'un indicateur, l'absence de différence significative entre deux dates peut indiquer soit une stabilité réelle de l'indicateur, soit une taille d'échantillon insuffisante pour détecter un changement. Il reste difficile de trancher entre ces deux hypothèses. Il est donc recommandé, dans de tels cas, d'augmenter la taille de l'échantillon lors des enquêtes ultérieures (Greenwell, 2014).

Le tableau 1 présente les seuils de pauvreté retenus pour les trois enquêtes analysées. En 2007, le seuil de pauvreté était fixé à 1 590 894 GNF par personne et par an, soit 4 359 GNF par jour. En 2012, il s'élevait à 3 217 305 GNF, correspondant à 8 815 GNF par personne et par jour. Pour l'enquête EHCVM 2019, le seuil national de pauvreté atteignait 5 006 533 GNF, soit 13 716 GNF par personne et par jour.

Les seuils de pauvreté de 2007 et 2012 correspondent respectivement aux seuils internationaux de 1 USD et 1,25 USD par jour. En revanche, le seuil international de pauvreté appliqué à l'enquête de 2019 est estimé à 5 947 113 GNF, soit environ 1,90 USD par personne et par jour. Dans le cadre de cette analyse, les seuils internationaux de pauvreté définis par la Banque Mondiale[1] ont été retenus, afin d'assurer une comparabilité internationale des résultats.

[1] Le changement de méthodologie dans le calcul du seuil de pauvreté entre 2012 et 2018/2019 rend difficile la comparaison directe des taux de pauvreté basés sur le seuil national de pauvreté calculé par l'INS. Par conséquent, le seuil international de pauvreté est souvent utilisé pour permettre une comparaison plus cohérente. Le seuil de pauvreté international permet d'évaluer et de comparer la pauvreté entre les pays en offrant une référence commune. La Banque mondiale ajuste régulièrement ce seuil pour tenir compte de l'inflation et de l'évolution du coût de la vie dans les différentes régions du monde. Ainsi, le seuil de pauvreté extrême a été fixé à 1 USD par personne et par jour en 1990, puis réévalué à 1,25 USD en 2008, à 1,90 USD en 2015 et à 2,15 USD en 2022.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Tableau 1: Seuil de pauvreté et indice d'inégalité selon le milieu de résidence et l'année de l'enquête

Année	Seuil alimentaire	Seuil de pauvreté global (annuel)	Seuil de pauvreté journalier en GNF	Conversion 1 $ US en GNF	Seuil de pauvreté journalier en USD	Rapport interdécile	Indice de Gini (%)
2007	786 292	1 590 894	4 359	4 151	1,05	4,2	31,2
2012	1 837 983	3 217 305	8 815	7 052	1,25	4,1	31,6
2019	3 068 265	5 947 113	16 520	8 695	1,90	3,6	27,2

Source : Données de ELEP 2007, ELEP 2012 et EHCVM 2019.

Tendance de la pauvreté entre 2007 et 2019

Le tableau 2 donne, pour chaque indicateur, les estimations ainsi que les limites inférieure et supérieure des intervalles de confiance pour les indicateurs de pauvreté, au niveau national et selon les milieux de résidence (urbain et rural). Globalement, la proportion d'individus en situation de pauvreté est passée de 53% en 2007 à 55% en 2012, puis à 58% en 2019. Cette tendance à la hausse est également observée dans les deux milieux de résidence (urbain et rural).

Le graphique 1 présente l'incidence de la pauvreté avec les limites supérieures et inférieures de l'intervalle de confiance aux différentes années. En 2007, la proportion de pauvres se situait entre 50,7% et 55,3% ; en 2012, elle variait de 52,9% et 57,5%, et en 2019, l'incidence varie entre 55,8% et 60,7%. On observe les mêmes tendances selon les milieux de résidence. En milieu urbain, la proportion des pauvres atteint près d'un tiers des ménages et en milieu rural, plus des deux tiers des ménages. Dans les deux cas, les intervalles de confiance se chevauchent (graphique 1).

Tout comme l'incidence, la profondeur de la pauvreté touche les deux cinquièmes des ménages quelle que soit l'enquête considérée. Toutefois, les variations constatées ne sont pas statistiquement significatives. Durant la période 2007–2019, l'écart moyen des dépenses des pauvres relativement au seuil de pauvreté s'est maintenu voire aggravé. Cependant, entre 2012 et 2019, une réduction de la profondeur de la pauvreté est observée, avec un intervalle de confiance passant de 35%–43% en 2012 à 21%–26% en 2019, suggérant une amélioration des conditions de vie des populations.

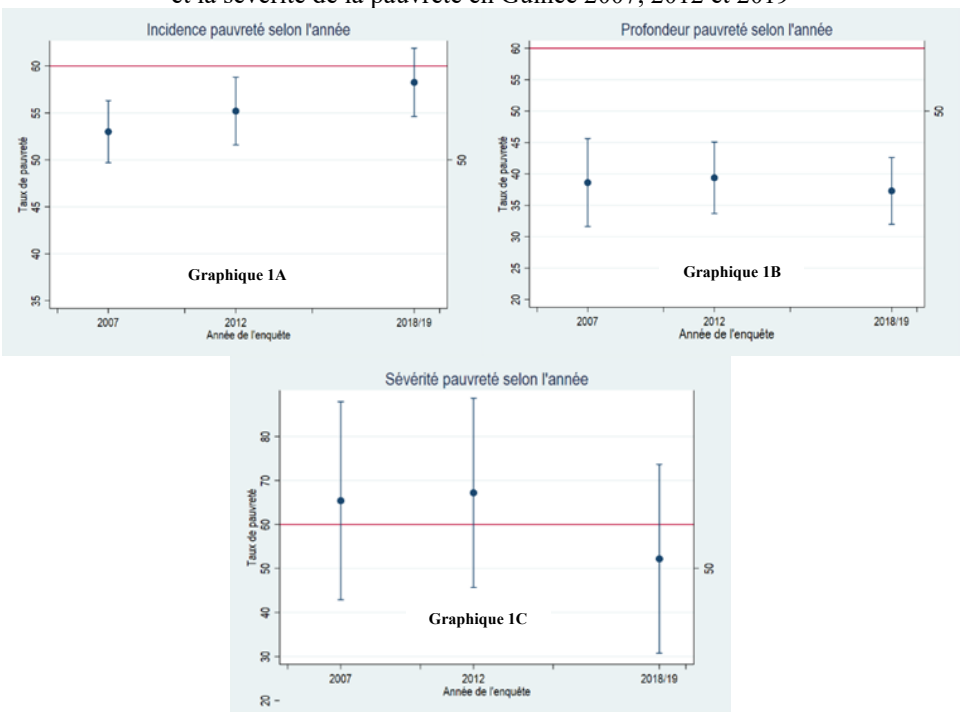
La sévérité de la pauvreté, qui reflète le degré d'inégalité parmi les populations pauvres, suit une trajectoire similaire à celle de la profondeur. Aucun accroissement notable n'est enregistré entre 2007 et 2012, tandis qu'une diminution est observée entre 2012 et 2019, le niveau national passant de 67% à 52%.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Cette tendance à la baisse est particulièrement marquée en milieu urbain, où la sévérité chute de 35% en 2012 à 10% en 2019. En milieu rural, une diminution plus modérée est constatée, avec une baisse de 82% à 75% sur la même période. Cependant, comme le montre le graphique 1C, les intervalles de confiance se chevauchent largement, ce qui indique que cette diminution de la proportion des ménages concernés par l'extrême pauvreté n'est pas statistiquement significative.

L'analyse de l'évolution de la pauvreté entre 2007 et 2019, montre qu'elle est restée stable en milieu urbain alors qu'en milieu rural, elle a augmenté de six points de pourcentage. Une des explications à cette situation serait les améliorations notables enregistrées dans l'accès à l'électricité et à l'eau potable, en particulier dans les grandes agglomérations urbaines.

Graphique 1 : Estimations et intervalles de confiance associés à la l'incidence, profondeur et la sévérité de la pauvreté en Guinée 2007, 2012 et 2019



Source : Calculs de l'auteur à partir des données ELEP 2007, ELEP 2012 et EHCVM 2019

Par ailleurs, l'accès aux services de santé, d'éducation et de formation professionnelle s'est également amélioré au cours de la période 2015-2018.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Tableau 2: Tendances des indicateurs de pauvreté, 2007, 2012 et 2019

Indicateur	Valeur (M)	Écart type (ET)	Erreur relative (ET/M)	M-2ET	M+2ET
Incidence pauvreté					
Ensemble					
P_0-2007	53,0	1,1	0,02	50,7	55,3
P_0-2012	55,2	1,2	0,02	52,9	57,6
P_0-2019	58,3	1,2	0,02	55,8	60,7
Urbain					
P_0-Urbain-2007	30,5	1,4	0,05	27,7	33,3
P_0-Urbain-2012	35,4	1,2	0,04	32,9	37,9
P_0-Urbain-2019	36,3	1,3	0,04	33,7	39,0
Rural					
P_0-Rural-2007	63,0	1,5	0,02	60,1	65,9
P_0-Rural-2012	64,7	1,6	0,02	61,5	67,8
P_0-Rural-2019	70,3	1,7	0,02	66,8	73,7
Profondeur pauvreté					
Ensemble					
P_1-2007	38,6	2,3	0,06	33,9	43,3
P_1-2012	39,4	1,9	0,05	35,6	43,2
P_1-2019	37,3	1,8	0,05	33,7	40,8
Urbain					
P_1-Urbain-2007	14,5	1,4	0,10	11,6	17,3
P_1-Urbain-2012	19,1	1,5	0,08	16,1	22,2
P_1-Urbain-2019	13,7	0,8	0,06	12,1	15,2
Rural					
P_1-Rural-2007	49,3	3,2	0,07	42,8	55,8
P_1-Rural-2012	19,1	1,5	0,08	16,1	22,2
P_1-Rural-2019	50,2	2,7	0,05	44,7	55,7
Sévérité pauvreté					
Ensemble					
P_2-2007	65,4	7,5	0,11	50,4	80,4
P_2-2012	67,2	7,2	0,11	52,9	81,5
P_2-2019	52,2	7,1	0,14	37,9	66,5
Urbain					
P_2-Urbain-2007	19,3	4,5	0,23	10,3	28,4
P_2-Urbain-2012	35,2	8,9	0,25	17,4	53,0
P_2-Urbain-2019	10,3	1,0	0,10	8,3	12,3
Rural					
P_2-Rural-2007	85,8	10,5	0,12	64,8	106,9
P_2-Rural-2012	82,5	9,7	0,12	63,0	101,9
P_2-Rural-2019	75,1	11,1	0,15	53,0	97,3

Source : Calculs de l'auteur à partir des données ELEP 2007, ELEP 2012 et EHCVM 2019

Analyse des inégalités

L'analyse des inégalités de revenu à l'aide de l'indice de Gini montre pour l'année 2007 un indice global de 0,31, indiquant une inégalité modérée

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

dans la distribution des revenus. La décomposition de cette inégalité suivant les critères de résidence et de revenu montre que pour le milieu de résidence, 93% de l'inégalité provient des différences internes aux groupes urbain et rural, suggérant que les inégalités au sein des milieux sont plus importantes que celles observées entre les groupes (Tableau 3). En milieu urbain, le revenu moyen est de 2 350 448 GNF, représentant 40,3% de la richesse totale. En milieu rural, le revenu moyen est de 1 545 240 GNF représentant 59,7% de la richesse totale (Tableau 4). Bien que les revenus soient plus élevés en milieu urbain, l'écart d'inégalité est relativement similaire entre les deux milieux (Gini interne de 0,29).

Tableau 3: Décomposition de l'Indice de Gini selon les trois enquêtes

Variables	2007			2012			2019		
	Total	Inter-groupe	Intra-groupe	Total	Inter-groupe	Intra-groupe	Total	Inter-groupe	Intra-groupe
Milieu de résidence	31,2	93,1	6,9	31,6	93,4	6,5	27,2	90,9	9,1
Quintile	31,2	29,9	73,1	31,6	27,3	72,7	27,2	25,5	74,5
Inégalité inter-groupe = Inégalités au sein des groupes *Inégalité intra-groupe = Inégalités entre les groupes*									

Source : Calculs de l'auteur à partir des données ELEP 2007, ELEP 2012 et EHCVM 2019

Suivant le quintile de revenu, il apparaît que 73% des inégalités proviennent des différences entre les quintiles de revenu, ce qui montre que la majeure partie des inégalités est due à la structure de la distribution des revenus. Le revenu moyen des deux premiers quintiles est bien inférieur à celui des deux derniers quintiles. En effet, le revenu moyen du 5e quintile est 5 fois supérieur à celui du 1er quintile (respectivement 3 519 812 GNF et 701 207 GNF). Le 5e quintile détient 39,3% de la richesse totale, tandis que le 1er quintile ne détient que 7,8%, mettant en évidence une concentration très marquée des revenus au sommet de la distribution.

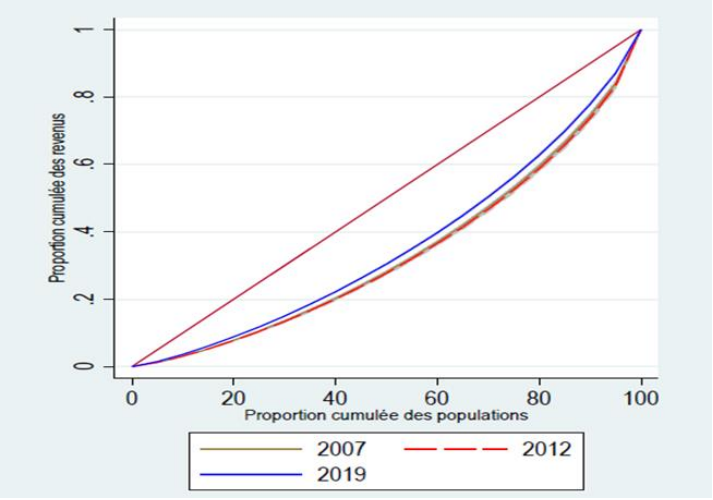
Pour 2012, on observe la même tendance que pour 2007. En effet, la grande majorité des inégalités de revenu (93,5%) provient des écarts à l'intérieur des milieux de résidence, urbains ou ruraux. Bien que les revenus moyens diffèrent entre ces deux milieux, ce sont surtout les disparités entre individus d'un même environnement qui explique l'essentiel de l'inégalité globale. Par exemple, en zone urbaine le coefficient de Gini (0,31) est plus élevé qu'en zone rurale. Les inégalités entre milieux (urbain vs rural) ne représentent que 6,5% des inégalités totales, bien qu'une différence claire existe. En effet, les urbains, qui ne représentent que 32,3 % de la population, captent 41,9% du revenu total, tandis que les ruraux, majoritaires (67,7 %), ne reçoivent que 58,1% des revenus. Le revenu moyen des urbains est environ 1,5 fois plus élevé que celui des ruraux (4 639 753 GNF contre 3 068 127 GNF). Cela montre une inégalité intergroupe réelle, mais relativement faible

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

en poids par rapport aux inégalités internes. Ainsi, les inégalités internes aux ménages urbains sont le principal facteur des déséquilibres économiques constatées en 2012.

En 2019, on observe que les revenus moyens entre les ménages urbains et ménages ruraux diffèrent sensiblement (7 739 151 GNF en milieu urbain contre 5 132 125 GNF en milieu rural), mais les disparités internes sont comparables, avec des coefficients de Gini très proches. L'indice de Gini globale pour 2019 est de 0, 27. C'est une inégalité plus modérée que dans les résultats des enquêtes précédentes. Les résultats des décompositions du coefficient de Gini montrent que les inégalités de revenu sont ici aussi principalement déterminées par le niveau de richesse, plutôt que par le milieu de résidence. Lorsque la population est regroupée selon le milieu urbain ou rural, plus de 90% des inégalités proviennent des écarts à l'intérieur même de chaque milieu, et seulement 9% s'expliquent par les différences entre zones. Cela signifierait que le lieu de résidence n'est pas un facteur majeur dans la structuration des inégalités économiques.

Graphique 2 : Courbe de Lorenz pour les 3 enquêtes, ELEP 2007, ELEP 2012 et EHCVM 2019



Source : Calculs de l'auteur à partir des données ELEP 2007, ELEP 2012 et EHCVM 2019

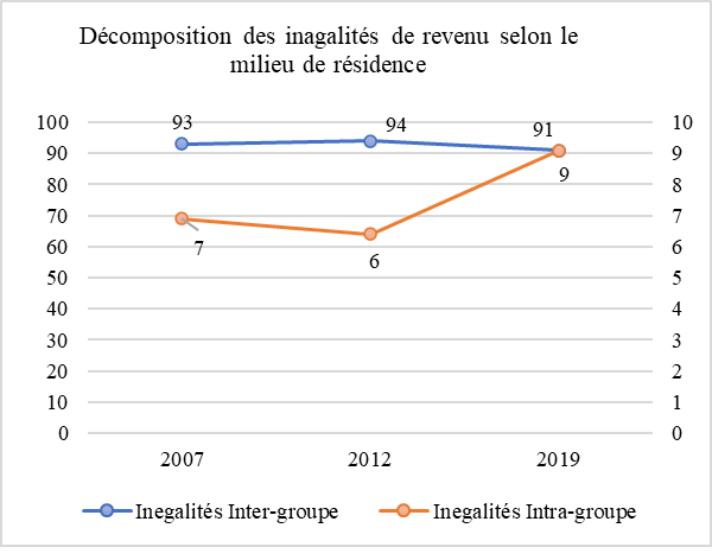
Par ailleurs, la décomposition par quintile de richesse révèle que près de 75% des inégalités proviennent des écarts entre les groupes de richesse. Le revenu moyen du quintile le plus pauvre (Q1) est de 3 085 594 GNF, tandis que celui du quintile le plus riche (Q5) atteint 12 659 965 GNF, soit plus de quatre fois plus élevé. Le 5e quintile, bien qu'il ne représente que 11,5% de la population, capte 24,1% de la richesse totale. À l'inverse, le 1er quintile, qui représente 28,8% de la population, ne détient que 14,7% de la richesse, ce qui reflète un certain déséquilibre dans la répartition des revenus. De plus, les inégalités à l'intérieur de chaque quintile sont relativement faibles, surtout

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

dans les quintiles centraux (2, 3, 4) avec des Gini variant entre 0,04 et 0,05. En revanche, le 1er et le 5e quintile présentent les inégalités internes les plus élevées respectivement 0,129 et 0,124. Cela peut indiquer une plus grande hétérogénéité parmi les ménages les plus pauvres et chez ménages riches.

Pour les trois enquêtes, l'essentiel des inégalités provient des disparités au sein des groupes, avec un pic en 2012 (93,6%). L'inégalité entre groupes (inter-groupes), bien que faible, augmente entre 2012 et 2019, passant de 6,5% à 9,1%, ce qui pourrait indiquer une accentuation des écarts moyens entre sous-groupes (par exemple entre milieux urbain/rural, régions, quintile de richesse, etc.).

Graphique 3 : Tendance des inégalités intergroupe et intragroupe de 2007 à 2019



Source : Calculs de l'auteur à partir des données ELEP 2007, ELEP 2012 et EHCVM 2019

Tableau 4: Indicateurs d'inégalités de revenus par milieu de résidence et quintile de revenu Guinée, 2007, 2012 et 2019

Variables	Part de la population			Revenu moyen (GNF)			Part du revenu total			Indice de Gini (pour 100)		
	2007	2012	2019	2007	2012	2019	2007	2012	2019	2007	2012	2019
Milieu de Résidence												
Urbain	30,7	32,2	35,4	2350448	4639752	7739150	40,2	41,8	45,2	29,0	31,4	25,0
Rural	69,2	67,7	64,6	1545240	3068126	5132125	59,8	58,1	54,7	29,5	29,0	25,0
Quintile												
Q1	20,0	20,0	28,8	701207	1433750	3085594	7,8	8,0	14,7	17,7	13,7	12,9
Q2	20,0	20,0	23,4	1164257	2278804	4795107	12,9	12,7	18,5	5,3	51,0	5,1
Q3	19,9	19,9	19,8	1534781	3012230	6263180	17,1	16,8	20,5	4,2	4,5	4,2
Q4	19,9	20,0	16,3	2044646	4017801	8190947	22,8	22,4	22,1	5,4	5,2	5,0
Q5	19,9	19,9	11,5	3519812	7136736	12659965	39,2	39,9	24,1	17,2	19,1	12,3
Ensemble	**100,0**	**100,0**	**100,0**	**1792707**	**3575539**	**6054474**	**100,0**	**100,0**	**100,0**	**31,2**	**31,6**	**27,2**

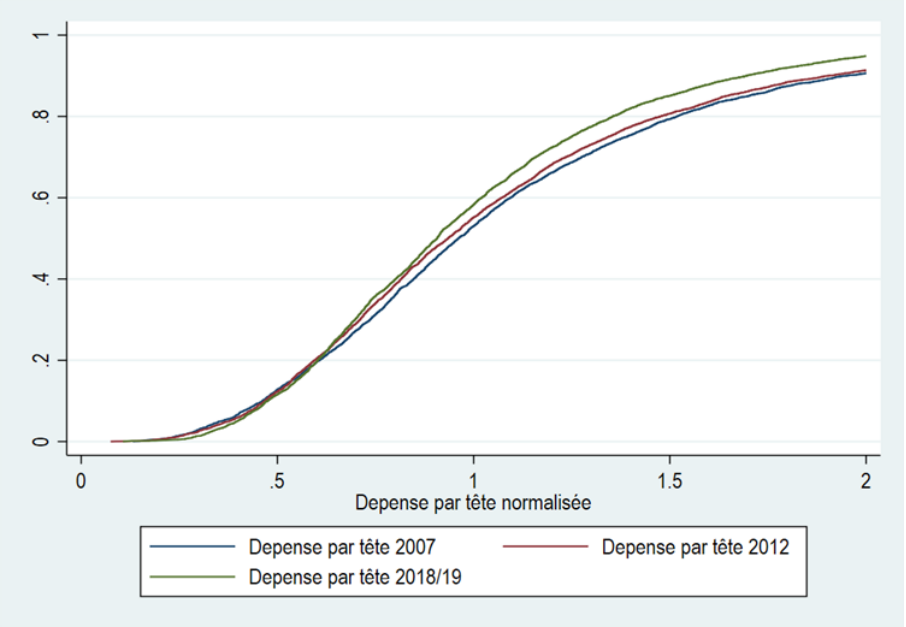
Source : Calculs de l'auteur à partir des données ELEP 2007, ELEP 2012 et EHCVM 2019.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Analyse des courbes de dominance stochastique

Le graphique 3, présente les courbes de dominance stochastique de distributions de la consommation en Guinée en 2007, 2012 et 2019. L'axe Y donne la consommation par habitant et
l'axe X le pourcentage des personnes vivant dans des ménages dont la consommation par habitant est inférieure à ce niveau.

Graphique 4 : Courbe de dominance stochastique, ELEP 2007, ELEP 2012, EHCVM 2019



Source : Calculs de l'auteur à partir des données ELEP 2007, ELEP 2012 et EHCVM 2019

À chaque seuil de pauvreté représenté sur l'axe Y correspond un taux de pauvreté sur l'axe X. L'analyse des allures des courbes de dominance stochastique montrent que les niveaux de dépenses des ménages étaient similaires entre 2007, 2012 et 2019 pour les premières tranches de la distribution de la consommation et confirme le fait que la pauvreté n'a pas baissé entre 2007 et 2019. Dans le premier tiers de la courbe, les trois distributions sont confondues, indiquant ainsi que les niveaux de dépenses des ménages sont identiques dans cette plage. Ceci suggère une homogénéité dans le comportement de consommation ou de niveaux de vie au sein des trois groupes durant cette période. Cependant, si on dépasse le seuil de 0,7, la courbe correspondant à l'enquête de 2019 se situe au-dessus des deux autres courbes. Ainsi le niveau de pauvreté pour cette année semble plus élevé que pour les deux enquêtes précédentes.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Conclusion

La présente étude a examiné l'évolution de la pauvreté en Guinée entre 2007 et 2019, en utilisant les données des enquêtes ELEP 2007, ELEP 2012 et EHCVM 2019. L'analyse des indices de pauvreté (P_0, P_1, P_2) et la comparaison des intervalles de confiance ont permis d'évaluer la significativité des changements observés. Les résultats indiquent une évolution contrastée de la pauvreté, avec des légères variations selon les périodes et les zones géographiques. Bien que des efforts aient été déployés par les gouvernements successifs, à travers la mise en œuvre des Stratégies de Réduction de la Pauvreté et des Plans Nationaux de Développement, l'impact de ces efforts sur la réduction de la pauvreté reste faible. Les conditions de vie de la population guinéenne restent précaires, en particulier en milieu rural.

L'analyse des inégalités de revenu révèle une inégalité globale modérée (l'indice de Gini varie entre 0,27 et 0,31). Les résultats des trois enquêtes montrent de façon constante que les inégalités internes aux milieux de résidence expliquent plus de 90% des disparités totales, tandis que les inégalités entre ces milieux restent marginales (environ 7 à 9%). Autrement dit, c'est davantage la distribution inégale des revenus au sein des zones que leur opposition qui structure les inégalités en Guinée. En outre, la répartition par quintiles de revenu met en évidence une forte concentration de la richesse au sommet de la distribution. Le 5e quintile détient systématiquement une part disproportionnée du revenu jusqu'à 5 fois supérieur à celui du 1er quintile. Près de 75% de l'inégalité totale provient des écarts entre les niveaux de richesse, ce qui souligne que la stratification économique reste le principal facteur d'inégalité.

Entre 2007 et 2019, la pauvreté absolue a augmenté mais l'indice de Gini a diminué, cela semble contradictoire car habituellement l'augmentation du taux de pauvreté est associée à une augmentation des inégalités. Il est possible qu'un grand nombre de personnes appartenant à la classe moyenne s'est retrouvé en situation de pauvreté, cela peut réduire les inégalités entre les plus riches et les plus pauvres, même si ces derniers sont encore dans des conditions de pauvreté. La forte croissance économique observée après 2015 et qui a été tirée principalement par l'extraction minière et l'augmentation de la production énergétique n'a pas été suffisamment inclusive pour profiter à toutes les couches sociales du pays. Le secteur tertiaire, notamment l'informel serait celui qui a le plus bénéficié de cette embellie économique.

Les résultats de cette étude suggèrent que pour réduire efficacement les inégalités, les politiques publiques devraient prioritairement s'attaquer aux disparités existant au sein même des groupes sociaux et économiques, plutôt que de se focaliser sur les écarts entre régions géographiques.

Cette étude complète et enrichit une étude précédente de l'Institut National de la Statistique (INS) faite en 2012 sur les tendances de la pauvreté

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

entre 1994 et 2012. Elle comble certaines insuffisances constatées dans les rapports de l'INS, telles que l'absence d'intervalles de confiance pour les principaux indicateurs permettant de bien apprécier l'étendue de la pauvreté en Guinée.

Conflit d'intérêts : L'auteur n'a fait état d'aucun conflit d'intérêts.

Disponibilité des données : Toutes les données sont incluses dans le contenu de l'article.

Déclaration de financement : L'auteur n'a obtenu aucun financement pour cette recherche.

References:

1. Backiny-Yetna, P. &. (2010). *Poverty in Guinea from 1994 to 2007: Trends, Perceptions, and Household Priorities.* Récupéré sur https://mpra.ub.uni-muenchen.de/34380/
2. Banque mondiale. (2014). *République du Niger : Mesure des tendances de la pauvreté - Questions méthodologiques et analytiques.* (B. mondiale, Éd.) Consulté le 2024, sur https://documents1.worldbank.org/curated/fr/813041468188352096/89838-FRENCH-WP-P146536-PUBLIC-Box393186B.docx
3. Banque mondiale. (2024). *GDP (current US$) - World Bank Data*. Récupéré sur https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=GN
4. Besançon, L. &. (2017). *La Différence Significative entre Valeurs p et Intervalles de Confiance ", 29ème conférence francophone sur l'Interaction Homme-Machine, AFIHM,.* Récupéré sur https://inria.hal.science/hal-01562281v2/document
5. Bonzik, B. &. (2004). *Dynamique de la pauvreté au Burkina Faso : Evolution du profil de pauvreté 1994-1998.* Récupéré sur https://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/files_events/3rd_dakar/Wetta.pdf
6. Christiaensen, B. K. (2019). *Accélerer la réduction de la pauvreté en Afrique.* Consulté le Novembre 2024, sur https://openknowledge.worldbank.org/entities/publication/f437cb8e-d90e-55e0-9759-f17cf4d61b1a/full
7. Coulibaly, S. (2008). *Note pour l'analyse de la pauvreté pour des perspectives de comparaison régionale : proposition méthodologique.* Récupéré sur Afristat.org: https://www.afristat.org/wp-

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

content/uploads/2022/04/DEX13_Note-analyse-regionale-pauvrete.pdf

8. Greenwell, K. F. (2014). *Tendances de la santé infantile en Guinée : Analyse approfondie des Enquêtes Démographiques et de Santé (EDS) de 2005 et 2012.* ICF International. Rockville, Maryland, USA: ICF. Consulté le 2024, sur https://www.dhsprogram.com/publications/publication-fa95-further-analysis.cfm?csSearch=1814518_1
9. Heikkuri, V.-M. a. (2024). *Subgroup Decomposition of the Gini Coefficient: A New Solution to an Old Problem. FIT Working Paper.* Récupéré sur https://verotutkimus.fi/verotutkimus/wp-content/uploads/2024/12/FIT-WP-30-Heikkuri-Schief-Gini-Decomposition-3.pdf.
10. INS & ICF. (2019). *Enquête Démographique et de Santé (EDS) 2018.* Rocqueville, Maryland, USA: Institut National de la Statistique et ICF. Consulté le Novembre 2024, sur https://dhsprogram.com/pubs/pdf/SR262/SR262.pdf
11. INS & PAM. (2018). *Analyse globale de la vulnérabilité, de la sécurité alimentaire et de la nutrition (AGVSAN).* Conakry, Guinée: Institut National de la Statistique. Consulté le 2024
12. INS. (2012). *Tendances de la pauvreté en Guinée 1994 à 2012.* Conakry, Guinée: Institut National de la Statistique. Consulté le Novembre 2024, sur www.stat-guinee.org: https://www.stat-guinee.org/images/Documents/Publications/INS/rapports_enquetes/Pauvrete_Inegalite_Guinee_fev_2012.pdf
13. INS. (2019). *Enquête harmonisée sur les conditions de vie des ménages.* Conakry, Guinée: Institut National de la Statistique. Consulté le 2022, sur https://www.stat-guinee.org/images/Documents/Publications/INS/rapports_enquetes/INS_Rapport_Final_EHCVM%20GUINEE_01_03_2021.pdf
14. INS. (2022). *Compte natioanaux définitifs 2020.* Conakry, Guinée: Institut National de la Statistique. Consulté le Decembre 2024, sur https://www.stat-guinee.org/images/Documents/Publications/INS/annuelles/CN/Comptes_nationaux_definitif_2020_Provisoire_2021_INS.pdf
15. Kabore, T. (2004, Decembre). *Dynamique de la pauvreté : Revue des approches de décomposition et application avec des données du Burkina Faso.* Récupéré sur https://www/pep-net.org/sites/pep-net/org/typo33doc/pdf
16. Keely, B. (2015). *Inégalités de revenu : l'écart entre les riches et les pauvres.* (P. 2. Editions OCDE, Éd.) Consulté le Decembre 2024, sur

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

https://www.oecd.org/content/dam/oecd/fr/publications/reports/2015/12/income-inequality_g1g5c8d6/9789264300408-fr.pdf

17. Lachaud, J.-P. (1999). *Les différences spatiales de pauvreté en Mauritanie : un test de dominance.* Consulté le Octobre 2024, sur https://core.ac.uk/download/pdf/7358998.pdf?form=MG0AV3
18. Lubrano, M. (2008). *Introduction à l'économétrie des mesures de pauvreté.* Consulté le 2024, sur https://shs.hal.science/halshs-00277281/document
19. MPDE. (2017). *Plan National de Développement Economique et Social (PNDES) 2016-2020.* Conakry, Guinée: Ministère du Plan et du Développement Economique. Consulté le 2024, sur http://mplan.gov.gn/wp-content/uploads/2019/10/PNDES-Projet-Guinee-fevrier-2017.pdf
20. Navarro, M. (2022). *Comment mesurer les inégalités économiques ?* Consulté le Decembre 2024, sur http://ses.ens-lyon.fr/articles/comment-mesurer-les-inegalites-economiques
21. ONU. (2020). *Ending poverty and ensuring dignity for all.* Consulté le Nvembre 2024, sur Nations Unies: https://www.un.org/fr/global-issues/ending-poverty.
22. Porte, J. (2021). *Rwanda : un modèle de développement efficace face au défi de sa soutenabilité. Agence Française de Développement.* Paris: Agence française de développement. Récupéré sur https://www.afd.fr/fr/ressources/rwanda-un-modele-de-developpement-efficace-face-au-defi-de-sa-soutenabilite

ESJ Social Sciences Peer-reviewed

Approche sociologique de l'économie Informelle dans la ville de Bouaké en Côte d'Ivoire

Dr. Adou Paul Venance
Dr. Fofana Valoua
Département d'Anthropologie et Sociologie,
Université Alassane Ouattara, Côte d'Ivoire

Doi:10.19044/esj.2025.v21n19p241

Submitted: 18 April 2025
Accepted: 27 June 2025
Published: 31 July 2025

Cite As:
Venance, P.A. & Fofana, V. (2025). *Approche sociologique de l'économie Informelle dans la ville de Bouaké en Côte d'Ivoire.* European Scientific Journal, ESJ, 21 (19), 241. https://doi.org/10.19044/esj.2025.v21n19p241

Résumé

Cette recherche porte sur l'économie de la précarité dans la ville de Bouaké, deuxième pôle urbain de la Côte d'Ivoire, caractérisé par une forte diversité ethnique, la prépondérance du secteur informel et l'impact de crises socio-politiques récentes. Son objectif principal est d'analyser les mécanismes sociologiques structurant cette économie en s'intéressant aux activités précaires (vente de vivriers, restauration, artisanat, commerce d'électronique de seconde main, travail du sexe), aux stratégies de survie des acteurs et à leur impact sur le développement urbain. Adoptant une démarche qualitative et s'appuyant sur la théorie de la structuration sociale sociaux structuration sociale, l'étude mobilise l'observation directe et des entretiens semi-directifs. Notre démarche porte sur le rôle des dynamiques sociales et des réseaux communautaires dans la structuration et la reproduction de l'économie informelle. En ce sens, les résultats montrent que l'économie précaire s'organise autour de réseaux sociaux et ethniques, avec une hiérarchisation fondée sur la rentabilité et une adaptation continue aux contraintes urbaines. Les stratégies économiques incluent la diversification des activités, le recours à des systèmes de crédit informel et la création de solidarités professionnelles. Bien que cette économie renforce les liens communautaires et stabilise le tissu social en créant des emplois informels, elle reste marquée par des défis tels que la précarité des conditions de travail, l'absence de protection sociale et la vulnérabilité aux chocs économiques.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Mots clés : Approche sociologique, économie informelle, ville de Bouaké, tissu sociale, stratégies économiques, liens communautaires

Sociological Approach to the Informal Economy in the City of Bouaké, Côte d'Ivoire

Dr. Adou Paul Venance
Dr. Fofana Valoua
Université Alassane Ouattara, Côte d'Ivoire

Abstract

This research focuses on the economy of precarity in the city of Bouaké, Côte d'Ivoire's second-largest urban hub, characterized by significant ethnic diversity, a predominant informal sector, and the lasting effects of recent socio-political crises. The main objective is to analyze the sociological mechanisms underpinning this economy, examining precarious activities (selling foodstuffs, street food, artisanal work, second-hand electronics trade, and sex work), survival strategies, and their impact on urban development. Using a qualitative approach grounded in the theory of social structuration, the study employs direct observation and semi-structured interviews. Our research focuses on the role of social dynamics and community networks in the structuring and reproduction of the informal economy. In this regard, findings reveal that the precarious economy is structured around social and ethnic networks, with activities ranked by profitability and continuous adaptation to urban constraints. Economic strategies include activity diversification, reliance on informal credit systems, and the establishment of professional solidarities. While this economy strengthens community bonds and provides informal employment, it faces persistent challenges, such as precarious working conditions, lack of social protection, and vulnerability to economic shocks.

Keywords: Sociological approach, Informal Economy, City of Bouaké, Social fabric, Economic strategies, Community ties

Introduction

La littérature en sciences sociales aborde la question des revenus informels dans les communautés des villes africaines en se focalisant sur l'analyse des dynamiques sociales et économiques qui façonnent les interactions interpersonnelles et intergroupes. Dans ce contexte, nous recensons, d'une part, des écrits relevant du champ des études sur la

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

formalisation de l'économie informelle. Parmi eux, figurent notamment les travaux des auteurs suivants : De Soto Hernando (2000) ; Portes Alejandro (1987) ; Tokman Víctor (1992) ; Lafortune Jacques (2001) ; OIT (2007)[1]. D'autre part, nous recensons les travaux portant sur l'économie informelle dans son imbrication socio-communautaire. Nous citons dans ce sillage les écrits des auteurs tels que Saskia Sassen (1991) ; Deirdre McCloskey (2006) ; Robert Putnam (2000) ; Gayatri Chakravorty (1988) ; Amartya Sen (1999). Brièvement, dans l'ensemble des études, l'économie de la précarité émerge comme un objet d'étude central pour comprendre les mécanismes de survie déployés par les populations vulnérables dans des contextes marqués par l'instabilité économique et sociale. La ville de Bouaké, deuxième pôle urbain de la Côte d'Ivoire, constitue un laboratoire idéal pour explorer ces dynamiques, en raison de sa position géographique stratégique, de sa diversité ethnique (Baoulé, allochtones, allogènes) et de son histoire récente marquée par des crises socio-politiques. Dans le cadre de cette recherche, le concept d'économie de la précarité désigne l'ensemble des activités économiques informelles qui, bien qu'en marge des structures formelles, sont essentielles à la survie quotidienne des populations urbaines défavorisées. Ces activités, allant de la vente de vivriers à la restauration de rue, en passant par l'artisanat ou encore le commerce d'électronique neuf ou de seconde main, reflètent à la fois une capacité d'adaptation des acteurs économiques et les contraintes structurelles d'un système marqué par des inégalités profondes. Dans la ville de Bouaké les activités liées à l'entrepreneuriat réglementé et informel se déploient depuis les habitats[2] et s'étendent jusqu'au centres[3] commerciaux. L'économie informelle est fort dynamique en ce sens qu'il voit émerger une classe sociale capable de pourvoir aux besoins de subsistance, d'investir dans l'immobilier. Ici, notre démarche, répond à la préoccupation suivante : Comment les dynamiques sociales et les réseaux communautaires contribuent-ils à structurer et à faire perdurer l'économie informelle de la ville, dans un contexte de diversité ethnique et de contraintes sociales. Ainsi, cette recherche

[1] L'Organisation Internationale du Travail (OIT) est citée ici dans le contexte de ses rapports réguliers sur l'économie informelle, notamment dans le cadre de ses activités de l'année 2017.
[2]Dans le contexte des activités informelles, la ville de Bouaké présente une architecture organisationnelle atypique, caractéristique des centres urbains des villes africaines. Celle-ci se manifeste par l'installation d'étalages dédiés au commerce de produits et de denrées alimentaires, de quincailleries, de produits pharmaceutiques prohibés, ainsi que par la prolifération de salons de coiffure, de petits magasins de friperies, de restaurants et de maquis-bars au sein des habitats et à leurs proximités.
[3] Les centres commerciaux représentent des espaces aménagés par les municipalités. Jusqu'en 2020, Bouaké comptait deux centres commerciaux situés au « Commerce », dans le quartier de Nimbo, et au « Grand Marché », dans le quartier Dar-es-Salam. Désormais, ce nombre a évolué et la ville dispose de deux nouveaux centres, situés dans les quartiers Ahouanssou et Air-France.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

vise non seulement à identifier les formes et stratégies des acteurs[4] engagés dans cette économie, mais aussi à comprendre comment ces dynamiques participent au développement urbain tout en posant des défis majeurs en termes de protection sociale et de durabilité. Notre ambition de cerner les variabilités liées de l'économie informelle à Bouaké répond à l'objectif suivant : cerner les logiques sociocommunautaire et économiques liées au secteur informel à Bouaké.

Méthodologie

Dans le cadre de cette recherche sociologique sur l'économie de la précarité à Bouaké, nous avons adopté une démarche méthodologique qualitative afin de mieux comprendre les mécanismes, les dynamiques sociales, et les stratégies de survie des acteurs évoluant dans ce secteur. Nous avons eu recours à un échantillonnage opportuniste et raisonné, ciblant des acteurs représentatifs des principales catégories socioprofessionnelles impliquées dans l'économie précaire de Bouaké. Ce choix s'est fondé sur la diversité des activités observées, afin d'obtenir un éventail varié d'expériences et de pratiques. Nous avons eu recours à deux techniques d'échantillonnage dans cette étude. D'abord, l'échantillonnage raisonné, fondé sur des critères de sélection liés aux catégories socioprofessionnelles de l'économie informelle. Ensuite, l'échantillonnage opportuniste, les personnes interrogées[5] ayant été choisies en fonction de leur accessibilité et de leur disponibilité. Ainsi, notre échantillon comprenait : Commerçants de produits et denrées alimentaires (12 enquêtés), Commerçants de quincailleries (8 enquêtés), Vendeurs de produits pharmaceutiques prohibés (8 enquêtés), Gérants de salons de coiffure (6 enquêtés), Propriétaires de petits magasins de friperies (4 enquêtés), Responsables de restaurants ou maquis (8 enquêtés). Au total, 46 enquêtés issus de ces catégories ont participé à des entretiens approfondis, complétés par des observations de terrain. Pour la collecte des données, nous avons utilisé plusieurs techniques de collecte de données : Les entretiens semi-directifs : Ces entretiens, réalisés auprès des enquêtés, visaient à explorer les motivations, les stratégies économiques et les perceptions des acteurs quant à leurs conditions de travail et à leurs perspectives d'avenir. Les entretiens avec

[4] Mention éthique de l'étude : les personnes impliquées dans cette étude ont volontairement consenti à la confidentialité de leur identité civile. Elles ont accepté que toute référence à leur personne soit remplacée par des sobriquets ou des initiales, de manière à empêcher tout lien identifiable avec leur identité réelle. Cette démarche vise à garantir la liberté d'expression des enquêtés, afin qu'ils puissent s'exprimer sans contrainte dans l'intérêt de la recherche.

[5] Les personnes interrogées sont identifiées dans les résultats de cette recherche à l'aide de pseudonymes à connotation culturelle, de manière à refléter leur ancrage socioculturel. Précisons qu'en tant que sobriquets, ces pseudonymes n'ont aucun lien avec leur identité civile et ne permettent pas de les identifier nominativement, conformément aux exigences de confidentialité.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

des informateurs clés : Nous avons également échangé avec 10 représentants municipaux et communautaires pour recueillir des perspectives plus globales sur l'impact de l'économie informelle dans le développement social et économique de Bouaké. Les Observations directes : Ces observations, effectuées dans les lieux d'activité (marchés, salons de coiffure, petits commerces, restaurants), ont permis de mieux appréhender les pratiques économiques, les interactions sociales, et les conditions de travail des acteurs. L'analyse des données s'appuie sur la théorie de la structuration d'Anthony Giddens, formulée dans son ouvrage *The Constitution of Society* (1984), la théorie de la structuration propose une analyse de l'interaction dialectique entre les structures sociales et les pratiques des individus. Elle met en lumière la dualité entre les contraintes structurelles et la capacité d'action des acteurs.

Résultats

Structure de l'économie précaire à Bouaké

Cette recherche portant sur l'économie informelle à Bouaké met en évidence une organisation complexe, à la fois diversifiée dans ses activités et fortement structurée par des dynamiques sociales spécifiques. Cette section explore la cartographie des activités économiques, ainsi que l'organisation sociale qui en constitue le fondement.

Cartographie des activités économiques de la ville

Dans cette recherche, les activités classées sur le registre de l'économie de précarité à Bouaké couvrent un large éventail de secteurs, répondant aux besoins essentiels des populations urbaines tout en s'adaptant aux contraintes du marché informel. Nous recensons en général cinq catégories d'activités correspondant aux indications de cet article. Il s'agit du commerce des viviers, de la restauration de rue, des services artisanaux, du commerce électronique et des activités marginales telles que la vente ambulante d'articles et le travail du sexe. Selon Monsieur AKA, un responsable municipal : « *les activités informelles dans notre commune sont d'abord liées aux manœuvres des populations sans emploi formel pour assurer leur subsistance. Ensuite, elles concernent l'initiative des plus jeunes à réussir dans l'entrepreneuriat* ». (Aka, 20/03/2025, 09 heures du matin, entretien semi-structuré, avis sur les catégories des acteurs du secteur informel de Bouaké). S'agissant du commerce de vivriers, nous indiquons que ce secteur constitue le cœur de l'économie précaire, avec une forte présence féminine. Il inclut la vente de produits agricoles (ignames, manioc, légumes) sur les marchés ou dans des étals de fortune. Ces activités assurent l'approvisionnement alimentaire des quartiers populaires. L'avis de madame KOUAME nous situe sur l'utilité de cette activité au plan socioéconomique : « *La vente des denrées alimentaires à Bouaké permet à plusieurs familles*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

d'assurer l'alimentation, la scolarité, les soins et les factures. Moi-même étant commerçante du vivrier, j'arrive à subvenir aux besoins de ma famille surtout, depuis que mon mari a perdu son emploi ». (Kouamé 1, 27/02/2025, 12 heures du matin, entretien semi-structuré relatifs à l'importance du commerce du vivrier dans les familles en crise d'emploi). L'activité de restauration de rue regroupe des restaurateurs et des vendeurs ambulants. Cette activité répond à une demande croissante de repas accessibles et prêts à être consommés. Les petites gargotes et les stands mobiles jouent un rôle clé dans la subsistance des travailleurs urbains. Monsieur COULIBALY, un fonctionnaire souligne la nécessité de la restauration de proximité dans l'alimentation du travailleur en ces termes : *« Ma pause déjeuner est seulement d'une heure pendant le service. Dans ce cas, je ne trouve pas utile de perdre le temps et assez d'argents pour me faire un repas à la maison. La nourriture proposée par les restaurants sont convenables et accessibles pour toutes les bourses* ». (Coulibaly 1, 07/03/2025, 11 heures du matin, entretien semi-structuré sur la restauration accessible, une alternative à la ponctualité au service). Les services artisanaux incluent des activités comme la couture, la coiffure et la réparation d'équipements. Ces services, souvent organisés de manière individuelle ou familiale, sont essentiels à la vie quotidienne des habitants de Bouaké. Madame DJENEBA, une représentante de l'association des artisans de la ville évoque la diversité du secteur artisanale en ces termes : « *À Bouaké, nous disposons des services essentiels liés à la beauté, au soin corporel, à la mode vestimentaire, à l'assistance technique. Bref, quels que soient les goûts et les tendances des populations* » (Djeneba, 13/02/2015, 14 heures du soir, entretien semi-directif sur Bouaké est une ville à la mode). Le commerce de matériels électroniques est en plein essor à Bouaké. Ce secteur d'activité est constitué des vendeurs de matériels électroniques neufs et ceux de seconde main appelés couramment les « France aurevoir ». Les appareils vendus sont des électroménagers et des téléphones portables. L'activité électronique est marquée par les tendances du moment et reflète une adaptation au numérique. Ce secteur attire principalement les jeunes, qui y voient une opportunité d'auto-emploi. Monsieur SEYDOU, nous présente l'un des motifs des jeunes de sa génération à œuvrer dans ce secteur à travers cette assertion : « *L'échec scolaire a conduit mes compagnons d'enfance et moi à constituer un capital de démarrage de notre business de vente d'électroniques. Aujourd'hui grâce à cette initiative, nous nous prenons en charge dans tous les domaines de la vie* ». (Seydou, 21/03/2025, 15 heures du soir, entretien semi-directif sur les motivations de l'entrepreneuriat). Les activités marginales incluent pour bonne part à Bouaké, des occupations comme le travail du sexe, ces activités, bien que souvent stigmatisées, constituent une source de revenus essentielle pour les populations les plus vulnérables. Bien qu'apparemment stéréotypée le travail du sexe regroupe majoritairement différentes catégories sociales de

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

jeunes. Ainsi, les acteurs de ce secteur sont des étudiantes, des élèves, des déscolarisées et les professionnelles du sexe. Madame NABINTOU, une professionnelle du sexe, nous partage cette confidence au sujet de l'organisation du secteur en ces mots : « *Notre milieu d'activité est constitué des professionnelles et des travailleuses occasionnelles. Quelle que soit la catégorie concernée, les enjeux sont économiques bien que les actrices soient différentes* ». (Nabintou, 21/03/2025, 18 heures du soir, entretien semi-directif sur les diversités des acteurs en lien avec la profession su sexe).

Organisation sociale de l'économie de précarité

L'économie informelle de Bouaké repose sur une organisation sociale extra-institutionnelle mais hautement structurée, façonnée par des relations interpersonnelles, des solidarités communautaires et des hiérarchies internes. Nous abordons dans ce champ des dynamiques sociales d'abord, les réseaux ethniques ensuite. Les activités économiques s'organisent souvent autour du lien communautaire des entrepreneurs. Bouaké est une ville cosmopolite constituée en majorité des autochtones Baoulé, des allogènes et allochtones malinké. Monsieur TUO du service recouvrement des taxes de la municipalité, nous éclaire davantage en ces termes : « *Dans cette ville, les activités commerciales impliquent les différents intérêts des groupes communautaires en présence* ». (Tuo, 04/04/2025, 10 heures du matin, entretien semi-directif sur la diversité des groupes d'intérêt dans le secteur informel à Bouaké). Ainsi, les arrangements économiques impliquant les liens ethniques sont prônés au premier plan par les allochtones malinké[6] et les allogènes mandingue[7]. Au second plan, nous recensons la communauté Baoulé impliquée dans le brassage ethnique local. D'une part, la scène des activités commerciales est partagée au premier plan entre les allochtones et les allogènes. D'autre part, entre autochtones Baoulé et les autres groupes ethniques. En ce sens, le commerce de l'électronique et du vivrier est détenu de manière prépondérante par les malinkés et les mandingues. Tandis que, le commerce du vivrier, la restauration et les ventes à l'étalage est assuré par les autochtones, les allochtones et les expatriés. La communauté Baoulé de Bouaké et des localités voisines assure l'approvisionnement en vivres des différents marchés hebdomadaires dans la ville. Par conséquent, madame KANGOUTÉ, du même service de la municipalité estime une classification des groupes d'intérêts impliqués dans le registre de ces activités à travers cette assertion :

[6] Les Malinkés présents à Bouaké sont principalement originaires du nord de la Côte d'Ivoire, plus précisément des régions telles que Katiola, Korhogo, Ferkessédougou et Odienné. Parmi eux, on retrouve majoritairement des groupes ethniques tels que les Sénoufos, les Dioulas et les Koyakas.

[7] Les allogènes mandingues à Bouaké proviennent principalement du Mali et du Burkina Faso. La ville de Bouaké abrite d'ailleurs la plus grande communauté malienne de Côte d'Ivoire.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

« *Selon nos données, la première place des activités commerciale est détenue par les Dioulas, ensuite, les Baoulés et enfin par les autres groupes communautaires* ». (Kangouté, 08/02/2025, 10 heures du matin, entretien semi-directif sur la cartographie sociale des communautés prédominantes du secteur informel). À présent, nous explorons les hiérarchies internes. En effet, les activités que nous avons répertoriées dans cette recherche, appartenant au champ de l'économie de la précarité, présentent des niveaux variés de rentabilité et de reconnaissance sociale. Il ressort de nos enquêtes que le champ de l'entrepreneuriat est d'abord le lieu de la reproduction des valeurs socioculturelles. Ceci se traduit dans l'imagerie collective par la reconnaissance des « activités légitimes » acceptées par la communauté et des activités illégitimes, contraires aux valeurs communautaires. En ce sens, les vendeurs de matériels électroniques, les commerçantes de vivriers, les restaurateurs de rue et les artisans jouissent d'un statut plus valorisé que les travailleurs du sexe et les vendeurs ambulants, révélant ainsi une hiérarchisation implicite au sein de l'économie informelle. Monsieur TRAORÉ, un responsable de la filière commerce relate cette catégorisation sociale des « petits métiers » par cette allégation : « *Les commerçants d'appareils, de vêtements, de produits agricoles, les restaurateurs bénéficient d'une plus grande considération que ceux qui se baladent pour vendre et les prostitués. Conformément à nos croyances et valeurs les métiers ne se valent pas* ». Aussi, est-il indéniable d'évoquer ici divers ordres de relations entre les groupes d'acteurs comme facteur de réussite ou de succès chez les acteurs de l'économie informelle. De ce fait, les interactions entre différents groupes économiques reposent sur des relations de confiance, d'échange et parfois de dépendance. Le facteur « confiance » est fortement lié à l'appartenance culturelle. Dans ce sens, il ressort de nos entretiens et observations que les regroupements d'intérêts sont souvent confinés au sein des ressortissants du même groupe ethnique. C'est bien ce que laisse entrevoir l'assertion de Monsieur SANOGO, un commerçant Malinké : « *Il existe l'association d'aide des dioulas nationaux ou étrangers mais, aussi des nigérians dans ce centre commercial. L'entraide entre ces communautés fonctionne, c'est pourquoi, ce sont eux qui détiennent la majorité des activités ici* ». (Sanogo, 13/04/2025, 11 heures du matin, entretien semi-structuré sur les modes communautaires de gestion de solidarité). En outre, il existe une collaboration technique entre les acteurs exerçant dans des activités complémentaires. C'est le cas des commerçants de vivriers qui collaborent avec des transporteurs informels pour acheminer leurs marchandises, tandis que les artisans s'appuient sur des fournisseurs locaux, des localités voisines et d'Abidjan. Monsieur DAO, un vendeur de pièces détachés d'automobiles, nous expose ce type partenariat à travers cette affirmation : « *Pour le transport de mes pièces en provenance du port d'Abidjan, je sollicite le camion d'un frère de la communauté qui exerce*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

dans le transport de vivriers Abidjan-Bouaké ». (Dao, 13/02/ 2025, 15 heures du soir, entretien semi-structuré sur le lien de filiation, une solution de contournement des blocages).

Contextes socioéconomiques et urbaines

La structure de l'économie précaire à Bouaké reflète une adaptation dynamique aux réalités socio-économiques et urbaines de la ville. Les besoins primordiaux de consommation de la population sont contenus dans l'alimentation, l'habillement, l'équipement et la festivité. Ces activités sont diversifiées et interconnectées, tandis que l'organisation sociale repose sur des réseaux de solidarité et des mécanismes hiérarchiques qui permettent à cette économie de perdurer malgré son caractère informel et vulnérable. Nous examinons les formes organisationnelles des structures étudiées. D'abord, l'alimentation en termes d'offre correspond essentiellement à la vente de nourriture. Cette activité est structurée en deux sous sections à savoir les restaurants fixes et les restaurants ambulants. L'estime sociale liée à la demande est premièrement portée sur les services de restauration dans les habitats et ceux des officines en plein air. Monsieur KOUASSI, un client de restaurant fixe, évoque le motif pour ce type d'alimentation en ces mots : « *En dépit d'une cuisine de qualité à des tarifs abordables, c'est la discrétion et le cadre convivial qui est captivant dans les restaurants de maison et de plein-air* ». Par ailleurs, la restauration ambulante, en plus de s'adresser à tous types de clients, est surtout destinée à ceux de second plan et aux plus pressés. En dehors de l'aspect marginal de cette offre alimentaire, nous observons également sa convenance pour les commerçants installés dans les centres commerciaux. Monsieur ADAMA, un commerçant du centre commercial du centre-ville, expose les logiques du choix de la restauration mobile à travers cette assertion : « *Le temps est un luxe que je ne peux me permettre dans mon activité, c'est pourquoi je choisis la restauration ambulante. De plus, elle est moins chère que les restaurants conventionnels et me permettent pas de réaliser des économies* ». (Adama,15/03/2015, 10 heures du matin, entretien semi-directif sur l'optimisation de la tâche avec la restauration ambulante). Le secteur de l'habillement est composé également de deux sous-structures. La première sous-structure est la vente de vêtements sur mesure et des vêtements importés « prêt-à-porter » de premier choix, produits soit par les couturiers locaux, soit par l'industrie vestimentaire « made in China ». La seconde sous-section est entièrement représentée par la vente de friperie. Il n'existe pas, à ce niveau, une clientèle distinguée pour les deux modes vestimentaires en vogue dans cette ville. Ainsi, depuis les fonctionnaires jusqu'aux artisans de petits métiers, le choix vestimentaire alterne entre l'achat d'habits neufs et de friperies, car chacun en dispose selon ses revenus. Monsieur KASSI, un fonctionnaire, explique la raison d'opter pour cette alternance vestimentaire

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

en ces termes : « *Je dispose, pour le service et les cérémonies, de vêtements sur mesure ou prêts-à-porter, tandis que les friperies me servent pour les balades, les voyages et souvent pour les cérémonies* ». (Kassi, 19/04/2025, 09 heures du matin, entretien semi-directif sur les choix vestimentaires). Le secteur de l'équipement est scindé en deux. Il s'agit de la vente d'articles neufs ou d'occasion que l'on retrouve dans les magasins et les supermarchés. Selon les indications que nous avons pu observer sur des articles, la plupart de ces produits proviennent de la Chine ou de la France, ainsi que des artisans locaux. Aussi faut-il noter le caractère varié des équipements de ce type. Mais, en dépit de cette diversité, ce sont les produits électroniques qui sont les plus vendus. Ce sont les différentes couches sociales qui constituent le registre des clients de divers articles, avec une préférence pour les produits électroniques et les meubles. Monsieur DIABATE, un vendeur de meubles et de matériels électroniques, nous fait la confidence suivante : « *Mes clients sont des commerçants, des fonctionnaires, des paysans et des démarcheurs qui achètent souvent des téléphones portables, appareils et accessoires, mais occasionnellement des meubles* ». (Diabaté, 23/04/2025, 10 heures du matin, entretien semi-directif sur la pluralité des clients pour une diversité de produits commerciaux). Enfin, le secteur de la festivité est subdivisé en trois catégories. D'abord, il y a les bistrots, « les maquis », situés dans les habitats et dans les aires dédiées. Ensuite, il y a des espaces de réception « maquis-restaurant » et événementiels. Les clients de ces espaces festifs sont de deux ordres. La première catégorie est assidue dans les bistrots, et la seconde catégorie loue ou occupe des maquis et des espaces événementiels pour des occasions de réjouissance. Madame COULIBALY, une représentante de la municipalité, renchérit sur la configuration des structures locales par cette assertion : « *Notre ville est animée par des espaces prestigieux et usuels pour des cérémonies et des rencontres de tous types* ». (Coulibaly 2, 02/05/2025, 10 heures, entretien semi-directif sur la prestation de services variés à Bouaké). Cette structuration souligne également le rôle central des relations sociales dans la résilience des populations face aux défis urbains.

Stratégies économiques et sociales

Les acteurs de l'économie précaire à Bouaké développent des stratégies économiques et sociales variées pour répondre aux défis imposés par leur contexte de précarité. Ces mécanismes témoignent d'une capacité remarquable à s'adapter aux contraintes et à innover pour assurer leur subsistance et leur intégration sociale.

Mécanismes de survie

Les stratégies mises en œuvre par les acteurs de l'économie précaire reposent sur une combinaison de pratiques économiques et de solidarités

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

sociales, qui visent à maximiser leurs opportunités tout en minimisant les risques. Ces manœuvres de survie se traduisent par la diversification des activités, les systèmes de crédit informel et la solidarité professionnelle. En premier lieu, la diversification des activités est liée à l'instabilité des revenus des acteurs. En effet, les commerçants et artisans œuvrant dans les activités informelles sont généralement confrontés à des problèmes de régularité des revenus. Alors, pour maintenir un niveau de vie économique dynamique, ceux-ci sont obligés de s'adonner le plus souvent à plusieurs activités. Ainsi, dans un même magasin, des articles électroniques, cosmétiques et vestimentaires peuvent être vendus. Monsieur BAMBA évoque la raison de cette mixité commerciale en ces termes : « *Au départ, mon magasin était basé sur la vente de produits cosmétiques, mais j'avais souvent des soucis d'argent. Alors, m'inspirant de la demande d'une frange de ma clientèle, j'ai associé à mes articles des téléphones portables* » (Bamba, 04/02/2025, 11 heures, entretien semi-directif sur la réorganisation de l'offre, une solution pour la mévente). Cette diversification réduit leur dépendance à une seule source de revenus et constitue une stratégie de résilience face aux fluctuations du marché. En deuxième lieu, concernant les systèmes de crédit informel, les acteurs de l'économie précaire s'appuient souvent sur des mécanismes de crédit informel tels que les tontines[8] ou des prêts entre membres d'un même réseau. Que ce soit dans les tontines ou dans les prêts communautaires, l'objectif est la solidarité professionnelle et l'assistance sociale. Rappelons que le réseau d'entraide entre les membres d'une même communauté ethnique et religieuse est le plus actif, dans le but de permettre la mise en place d'une activité, de combler les déficits économiques et de soutenir les acteurs en crise. Toutefois, il arrive que ces fonds de solidarité communautaire prennent aussi en compte le financement des événements communautaires et des actions privées. Monsieur COULIBALY relate la configuration du système économique communautaire auquel il appartient en ces termes : « *Dans notre tontine, nous sommes tous de la même communauté et de la même religion. Loin de faire dans l'exclusion, nous recherchons la sécurité financière et l'épanouissement de nos membres* ». (Coulibaly 3, 12/05/2025, 11 heures du matin, entretien semi-directif sur les fonds communautaires basés sur les liens sociaux). Ces pratiques pallient le manque d'accès aux institutions financières formelles et favorisent la circulation des ressources au sein des communautés. En dernier lieu, s'agissant de la solidarité professionnelle, il faut souligner qu'elle est à l'image du système de crédit communautaire. Sauf qu'elle est basée sur l'assistance technique et matérielle, cette fois-ci, de l'ensemble des acteurs qui occupent un espace d'activité donné. En ce sens, nous explorons

[8] Un système informel d'épargne communautaire dans lequel chaque souscrivant remet une somme forfaitaire pour constituer le capital de rétribution. Les souscrivant sont appelles à bénéficier à tour de rôle le capital communautaire constitué.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

des dynamiques d'entraide technique dans lesquelles les compétences des acteurs sont mutuellement mises à profit pour résoudre une quelconque difficulté. Monsieur KARIM, un vendeur d'équipements informatiques, décrit ces pratiques par cette assertion : « *Je mets à disposition ma connaissance informatique pour dépanner mes collègues, afin de permettre à ces derniers de faire des économies. À mon tour également, les collègues, en fonction de leurs compétences, m'assistent* ». (Karim, 17/04/2025, 09 heures du matin, entretien semi-directif relatif aux confidences sur l'aide communautaire).

Adaptations aux contraintes

Les contraintes socio-économiques, telles que l'instabilité des marchés, les faibles revenus et l'absence de protection sociale, obligent les acteurs de l'économie précaire à développer des approches innovantes et flexibles pour gérer les risques et mobiliser leurs ressources. Ainsi, nous regroupons les différentes approches de l'adaptabilité des acteurs à la variabilité de l'environnement des affaires à travers la gestion des risques, la mobilisation des ressources et l'innovation sociale. Concernant la rubrique relative à la gestion des risques, il ressort de nos enquêtes que les acteurs adoptent des pratiques prudentes, comme l'investissement progressif dans leurs activités, afin de limiter les pertes en cas de crise économique. En ce sens, un vendeur de matériels électroniques peut commencer par un stock limité avant d'élargir son offre en fonction de la demande. Monsieur MAMADOU, un propriétaire de magasin de vente de téléphones portables explique sa méthode de sécurisation de son investissement par cette affirmation : « *Les perturbations liées aux contestations militaires dans la ville m'ont amené à ne vendre que les articles les plus demandés par mes clients. Ainsi, le cycle de mes stocks est limité à une courte période* ». » (Mamadou, 14/05/2025, 15 heures du soir, entretien semi-directif sur la réorganisation des articles de vente en périodes de crise militaire). Cette mobilisation est souvent facilitée par les relations ethniques ou communautaires. Dans l'ordre des réseaux sociaux exploités par les acteurs de l'économie de la précarité à Bouaké, la vie associative communautaire demeure la plus profitable. C'est surtout ce que nous explique Monsieur MOUSSA en ces termes : « *L'association des commerçants malinké à laquelle j'appartiens m'a octroyé de l'argent pour redémarrer mon commerce après le cambriolage de mon magasin. La fiabilité de l'aide associative communautaire me motive à toujours verser ma contribution* ». (Moussa, 21/05/2025, 10 heures du matin, entretien semi-directif relatif à l'aide communautaire, une assurance contre la faillite économique). Concernant le volet lié à l'innovation, nous retenons que les commerçants souscrivent de plus en plus à la virtualisation de l'offre commercial par la création et l'alimentation des plateformes de « e-commerce ». Ainsi, les offres électroniques, vestimentaires, cosmétiques,

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

gastronomiques et alimentaires se retrouvent de plus en plus sur les plateformes de commerce en ligne telles que « *Djassa Bouaké* », « *Marketplace* » et « Jumia deals ». Par le biais de l'offre dématérialisée du commerce via le réseau internet, les commerçants de Bouaké qui utilisent ce moyen de vente disposent d'une clientèle issue des autres villes du pays. Monsieur KARIM, un vendeur de téléphones portables de marque d'occasion, nous explique comment il a pu diversifier sa clientèle à travers le commerce en ligne par cette affirmation : « *Je prends en photo les téléphones de seconde main à ma disposition. Ensuite, je les propose en ligne sur Djassa Bouaké. Les clients de Yamoussoukro, Daloa, Korhogo et bien d'autres villes en font la commande* ». Karim, 21/05/2025, 11 heures du matin, La vente en ligne, entretien semi-directif relatif aux moyens de diversification commerciale).

Stratégies économiques et sociales autour du « don » et du « contre-don »

Les stratégies développées par les acteurs de l'économie précaire de Bouaké illustrent leur capacité à naviguer dans un contexte d'incertitudes économiques et sociales. En diversifiant leurs activités, en mobilisant des réseaux de solidarité et en innovant face aux contraintes, ils réussissent non seulement à survivre mais également à participer activement à la dynamique urbaine du contre-don, de même que dans la perspective de Marcel Mauss (2021 : 288)[9] Ces mécanismes révèlent une résilience collective qui transcende les limites de l'économie classique. Il y a deux valeurs de souche qui soutiennent ces formes élémentaires d'économie que nous avons pu induire chez les acteurs de « l'économie informelle ». D'abord, cette économie est basée sur le lien culturel. C'est à l'intérieur d'un groupe culturel singulier que le don et le contre-don prennent leur sens. Ensuite, cette forme primaire d'échange est basée sur la croyance en une valeur supérieure aux individus. Il s'agit ici de la croyance religieuse et symbolique. Ainsi, nous avons répertorié une forme d'échange propre à chaque groupe dominant : il s'agit du « *Gouassou* » Baoulé et du « *Soutra* » Malinké. Madame AKISSI, membre de la communauté Baoulé, décrit en quoi consiste cette forme d'échange communautaire dans ses activités commerciales par cette assertion : « *Le gouassou me permet de bénéficier de la qualité et de la quantité des marchandises lors d'un achat chez un membre communautaire. Le « Gouassou » est rétroactif alors, quand il s'agit de moi, c'est un investissement rentable* ». (Akissi, 15/03/2025, 09 heures du matin, entretien semi-dircetif relatif au don et contredon communautaire). Aussi, Monsieur KAMAGATE, membre de la communauté malinké, explique en quoi consiste le « soutra » dans son activité en ces termes : « *Le soutra me permet de bénéficier dans mon activité des articles et des services sans un sou. Le devoir*

[9] Collection petite bibliothèque Payot, Économie / Sociologie, Janvier 2021.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

communautaire m'oblige à en faire de même ». » (Kamagaté, 24/05/2025, 10 heures du matin, entretien semi-directif sur les formes d'entraides communautaires). Ici, la dynamique relationnelle et transactionnelle transcende « la monnaie » et repose sur la valeur immuable du lien culturel. Ensuite, rappelons que l'économie du don et du contre-don repose sur la symbolique du lien d'unité. En ce sens, il existe au plan national un vocable consacré aux alliances interethniques : « *Toupkê* ». Bien plus qu'une simple imagerie collective, « *Toupkê* » traduit ici l'humanité et l'altérité sans réserve entre alliés. Dans cet ordre, la symbolique de l'alliance interethnique permet aux acteurs, notamment ceux des groupes ethniques des autochtones Baoulé et des allochtones Malinké, la promotion endogène des actions d'assistance et de protection. Madame KOUAME, une couturière Baoulé relate la dynamique du « *Toupkê* » qui lui a permis d'échapper en période de crise à la sanction pénale : « *J'ai reçu une plainte au commissariat de la part d'un client mécontent pour escroquerie. Mais le commissaire a bien voulu régler le différend à l'amiable parce qu'il était un allié Agni et la plaignante était Andoh* ». (Kouamé 2, 26/02/2025, 11 heures du matin, l'alliance interethnique, entretien semi-directif relatif aux gages communautaires de résolution des conflits). Dans cette même logique, Monsieur VAMOUSSA, un mécanicien ressortissant malinké « *Koyaka* », échappe grâce au « *Toupkê* » à une plainte pénale pour vol de biens de la part d'un client. Il partage le récit suivant :

> « *J'ai reçu une délégation des dignitaires Yacouba qui m'ont notifié la réclamation d'un poulet blanc à l'effet d'abandon de plainte pour vol de cent mille francs. Le plaignant, Monsieur DOUGON, un client et allié Yacouba a constaté la perte de son argent depuis le coffre à gang de sa voiture qui se trouvait dans mon garage pour réparation au moment de l'infraction* ». (Vamoussa, 28/02/2025, 09 heures du matin, entretien semi-diectif relatif à l'alliance interethnique, un rempart contre inculpation pénale).

Discussion

Des structures économiques et logiques d'acteurs

Anthony Giddens insiste sur le fait que les structures sociales ne sont pas simplement des contraintes externes, mais qu'elles sont constamment reproduites et transformées par les actions des individus. À Bouaké, l'économie précaire est structurée par des dynamiques sociales informelles (comme les réseaux ethniques et les hiérarchies internes), mais elle est également façonnée par les initiatives individuelles et collectives des acteurs. À titre illustratif, les commerçantes de vivriers ou les jeunes entrepreneurs dans le secteur électronique ne se contentent pas de subir les contraintes

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

économiques ; ils agissent pour créer des opportunités et s'adapter aux réalités du marché informel. Cette dualité entre structure et logiques d'acteurs est particulièrement visible dans les témoignages des acteurs, comme celui de Madame KOUAME, qui utilise le commerce de produits vivriers pour subvenir aux besoins de sa famille, ou de Monsieur SEYDOU, qui voit dans le commerce électronique une opportunité d'auto-emploi malgré l'échec scolaire. Par conséquent, Anthony Giddens (1984) explique cette dialectique en affirmant : *« Les structures sociales sont à la fois le moyen et le résultat des pratiques qu'elles organisent de manière récursive* ». De même, Pierre Bourdieu (1980) souligne que les individus agissent dans un cadre structuré, mais qu'ils ont aussi la capacité de le transformer : « *Les agents sociaux ne sont pas de simples marionnettes manipulées par les structures ; ils disposent d'une marge de manœuvre pour interpréter et réinventer les règles du jeu social* ». Par ailleurs, nous appréhendons ici, les réseaux ethniques comme source de reproduction sociale. Dans ce contexte, Giddens souligne que les structures sociales sont à la fois contraignantes et habilitantes. À Bouaké, les réseaux ethniques jouent un rôle central dans l'organisation de l'économie précaire. Ces réseaux, bien qu'informels, sont hautement structurés et reflètent des hiérarchies et des solidarités communautaires. Notamment, les Malinkés et les Mandingues dominent le commerce électronique et du vivrier, tandis que les Baoulés sont plus impliqués dans la restauration et les ventes à l'étalage. Ces arrangements ethniques ne sont pas seulement des contraintes ; ils offrent également des ressources et des opportunités pour les membres de ces communautés. Comme le note Monsieur SANOGO, l'entraide entre les Dioulas et les Nigériens permet de maintenir leur domination dans certains secteurs économiques. Cela illustre comment les structures ethniques sont à la fois reproduites et renforcées par les actions des individus. En plus, Anthony Giddens (1990) explique cette dynamique en soulignant : « *Les structures sociales ne sont pas seulement des limites ; elles fournissent aussi les ressources nécessaires à l'action humaine* ». Aussi, Margaret Archer (1995) ajoute que les structures sociales sont à la fois le produit et le cadre de l'action : « *Les structures émergent des interactions humaines, mais elles contraignent et habilitent également les actions futures* ». De surcroît, nous abordons dans l'ordre logique de notre raisonnement, les hiérarchies sociales et la légitimité des activités. Dans cette dynamique, la théorie de la structuration met en avant l'importance des normes et des valeurs dans la reproduction des structures sociales. À Bouaké, il existe une hiérarchisation implicite des activités économiques, où certaines sont considérées comme plus légitimes que d'autres. À titre d'exemple, les vendeurs de matériels électroniques et les commerçantes de vivriers jouissent d'un statut social plus valorisé que les travailleurs du sexe ou les vendeurs ambulants. Cette hiérarchie reflète les valeurs socioculturelles de la communauté, comme l'illustre l'affirmation de

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Monsieur TRAORÉ : « *Conformément à nos croyances et valeurs, les métiers ne se valent pas* »[10]. Cette distinction entre activités légitimes et illégitimes montre comment les normes sociales influencent les pratiques économiques et contribuent à la reproduction des inégalités. Pierre Bourdieu (1994) analyse cette hiérarchisation à travers le concept de *capital symbolique* : « *La légitimité d'une activité ou d'une pratique sociale est déterminée par sa reconnaissance dans le champ social, qui est elle-même liée aux structures de pouvoir et de domination* ». Anthony Giddens (1984) complète cette idée en soulignant que les normes sociales sont à la fois contraignantes et habilitantes : « *Les normes sociales ne sont pas simplement des règles imposées ; elles sont intériorisées par les acteurs et deviennent des ressources pour l'action* ». Aussi, pouvons-nous tabler sur l'adaptation et la résilience face aux défis urbains dans la logique théorique des structures d'Anthony Giddens. En ce sens, nous insistons ici sur la capacité des acteurs à s'adapter et à transformer les structures sociales. À Bouaké, l'économie précaire reflète une adaptation dynamique aux réalités socio-économiques et urbaines. Les acteurs développent des stratégies de survie et de résilience, comme la collaboration technique entre commerçants de produits vivriers et transporteurs informels, ou l'utilisation de la restauration ambulante par les travailleurs pressés. Ces pratiques décrivent comment les individus utilisent les ressources disponibles pour faire face aux contraintes structurelles. Comme le note Madame COULIBALLY[11], la ville est animée par des espaces festifs et des réseaux de solidarité qui permettent aux populations de résister aux défis urbains. Subséquemment, Margaret Archer (1988) met en avant le rôle de l'« *agency* » dans la transformation des structures : « *Les acteurs sociaux ne sont pas passifs face aux structures ; ils les utilisent, les contournent ou les transforment pour atteindre leurs objectifs* ». Anthony Giddens (1990) ajoute que cette adaptation est un processus continu : *« L'action humaine est à la fois contrainte et habilitée par les structures, mais elle a aussi le pouvoir de les modifier à travers des pratiques récursives* ». Enfin, la théorie de la structuration met en lumière l'interdépendance entre les différentes dimensions de la vie sociale. À Bouaké, les activités économiques sont diversifiées mais interconnectées, reflétant une organisation sociale complexe. Le cas, des commerçants de vivriers qui dépendent des transporteurs informels, tandis que les artisans s'appuient sur des fournisseurs locaux. Cette interdépendance montre comment les structures économiques et sociales sont imbriquées et se renforcent mutuellement. Comme le souligne Monsieur DAO[12], les partenariats entre acteurs de secteurs complémentaires sont

[10] Monsieur TRAORÉ, *Op.cit.*
[11] Madame COULIBALLY, *Op.cit.*
[12] Monsieur DAO, *Op.cit.*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

essentiels pour maintenir l'économie informelle. Anthony Giddens[13] explique cette interdépendance en soulignant : « *Les structures sociales sont des systèmes de relations qui se reproduisent à travers les pratiques quotidiennes des acteurs* ». Pierre Bourdieu (1980)[14] retorque que ces relations sont souvent marquées par des rapports de pouvoir :« Les interactions sociales sont structurées par des logiques de domination et de dépendance, qui se manifestent dans les échanges économiques et symboliques ».

Des Stratégies économiques et sociales des acteurs

Nous abordons cette rubrique par un diagnostic portant sur la diversification des activités et résilience économique, les systèmes de crédit informel et solidarités communautaires, la solidarité professionnelle et entraide technique, les adaptations aux contraintes, le don et le contre-don et les alliances interethniques, la symbolique du « *Toupkê* ». Au titre de notre premier argumentaire, nous relevons que la diversification des activités est une stratégie centrale pour les acteurs de l'économie précaire à Bouaké. Confrontés à des revenus irréguliers, ces acteurs adoptent une approche polyvalente pour minimiser les risques et maximiser leurs opportunités. En ce sens, un commerçant peut vendre à la fois des articles électroniques, des cosmétiques et des vêtements dans un même espace, comme l'illustre le témoignage de Monsieur BAMBA[15]. Cette pratique reflète une adaptation pragmatique aux fluctuations du marché et une volonté de réduire la dépendance à une seule source de revenus. Anthony Giddens (1984), souligne que les acteurs sociaux ne sont pas passifs face aux structures économiques, mais qu'ils les utilisent et les transforment à travers leurs pratiques quotidiennes : « *Les structures sociales sont à la fois le moyen et le résultat des pratiques qu'elles organisent de manière récursive* ». Dans notre deuxième phase d'analyse, il ressort indubitablement dans cette étude que les systèmes de crédit informel, tels que les tontines et les prêts communautaires, jouent un rôle crucial dans l'économie précaire. Ces mécanismes, fondés sur la confiance et l'appartenance à des réseaux ethniques ou religieux, permettent aux acteurs de pallier le manque d'accès aux institutions financières formelles. Comme le note Monsieur COULIBALY[16], ces systèmes visent à assurer la sécurité financière et l'épanouissement des membres de la communauté. Marcel Mauss (1925), dans son essai sur le don, met en avant l'importance des échanges réciproques dans les sociétés traditionnelles : « *Le don crée un lien social et une obligation de réciprocité, qui renforcent la cohésion du groupe* ». Cette perspective éclaire les pratiques de solidarité observées à Bouaké, où le don et le contre-don

[13] Anthony Giddens, *Op.cit.*
[14] Pierre Bourdieu, *Op.cit.*
[15] Monsieur Bamba, *Op.cit*.
[16] Monsieur Coulibaly, *Op.cit*.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

(comme le « *gouassou* » Baoulé ou le « *soutra* » Malinké) sont des mécanismes essentiels pour maintenir la cohésion sociale et économique. Dans notre troisième progression, nous affirmons sans ambages que la solidarité professionnelle, basée sur l'assistance technique et matérielle, est un autre pilier de l'économie précaire. Les acteurs partagent leurs compétences et leurs ressources pour surmonter les difficultés, comme l'illustre le témoignage de Monsieur KARIM[17], qui met ses connaissances informatiques au service de ses collègues. Cette entraide renforce la résilience collective et permet aux acteurs de faire face aux défis quotidiens. Pierre Bourdieu (1980), insiste sur l'importance des réseaux sociaux et du capital social dans les stratégies individuelles et collectives : « *Les réseaux sociaux sont des ressources essentielles pour les acteurs, leur permettant d'accéder à des opportunités et de surmonter les obstacles* ». À Bouaké, ces réseaux sont souvent structurés autour de liens ethniques ou communautaires, ce qui renforce leur efficacité. Dans la quatrième mouvance d'interprétation, nous soulignons que les acteurs de l'économie précaire développent des stratégies innovantes pour gérer les risques et mobiliser leurs ressources. À titre illustratif, les commerçants investissent progressivement dans leurs activités pour limiter les pertes en cas de crise, comme l'explique Monsieur MAMADOU[18]. De plus, l'essor du commerce en ligne via des plateformes d'internet comme « *Djassa Bouaké* » ou « *Jumia deals* » montre une adaptation aux nouvelles technologies et une volonté d'élargir leur clientèle. Margaret Archer (1995), souligne que les acteurs sociaux sont capables d'innover et de transformer les structures sociales pour répondre à leurs besoins : « *L'innovation sociale émerge des interactions entre les acteurs et leur environnement, permettant de surmonter les contraintes structurelles* ». Le cinquième sillage de notre argumentaire indique que les pratiques de don et de contre-don, comme le « *gouassou* » Baoulé ou le « soutra » Malinké, révèlent d'une économie symbolique fondée sur des valeurs culturelles et religieuses. Ces mécanismes, qui transcendent la logique monétaire, renforcent les liens communautaires et permettent une redistribution des ressources au sein des groupes. Comme l'explique Madame AKISSI[19], ces échanges sont à la fois économiques et symboliques, car ils reposent sur des valeurs immuables de solidarité et de réciprocité. Marcel Mauss[20] montre que le don et le contre-don ne sont pas de simples transactions économiques, mais des actes chargés de sens social et symbolique : « *Le don crée une obligation morale de rendre, qui renforce les liens sociaux et la cohésion du groupe* ». Au terme de notre argumentaire, il est aussi important de comprendre que le « *Toupkê* », qui désigne les alliances interethniques,

[17] Monsieur Karim, *Op.cit.*
[18] Monsieur Mamadou, *Op.cit.*
[19] Madame Akissi, *Op.cit.*
[20] Marcel Mauss, Essai sur le don, 1925. *Op.cit.*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

illustre comment les acteurs de l'économie précaire mobilisent des réseaux sociaux élargis pour surmonter les crises. Ces alliances, fondées sur des valeurs d'humanité et d'altérité, permettent une entraide qui dépasse les clivages ethniques. Les témoignages de Madame KOUAME[21] et de Monsieur VAMOUSSA[22] montrent comment ces réseaux peuvent jouer un rôle protecteur dans des situations de conflit ou de crise. Pierre Bourdieu[23] souligne que les réseaux sociaux sont des ressources stratégiques pour les acteurs : « *Les alliances et les réseaux permettent de mobiliser des ressources symboliques et matérielles pour faire face aux défis* ». Bref, le « *Toupkê* » en est une illustration concrète, montrant comment les liens interethniques peuvent être mobilisés pour résoudre des problèmes économiques et sociaux.

Conclusion

L'économie précaire à Bouaké, à travers ses multiples dynamiques, représente un phénomène complexe mais essentiel dans la structuration sociale et économique de la ville. Ce système informel, qui touche divers secteurs allant du commerce de vivriers à la restauration de rue, en passant par les services artisanaux et le travail du sexe, reflète une adaptabilité remarquable des acteurs face aux contraintes économiques et sociales. L'éclairage théorique des structures sociales selon Anthony Giddens, relève les logiques sous-jacentes à l'initiative des stratégies développées par ces acteurs, telles que la diversification des activités, la création de mécanismes alternatifs de financement, et la mobilisation de réseaux de solidarité ethniques et professionnelles. Par ailleurs, les dynamiques d'accès aux opportunités et de contrôle de l'économie informelle témoignent de la résilience des acteurs et de leur capacité à répondre aux contraintes imposées par leur environnement. Cependant, bien que l'économie informelle apporte des solutions temporaires aux populations vulnérables, elle soulève aussi de nombreuses interrogations. Si elle crée des opportunités économiques et renforce les liens sociaux, elle peut également reproduire les inégalités sociales. L'absence de protection sociale, la faiblesse de l'accumulation de capital et la vulnérabilité face aux chocs économiques soulignent les limites de ce modèle économique. La question de la formalisation de ces activités se pose alors, avec l'espoir d'offrir une plus grande sécurité aux acteurs tout en intégrant ces activités dans une dynamique de développement durable. Cependant, une approche trop rapide ou mal adaptée à la réalité du terrain pourrait entraîner des ruptures sociales et économiques, exacerbant les inégalités au lieu de les atténuer. Une transition progressive, soutenue par des politiques publiques de régulation, d'inclusion et d'accompagnement, semble

[21] Madame Kouamé, *Op.cit.*
[22] Monsieur Vamoussa, *Op.cit.*
[23] Pierre Bourdieu, Raisons pratiques, 1994. *Op.cit.*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

être la voie la plus appropriée pour garantir que cette économie informelle puisse se transformer en un moteur de développement inclusif.

Conflit d'intérêts : Les auteurs n'ont signalé aucun conflit d'intérêts.

Disponibilité des données : Toutes les données sont incluses dans le contenu de l'article.

Déclaration de financement : Les auteurs n'ont obtenu aucun financement pour cette recherche.

References:

1. Archer, M. (1988). *Culture and Agency : The Place of Culture in Social Theory*. Cambridge University Press, 352 p.
2. Archer, M. (1995). *Realist Social Theory : The Morphogenetic Approach*. Cambridge University Press, 368 p.
3. Bourdieu, P. (1980). *Le Sens pratique*. Éditions de Minuit, 475 p.
4. Bourdieu, P. (1994). *Raisons pratiques : Sur la théorie de l'action*. Seuil, 251 p.
5. De Soto, H. (2000). *The Mystery of Capital : Why Capitalism Triumphs in the West and Fails Everywhere Else*. Basic Books, 288 p.
6. Giddens, A. (1984). *The Constitution of Society : Outline of the Theory of Structuration*. University of California Press, 402 p.
7. Giddens, A. (1990). *The Consequences of Modernity*. Stanford University Press, 188 p.
8. Lafortune, J. (2001). *L'économie informelle en Afrique : Enjeux et perspectives*. L'Harmattan, 210 p.
9. Mauss, M. (1925). *Essai sur le don : Forme et raison de l'échange dans les sociétés archaïques*. Presses Universitaires de France, 256 p.
10. McCloskey, D. (2006). *The Bourgeois Virtues: Ethics for an Age of Commerce*. University of Chicago Press, 616 p.
11. Organisation Internationale du Travail (OIT). (2007). *L'économie informelle en Afrique : Promouvoir la transition vers la formalité*. OIT, 120 p.
12. Portes, A. (1987). *The Informal Economy : Studies in Advanced and Less Developed Countries*. Johns Hopkins University Press, 312 p.
13. Putnam, R. (2000). *Bowling Alone : The Collapse and Revival of American Community*. Simon & Schuster, 544 p.
14. Sassen, S. (1991). *The Global City : New York, London, Tokyo*. Princeton University Press, 480 p.
15. Sen, A. (1999). *Development as Freedom*. Oxford University Press, 366 p.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

16. Spivak, G. C. (1988). *Can the Subaltern Speak?* In C. Nelson & L. Grossberg (Eds.), *Marxism and the Interpretation of Culture* (pp. 271-313). University of Illinois Press, 480 p.
17. Tokman, V. (1992). *Beyond Regulation: The Informal Economy in Latin America*. Lynne Rienner Publishers, 224 p.