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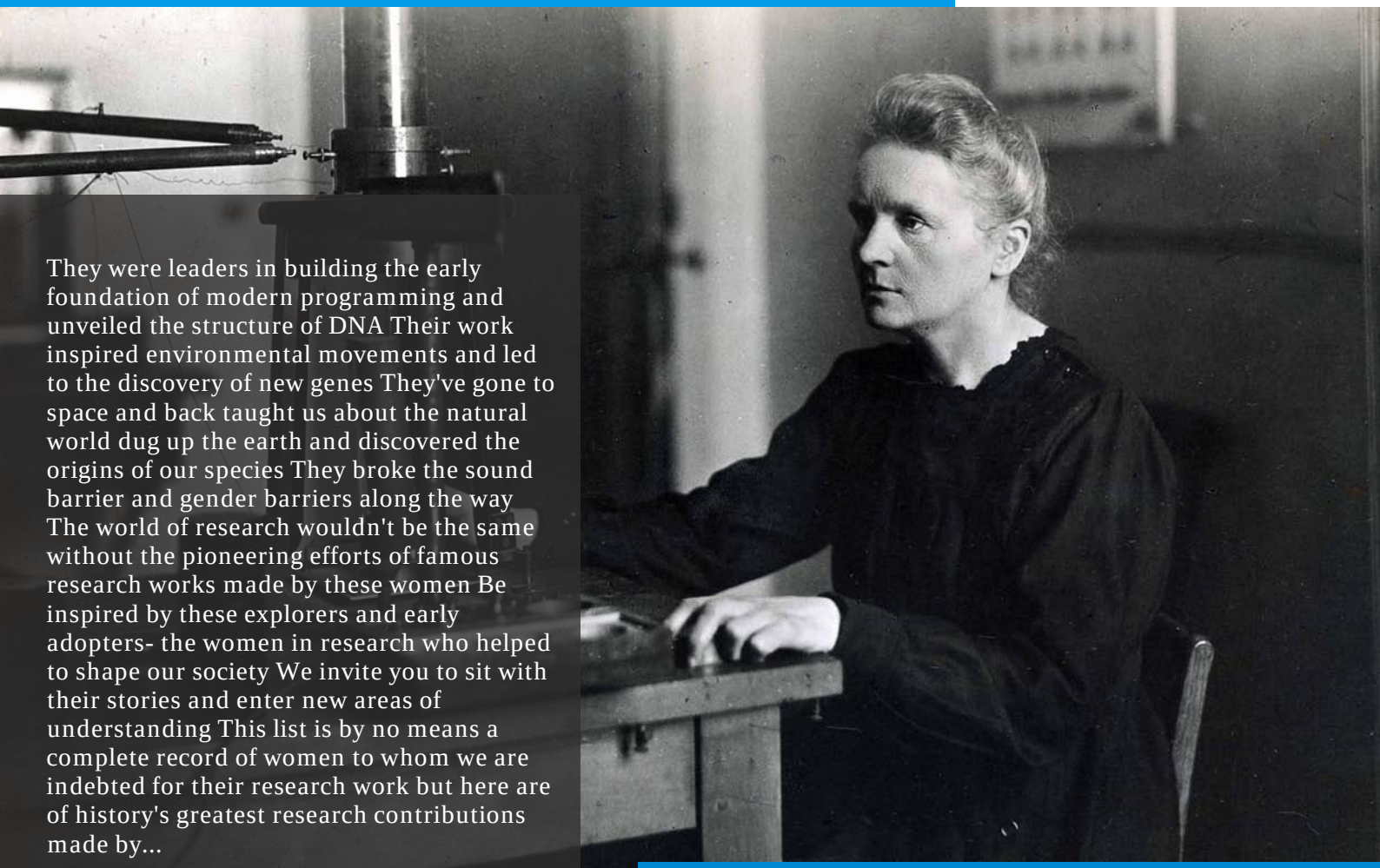

They were leaders in building the early foundation of modern programming and unveiled the structure of DNA Their work inspired environmental movements and led to the discovery of new genes They've gone to space and back taught us about the natural world dug up the earth and discovered the origins of our species They broke the sound barrier and gender barriers along the way The world of research wouldn't be the same without the pioneering efforts of famous research works made by these women Be inspired by these explorers and early adopters- the women in research who helped to shape our society We invite you to sit with their stories and enter new areas of understanding This list is by no means a complete record of women to whom we are indebted for their research work but here are of history's greatest research contributions made by...

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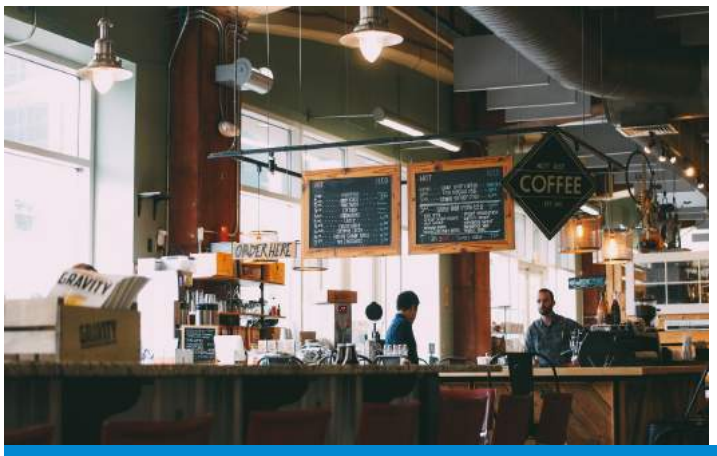

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Management and Leadership: Exploring their Interactions and Interdependence?

PhD Haddou Zamani & Prof. Jalila Ait Soudane

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ABSTRACT

This research, purely theoretical, highlights in a synthetic way the evolution of the most salient approaches of the concept of management from its genesis to its modern conception, through a numerous kind of schools, including the classical one centered on the administrative and scientific organization of work and the human relations one, whose ideology reacts against the excesses of the technical and scientific approach aiming to improve the work of employees and the satisfaction of their needs. Moreover, the study also highlights how the concepts of management and leadership have evolved in response to changing economic and technological contexts such as the rise of Scientific Management during industrialization, particularly within developed countries (United States, Japan, France and UK). This research revealed that the concepts associated with leadership and management have often been conflated, considered one and the same phenomenon by some and then considered by others to be quite distinctive. The same ambiguity is even truer at the level of application and practicality. Only a handful of studies have attempted empirically to differentiate between the two concepts. Thus, Management and Leadership may be perceived as similar or completely opposite on one hand; but complementary and cannot be isolated on the other hand, because of the dynamic aspect of today's organizations and their managerial implications.

Keywords: management; leadership; similar; different; complementary; Organizational Dynamics; Managerial Evolution, Leadership Roles, Strategic Integration, Human Relations.

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This research, purely theoretical, highlights in a synthetic way the evolution of the most salient approaches of the concept of management from its genesis to its modern conception, through a numerous kind of schools, including the classical one centered on the administrative and scientific organization of work and the human relations one, whose ideology reacts against the excesses of the technical and scientific approach aiming to improve the work of employees and the satisfaction of their needs. Moreover, the study also highlights how the concepts of management and leadership have evolved in response to changing economic and technological contexts such as the rise of Scientific Management during industrialization, particularly within developed countries (United States, Japan, France and UK). This research revealed that the concepts associated with leadership and management have often been conflated, considered one and the same phenomenon by some and then considered by others to be quite distinctive. The same ambiguity is even truer at the level of application and practicality. Only a handful of studies have attempted empirically to differentiate between the two concepts. Thus, Management and Leadership may be perceived as similar or completely opposite on one hand; but complementary and cannot be isolated on the other hand, because of the dynamic aspect of today's organizations and their managerial implications.

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I. INTRODUCTION

The evolution of management in the 21st century, following two centuries of development in managerial thought, invites us - as researchers in the field of management sciences in general, and leadership studies in particular - to clarify the ambiguity between the concepts of management and leadership *through* their semantic and functional nuances. The purpose of this theoretical research, which focuses on leadership, is not to delve into the details as we did in our article dedicated to the definitions of leadership where we highlighted that definitions of leadership are evolving and differ in time and space, depending on the context, the personality of leaders, their followers and, above all, their internal interactions as well as those with the external environment (ZAMANI, H. & AIT SOUDANE, J., 2020). Instead, this article aims to provide a concise synthesis of its evolution, highlight the main characteristics that differentiate it from the notion of leadership, and, most importantly, emphasize the strong interdependence that links these two concepts. In other words: Is complementarity between managers and leaders essential for organizations` *prosperity and sustainability?*

As we went through the literature, we noticed that the interaction between leadership and management has insufficiently been explored in detail or in a deeper comparative framework, such as specific aspects of each notion within an organization and more importantly, their various interactions and interdependence.

To further address this issue, we will begin by presenting the origins and evolution of the concept of management, followed by its various interactions with leadership, before focusing on their main managerial implications.

II. THE CONCEPT OF MANAGEMENT

2.1. Origins

The linguistic origin of the word *"manager"* comes from the Latin *manus*, meaning "hand." This word was first used in England in 1588. Scottish economist Adam SMITH (1723-1790) used the terms "manage", "manager" and "management" in his famous work entitled "Inquiry into the Nature and Causes of the Wealth of Nations", published in 1776. From 1880 onwards, the term "management" began to appear in texts written by American engineers (HOFSTEDE, 1993). Hofstede's Cultural Dimensions Theory is a framework used to understand etiquette and facilitate communication across cultures in areas ranging from business to diplomacy, and where the differences in culture across countries depend on several key dimensions including power distance, uncertainty avoidance, individualism-collectivism, masculinity-femininity, short vs. long-term orientation, and restraint vs. indulgence. Furthermore, it was not until the early 20th century that the word "management" was popularized by the American Frederick W. TAYLOR. TAYLOR (1856 - 1915) to describe what he had previously called the study of work or the study of tasks, and what we now call industrial engineering.

On the other hand, the term *"leader"* (or *"Dirigeant"* in French), is defined by the *Larousse* dictionary as "a person who is at the head of an organization of any kind." While this term can be seen as one of the possible translations of *"manager"* in Anglophone literature, it is worth noting that the Anglo-Saxon interpretation places greater emphasis on the *role* of the individual rather than their *position* within the organization.

According to the *Oxford* dictionary, a *"manager"* is "a person responsible for controlling or administering an organization or a group of employees." This implies that, in the absence of a universal principle or standard, leaders from different cultures and backgrounds may interpret this term in a much broader sense than merely a position within an organization.

Thus, the term *"leader"* can refer not only to those at the top of an organization but also to individuals involved in the administration of a company or institution at any level of the hierarchy. It further means that, within the sphere of operational management, the title of *"leader"* is specifically reserved for those who make decisions and ensure their execution (K. Vu, 2013).

2.2. Evolution of the Concept of Management

Although reflections on business organization began with the advent of the industrial era in the 19th century, management only evolved significantly at the dawn of the 20th century, progressing through three main phases. First, the *industrialization phase*, during which the social function of management was primarily focused on personnel administration. Next came the phase of *integrating human relations* into large organizations, marked by reactions against the limitations of Scientific Organization of Work (SOW), the sociology of work, and the growing recognition of non-economic factors such as motivation and productivity. Finally, the *Information and Communication Technologies (ICT) phase*, during which economic globalization underscored the importance of strategic Human Resources (HR) management, emphasizing both quantitative and qualitative optimization through processes like selection for recruitment, training, communication, and motivation...

In this regard, several schools and theories have contributed to the development of the concept of management, focusing on administrative and

scientific work organization, the integration of the human factor and technology, and motivation.

2.2.1. The Classical School

With the objective of increasing organizational productivity, the classical school focused on the administrative and scientific organization of work, where humans were viewed primarily as a workforce motivated by financial factors, depending on their behavior within the organization. Three key authors contributed to the establishment of this school: F.W. Taylor, Henri Fayol, and Max Weber.

- Taylorism (Frederick Winslow Taylor, 1856-1915)

An engineer by profession, the American Frederick W. Taylor developed the Scientific *Organization of Work* during the Second Industrial Revolution, drawing on research conducted in steel companies in the United States. Taylor scientifically studied industrial operations and proposed *"principles of work organization that enabled unskilled labor to quickly adapt to the new machines"* (N. Dorval, 1988). The goal was to define the optimal procedure for performing work. In this early attempt to rationally organize businesses, the role of the engineer was central, as the organization was based on the *vertical division of labor*. This approach relied on the scientific allocation of workers and tasks, with each task being timed to establish a minimum completion time. Furthermore, tasks were carefully observed to eliminate unnecessary operations and identify the best method to assign each worker a specific task according to their skills. In this context, decisions based on experience and intuition lost their importance and relevance. Employees were no longer allowed to propose ideas or assume responsibilities, as their role was limited to executing the assigned tasks.

- Jules Henri Fayol (1841-1925)

Based on his experience and observations as a French engineer, scientist, and company director, Henri Fayol developed his theory on business management. He established a list of 14 general principles that serve as a guide for effective management. These include the division of work, discipline, unity of command and direction, the degree of centralization or decentralization, the hierarchical chain, order, fairness in employee treatment, staff stability, and initiative. Within this framework, Fayol's approach emphasizes a doctrine grounded in decentralization logic and a clear distinction between hierarchical roles and advisory roles, a model later associated with Sloan (Déry R., 2007).

- The Rationalization of Managerial Thought – Max Weber (1864-1920)

As an economist and sociologist, Max Weber was the third influential figure in the effort to standardize managerial thought. For Weber, the best form of management is one based on rules, adherence to the hierarchical chain, and respect for *positions* rather than individuals.

Weber focused on defining the ideal bureaucratic administration as a strictly hierarchical structure that derives its efficiency from impersonal, transparent rules applicable to all. This framework ensures rational decision-making and transforms the company into a space for structured, rationalized interactions among individuals. In such a system, rules, procedures, and structures are clearly defined and formalized to maximize efficiency in achieving objectives. Within this model, the engineer produces the ideas and design, while the worker embodies the productive force.

Building on the foundational works of the three key contributors to Scientific Management (SOW), who sought to generalize management theory and practice, two other authors - Elton Mayo and Kurt Lewin - significantly advanced managerial approaches through the *Human Relations School*. Their contributions have had a lasting impact on modern-era management.

2.2.2. The Human Relations School

The Human Relations School is an intellectual movement that emerged in the 1930s, reacting against the excesses of Scientific Management (SOW) by emphasizing the integration of workers

into the organization and improving their working conditions (N. Dorval, 1988). In the United States, Elton Mayo, a professor at Harvard University, was the leading advocate of this school of thought. Mayo introduced new methods to Scientific Management, including human relations policies, Participative Management by Objectives (PMBO)[1], and decentralization. The ultimate goal was to improve the social climate within organizations by focusing on employee supervision and communication, both of which played a central role in encouraging employee engagement and their integration into a social group. This, in turn, fostered a sense of belonging, which enabled the simultaneous satisfaction of individual needs and organizational goals. Elton Mayo's research focused on understanding the real motivations of workers to improve their working conditions with the aim of enhancing productivity. Between 1927 and 1932, Mayo's team conducted studies at the workshops of the Western Electric Company in Hawthorne (Wren & Bedeian, 2009)[2] to examine the relationship between workers' motivations, their working conditions, and productivity levels.

These studies scientifically demonstrated that *human factors* were often more significant than physical conditions in motivating employees to increase their productivity. Mayo also showed that efforts should focus more on aligning organizational goals with workers' objectives, where personal goals and motivations would take on a central role.

By emphasizing the human factor in organizations, Elton Mayo became the first to challenge the behavioral assumptions of Scientific Management (SOW) as established by Taylor and Fayol.

In the same vein, the American psychologist and sociologist Kurt Lewin conducted studies on small groups and the forms of power within them[3]. The results highlighted the benefits of *cooperation over the division of labor*, thus reinforcing Elton Mayo's approach. Even further, Lewin's theories on leadership confirmed the critical importance of collaboration compared to the strict division of tasks.

In addition to integrating the human factor into Scientific Management (SOW), as demonstrated by Mayo and Lewin, other significant aspects were also addressed by Eric Lansdown Trist, who is considered the founder of the socio-technical systems school.

2.2.3. Eric L. Trist and the Socio-Technical Systems Theory (1909–1993)

Eric Lansdown Trist was a psychologist, teacher, consultant, and a leading figure in the field of organizational development. He co-founded the "Quality of Work Life" movement and was an influential member of the Tavistock Institute of Human Relations in London, renowned for its "T-groups," which studied self-organizing systems and group dynamics during the 1950s and 1960s. He was also one of the key founders of the Tavistock Institute of Human Relations in London, established in 1946. The Institute brought together psychologists and sociologists conducting research, particularly on issues related to work within organizations.

In 1949, along with a group of researchers from the Tavistock Institute of Human Relations in London, Eric Trist conducted studies at a British coal mine near Yorkshire. Their work revealed a *new approach to organizing work through the characteristics of highly autonomous, self-organizing, and accountable teams*. The example of the Yorkshire coal mine demonstrated that a new alignment between the needs of customers, producers, and their technology could be achieved in an alternative way, challenging the

[1] The Participative Management by Objectives (PMBO), which revolves around three key tools: annual reviews, objective contracts, and performance measurement was initially applied to executives before being extended to employees. Its primary aim is to enhance or generate their motivation.

[2] The results of these studies on motivation led to the Hawthorne Effect (A type of human behavior reactivity in which individuals modify an aspect of their behavior in response to their awareness to be observed).

[3] Kurt Lewin's work was conducted at the Research Center for Group Dynamics at the Massachusetts Institute of Technology (MIT) in the United States in 1946.

production system dominated by Frederick Taylor's *Scientific Management* principles. Eric Trist coined the term "socio-technical system" to emphasize that the interaction issues between people, tools, and techniques are not accidental but result from bottlenecks in the system. This insight led him to develop the Socio-Technical Systems Theory in 1952. It is about a theory that considers both the social and technical aspects when designing jobs. He was one of the leading advocates of socio-technical theory. He views organizations as open systems that constantly interact with their external environment and are composed of a techno-economic subsystem, a social subsystem, and an environmental subsystem, all within an organizational framework that must be jointly optimized. This approach allows for analysing the relationships between the different components and the mechanisms for regulating them (Jérôme Ibert, 2017). For Trist, the socio-technical approach highlights the absurdity of the fragmentation of tasks introduced by Taylorism. Instead, it treats the work system as a whole, using it as the unit of analysis rather than studying individual and isolated tasks.

For him, effective management requires a multiform analysis that considers both expertise and the attention given to individuals within an organization. This approach challenges the classical conception, which holds that a single form of work organization corresponds to a specific technology. In fact, the socio-technical school proposes the creation of *autonomous or semi-autonomous groups*, with a certain degree of freedom regarding the organization of their work, based on the necessary effort of training and gaining the commitment of the personnel involved.

Indeed, according to this author, management issues must be analyzed systemically, considering the following four subsystems: The environmental subsystem; The social subsystem, inherent to the psychosocial aspects of humans, with their subjective and sometimes irrational characteristics; The technical subsystem, primarily linked to mass production supported by the use of technologies; The organizational structure, designed to connect and align these elements.

In fact, this theory marks a sharp contrast with Frederick Taylor's Scientific Management. Moreover, other theories primarily focused on *motivation* have emerged, the most notable being Maslow's Hierarchy of Needs, Frederick Herzberg's Hygiene and Motivation Factors, Douglas McGregor's Theory X and Theory Y, and William Ouchi's Z Theory.

2.2.4. The Motivation Theories

With the Human Relations School, Taylor's hypothesis of the rational economic man was challenged by motivation theory, which focuses on the individual and aims to fulfill each person's needs. This theory, developed by A.H. Maslow attempted to establish a relationship between productivity and the satisfaction of workers' needs (N. Dorval, 1988). In addition to Maslow, other authors have also contributed to the development of motivation theory, which deserves further exploration.

- Abraham H. Maslow and the Hierarchy of Needs (1908–1970)

The American psychologist Abraham H. Maslow developed, based on observations made in the 1940s and presented in 1943, a theory of needs closely tied to motivation to identify the needs that drive human behavior (Abraham Maslow, 1973). In this regard, he formulated his theory and structured these needs hierarchically, drawing on the work of American psychologist Henry Murray, who identified twenty-seven different needs that people strive to satisfy (Murray, H. A., 1938). It was published in the second edition of his work *"Motivation and Personality"* published in 1970 where Maslow presented his motivation theory in its entirety, commonly known as Maslow's Pyramid. Within this framework, Maslow emphasizes that his classification of needs is universal while underlining that the specific nature of motivation is shaped by various determinants such as culture, social environment, or education. He further explains that behind every motivation or object of desire lies a fundamental need.

❖ F. Herzberg and the Hygiene and Motivation Theory (1923–2000)

As organizational theory evolved, it became clear that certain factors influence individuals' motivation and satisfaction to varying degrees. In this context, Frederick Herzberg sought to identify the different factors driving motivation and satisfaction in an industrial environment and to highlight their relationships and impacts on productivity. To achieve this, Herzberg focused on motivation and, in 1959, developed a list of factors based on Maslow's Hierarchy of Needs. He distinguished between two categories of job elements: those related to working conditions, team relationships, and salary, which he grouped as hygiene factors, and those addressing deeper aspirations, which he called internal factors (task content, achievement, promotion, independence, and autonomy) (Kennedy C., 2003). According to Herzberg, hygiene factors are not true sources of motivation but rather elements of satisfaction. Once these needs are met, they reduce dissatisfaction but cease to be motivating. However, the absence of these factors can lead to discontent and demotivation. Conversely, only internal factors, which are intrinsic to humans, act as true motivators. Individuals are driven to do their utmost not only to achieve their goals but also to exceed them. Thus, Herzberg concluded that hygiene factors must first be present in the workplace before motivation factors can be used to effectively stimulate workers.

❖ Douglas McGregor and Theories X and Y (1906–1964):

Another key figure in the school of motivation, Douglas McGregor, a social psychologist, drew on Maslow's Hierarchy of Needs to develop a theory on the management of organizations (Douglas McGregor, 1971). In this regard, he formulated in 1960 a philosophical view of humanity through his two theories, X and Y, whose principles have influenced the design and implementation of personnel policies and practices within organizations[4]. These two opposing perspectives theorized how people perceive *human behavior in the workplace* and *organizational life*.

According to Theory X, the role of management is to coerce and control employees (autocratic style). Indeed, beyond their constant concern for security, they inherently dislike work and will avoid it whenever possible. Similarly, they prefer to be directed because they do not seek responsibility, have little or no ambition, and must therefore be forced, controlled, directed, or threatened with punishment to achieve the organization's goals.

In contrast, Theory Y offers new assumptions that are the complete opposite of those in Theory X. These assumptions are rooted in a deeper understanding of human behavior. In this perspective, the role of management is to develop employees' potential and help them channel that potential toward shared goals (participative style). This is because, far from being lazy, people enjoy working autonomously and are naturally driven to succeed. Furthermore, they commit to achieving the expected objectives based on the rewards tied to their completion.

Combining lower-order needs (Theory X) and higher-order needs (Theory Y), McGregor suggested that company management could use either set of needs to motivate employees. However, he argued that better results would be achieved by applying Theory Y rather than Theory X. It is worth noting that McGregor also proposed the idea of Theory Z, but he did not develop it further.

William Ouchi[5] and Theory Z

In response to the rapid rise of Japanese companies, particularly in terms of motivation and productivity, and the deep challenges faced by American and European organizations in the 1980s—when Japan became the world's second-largest economic power in 1981, with

[4] McGregor's book, *"The Human Side of Enterprise"* (1960), had a profound influence on the field of management, largely due to his Theory X and Theory Y. President of Antioch College, he later became a professor of management at the Massachusetts Institute of Technology (MIT) before being succeeded by Warren Bennis.

[5] William G. Ouchi (born in 1943) is an American professor who grew up in Honolulu, Hawaii.

productivity levels twice that of the United States—many researchers began to view the Japanese model as a solution to these issues.

Among these scholars, William Ouchi, an American professor and management expert, conducted studies on the differences between Japanese and American management styles. In his renowned book, *"Theory Z: How American Management Can Meet the Japanese Challenge"* (Ouchi, 1981), he sought to develop a management style that combines the best Japanese techniques, adapted to Western societies, while also leveraging the advantages offered by the American management system. Through this comparative analysis, aimed at applying and adapting the best Japanese methods to Western societies, Ouchi identified one of the main characteristics of Theory Z, also known as "Japanese management." According to Ouchi, this theory focuses on the importance of employee well-being, engagement, and loyalty, with the goal of promoting job stability and ensuring higher productivity along with elevated employee morale and satisfaction. These core principles allow organizations to adopt long-term evaluations and provide continuous training focused on versatility, thereby avoiding the pitfalls of overly specialized jobs. Through Theory Z, Ouchi concluded that the ideal company, referred to as a "Z company," functions as a community of equals with a shared culture where employees collaborate to achieve common goals. This type of organization guides behavior based on commitment, loyalty, and trust, rather than relying on strict hierarchy and supervision.

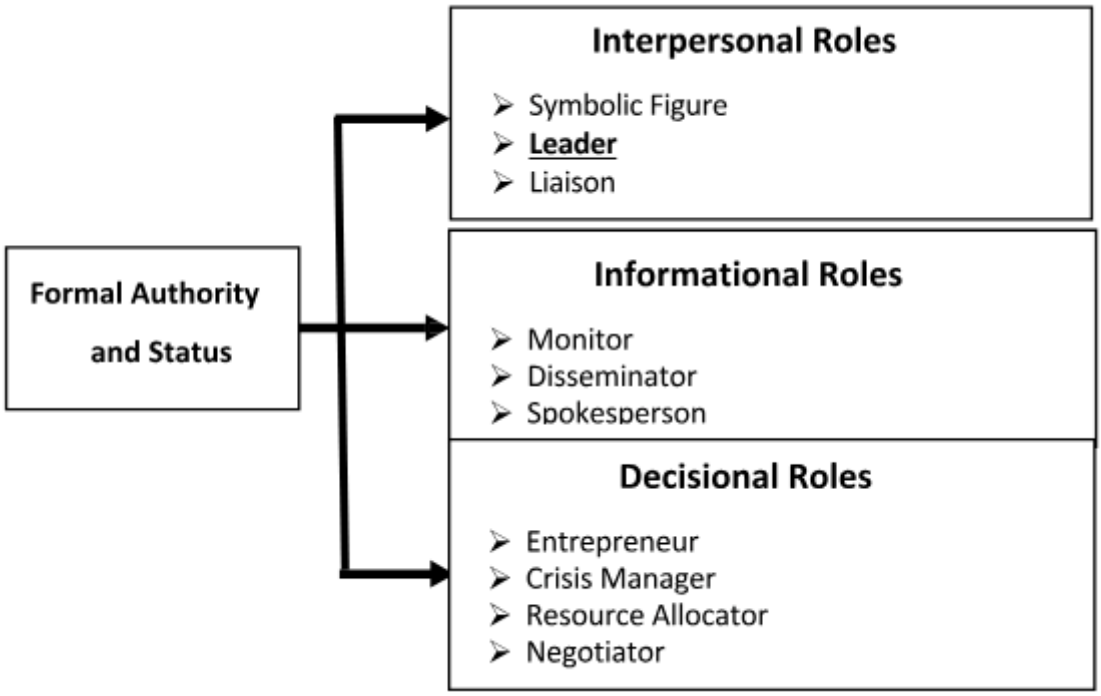
While the evolution of management theories has significantly transformed organizational dynamics, particularly with the integration of the human factor and its various motivations to improve productivity, modern managers continue to implement it while adapting it to the numerous challenges of today.

2.2.5. Modern Management

Since the beginning of the 21st century, the general environment of organizations has transformed significantly, becoming increasingly Variable, Uncertain, Complex, and Ambiguous (VUCA). The pressure from this environment is growing stronger and is expressed through key variables that need to be managed both in the short term and anticipated for the medium and long term.

This is reflected in the numerous changes and constraints that organizations face today, such as globalization of activities, technological innovations, social expectations, regulations, political movements, cultures and value systems, economic challenges (such as the growing professionalization of personnel, increased competition, capital concentration, and greater state intervention), ecological concerns, and broader societal phenomena, such as ethics, union radicalization, and public health. In such an environment, organizations can no longer be managed as they were in the past, as traditional concepts and practices have become inadequate.
In this context, Henry Mintzberg [6]argues that today's management is fundamentally anti-Taylorian. He concluded that the manager's role can be described through ten essential roles that form an integrated whole. These roles consider interpersonal relationships, information management, and decision-making processes, as illustrated in Figure 1 below (Mintzberg H., 2006).

[6] Henry Mintzberg, born on September 2, 1939, in Montreal, is a Canadian professor, organizational sociologist, and management sciences academic. He is the author of several works on management, focusing on topics such as executives' time management, managerial effectiveness, organizational structure, power dynamics, and strategic planning, among others.



Source: (Mintzberg, 1975)

Figure No. 1: Managerial roles

During his first visit to Morocco, at a training session organized by the international cabinet ``*Icompétences*`` in April 2014 in Casablanca, Mintzberg highlighted the importance of considering the human factor within organizations. He stated: *"By seeking efficiency at all costs and in the short term, organizations risk losing what truly matters: the commitment of individuals. The drive to professionalize management could be the main danger, leading to a loss of team engagement."* [7]Thus, management has evolved significantly since the beginning of the 19th century, thanks to the contributions of eminent authors and researchers who have greatly improved organizational management. This evolution spans from the Scientific Management approach to modern management, where employees, as human beings, have increasingly become the central focus of managers. In parallel with the evolution of management, the concept of leadership has also developed, establishing itself as a theory and practice essential for the sustainability of organizations, particularly in the 21st Century, where challenges have become increasingly complex and uncertain. In this regard, to avoid confusing these two concepts, it is important to examine the significant differences that distinguish them.

III. MANAGEMENT AND LEADERSHIP: WHAT'S THE DIFFERENCE?

A recent study revealed that the concepts associated with leadership and management have often been conflated, considered one and the same phenomenon by some and then considered by others to be quite distinctive. The same ambiguity is even truer at the level of application and practicality. Only a handful of studies have attempted empirically to differentiate between the two concepts (Ronnie Thomas Collins II and Claudia Algaze; Barry Z. Posner; 2023).

Thus, analyzing several articles addressing these two themes has allowed us to identify three prominent positions. First, management and leadership are considered synonyms and therefore similar. Second, some authors argue that the two concepts are entirely distinct. Finally, there is the position that, while the two notions are indeed

[7] *La Vie Économique*, February 21, 2014.

different, their presence and interdependence remain essential for the prosperity of organizations.

3.1. Management and Leadership: Two Interchangeable or Even Similar Concepts

In the past, the distinctions between the notions of "leadership" and "management" were blurry and often used interchangeably (Matthew R. Fairholm, 2002). Indeed, these terms were treated as synonyms across all academic disciplines focusing on management and leadership studies, by a number of scholars (Azad et al., 2017; Bass, 1990; Kent, 2005) while others have, however, suggested the two are distinctly different (Algahtani, 2014; Kniffin et al., 2020; Kotterman, 2006).

This practice was particularly prevalent during the industrial era, when researchers adopted the values of the industrial paradigm and equated leadership with effective management. Indeed, the merging of these two concepts continued to dominate leadership studies until the late 1980s (Joseph C. Rost, 1985). Management has typically been centered on organizational processes and structures, while leadership emphasized people and the human side of the enterprise. These two domains have often been referred to as task or production versus people or relationships (Blake and Mouton, 1964; Hersey and Blanchard, 1969; Yukl et al., 2002). Others have conceptualized these two domains as working with "things" or working with "people." Bennis and Nanus (2007, p. 12) made the argument that "managers do things right, while leaders do the right thing."

Indeed, several authors and practitioners continue to equate the two concepts, making no distinction between them (Zaleznik, 1977). Researchers such as Fiedler defend this practice of assimilation in the name of diversity of thought or academic freedom within a culture of permissiveness. Since the 1960s, Fiedler has upheld that leaders and managers are the same (Joseph C. Rost, 1991). For their part, Northouse and Yukl argue that there is no strict distinction between leadership and management, as leaders often perform managerial tasks, and managers, in turn, take on leadership roles (Busse Ronald, 2014).

It is important to note, however, that while some authors have considered these two concepts to be similar, others firmly believe that the two notions remain fundamentally different.

3.2. Management and Leadership: Two completely different concepts

Several authors have thoroughly reexamined the notion of leadership to identify the key characteristics that distinguish it from management, particularly in terms of personality, roles, and the nature of the work environment (See Table 1 below).

Tableau 1 : Distinction between Leadership and Management

MANAGER	LEADER
Manages complexity (Transactional Leadership)	Manages change (Transformational Leadership)
Roles / Activities	
- Sets objectives (short-term focus) - Develops an action plan - Creates an organizational structure - Recruits - Informs and delegates - Controls - Ensures the smooth running of daily activities - Resolves conflicts - Takes an impersonal approach to goals - Promotes a facilitation approach - Engages with people based on their role - Centralizes knowledge	- Builds a vision (long-term focus) - Strategically orients the organization - Develops strategies - Aligns teams - Motivates and inspires - Stays the course - Appeals to values, aspirations, and fundamental human emotions - Nurtures creativity - Seeks out opportunities - Engages with people intuitively and empathetically, rather than based on the organization's hierarchy - Generates new ideas
Personality	
- Rational - Methodical - Organized - Cautious - Structured - Teamwork advocate - Perseverant	- Strong personality - Charismatic - Independent - Empathetic - Emotional - Intuitive - Daring; Courageous and Passionate
Work Environment	
Organized	Chaotic / Turbulent

Source: (Claudia Bélanger B.A.A., 2016; Dubrin, 2012; Schermerhorn et al., 2010; Gauthier, 2008; Lainey, 2008; Zaleznik, 2004)

In 1977, Zaleznik was the first to highlight the contrast between leadership and management when addressing organizational issues. He portrayed the leader as an artist, using creativity and intuition to navigate chaotic situations, while the manager was depicted as a controller, relying on logic and pragmatism (Richard Bolden, 2004).

This approach has been supported by other authors, who emphasize that the difference between managers and leaders lies in their perceptions and responses to "chaos and order." Managers embrace processes, seek stability and control, and instinctively try to resolve problems quickly. In contrast, leaders tolerate chaos and a lack of structure and are willing to delay problem-solving to gain a deeper understanding of the underlying issues (Susanne Burns et al., 2011). In the same vein, Schermerhorn and his collaborators argue that the role of management is to promote stability and ensure the organization functions smoothly, while the role of leadership is to drive meaningful and adaptive changes to align with the organization's environment (Schermerhorn, J., et al., 2000).

In the same year (1977), Warren Bennis also argued that leadership is different from management. On this point, he stated: *"To lead is not to manage; the difference between the two is crucial. I know many institutions that are very well managed and very poorly led."*

Similar statements appear in numerous articles. In their book published in 1985, Bennis and Nanus note: *"To manage" means 'to accomplish, to achieve, to take responsibility for.' To lead means 'to influence, to guide in direction, action, or opinion'* (Bennis, W., & Nanus, B., 1985). For these two authors, managers are people who *"do things right,"* while leaders are those who *"do the right things."* The difference can be summarized as activities of vision and judgment effectiveness versus the mastery of routines and efficiency (Joseph C. Rost, 1991). Similarly, leaders act as catalysts with a focus on strategy (Bryman, A., 1986), while managers are operators or technicians primarily concerned with achieving immediate operational objectives (Richard Bolden, 2004).

In this same context, managers are masters of routine inasmuch as they accomplish tasks and are efficient (Warren Bennis & Burt Nanus, 1985); whereas leaders are masters of change they influence and are effective (Matthew R. Fairholm, 2002).

Once again, the clear distinction between management and leadership gained consensus among leadership researchers in the 1980s, affirming that leadership is fundamentally different from management and that the two terms should not be used as synonyms. In this context, Rost developed a conceptual model that differentiates leadership from management based on twelve distinct criteria (Joseph C. Rost, 1991).

In 1989, the distinction between leaders and managers resurfaced with emphasis through the publication of a famous article in the *Harvard Business Review* (Abraham Zaleznik, 1977; 1992; 2007). This article caused an uproar in business schools. Zaleznik highlighted that the distinction between management and leadership is based on personality differences between managers and leaders. According to the same author, leaders are fully committed, driven by their courage and convictions, to realizing their own vision, while the behavior of managers is dictated by consensus and guided by procedural and administrative tasks in day-to-day operations. In the same vein, Zaleznik shows us that good leaders do everything in their power to move things forward, whereas managers are content to implement the leader's vision. This distinction between the two concepts was also emphasized in the work of Kotter, who highlighted the leadership focus on driving change (Bolden R., 2004).

In 2007, Sloane emphasized that innovation is the main distinction between managers and leaders, noting that successful and competitive organizations are led by individuals who demonstrate and foster a culture of creativity, entrepreneurship, and risk-taking (Sloane, P., 2007).

Thus, it is essential to conclude that while these two concepts are distinctly different, other authors advocate for a middle-ground position, where management and leadership, though distinct, remain complementary and essential for the prosperity and sustainability of any organization.

3.3. Management and Leadership: Two complementary concepts

First, it is important to emphasize that a significant body of research suggests that, far from being distinct, the practices described as "management" and "leadership" are part of the same work. Based on detailed observations of what managers actually do, Mintzberg identified 10 key roles, one of which is "leadership" (see Figure 1).

He concluded that, rather than being separated and distinct from management, leadership is simply one dimension of a multidimensional management role (Richard Bolden, 2004).

Moreover, J. Gosling and H. Mintzberg observe that separating management and leadership poses a risk. According to these authors, leadership without managerial knowledge can harm the organization, as the leader may become disconnected from administrative realities and exhibit arrogant behavior capable of undermining the very foundations of the organization. Conversely, a manager lacking leadership expertise suffers from a lack of inspiration and may display apathetic behaviors, which can

jeopardize the organization's survival (J. Gosling & H. Mintzberg, 2003).

In reality, the two concepts are closely connected and represent two sides of the same coin: on one hand, the responsibility toward employees and the optimal management of processes, which fall under the domain of managed activities; and on the other hand, the guidance of employees to motivate them to achieve the set objectives.

Ultimately, management and leadership evolve over time, requiring leaders to seek a balance between the two.

As an example, in the area of "results in Table 02" he explains that effective management brings order and relevance to organizational processes and objectives, while leadership is required for driving dynamic, long-term changes (Richard Bolden, 2004).

Table 2: Complementarity of Leadership and Management

	Leadership functions	Management functions
Creating an Agenda	Establishing direction: A vision for the future, developing change strategies to achieve objectives.	Plans and budgets: Deciding on action plans and timelines and allocating resources.
Personnel Development	Aligning People: Communicating the vision and strategy, influencing the creation of teams that accept and validate the objectives.	Organizing and Managing Personnel: Designing the structure, assigning personnel, developing policies, and ensuring procedure follow-ups.
Execution	Motivating and inspiring: Encouraging people to overcome obstacles and satisfy their human needs.	Control and Problem Resolution: Monitoring results against the plan and taking corrective actions where needed.
Results	Producing positive and sometimes dramatic changes.	Producing order, coherence, and predictability.

Source: (Richard Bolden, July 2004) and (Buchanan & Huczynski, 2004, p. 718 – according to Kotter, 1990)

3.4. Managerial Implications of the Two Concepts

This research addresses the importance of managing an organization through the nature of the management approach adopted by a company, while considering the degree to which Management (M) and Leadership (L) are implemented. In other words: Does the organization rely exclusively on management or on leadership? Is it governed by managers and leaders who are completely independent of one another? Is it led by a single leader who already possesses managerial skills?

These questions prompt us to highlight the main managerial implications associated with each configuration, offering leaders and managers at the helm of organizations a preliminary insight. The table below will serve as a foundation for further brainstorming and in-depth diagnostics, supported by appropriate experiments and training programs. The goal is to leverage the opportunities presented while anticipating and mitigating, if not countering any potential imminent risks.

Table 3: Opportunities and risks per approach

Situation		Opportunities	Risks
1.Leadership (L) is perceived as Management (M) (similarity)		- Well-developed strategies and well-executed action plans. - Well-established operational procedures and regulations. - Good organizational design. - Financial autonomy. - Functional autonomy. - Effective controls	- Lack of vision. - Excessive authority - Lack of anticipation - Risk of conflicts - Lack of coordination. - Lack of coherence - Information not systematically shared. - Bankruptcy…
2. Approach Focused 2. Approach Focused exclusively on M or on L (Distinct)	M	Same as Situation 1	Same as Situation 1
	L	- Well-developed vision - Transparency in the decision-making process - Consideration of the human factor (motivation and influence) - Strong ambitions for change - Strong inspiration / role model -Excellent communication strategy -Favorable platform for innovation and creativity (talents) -Excellent long-term performance -Skill in negotiations…	-Poor administration (HR, daily activities) -Uncalculated ventures -Instability / turbulence -Risk of bankruptcy…
3.Integrated Approach (Simultaneous consideration of M and L)		-Easy implementation of the vision -High degree of coherence in direction -Compatible strategies and action plans -Efficient communication strategy -Trust is easy to maintain -Opportunity for innovation and creativity -Excellent performance	-Resistance to change -Funding issues -Incompetence of certain -employees -Conflicts of interest

Source: Self-conceived

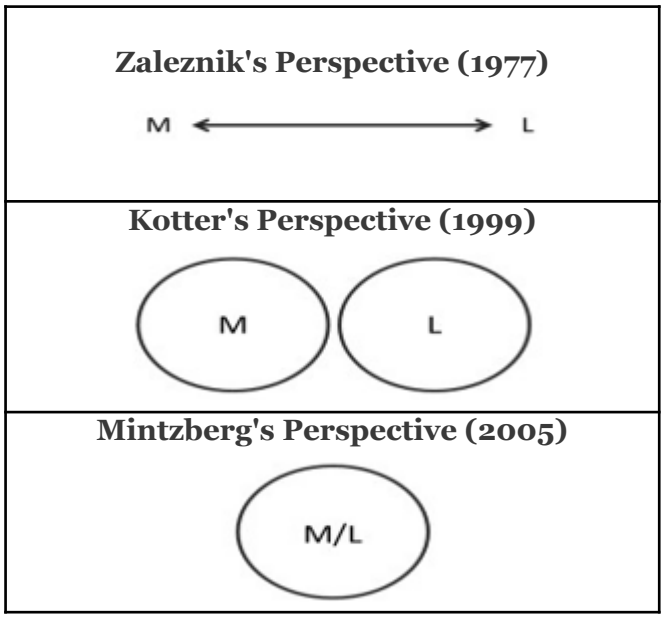
IV. CONCLUSION

In summary, while management and leadership have often been used interchangeably by many authors under the pretext of academic permissiveness, the polarized view of managers and leaders as completely different individuals can also be misleading and potentially harmful in practice.

Indeed, if we believe that leaders and managers are inherently different people, we might conclude, on the one hand, that it is necessary to frequently change the management team as circumstances evolve, and on the other, managers can`t become leaders (and vice versa). Such a perspective greatly underestimates the potential of individuals in both management and leadership roles. However, this does not mean that all individuals possess the skills required to be good leaders and managers, nor that there is a single, appropriate profile for all situations. Instead, to achieve maximum effectiveness, we should aim to recruit and train "leader-managers" who are capable of fully assuming these roles. According to Raubenheimer (2004), both managers and leaders are essential to an organization's prosperity, as leaders develop the vision while managers execute it (Sultan Aalateeg, 2017).

In this regard, many authors conclude that only organizations that combine both sets of competencies can thrive in times of turbulence (Zaleznik, 2004; Kotter, 2001; Gosling &

In reality, the evolution of the relationship between management and leadership appears to hold promising prospects, following the trend initiated by Mintzberg in 2005. He asserts that an organization can only achieve the desired prosperity by adopting an approach focused on the integration of management and leadership within the same management strategy (see Figure 2 below).



Source: (Mintzberg, 2005) and (Simonet & Tett, 2013)

These integrated strategies focused on the development of highly competent "manager-leaders" remain, in our view, the best approach for organizations—particularly large companies—to address the numerous challenges of the 21st century, which have become increasingly volatile, uncertain, complex, and ambiguous, as demonstrated by the COVID-19 health crisis outbreak.

Furthermore, beyond the findings of this research, which remain purely theoretical, our work has certain limitations. To be more conclusive, it requires additional empirical evidence drawn from multiple organizations, where the management approach would be subjected to qualitative and quantitative experimentation.

It is also important to highlight other constraints in this regard, particularly in the public sector, where the burden of administrative procedures, combined with resistance to change, severely hinders the spirit of innovation and creativity among leaders and managers, especially at the strategic level.

Similarly, in certain countries, mentalities and cultural norms do not allow for the effective and meaningful integration of a gender approach in the leadership sphere. This represents a significant barrier to the emergence of competent leaders capable of addressing the numerous challenges of tomorrow. In Morocco, for example, despite the significant increase in the feminization rate within the public sector—from 34% in 2002 to 39.5% in 2015—the appointment of women to positions of responsibility, while it has evolved from 10% in 2002 to 21.5% in 2015, remains concentrated at the lower levels of public administration (Benabdelhadi A., El Kaout H., 2018).

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Impact of Managerial Over Confidence, Internal Control and Cash Holdings in Chinese Firms

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ABSTRACT

This study systematically evaluates the effects of managerial overconfidence on corporate capital holdings. According to the theoretical framework, this study conducted an empirical analysis using data on listed Chinese companies from 2010 to 2022. Traditional economic theories are based on rational human assumptions, and theories that explain corporate cash holdings concentrate on the potential uses of corporate cash assets; however, they neglect to consider decision-makers' beliefs that ultimately dictate cash utilization and cannot verify the difference between managers overconfidence and over-optimism. Therefore, this study not only verify the difference between managers overconfidence and over-optimism, but also based on psychology theory to explain why cognitive bias leads managers to be more overconfident in China and affects corporate cash holding levels. These findings indicate that managers' overconfidence positively associated with corporate cash holdings. Additionally, the high-quality internal controls mitigate overconfident managers holding more cash by alleviating information asymmetry. Collectively, this study effectively connects cognitive psychology to enrich the research on the correlation between managerial overconfidence and cash holdings. In addition, these findings illustrate the important implications of enforcing cash-use efficiency and alleviating cognitive bias in overconfident managers.

Keywords: managerial overconfidence; cash holdings; internal control.

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I. INTRODUCTION

The financial crisis had a significant influence on promoting public consciousness surrounding the importance of cash reserves. Both the emerging and developed markets have significant cash reserves. According to Zheng and Chen (2018), 10% is a reasonable cash-holding level in China, and Bo et al. (2024) illustrated that the mean and median value of cash holding in China are 18% and 13% respectively, which means that Chinese listed companies have a higher cash holding level.

The manager is central to the company's power and leadership. Managers are responsible for strategic planning and organizational decision making (Sheikh, 2018); and their psychological bias impact their behavior (Bo & Li, 2024). These ideas assume that individuals are rational and disregard cognitive biases. However, the current psychological literature indicates that people are overconfident in their knowledge and abilities (Larwood et al., 1977; Heaton, 2002), which leads to self-attribution, control and knowledge illusion, and overly optimistic (Bo et al., 2024). Moreover, overconfident managers are likely to be hired, retained, or promoted. Generally, people who apply for management positions are more confident and optimistic. Companies that hire managers tend to believe that overconfident and excessively optimistic candidates may have higher ability due to capital market asymmetric information (Gervais et al., 2003). Goel and

Thakor (2008) suggested that overconfident managers are more likely to be promoted to the CEO. In addition, owing to the role of self-attribution bias, enterprise managers think that their success is mainly due to their ability, which leads to an overconfidence degree (Gervais et al., 2011).

Additionally, according to Ali and Tauni (2021), Chinese managers may be more overconfident. First, culture is the main body of traditional Chinese culture, advocating the hierarchical idea and emphasizing the importance of authority in Chinese interpersonal relations, making enterprise managers vulnerable to "control illusions," which developed a self-assured cognitive bias (Zheng & Chen, 2018). Secondly, China's unique transforming economic environment has shaped several "godfather-level" state-owned enterprise leaders and private enterprise founders, and their pivotal role in entrepreneurship and business growth and continued success may strengthen their confidence in psychology, leading to knowledge and control illusions (Feng & Chen, 2020). Thirdly, flaws in internal governance and external supervision mechanisms assist Chinese enterprises in creating a suitable "soil" for managers' overconfidence (Jiang & Kim, 2020). Therefore, the proportion of overconfidence in Chinese-listed companies may be higher than that in foreign-listed companies because of the influence of the Confucian hierarchy and imperfect external governance mechanism (Jiang et al., 2009).

According to research on cash holdings, companies primarily build cash assets for preventive and agency motivations (Chen et al., 2020). While pecking order theory and agency theory lead to distinct objectives, which means that the preventive motive may result in agency issues. This is because excessive cash holdings give managers excessive discretion (Opler et al., 1999). Nevertheless, fluctuations in economic situations and business environments lead enterprises to retain cash assets for precautionary motivation rather than for agency motives (McLean, 2011). In addition, Bo and Li (2024) pointed that overconfident managers hold more cash to reduce external finance costs and grasp future good investment opportunities to show their ability and values.

In addition, an extensive and outdated banking industry primarily controls China's financial system. Additionally, the country has a developing but inefficient and unequal capital market (Chen et al., 2020). These problems result in expensive external financing. Because of the imperfect capital market and governance mechanisms in China, external financing and internal agency costs are both high for companies (Jebran et al., 2019). Therefore, do Chinese public companies reserve more cash from internal financing to defend against external financing constraints or satisfy personal interests? What factors contribute to the high cash holding level—agency issues or precautionary motives? This is a question that warrants an in-depth investigation. Moreover, managing liquidity is a crucial issue for many Chinese enterprises, especially when there is a possibility of economic downturns. However, a higher cash holding level may result in agency problems for enterprises in real-world operations. This institutional context provides a distinctive opportunity to analyse the influence of efficient internal controls on cash management. As a result, China's unique background provides an incentive for assessing the effectiveness of internal controls in enhancing cash management except to considering the scope and objectives of these controls.

However, a series of problems cannot be solved. Firstly, most researchers mix the managers overconfidence and over-optimism into one concept. Overconfidence is a cognitive bias generated by an individual's self-evaluation emphasizing the self-assessment of their abilities, and the objects of the assessment are themselves (Karki et al., 2024). Over-optimism mainly refers to the individual's cognitive bias regarding the external environment and events, stressing the individual's expectation of positive results or conditions, and the objects of the assessment are external events and environments (Kambourova & Stam, 2017). Therefore, alleviating the managers' overconfidence should focus on improving internal control and information transparency,

rather than mainly focus on external economic environmental uncertainty and policy. Secondly, the results about the association between high-quality internal control and cash holdings are inconsistent. On the one hand, some scholars pointed that that internal control negatively related with cash holdings that based on the agency theory (Chen et al., 2020). On the other hand, some scholars believe that the higher level of the internal control, the higher the cash holdings (Xiong et al., 2021), and its theoretical basis mainly lies in two aspects: (1) reducing the irrational behavior of management and (2) defensing on plunder risks. Therefore, the impact of high-quality internal control on overconfidence cash holding is essential for Chinese listed companies. Thirdly, current research most focus on internal control and cash holding value (Anderson, 2022), internal control and corporate resource (Gao & Jia, 2016), corporate performance (Magerakis & Tzelepis, 2023; Yun et al., 2021) or corporate internal control as the moderating variable to check the relationship between risk management and cash holdings (Chen et al., 2020), relation trading and corporate cash holding (Lin et al., 2017) and so on. This means there is rarely research pay more attention to the moderating effects of managers' overconfidence and internal control on cash holdings. However, high-quality internal controls effectively reduce information asymmetry and cognitive bias for managers, which is important to alleviate managers' overconfidence and improve cash use efficiency for enterprises.

This paper points out that managers' overconfidence is positively associated with cash holdings. Moreover, the moderating effect of internal controls mitigate the positive relationship between managers' overconfidence and cash holdings. Multiple rigorous tests prove the reliability and consistency of the empirical findings. The Fix Effect Model as the base regression test, and robustness test involves GMM regression to mitigate endogenous problems.

This study presents a new research perspective and enriches the research on cash holdings by distinguishing managers' overconfidence and over-optimism and connecting internal control to alleviate managers' cognitive bias. Although numerous studies have been dedicated to the subject of internal controls or managers' overconfidence on cash holdings, there is a dearth of research explaining why managers' cognitive bias leads them to hold more cash. Hence, this research not only enhances the understanding of economic repercussions, but also contributes to the concern for the impact of internal governance mechanisms on overconfidence cash holding of Chinese listed companies.

II. LITERATURE REVIEW

Chen et al. (2020) illustrate that managers' cognitive biases can directly affect corporate behavior, and the impact of cognitive bias on manager overconfidence is particularly significant. "Overconfidence" comes from research in cognitive psychology, which is a common psychological phenomenon. Studies have shown that people are not completely rational, and they are self-centered. Moreover, people always believe in their own cognition and judgment, and are more overconfident in their own knowledge and ability. Generally, people's decisions, beliefs, and preferences often exhibit systematic biases and overconfidence (Kahneman et al., 1982). Weinstein (1980) pointed out that people generally show overconfidence in making judgments, particularly in groups such as entrepreneurs and managers. Ben-David et al. (2007) showed that managers' overconfidence bias tends to raise large amounts of money for investment activities. Heaton (2002) found that overconfident managers tend to use internal corporate funds. This means that overconfident managers would reduce external financing cost and grasp future good investment opportunities through preparing enough internal cash.

Zheng and Chen (2018) illustrate that the degree of managers' overconfidence in China is more serious than that in foreign enterprises because of problems such as the prominent status of authority in interpersonal relationships, special transition economy environment, and imperfection of enterprise internal and external mechanisms. They also found that M&A behavior carried out by overconfident managers eventually

damages the value of the enterprise (Yu et al., 2006; Malmendier & Tate, 2008; Hribar & Yang, 2016).

This study investigates the correlation between managers' overconfidence and cash holding levels. However, most studies apply agency theory and pecking order theory to explain the above relationship, and assume that people are rational and disregard cognitive biases. However, the agency problem can be alleviated if managers are overconfident (Dong, 2019). This study is based on psychology theory and uses overconfidence theory to explain why overconfident managers hold more cash. First, the agency problem can be mitigated if managers are overconfident (Xing, 2023). This is because overconfident managers rely on shareholder loyalty to shareholders (Heaton, 2002). A high level of overconfidence can motivate managers to work harder and alleviate agency problems to a certain extent (Gervais et al., 2003). Second, overconfident managers overestimate their abilities and underestimate future risks, leading to cognitive bias (Bo et al., 2024). Thirdly, overconfident managers are willing to hold more cash to grasp future investment opportunities and provide stable and sustainable funding support for more R&D investments. Fourthly, overconfident managers overestimate future investment return and underestimate future risks and uncertainty. Therefore, overconfident managers tend to hold more cash for internal financing because they want to reduce external financing costs and grasp future good investment opportunities (Zheng & Chen, 2018). Consequently, overconfident managers tend to hold more cash in business operations. Based on the above analysis, Hypothesis 1 can be expressed as follows:

H1: managers' overconfidence has the positive correlation with cash holdings.

This study uses internal control as a moderating variable to investigate the influence of the above correlation. High-quality internal controls can mitigate information asymmetry through effective institutional arrangements that enhance the supervision of enterprise decision-making and implementation processes. In addition, high-quality internal control enables managers to be more cautious, repeatedly assess the consequences of decision making, and constantly correct their perceptions of self-reliance, thereby reducing their overconfidence. Constrained and supervising managers' overconfidence behavior through effective internal control can promote optimization of enterprise resource allocation. In scholars' studies, Chen et al. (2021) pointed that effective corporate governance can mitigate the problem of excessive investment resulting from overconfident managers. According to Sani and Chaharmahalie (2012), effective internal controls can mitigate the adverse effects of overconfident managers on accounting. Zheng and Chen (2018) demonstrated that effective internal controls can monitor and discipline managers' behaviors. Managers overestimate their decision-making abilities, especially when they have considerable power and influence (Moore & Kim, 2003). Nevertheless, managers' overconfidence can be reduced when their decision-making and control powers are limited (Banerjee et al. 2015). Effective internal controls can encourage managers to exercise greater prudence in their decision-making processes and strengthen stakeholder involvement and supervision, reducing their decision-making and control power while correcting cognitive deviations that caused by overconfidence. In other words, effective internal controls reduce overconfident managers holding excess cash (Chen et al., 2020). Therefore, Hypothesis 2 was as follows:

H2: Effective internal control mitigates overconfident managers hold excessive cash.

III. DATA AND METHODS

3.1 Sample Construction

This study uses data from A-share Chinese listed firms in Shanghai and Shenzhen between 2010 and 2022. The data were sourced from the CSMAR database and analyzed using Stata statistical software. The observation number is 46831, which does not include ST companies, and B and H share Chinese List companies.

3.2 Research models and variable measurements

Regression model 1 was constructed to investigate the correlation between managers' overconfidence and cash holdings. Model 2 assesses the impact of internal controls on managers' overconfidence in their cash holdings. Model 3 assessed the impact of product market competition on this relationship.

MODEL 1:

$$CH_{it} = \beta_0 + \beta_1 OC_{it} + \sum \beta_{it} CV_{it} + \varepsilon_{it} \quad (1)$$

Model 2:

$$CH_{it} = \beta_0 + \beta_1 OC_{it} + \beta_2 HIC_{it} + \beta_3 OC_{it} * HIC_{it} + \sum \beta_{it} CV_{it} + \varepsilon_{it} \quad (2)$$

In Models 1 And 2, Cash Holdings Denote Corporate Cash Holding. Oc Denotes Manager Overconfidence, Using Shareholding And Earnings Changes As A Measure To Denote Managers' Overconfidence, Which Is Measured Using The Changes In Shareholding Growth Rate Minus The Difference In Earnings Per Share Growth To Measure Managers' Overconfidence Level (Wang, 2021). This Index Not Only Reflects The Confidence And Conservative Characteristics Of Managers From The Direction But Also Quantifies The Manager Confidence Index Through The Deviation Of Specific Values. In Addition, Hic Denotes High-Quality Internal Control. ε_{It} Is The Error Term.

Moderating Variable Is Hic, Hic Is The Internal Control Index. According To The Yang And Wang (2020), Chen Et Al. (2017) And Chen Et Al. (2020) Measures Of Internal Control Index, The Model Is Measured As Follows. In The Model (1). W Represents The Weight Of Each Index For Internal Control Of Listed Companies; Strategy Represents The Strategic Index Of Listed Companies; Operation Represents The Operational Index Of Listed Companies; Reporting Represents The Reporting Index Of Listed Companies; Compliance Represents The Compliance Index Of Listed Companies; Asset Safe Represents The Asset Security Index Of Listed Companies; Correction Represents The Correction Index Of Listed Companies. When The Internal Control Index Exceeds The Sample Year's Median Value, Hic Takes One; When It Does Not, Hic Takes Zero.

$$HIC = \sum w_k * Strategy_k + \sum w_k * Operation_k + \sum w_k * \mathrm{Re}porting_k + \sum w_k * Compliance_k - w * Correction \quad (3)$$

Table 1: Variables definition

Variable name	Variable symbol	Variable meaning
Cash holding	CH	(Monetary funds + trading financial assets / Total assets)
Managerial overconfidence	OC	With holding growth rate minus the difference of earnings per share growth to measure managers overconfidence level

Internal control	HIC	If the internal control index is higher than the median industry of the sample year, HIC takes 1, otherwise, HIC takes 0
Customer concentration	CC	According to the "sales revenue of the top five customers in the proportion of the total sales revenue" disclosed in the annual reports of the listed companies
Managerial Ownership	MO	Managerial ownership is the ratio of ownership by executive directors to the number of shares outstanding at the end of fiscal year.
Firm size (CNY-100 million)	Size	Natural logarithm of the total assets at the end of the year
Dividend payment	Div	Dividend payment is taking 1, otherwise, Div takes 0
Duality of COB and CEO	Du	If the chairman and the general manager are held by the same person, the value is 1. Otherwise, 0
Enterprise nature	State	SOE is1. Non-SOE value 0

IV. RESULTS OF THE EMPIRICAL ANALYSIS

4.1 Statistics analysis

Table 2 indicates that the variable contained 46831 observations. The mean value of cash holdings was 17.8%. The mean value of OC is 0.469, which means that managerial overconfidence is present in nearly 50% of the managers.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std.dev.	Min	Max
CH	46,831	0.178	0.123	0.00136	0.980
OC	46,831	0.469	0.147	0.0924	1
HIC	46,831	0.948	0.223	0	1
Du	46,831	0.162	0.369	0	1
Div	46,831	0.709	0.454	0	1
Size	46,831	22.91	1.443	17.64	28.61
State	46,831	0.698	0.459	0	1
CC	46,831	27.11	21.16	0	157.9
MO	46,831	0.186	0.389	0	1

Note: Table 1 provides comprehensive definitions for all variables utilised in this paper.

4.2 Pearson's correlation analysis

Pearson's correlation coefficient was used to evaluate the relationships between the variables. Table 3 presents the associations between the variables in the sample. The main purpose of the Pearson correlation test was to determine whether multicollinearity existed among independent variables. Multicollinearity difficulties occur when correlation coefficients exceed 0.8 (Gujarati and Porter, 2009). Nevertheless, the correlation coefficients for the variables vary between -0.156 and 0.138, which is below the limit of 0.8, as indicated in Table 3. The results indicate that there was no multicollinearity problem in the present investigation.

Table 3: Correlation Matrix of the Pearson

	CH	OC	HIC	Du	Div	Size	State	CC	MO
CH	1								
OC	0.089***	1							
HIC	0.034***	-0.028**	1						
Du	0.029**	0.081***	0.045***	1					
Div	0.138***	-0.131***	0.076***	-0.00300	1				
Size	-0.156***	-0.238***	0.057***	-0.116***	0.232***	1			
State	-0.048***	-0.179***	0.00600	-0.253***	0.072***	0.223***	1		
CC	-0.0110	0.109***	-0.00800	-0.0180	-0.120***	-0.187***	-0.00800	1	
MO	-0.00900	-0.036***	0.0160	0.00800	0.049***	0.077***	-0.081***	-0.026**	1

Note: Table 1 provides comprehensive definitions for all variables in this paper.

4.3 Empirical results

Table 4 displays the link between managers' overconfidence and cash holdings and examines the influence of internal controls and product market competition on this correlation. The regression analysis uses the Fixed Effects Model (FEM) to investigate the correlation between managers' overconfidence and cash holdings, as shown in Column (1). Columns (2) present the outcomes of the moderating variable. The regression analysis in column (1) demonstrates a statistically significant and positive correlation at the 1% level, with a coefficient of 0.042. This finding illustrates that a one-unit rise in managerial overconfidence results in a 0.042-unit increase in cash holdings. This is because if overconfident managers want to show their abilities, they should ensure they have sufficient funds to seize investment opportunities and achieve higher returns. In addition, overconfident managers believe that the current enterprise is undervalued, external financing costs are higher, and they tend to undertake internal financing. Therefore, managers tend to hold more cash for internal financing, which can reduce their continuous dependence on the capital market, and do not need to provide information to capital investment projects. Therefore, the results verify a direct positive correlation between managerial overconfidence and amount of cash.

Column (2) shows the influence of internal controls on the relationship between managerial overconfidence and cash holdings. The coefficient is -0.076 at the 5% level. The result shows a negative interaction effect between internal control and managers' overconfidence (OC*HIC), which is consistent with H2. This result indicates that the positive effect of managerial overconfidence on cash holdings may diminish in regions with more effective internal controls. Thus, effective internal controls can mitigate overconfident managers holding excess cash and assist them in making reasonable decisions in their daily operations. The results suggest that stronger internal control measures reduce overconfident managers' tendency to retain excessive cash. Companies mitigate cash dissipation from insider trading, alleviate the risk of failure from operational losses, and incur higher borrowing expenses. These findings strongly suggest that high-quality internal controls are internal risk-management mechanisms for cash holdings.

Table 4: Regression Test between Managers' overconfidence and Cash Holdings

VARIABLES	OC	OC*HIC
	CH	CH
OC	0.042***	0.114***
	(3.64)	(3.59)
HIC		0.054***
		(3.30)
OC*HIC		-0.076**
		(-2.40)
Du	0.001	-0.000
	(0.16)	(-0.03)
Div	0.025***	0.024***
	(7.97)	(7.88)
Size	-0.016***	-0.016***
	(-5.68)	(-5.63)
State	-0.026***	-0.026***
	(-5.66)	(-5.70)
CC	0.000***	0.000***
	(2.90)	(2.94)
MO	-0.001	-0.001
	(-0.32)	(-0.28)
Constant	0.477***	0.427***
	(6.52)	(5.71)
Observations	46,831	46,831
R-squared	0.086	0.088
Number of code	4922	4922
ind FE	YES	YES
Year FE	YES	YES

*Note: t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Table 1 provides comprehensive definitions of all the variables utilized in this study.*

4.4 Endogenous problem test

These findings may be affected by endogeneity problem. Therefore, this study uses GMM to mitigate the endogeneity problem and as a robust test method to support the main regression results. From table 5, it can be seen that the GMM regression shows a positive relationship for OC and CH at the 1% level with a coefficient of 0.158. In addition, OC*HIC indicates a negative relationship, with a coefficient of -0.441 at the 5% level. These results indicate that effective internal controls can mitigate overconfident managers holding excess cash, consistent with the base regression results. Consequently, regardless of high-quality internal controls can alleviate managers' overconfidence by addressing the agency problem and information asymmetry, allowing overconfident managers to make irrational and reasonable cash holding decisions.

Table 5: The regression for GMM

VARIABLES	OC	OC*HIC
	CH	CH
L.CH	0.454***	0.505***
	(8.04)	(8.53)
OC	0.158***	0.528**
	(3.20)	(2.34)
OC*HIC		-0.441**
		(-2.09)
HIC		0.220**
		(2.06)
Du	-0.001	-0.028
	(-0.09)	(-0.95)
Div	0.009**	0.019*
	(2.24)	(1.66)
Size	0.007*	0.007*
	(1.66)	(1.78)
State	0.027**	0.055***
	(2.00)	(2.95)
CC	0.000	-0.000
	(0.93)	(-0.28)
MO	-0.007	-0.008
	(-0.62)	(-0.57)
Constant	-0.168*	-0.394**
	(-1.72)	(-2.57)
Observations	5,180	5,180
Number of code	4839	4839
ar1	-7.635	-7.993
ar1p	0	0
ar2	0.482	0.414
ar2p	0.630	0.679
hansen	261.9	123.9
hansenp	0.119	0.227
N	45180	45180

*Note: z-statistics are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Table 1 provides comprehensive definitions of all the variables utilized in this study.*

4.5 Heterogeneity analysis

Effective internal controls improve information transparency. However, combining increased information transparency with effective incentives for executives is essential. This is because competitive market governance is driven by executive effort and decisions. If shareholders use adequate information to identify executives' abilities and efforts but do not provide them with proper incentives and rewards, executives will be pushed to leave the company or seek recompense through slackness.

The unique history of China's economic development has resulted in large differences in corporate governance between state-owned enterprises (SOEs) and non-SOEs. The executive incentive mechanisms of state-owned enterprises are less efficient than those of non-state-owned enterprises are. State-owned enterprise executives rely on executive appointments from senior authorities, weakening the incentive of competitors within enterprises to promote performance competition and restricting internal incentives for promotion. In addition, state-owned enterprises' increased social responsibility is the main tool for implementing macro-control and industrial policies, which are difficult to measure accurately. Although non-state enterprises primarily focus on corporate performance, the performance characteristics that facilitate the evaluation of executives' incentive mechanisms are relatively effective. This further weakens the incentive effect of the rewards on state-owned enterprise executives. Finally, state-owned enterprises have fewer financing constraints than non-SOEs. This is because state-owned enterprises with "natural blood" and more political ties are more likely to have access to government support and bank loans than private enterprises. Based on the above analysis, we propose the following hypothesis: internal control has a significant impact on the relationship between managerial overconfidence and cash holdings for non-state-owned enterprises.

Table 6 shows the results of the heterogeneity analysis of the nature of enterprises. It can be finding that effective internal controls have a significant correlation for the non-state-owned enterprises.

The moderating effects of OC*HIC shows a coefficient of -0.255at the 1% level. The findings indicate that strong internal control measures significantly reduce this positive association. Compared to state-owned enterprises, non-state-owned enterprises play a crucial role in reducing the correlation between managerial overconfidence and cash holdings.

Table 6: Heterogeneity analysis for nature of enterprises

VARIABLES	OC*HIC	
	State=1	State=0
	CH	CH
OC	0.048	0.304***
	(1.36)	(4.65)
HIC	0.022	0.169***
	(1.26)	(4.85)
OC*HIC	-0.037	-0.255***
	(-1.05)	(-3.95)
Du	0.006	-0.001
	(1.32)	(-0.10)
Div	0.012***	0.035***
	(3.56)	(5.69)
Size	-0.012***	-0.012**
	(-3.52)	(-2.07)
CC	0.000***	0.000
	(2.58)	(1.06)
MO	0.002	-0.002
	(0.59)	(-0.30)
Constant	0.328***	0.575***

	(3.66)	(3.44)
Observations	4,771	2,060
R-squared	0.107	0.157
Number of code	24777	24346
ind FE	YES	YES
Year FE	YES	YES

*Note: t-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1. Table 1 provides comprehensive definitions of all the variables utilized in this study.*

V. CONCLUSION AND CONTRIBUTION

This study examines whether overconfident managers affect an enterprise's cash holdings. In addition, this study connects internal governance (internal control) to examine whether effective internal control mitigate the positive relationship above. The empirical findings support these predictions. The results illustrate that high-quality internal controls mitigate the relationship between manager overconfidence and cash holding levels. At the same time, the heterogeneity analysis of the nature of enterprises is shown in this study, which illustrates that high-quality internal control and fierce product market competition have a significant influence on non-own-state companies. This means that high-quality internal control can alleviate overconfident managers holding excess cash and help managers make rational cash holding decisions.

This study presents a new research perspective on managers' overconfidence and cash holding levels, and expands the literature review. Traditional finance research on enterprise cash holdings has assumed that managers are rational. This study focused on the irrational characteristics of overconfident managers. It examines how this characteristic affects corporate cash, and the mechanism that incorporates behavioral finance to enhance the interpretation of the findings. In addition, this study enhances the research on internal and external governance mechanisms.
Although there are numerous studies on corporate governance and cash holdings, research on the impact of internal governance factors on the correlation between managers' confidence and the currency reserves of enterprises is scarce. Hence, this research not only enhances the understanding of internal control in relation to economic repercussions, but also contributes to the concern for external governance mechanisms of Chinese listed companies. Third, it provides valuable guidance for establishing a cash holding strategy for Chinese listed companies.

This study's findings have important implications for listed Chinese companies. First, Companies should pay more attention to the influence of managers' irrational psychological characteristics on their decision making and improve the internal control mechanism. Overconfident managers' irrational psychological characteristics signifi-cantly affect company management. This study reminds companies to develop a scientific and rigorous internal control mechanism when making decisions, rather than trusting managerial decisions. Effective internal controls can limit managers' overconfidence and cognitive bias. Establishing an internal control mechanism for managers is essential for preventing the negative impact of overconfident managers on company management. On one hand, companies should punish managers who deliberately harm the interests of investors and shareholders because of their overconfidence. Companies must determine suitable and stable financing methods based on their operations and developments. Second, companies should rationally assess the purpose of their cash holdings. Managers who satisfy their private interests experience a reduced performance. Effective response to changes in the external financing environment can improve corporate performance. Enterprises should promptly evaluate changes in the external competitive environment, clarify the purpose of formulating corresponding cash holding plans, and improve the value of enterprise cash holdings.

Similar to other empirical studies, this study has several limitations. First, due to the availability and validity of the data, we chose shareholding and earning changes as a measure of managerial overconfidence. However, we did not construct an overconfidence indicator based on board members' personal characteristics. Future research could consider establishing a more accurate measurement system based on managers' gender, age, work experience, educational background, and tenure as well as more accurately studying the impact of managers' overconfidence on industry competitive pressure and corporate cash-holding relationships. Second, this study explored only the impact of managerial overconfidence on the cash holding level of Chinese listed companies. Further studies are needed on the impact of managerial overconfidence on corporate cash holdings in different industries.

Ethical Compliance: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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I. INTRODUCTION

The rise of cryptocurrencies has dramatically transformed financial markets, presenting both opportunities and challenges for traders and researchers. These currencies, characterized by high volatility, a decentralized nature, a lack of traditional regulatory frameworks, rapid shifts in market sentiment, and varying levels of liquidity (Gurdgiev et al., 2019; Johnson, 2020; and Lee & L'heureux, 2020). They deviate significantly from the stable and regulated environments of traditional asset classes (Trabelsi, 2018; Kurka, 2019). Such dynamics often violate the core assumptions of stationarity and normal distribution that underpin traditional statistical methods in pairs trading (Luo et al., 2019; Tatsumura et al., 2023). Traditional statistical techniques to pair trading such as cointegration and mean-reversion methods, rely on linear assumptions and static connections between asset pairings (Avellaneda and Lee, 2010). Historically, these traditional techniques relied on the premise of market efficiency and stable relationships between asset prices (Shin et al., 2023; Jeon & Kim, 2022; Lv et al., 2023; Coskun et al., 2023; Gupta et a., 2018). While they are effective for conventional assets like equities and commodities, these approaches falter in cryptocurrency markets due to their inherently dynamic and nonlinear nature. For instance, the high-frequency trading landscape of cryptocurrencies amplifies price movements, making it challenging for static models to adapt to

sudden and drastic changes in asset correlations. This often results in missed opportunities or increased risks, particularly during periods of market dislocation. Cryptocurrency markets thus have emerged as a fertile ground for algorithmic trading strategies, including pairs trading, which aims to exploit mispricing between asset pairs in a market-neutral manner (Fang et al., 2022 and Gatev et al., 2006). Specifically, Machine learning has emerged as a transformational approach for identifying complicated patterns and making dynamic modifications to trading strategies (Pandya, 2024).

Clustering algorithms, a type of unsupervised machine learning techniques, have shown to be very useful for pair trading strategies (Sarmento & Horta, 2020). By clustering cryptocurrencies based on similar traits, these algorithms can find hidden links that standard measures like correlation or cointegration may not reveal (Lorenzo & Arroyo, 2022). In particular, techniques such as k-means, hierarchical clustering, and density-based spatial clustering of applications with noise (DBSCAN) provide distinct benefits for detecting groups of assets with similar behavioural patterns (Jain, 2010). For example, k-means clustering is commonly utilized due to its simplicity and scalability, allowing traders to categorize cryptocurrencies based on price movements, trading volumes, or blockchain-specific indicators (Schmidt, 2024). Hierarchical clustering, on the other hand, generates a dendrogram representation of layered linkages between assets, which is useful for finding multi-level dependencies inside clusters (Murtagh & Contreras, 2012). DBSCAN is especially successful in dealing with the noisy, high-dimensional data seen in cryptocurrency exchanges since it separates outliers and discovers clusters of various forms (Ester et al., 1996).

Clustering-driven pair trading algorithms frequently use cryptocurrency-specific information such as blockchain transaction data, network activity, and developer activity indicators to increase clustering accuracy and forecast performance (Panigrahi et al., 2022). Clustering based on blockchain transaction data, for example, might indicate currencies that are widely traded together, suggesting underlying user behaviour or market dynamics (Lorenzo & Arroyo, 2022). Further, using sentiment analysis from social media platforms such as Twitter or Reddit improves clustering models by incorporating market sentiment into trading choices (Bollen et al., 2011). Advances in deep clustering algorithms, which combine clustering and deep learning techniques, hold significant potential for cryptocurrencies by allowing feature extraction and grouping to occur concurrently, boosting the resilience of trading strategies.

Furthermore, clustering algorithms are critical in tackling major issues in pairs trading, such as selecting ideal trading pairs and dynamically adapting strategies to market fluctuations (Aldridge, 2013). Adaptive clustering approaches, which enable real-time re-clustering of assets in response to changing market conditions, guarantee that trading pairs stay relevant in turbulent situations (Shivaraman, 2023). By constantly updating clusters, traders can catch ephemeral correlations and profit from short-term mispricing (Visagie, 2017). Reinforcement learning frameworks using clustering as a pre-processing step have shown enhanced performance in pairs trading because they allow the model to learn from past data while reacting to changing market conditions (Zong, 2021).

Clustering algorithms play a vital role in cryptocurrencies data analysis, as they provide insights into market dynamics, determine risky assets, and improve decision-making. They simplify data complexity, discover transactional trends for profiling, and enable real-time analysis via dimensionality reduction. Furthermore, clustering aids strategic planning by combining cryptocurrencies with similar on-chain properties, exposing market trends (Zekiye et al., 2023; Shin et al., 2019; Guo et al., 2019). Despite its benefits, clustering algorithms encounter issues such as susceptibility to noisy and missing data, which are common in cryptocurrencies transactions, resulting in inefficient clustering (Shah et al., 2021). They are computationally demanding, particularly when working with huge blockchain datasets, needing scalable frameworks (Shah et

al., 2021). Furthermore, understanding clustering results in high-dimensional datasets may be difficult, and the success of clustering is heavily dependent on the method and its parameters, such as the predetermined number of clusters in K-means (Guo et al., 2019; Shin et al., 2019). In addition, regulatory uncertainty and the danger of market manipulation add to the complexity, emphasizing the importance of comprehensive risk management frameworks when implementing clustering-based methods (Makarov & Schoar, 2020).

In summary, clustering algorithms are an effective tool for improving pairs trading techniques in the cryptocurrency market, allowing you to uncover and exploit intricate correlations between assets in a dynamic, high-volatility environment. These solutions have considerable potential for academic research and practical implementation because they capitalize on the unique characteristics of cryptocurrencies and use modern machine learning techniques. This study therefore aims to leverage the capabilities of clustering algorithms to conduct a comprehensive analysis of the daily prices of top 50 cryptocurrencies in the market. Especially, this study aims to find viable pairs for a pairs trading strategy by identifying clusters of cryptocurrencies with similar properties. The findings are likely to help design more robust and flexible trading platforms, as well as further the incorporation of machine learning into the fast-developing cryptocurrency market.

II. LITERATURE REVIEW

According to contemporary financial literature, pairs trading has become a prominent market-neutral approach that is gaining appeal in the cryptocurrency sphere due to the asset class's volatility and inefficiency. Recent research has offered insights into a variety of statistical methodologies for improving pairs trading tactics in cryptocurrency markets. These strategies pick ideal trading pairings using statistical qualities including cointegration, correlation, and mean reversion. For example, Ko et al. (2023) investigated six statistical techniques for pair trading in cryptocurrency marketplaces, including cointegration, correlation, and clustering. The study found that clustering-based methods outperformed traditional strategies in finding optimal trading pairs, resulting in solid profits even during periods of high volatility. In addition, Leung and Nguyễn (2018) developed a strategy for creating cointegrated cryptocurrency portfolios using the Johansen and Engle-Granger tests. Their research focused on assets like Bitcoin, Ethereum, and Litecoin, demonstrating the profitability of cointegration-based strategies even in tumultuous markets. They tested several configurations and discovered that strategies with stop-loss limitations produced superior risk-adjusted returns. Furthermore, Ntsaluba (2019) used evolutionary algorithms and artificial neural networks to predict directional changes in Bitcoin, Ethereum, and Ripple. The hybrid strategy was compared to statistical methods such as moving averages, displaying higher prediction accuracy and profitability.

More so, Long-short strategies, designed to exploit mispricing in financial markets, are increasingly applied in cryptocurrency trading. These strategies involve taking long positions on undervalued assets and short positions on overvalued ones, with the goal of achieving market-neutral returns. There are several recent research that highlights the theoretical and practical applications of long-short strategies in cryptocurrency markets. For instance, Nair (2021) examines long-short pairs trading in cryptocurrencies, employing methods such as correlation analysis, distance approaches, stochastic return differentials, and cointegration. This study shows that long-short portfolios consistently outperform long-only strategies, offering cumulative returns that question the efficiency of cryptocurrency markets. The research emphasizes the inverse relationship between correlation coefficients and trading pair distances, providing a foundation for constructing market-neutral portfolios. Ahroum and Achchab (2019) investigate long-short strategies in Islamic finance markets, including cryptocurrencies. Using wavelet theory for time-scale decomposition, the study identifies significant risk premiums that can be captured through

long-short portfolios, presenting a novel application for alternative asset classes. Further, Kim and Lee (2019) analyse the effect of shorting costs on long-short arbitrage strategies. Their findings reveal that these costs can reduce gross returns by up to 40%, significantly impacting profitability. This study highlights the importance of incorporating transaction costs and shorting constraints when designing long-short strategies in volatile markets like cryptocurrencies. Kessler and Gladchenko (2018) investigate the integration of multiple investment signals for constructing long-short portfolios. The study compares methodologies that combine weights from individual signals versus an integrated approach to signal combination. While primarily applied to traditional assets, the findings offer insights into optimizing strategies in cryptocurrency markets.

Furthermore, Machine learning (ML) is revolutionizing pair selection strategies in cryptocurrency trading by enhancing predictive accuracy and improving portfolio optimization. There are many studies highlighting ML applications and innovations in this domain. For example, Chen et al. (2022) proposed a machine learning-assisted method for selecting trading pairs across stocks and cryptocurrencies. By applying clustering algorithms, the model effectively combined asset classes to enhance diversification and reduce trading. Guijarro-Ordonez et al. (2021) propose a deep learning framework for statistical arbitrage that employs convolutional transformers to identify temporal price patterns and optimize trading portfolios. Although primarily tested on equities, the methodology offers insights into machine learning-driven pair selection for cryptocurrencies. Additionally, Zhang et al. (2022) apply ML techniques to momentum-based statistical arbitrage. The study demonstrates that ML models outperform traditional momentum strategies in identifying profitable asset pairs, providing a robust framework for cryptocurrency applications. Leung and Tam (2021) use elastic-net regression to construct replicated portfolios of peer assets, optimizing factor hedging and statistical arbitrage risk premiums. Their approach is adaptable to cryptocurrencies, where peer asset selection is critical. Beyond that, Huck (2019) investigates ML applications to large data sets for statistical arbitrage. The study highlights clustering algorithms for dynamic pair selection, with potential applications in high-frequency cryptocurrency trading. Also, Zhan et al. (2021) explore arbitrage opportunities using ML models for pair selection. The findings suggest that ML enhances the identification of temporary inefficiencies in cryptocurrency pairs, improving trading outcomes.

The application of clustering techniques in cryptocurrency market dynamics has gained momentum as traders and researchers seek to understand patterns, segment markets, and improve predictive models. The current literature indicates that by incorporating machine learning clustering algorithms, traders aim to refine pair selection and optimize trading strategies. For example, Cen et al. (2022) introduced a temporal clustering method for financial time series, enabling better feature extraction from market data. Although applied to traditional assets, this approach has implications for improving pair selection in cryptocurrency trading. Aspembitova et al. (2021) use k-means clustering and Support Vector Machines (SVM) to identify user behaviours in Bitcoin and Ethereum markets. They uncover four distinct behavioural types: optimists, pessimists, positive traders, and negative traders. This segmentation reveals differences in market views and strategies between Bitcoin and Ethereum users during local price fluctuations and systemic events. Likewise, Lorenzo and Arroyo (2022) apply prototype-based clustering techniques to analyse the cryptocurrency market. Their methods, including k-means and other clustering algorithms, provide insights into market segmentation and trading patterns. Further, Hachicha et al. (2023) investigate herding behaviour and its impact on price clustering within cryptocurrency markets. Their findings suggest that behavioural tendencies influence price patterns, presenting opportunities for predictive modelling. Besides, Guo et al. (2019) develop a dynamic network model to assess market segmentation and clustering in cryptocurrency trading. By identifying latent

communities, the study demonstrates how return predictability and crypto-specific features like hashing algorithms influence market behaviour. Recently, Soltani et al. (2023) employed time-frequency clustering to study the connectedness between investor sentiment, cryptocurrency markets, and external factors like the COVID-19 pandemic. Their results reveal behavioural contagion and volatility clustering during crisis periods.

III. GAP OF THE STUDY

Based on the reviewed studies, the following gaps emerge that need addressing to fulfill the stated objective. Firstly, most studies focus on a limited subset of cryptocurrencies, such as Bitcoin, Ethereum, or Litecoin. While these assets are widely studied, the broader market comprising the top 50 cryptocurrencies remains underexplored, especially in terms of pair selection for trading strategies. The current study in hand focus on the top 50 cryptocurrencies can provide a broader and more representative understanding of clustering patterns and trading opportunities across the cryptocurrency market. Secondly, as we know cryptocurrency markets are highly volatile and rapidly evolving, yet there is limited research on adaptive models that dynamically update pair selection strategies in response to market shifts. Thus, by leveraging adaptive clustering methods, the current study can propose frameworks that adjust to evolving market conditions, offering real-time utility for traders in the cryptocurrencies industry. Thirdly, the reviewed studies often use shorter timeframes or limited datasets, which may not fully capture long-term patterns and structural shifts in the cryptocurrency market. By analysing daily prices of the top 50 cryptocurrencies over an extended period, the current study in hand can provide a more comprehensive dataset for clustering and trading strategy development. Therefore, by addressing these gaps, the study will significantly advance the understanding and application of clustering algorithms in cryptocurrency trading, contributing both theoretical and practical insights to the field.

IV. METHODOLOGY

4.1 Data and Data sources

This study aims to conduct a clustering analysis on the top 50 cryptocurrencies in the crypto market to identify potential pairs for a pairs trading strategy. The dataset, sourced from Yahoo Finance using pandas_datareader, comprises daily closing price data in USD spanning from January 1, 2021, to November 11, 2024. This study emphasizes price pattern behavior as the key predictor of future cryptocurrency market trends, volatility, and returns, based on the premise that, according to the Efficient Market Hypothesis (EMH), asset prices already reflect all relevant information. Therefore, historical price movements alone are sufficient for analyzing and identifying clusters in market trends and investor behavior, without the need for external factors such as trading volume or sentiment. Furthermore, the period 2021–2024 was chosen as the cryptocurrency industry experienced significant volatility, market booms and crashes, alongside increasing institutional adoption, regulatory crackdowns, technological milestones, and emerging innovations, setting the stage for a more mature and resilient market. In addition, the top 50 cryptocurrencies were selected based on their market capitalization and their daily trading volume. This metric was chosen because it reflects the relative size, and prominence of each cryptocurrency in the market, ensuring the inclusion of actively traded assets and providing a comprehensive representation of the industry's leading assets. Six cryptocurrencies were excluded from the analysis due to incomplete data for the entire study period. These excluded currencies are SHIB, UNI1 ICP, COMP, GRT, and LUNA1. The remaining 43 cryptocurrencies, including BTC, ETH, BNB, XRP, ADA, DOGE, SOL, DOT, MATIC, LTC, AVAX, TRX, ATOM, XMR, LINK, XLM, BCH, ALGO, VET, FIL, EGLD, MANA, SAND, THETA, XTZ, AAVE, AXS, FTM, KSM, RUNE, ZEC, MKR, CAKE, ONE, BAT, BTT, ZIL, NEO, WAVES, DASH, ENJ, QTUM, and OMG, were included for further analysis.

4.2 Method of Analysis

To achieve its objective, this study employed unsupervised clustering techniques within machine learning. The analysis involved several steps. First, the process began with loading the dataset and essential Python packages (Appendix I), including libraries for data loading, analysis, preparation, and model evaluation. These packages were utilized throughout various stages of model development.

Second, an exploratory data analysis (EDA) was conducted, incorporating descriptive statistics to examine data structure and visualization techniques to assess post-clustering patterns. Third, data preparation for modeling was undertaken, starting with data cleaning to address missing values (either removing rows with NAs or imputing them with column means). This step ensured a reliable and clean dataset for clustering. Data transformation followed, focusing on daily returns and variance as variables, as they are key indicators of cryptocurrency performance and volatility. The StandardScaler from sklearn was applied to standardize features to a unit scale (mean = 0, variance = 1), ensuring all variables were on the same scale to avoid bias in clustering outcomes.

Fourth, after data preparation, clustering algorithms were explored and visualized. The study evaluated models such as k-means, hierarchical clustering (agglomerative clustering), and affinity propagation, applied to group the remaining 43 top cryptocurrencies in the market. These models were selected for their ability to identify distinct cryptocurrency clusters with different volatility patterns and trading behaviours. Finally, pair selection was performed, where the study scanned cryptocurrencies within each cluster and tested for cointegration between pairs. Once pairs were identified, the results were visualized, enabling their use in a pairs trading strategy.

V. ANALYSIS AND FINDINGS

Descriptive Statistics: In the descriptive statistics, the study looks into the shape of the data where the output result indicates that (1411 raw, 43 column), and the mean, Standard deviation, Min, 25%, 50%, 75% and Max (Appendix I). Then correlation between the variables in the study was conducting

Data Visualization: Visualizing data is one of the quickest ways to gain insights into it. This process involves examining each attribute in the dataset individually to better understand its characteristics. Key tools for this include the correlation matrix and scatter plot, which help reveal relationships within the data. The correlation matrix calculates and displays the correlation between every pair of variables. This not only highlights the relationship between independent and dependent variables but also reveals correlations among the independent variables. Understanding these relationships is essential, as highly correlated input variables can negatively impact the performance of certain machine learning algorithms, such as linear and logistic regression. However, a pairs trade strategy relies on the historical correlation between two assets, requiring a strong positive correlation between them. This correlation serves as the key factor driving the strategy's profitability. The correlation matrix results, presented in Appendix (II), indicate a strong correlation between the daily returns of cryptocurrencies, along with a significant negative correlation among the returns of various cryptocurrencies in the market. Additionally, the study uses a scatterplot matrix to visualize relationships between all regression variables. By examining the scatterplot (Appendix III), some linear relationships with the predicted variable are observed, providing further insights into the data.

4.1 Algorithms and Models and their Evaluation

Following Tatsat et al (2020), this study employed clustering algorithms to identify pairs of cryptocurrencies suitable for a pairs trading strategy. Three clustering techniques were utilized: k-means Clustering, Hierarchical Clustering, and Affinity Propagation Clustering. The outcomes of these techniques are visualized and analysed in this section.

4.2 k-means Clustering

k-means is one of the most widely recognized clustering techniques. Its primary objective is to identify and group data points into clusters with high internal similarity. The algorithm works by defining k clusters and minimizing the total variation (or error) within these clusters (Tatsat et al., 2020). To determine the optimal number of clusters, two methods were applied: the Elbow method, which relies on the sum of squared errors (SSE) within clusters, and the Silhouette method, which evaluates cluster quality using the silhouette score (Shi et al., 2021; and Hamka, & Ramdhoni, 2022). Their outputs are presented in Chart (1) and (2). Examining the previous charts, the optimal number of clusters appears to be around five. As the number of clusters increases beyond five, the within-cluster SSE (Sum of Squared Errors) begins to level off. In other words, the "elbow" in the SSE chart is noticeable at approximately five clusters. While other points in the graph may show slight kinks, the SSE difference becomes minimal after five clusters, making it reasonable to proceed with this number for the k-means model.

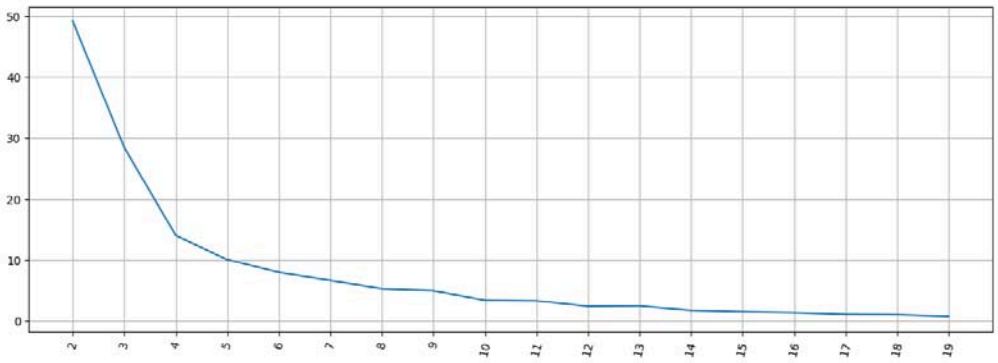


Chart (1): squared errors (SSE) within clusters

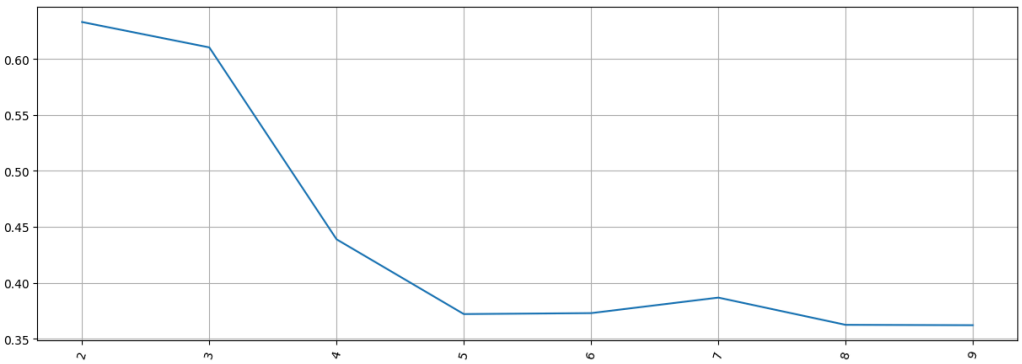
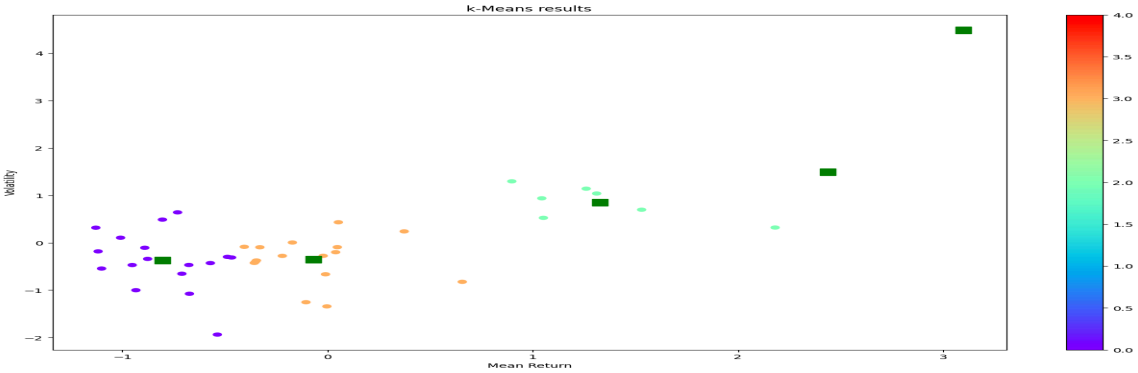


Chart (2): Silhouette score

Furthermore, the study explores how clusters form within a dataset containing a large number of variables. One way to visualize clusters in a two-dimensional space is through a simple scatterplot. The Chart (3) below displays the number of clusters and their distinct separation. In the plot, we can observe distinct clusters differentiated by colours, with the data points grouped fairly well. The centroids of these clusters, represented by square markers, also show clear separation, indicating a good clustering outcome.



The Chart (3): Displays the number of clusters and their distinct separation for k-means Clustering model

The diagram (1) illustrates the number of cryptocurrencies within each cluster, ranging from approximately 2 to 16. While the distribution is uneven, each cluster contains a substantial number of cryptocurrencies.

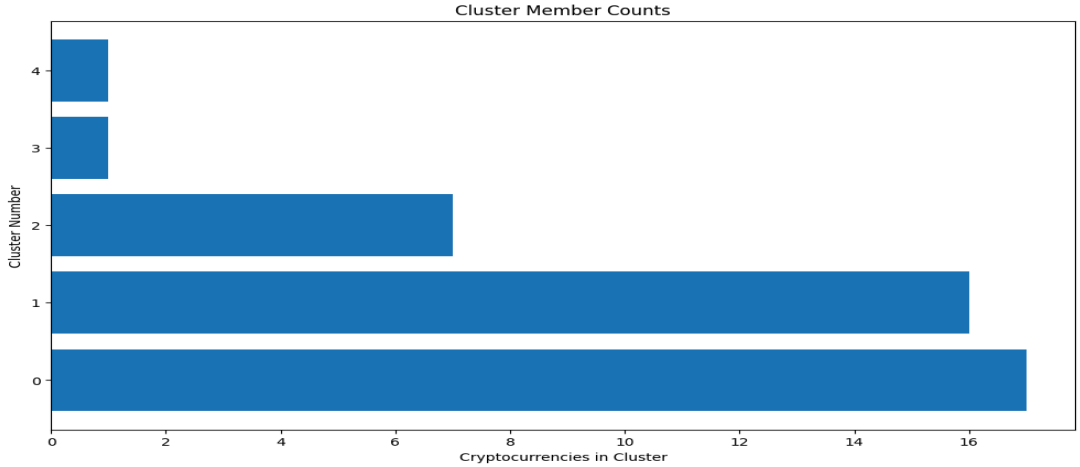


Diagram (1): Illustrates the number of cryptocurrencies in each cluster

4.3 Hierarchical Clustering

Hierarchical clustering organizes data into clusters with a clear top-to-bottom structure (Tatsat et al., 2020). Its advantages include ease of implementation, no need to predefine the number of clusters, and the ability to generate dendrograms that provide valuable insights into the data (Tatsat et al., 2020). However, interpreting dendrograms to determine the optimal number of clusters can be challenging for large datasets (Tatsat et al., 2020). In this study, we employed the agglomerative clustering algorithm, utilizing a dendrogram to analyse the data. The dendrogram displays a cluster tree, where the leaves represent individual cryptocurrencies, and the root represents the final, unified cluster. Setting a threshold cut at .8 resulted in 14 distinct clusters which are [array ([2, 1, 3, 5, 14, 12, 9, 11, 8, 6, 7, 10, 13, 4], dtype=int32)]. Chart (4) illustrates the dendrogram output from hierarchical clustering, where the distances between data points indicate dissimilarities, and the block heights reflect the distances between clusters.

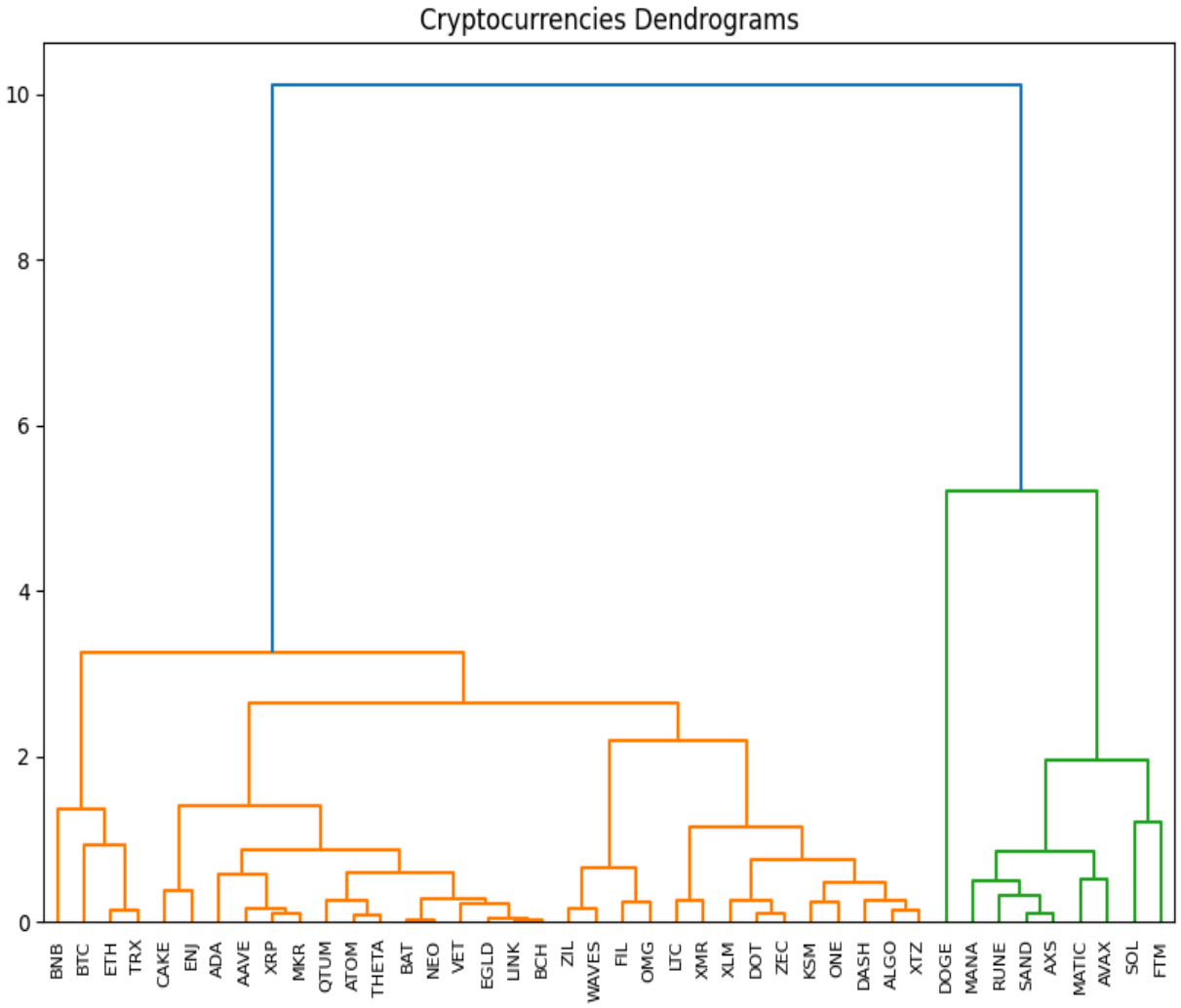


Chart (1): Illustrates the dendrogram output of cryptocurrencies

The study develops a hierarchical clustering model with 14 clusters and presents the results visually. As shown in Chart (5), the visualization reveals distinct clusters, similar to the k-means clustering plot, with each cluster distinguished by different colours.

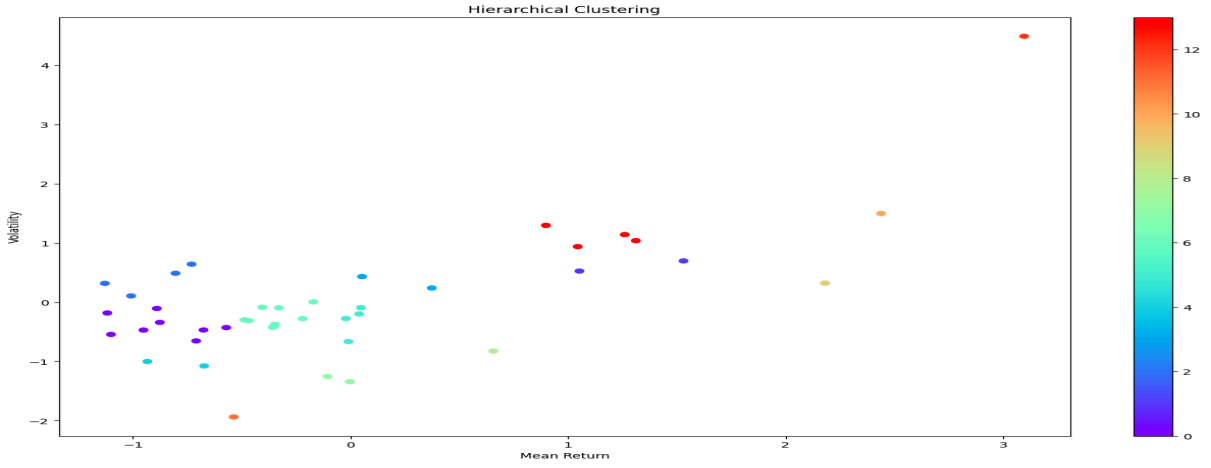


Chart (5): Illustrates the number of clusters for Hierarchical Clustering algorithm

4.4 Affinity Propagation Clustering

Affinity propagation creates clusters by exchanging messages between data points until a stable configuration is achieved (Tatsat et al., 2020). Unlike methods such as k-means, it does not require specifying or estimating the number of clusters beforehand (Tatsat et al., 2020). The results of the affinity propagation clustering, illustrated in Chart (6), reveal several distinct clusters represented by different colours. Additionally, Chart (7) provides further visualization, showing that the cryptocurrencies under study are divided into seven clusters. Using the configured hyperparameters, the affinity propagation model produced significantly more clusters compared to k-means and hierarchical clustering. While the results highlight clear groupings, the higher number of clusters has also led to increased overlap.

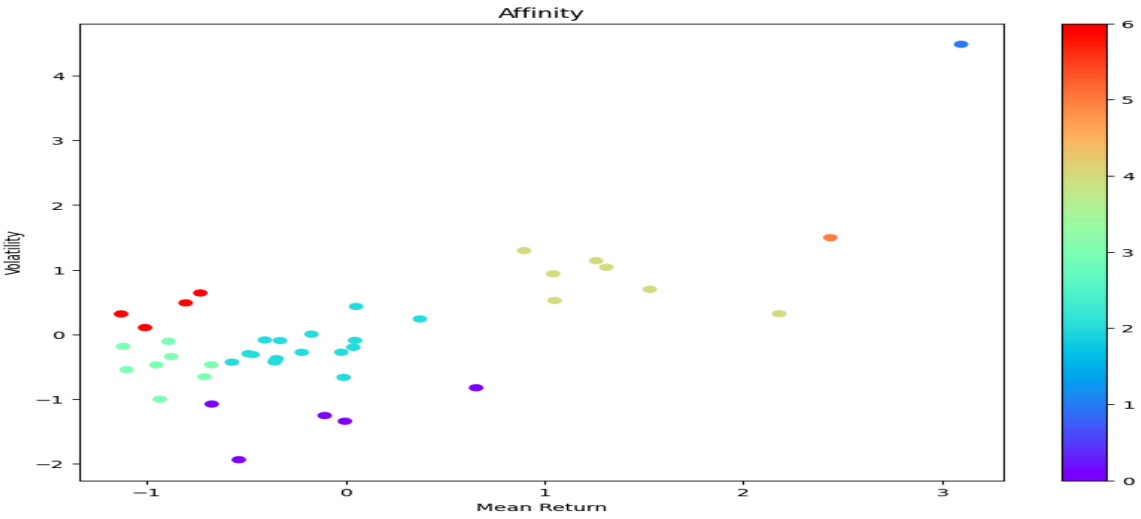


Chart (6): Affinity Propagation Clustering output

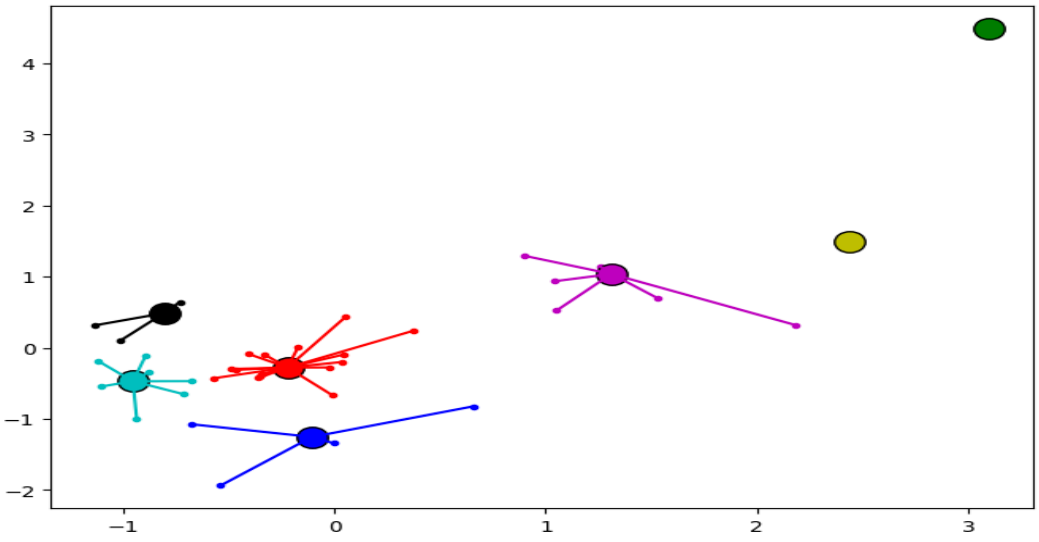


Chart (7): Shows the number of clusters under Affinity Propagation Algorithm

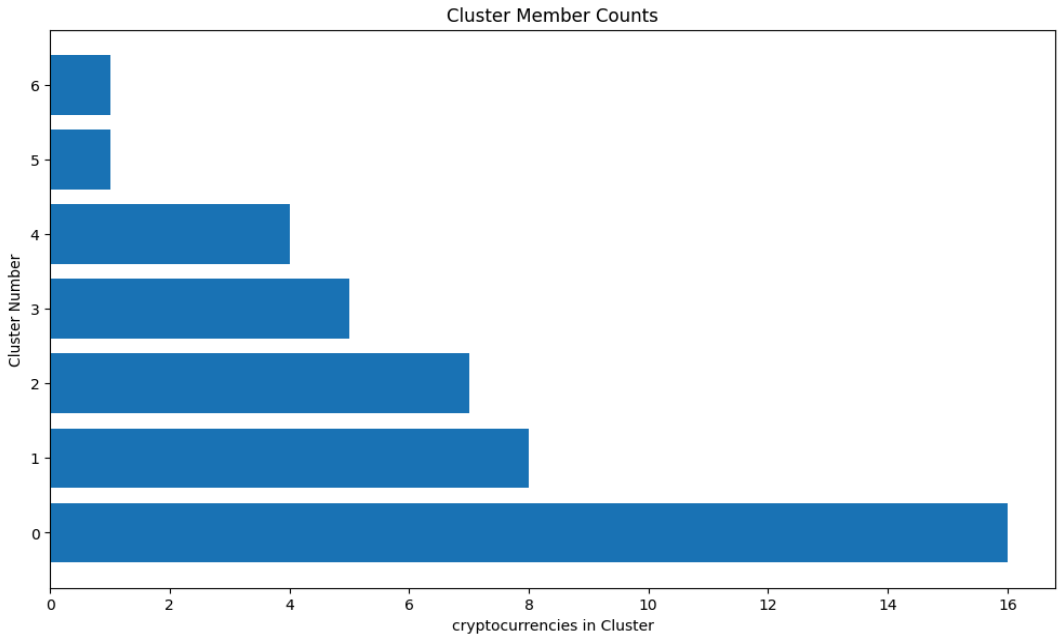


Diagram (2): Illustrates the number of cryptocurrencies in each cluster

The diagram shows the number of cryptocurrencies in each cluster, varying from around 2 to 16. Although the distribution is not uniform, every cluster holds a significant number of cryptocurrencies.

In the next stage, we will assess the performance of these clustering techniques. The silhouette coefficient serves as a tool for evaluating performance, with higher scores indicating more well-defined clusters (Tatsat et al., 2020). This metric is calculated for each of the clustering methods mentioned earlier, and the evaluation results are presented below.

km 0.3107887958879484

hc 0.3569912941484719

ap 0.3758087559209252

Since affinity propagation delivers the best performance, we will proceed with this method and utilize 7 clusters as determined by its clustering approach.

VI. VISUALIZING THE RETURN WITHIN A CLUSTER

The analysis employs a clustering technique and determines the final number of clusters. However, it is crucial to assess whether the clustering produces meaningful results. To evaluate this, the study visualizes the historical behaviour of cryptocurrency returns within these clusters, as illustrated in the following Charts (8). These charts reveal consistent movements and patterns in the returns of cryptocurrencies across all clusters, regardless of the number of cryptocurrencies involved. This consistency confirms the effectiveness of the clustering approach and may indicate cointegration among such cryptocurrencies in the market.

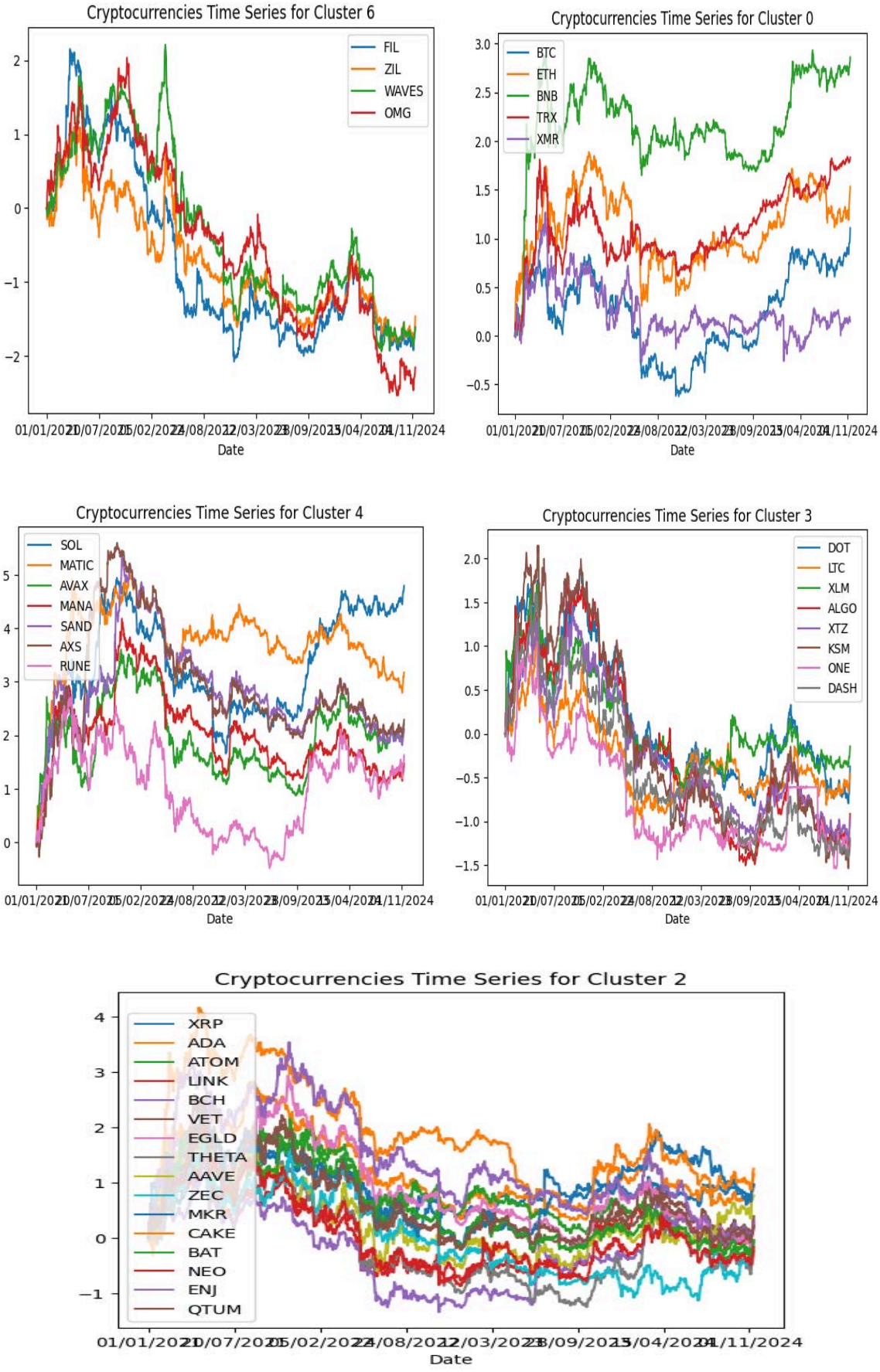


Chart (8): Visualizes the historical behaviour of cryptocurrency returns within these clusters

6.1 Pairs selection

After forming the clusters, various cointegration-based statistical methods can be utilized to identify cryptocurrency pairs within each cluster. Cointegration occurs when two or more non-stationary time series move together over time. The presence of cointegration can be confirmed using statistical techniques such as the Augmented Dickey-Fuller test and the Johansen test. In this stage, we analyse the cryptocurrencies within a cluster by testing for cointegration between potential pairs. To do this, we create a function (as detailed in the Appendix I) that generates a cointegration test score matrix, a p-value matrix, and identifies pairs with a p-value below 0.05.

Output:
The results of the pair selection analysis revealed 21 pairs, encompassing 24 unique tickers. A detailed list of these pairs is provided below.

[(XRP, ADA), (XRP, ATOM), (XRP, LINK), (XRP, BCH), (XRP, VET), (XRP, EGLD), (XRP, THETA), (XRP, AAVE), (XRP, ZEC), (XRP, MKR), (XRP, BAT), (XRP, NEO), (XRP, ENJ), (XRP, QTUM), (DOT, ALGO), (DOT, XTZ), (DOT, KSM), (DOT, DASH), (FIL, ZIL), (FIL, WAVES), and (FIL, OMG)].

6.2 Pair Visualization

This section presents the outcomes of the pair selection process. For detailed steps regarding pair visualization using the t-SNE technique, refer to the Jupyter notebook in Appendix (I). The chart (9) highlights the effectiveness of k-means in identifying unconventional pairs (marked with arrows in the visualization), indicating the presence of a long-term stable relationship between cryptocurrency price movements. These identified pairs can be utilized in a pairs trading strategy. When the prices of a cryptocurrency pair deviate from their established long-term relationship, an investor could take a long position in the underperforming cryptocurrency while shorting the outperforming one. Profits are realized when the prices revert to their historical relationship. In other words, a profit is made from the convergence of the prices.

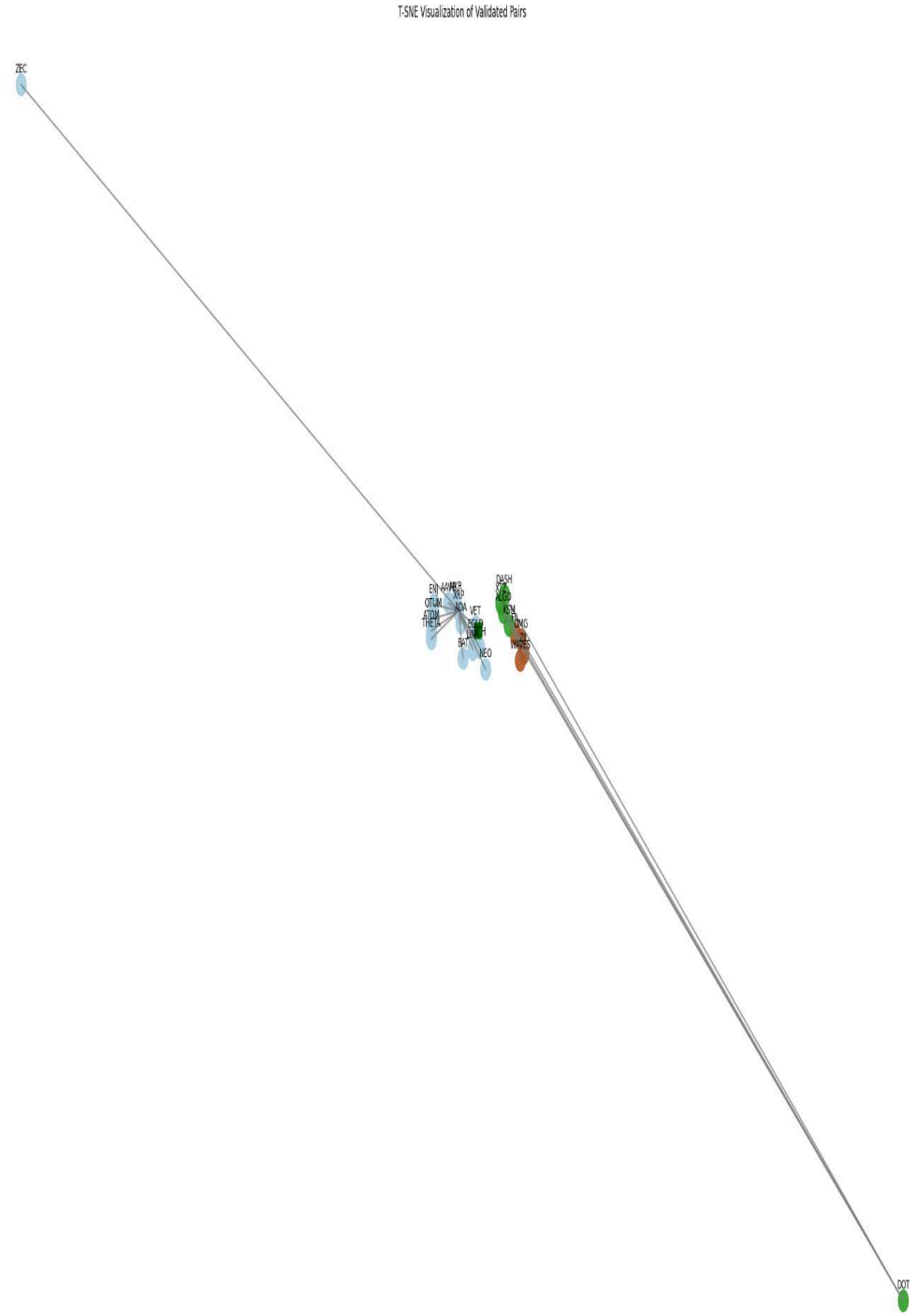


Chart (9): The effectiveness of k-means in identifying unconventional pairs

VII. CONCLUSION AND RECOMMENDATIONS

This study addresses the challenges posed by the high volatility and dynamic nature of cryptocurrency markets to traditional pairs trading strategies, which rely on static and linear assumptions. By employing machine learning clustering algorithms—specifically k-means, hierarchical clustering, and affinity propagation—the study enhances pair selection in pairs trading by uncovering latent relationships

among cryptocurrencies. The primary objectives were to leverage clustering algorithms to group cryptocurrencies based on similar behavioural price patterns, identify cointegrated pairs for trading, and evaluate the performance of these models in addressing market volatility and enhancing trading robustness. The methodology involved comprehensive steps, including data preprocessing, exploratory data analysis, clustering using unsupervised machine learning techniques, and cointegration testing to finalize trading pairs.

The main findings reveal that clustering algorithms are effective in grouping cryptocurrencies based on shared characteristics of price patterns and volatility, with affinity propagation outperforming other methods in cluster definition and robustness. This is because affinity propagation is more effective than k-means and hierarchical clustering in certain scenarios due to its ability to automatically determine the number of clusters by selecting representative data points (exemplars) based on a similarity matrix, without requiring prior assumptions. Unlike k-means, it can handle clusters of arbitrary shape, is not sensitive to initialization, and is more robust to outliers. Compared to hierarchical clustering, affinity propagation avoids chaining effects and arbitrary cut-off decisions. It also allows flexible similarity measures and performs well with high-dimensional data. In addition, the findings indicate that twenty-one cointegrated pairs were identified, highlighting significant trading opportunities. These findings underscore the potential of clustering algorithms to improve trading strategies, address market volatility, and adapt to dynamic market conditions.

The practical implications include advancing trading strategies for cryptocurrencies investors by incorporating machine learning clustering algorithms to enhance market efficiency and profitability. In which, a clustering-based pairs trading strategy can enhance cryptocurrency trading by dynamically identifying pairs with strong relationships, such as XRP and ADA, based on historical price movements and market similarities. Unlike traditional methods that rely on fixed correlations, clustering enables traders to capitalize on temporary price divergences more effectively. For example, when XRP's price drops relative to ADA, the trader can buy XRP and short ADA, expecting convergence. This approach improves pair selection, enhances profitability, and reduces risk by capturing nuanced market dynamics, providing a data-driven edge over traditional strategies. In addition, policymakers are encouraged to develop regulatory frameworks that support the integration of advanced technologies in financial markets. For example, regulatory frameworks can support clustering techniques in algorithmic trading by addressing challenges like market manipulation and ensuring ethical use of machine learning. These frameworks could include real-time monitoring systems to detect suspicious patterns, mandates for algorithm transparency and explainability, data governance guidelines to prevent bias, pre-deployment testing to certify model compliance, and collaboration on standardizing clustering methodologies. Such measures would enhance market integrity, transparency, and stability while mitigating risks associated with algorithmic trading. The theoretical contributions involve bridging gaps in the literature by extending the application of clustering algorithms to a broader dataset of cryptocurrencies over an extended period, highlighting adaptive and multidimensional clustering models for trading strategy development.

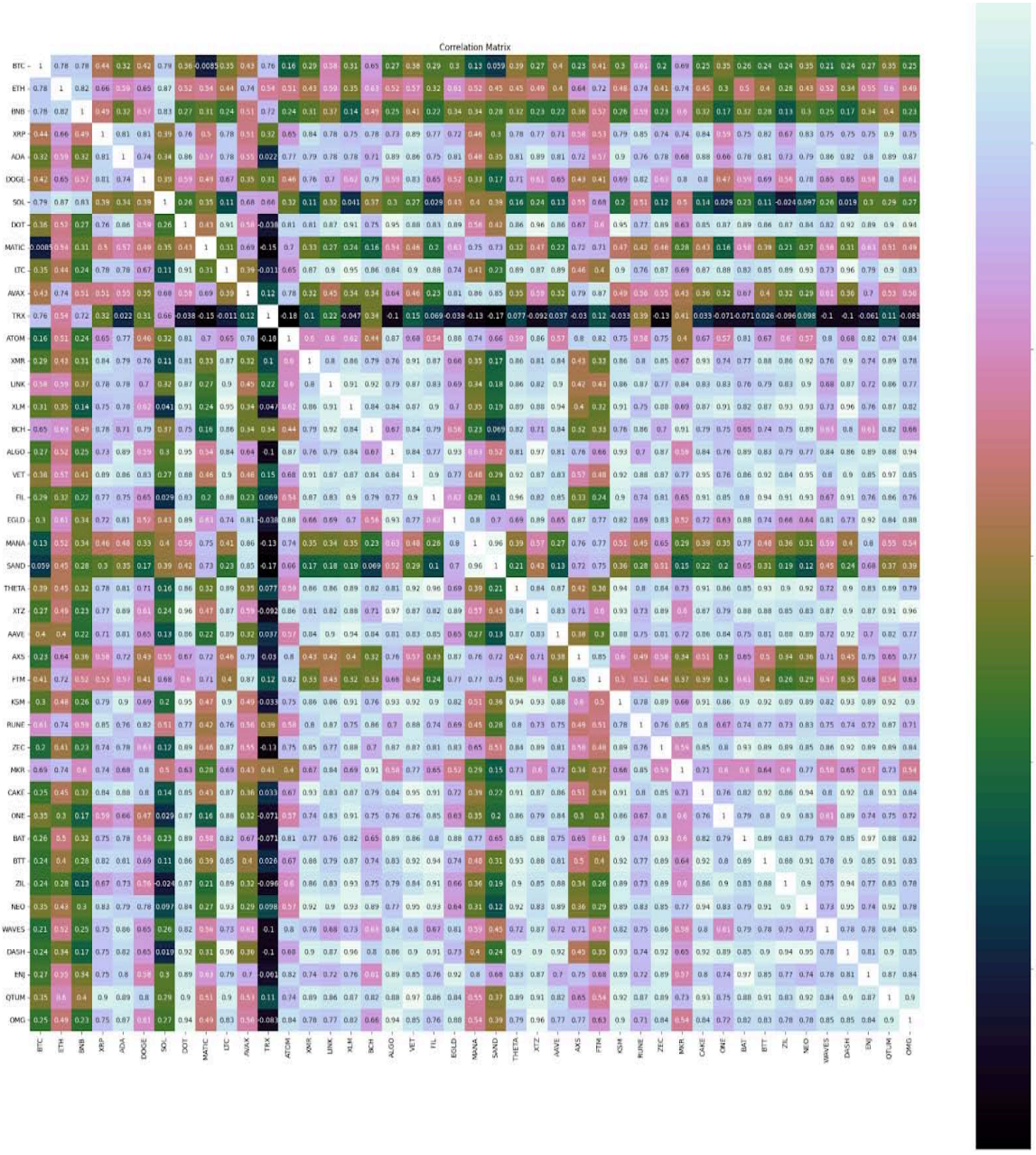
7.1 Recommendations for future researcher

Future research could expand upon existing clustering studies, which predominantly focus on limited attributes such as historical prices or volatility. There is a significant gap in approaches that incorporate a broader range of data, including network activity (e.g., transaction volumes and fees), technological features (e.g., consensus mechanisms), and social sentiment metrics. Integrating clustering algorithms to classify cryptocurrencies based on multidimensional attributes—such as price, volatility, liquidity, user sentiment, trading patterns, transaction volume, fees, and blockchain characteristics—could yield valuable insights for

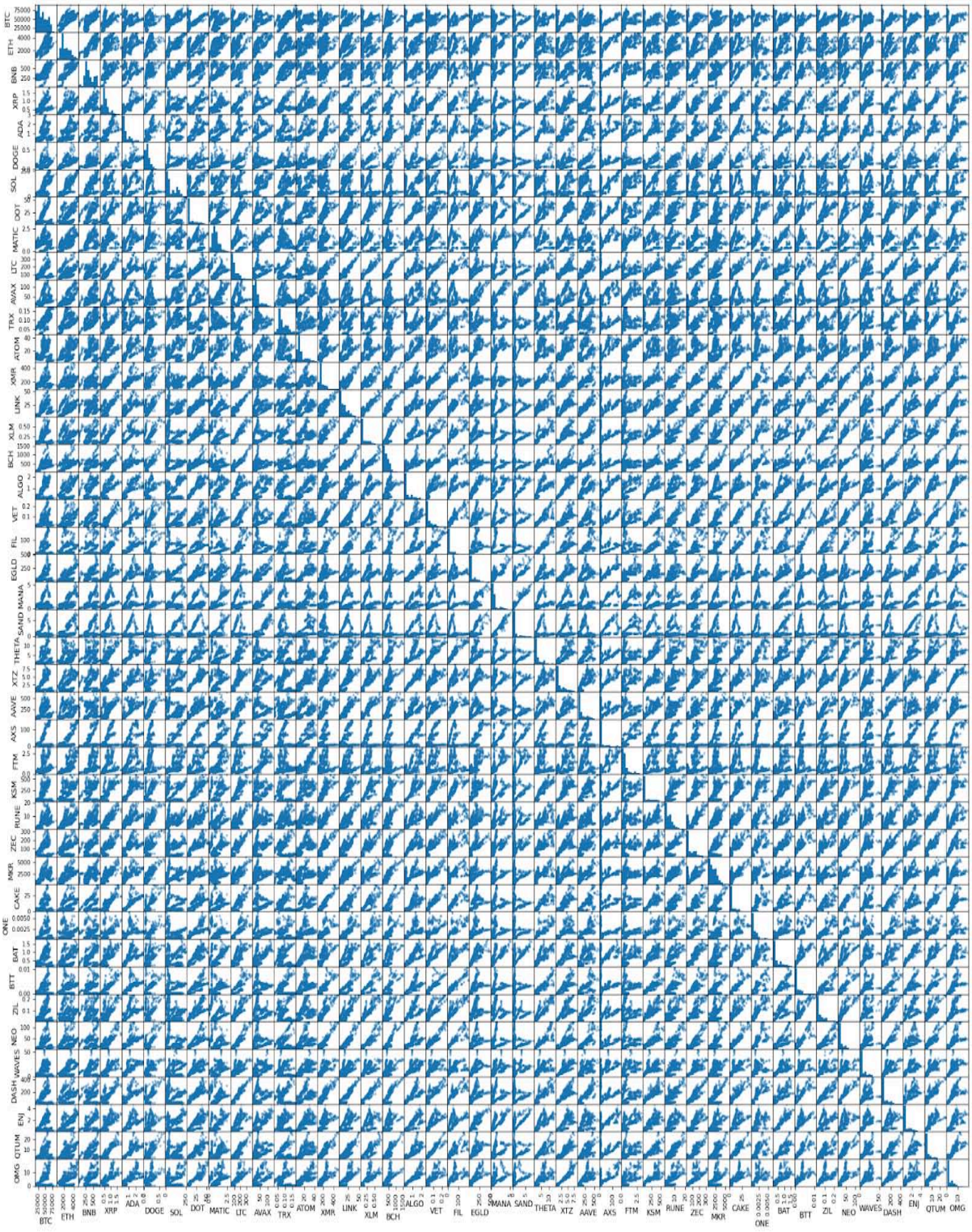
pairs trading. Utilizing a multivariate clustering framework that combines on-chain data, off-chain sentiment, and financial indicators may lead to more robust clusters, enhancing the ability to identify optimal trading pairs. In addition, the current study predominantly employs basic clustering algorithms such as k-mean, hierarchical clustering and affinity propagation clustering. While these are effective for general segmentation, they may not adequately capture complex and non-linear relationships in cryptocurrency data. For future research we recommend to incorporating advanced clustering techniques like spectral clustering, density-based clustering (DBSCAN), or deep learning-based clustering methods (e.g., autoencoders or contrastive graph clustering) and these clustering models could better reveal nuanced relationships between cryptocurrencies.

APPENDICES

Appindex (II); Correlation Matrix



Appindex (II): scatterplot



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Stereoscopic Tours in the Emperor's Collection: The World in Third Dimension

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ABSTRACT

This article focuses on the touristic stereoscopic images present in the photographs collection of Brazil´s Emperor, D. Pedro II. Firstly, we will present the concept of "stereoscopic tour" and its diffusion in nineteenth-century modernity. From the constitution of the Emperor's Collection, we will address its importance for the construction of an ideal of nation and for the emperor's image himself as a "monarch-citzen". Finally, we discuss the role occupied by tourist stereoscopies in the collection, their uses and functions and the possible relationships between them and the trips undertaken by this tropical monarch.

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Stereoscopic Tours in the Emperor's Collection: The World in Third Dimension

O Turismo Estereoscópico na Coleção do Imperador: O Mundo na Terceira Dimensão

Maria Isabela Mendonça dos Santos

RESUMO

Este[1] artigo tem como objeto as estereoscopias turísticas presentes na coleção de fotografias do imperador D. Pedro II do Brasil. Primeiramente apresentaremos o conceito de "turismo estereoscópico" e sua difusão na modernidade oitocentista. Partindo da constituição da Coleção do Imperador, abordaremos sua importância para a construção de um ideal de nação e para a própria imagem do imperador como um "monarca-cidadão". Por fim, pretendemos debater o papel ocupado pelas estereoscopias turísticas na coleção, seus usos e funções e as relações possíveis entre elas e as viagens empreendidas por este monarca tropical.

ABSTRACT

This article focuses on the touristic stereoscopic images present in the photographs collection of Brazil´s Emperor, D. Pedro II. Firstly, we will present the concept of "stereoscopic tour" and its diffusion in nineteenth-century modernity. From the constitution of the Emperor's Collection, we will address its importance for the construction of an ideal of nation and for the emperor's image himself as a "monarch-citzen". Finally, we discuss the role occupied by tourist stereoscopies in the collection, their uses and functions and the possible relationships between them and the trips undertaken by this tropical monarch.

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I. INTRODUÇÃO

Um dos grandes responsáveis pela modernização e educação do olhar dos observadores no século XIX, a fotografia estereoscópica consiste em pares de imagens quase idênticas que, vistas simultaneamente, produzem a ilusão de tridimensionalidade. A estereoscopia é considerada a principal tecnologia de produção de efeitos “realistas” na cultura visual de massas, baseando-se em uma reconstrução radical da experiência óptica. (CRARY, 2012: 18)

No Brasil, a fotografia e a estereoscopia encontraram no imperador d. Pedro II (1825-1891) o mais importante observador e divulgador. Primeiro brasileiro a adquirir e utilizar um equipamento de daguerreotipia, o monarca tornou-se a figura central da fotografia brasileira do século XIX, de modo a constituir a primeira grande coleção de fotografias do país. O imperador esteve à frente de um projeto civilizatório para a nova nação que tinha no binômio Civilização e Natureza, os componentes da sua formulação ideológica.

Importante mecenas, d. Pedro II criou o título de *Photographo da Casa Imperial,* considerado o primeiro do mundo a reconhecer o valor artístico da fotografia. (VASQUEZ, 2002) Entre 1851 e 1889 foram concedidos 20 títulos para os profissionais fotógrafos atuantes no Brasil. Nesta lista encontramos os mais relevantes nomes da fotografia brasileira do oitocentos, como Joaquim Insley Pacheco, Marc Ferrez, Augusto Stahl e Revert Henry Klumb. Este último pode ser considerado o pioneiro da fotografia estereoscópica no país, efetuando uma ampla

documentação com esse sistema entre os anos de 1855 e 1862. (SANTOS, 2019).

Estas e outras estereoscopias produzidas ao redor do mundo, encontram-se hoje na Coleção D. Thereza Christina Maria, também conhecida como a "Coleção do Imperador". Doadas pelo próprio quando do fim do regime monárquico no Brasil e seu consequente banimento do país, a coleção faz parte do acervo fotográfico da Fundação Biblioteca Nacional brasileira e leva o nome de sua esposa, a Imperatriz Thereza Christina (1822-1889).

Pretendemos analisar neste artigo especialmente as estereoscopias de temática "turística" presentes na coleção. Desse modo, apresentaremos o conceito de "turismo estereoscópico" e sua difusão na modernidade oitocentista. Posteriormente, abordaremos a constituição da Coleção D. Thereza Christina Maria, sua importância para a construção de um ideal de nação e para a construção de uma imagem de imperador. Por fim, pretendemos debater o lugar ocupado pelas estereoscopias turísticas na coleção, seus usos e funções e sua relação com as viagens empreendidas pelo monarca.

II. ESTEREOSCOPIA E TURISMO ESTEREOSCÓPICO: O MUNDO SEM SAIR DO SOFÁ

Nascido no âmbito dos estudos acerca da visão humana do final do século XVIII e início do século XIX, o visor estereoscópico foi idealizado como um modo de provar a existência e replicar a síntese estereoscópica envolvida na visão binocular. Logo se aliou a recém-inventada fotografia, ganhando o mercado de massas após David Brewster (1781-1868) o apresentar na forma portátil para lâminas de vidro na Exposição Universal de Londres (1851).

Dada a crença na sua objetividade, a fotografia estereoscópica dará grande impulso às expedições fotográficas e aos trabalhos de documentação realizados pelas nações imperialistas. O enorme consumo de vistas, alimentava os desejos dos observadores por paisagens longínquas, cenas urbanas e construções famosas. (TURAZZI, 1995: 51) Nesse sentido, considera-se a fotografia estereoscópica o primeiro sistema visual universal de comunicação, antes do cinema e da televisão (TRACHTEMBERG, 1989), podendo ser vista como o natural e direto antepassado do cinema de atrações. (GUREVICH, 2013). Colecionadas em grupos e séries jaziam, ao lado do álbum de família, disponíveis como objetos de uso nos rituais das trocas sociais apropriadas a sala de estar da família burguesa.

O sucesso desse tipo de fotografia revela um novo ordenamento da sociedade ocidental em torno do indivíduo, da família nuclear e dos mecanismos de autorrepresentação das camadas burguesas em ascensão. Trata-se de um fenômeno social da modernidade. Diferentemente do retrato, a fotografia estereoscópica, em geral, não era produzida a pedido do cliente. Seu mercado era majoritariamente suprido por empresas especializadas que já possuíam catálogos prontos para o consumo e que, a partir da década de 1860, foram paulatinamente se industrializando e alcançando cifras de produção e distribuição de escala global. Essas empresas consagraram o formato do cartão estereoscópico de Holmes (8 x 15 cm) que foi, ao lado do *carte de visite*, fundamental para a diminuição dos preços da imagem fotográfica. (ADAMS, 2004: 7).

Na última década do século XIX, o uso industrial da gelatina com brometo de prata permitiu a comercialização de filmes mais sensíveis e práticos a baixo custo. Essa transição marca a emergência das corporações norte-americanas, ultrapassando as empresas europeias. Nos Estados Unidos, a estereoscopia teve um desenvolvimento industrial e comercial impressionante. A América e seu povo, os grandes parques, o Grand Canyon, os negros, os povos originários e a guerra civil, apareciam como os grandes temas da estereoscopia estadunidense. (PARENTE, 1999: 15). Considerado o auge da fotografia estereoscópica como entretenimento, esse momento caracterizou-se pela venda de cartões avulsos, pequenos conjuntos narrativos e turísticos, ou de teor erótico. Em 1880, com a criação da empresa *Underwood & Underwood* teve início a organização dos cartões estereoscópicos em coleções. Um filão de sucesso

da indústria de vistas estereoscópicas foi o "turismo estereoscópico".

A indústria do turismo foi uma das muitas novidades que o século XIX apresentou ao mundo. Com o advento das estradas de ferro, dos navios a vapor e dos cabos submarinos, as distâncias entre os homens ao redor do mundo diminuíram consideravelmente e possibilitaram a um número cada vez maior de indivíduos o prazer de viajar. Nesse período, a indústria do *souvenier*, instituída com o turismo, foi favorecida pelo incremento das viagens, pela realização das exposições, e pela difusão da fotografia.

> As viagens ampliaram o mercado consumidor de *souveniers* à medida que mais e mais pessoas passaram a se deslocar de suas residências para outras regiões, cidades e países. Por outro lado, as viagens sempre estiveram ligadas à história da fotografia. Para os fotógrafos profissionais, viajar há muito tempo representava uma opção de trabalho: acompanhando expedições, deslocando seus próprios ateliês para onde a concorrência fosse menor, produzindo e depois vendendo imagens de lugares distantes ou inacessíveis à maior parte da clientela. Mas, nas últimas décadas do século XIX, quando a fotografia e as viagens se tornaram acessíveis a um grande contingente de pessoas, o consumo de imagens fotográficas como *souveniers* teve um impulso sem precedentes, alimentando aquilo que Jacques Le Goff chamou de "iconoteca da memória familiar". Através das viagens de lazer, do fotoamadorismo e, posteriormente, da explosão dos cartões postais – uma febre que contagiou o mundo no final do século – a fotografia transformou-se em divertimento de massa. (TURAZZI, 1995: 73-74)

Diversos manuais e compêndios de fotografia publicados no século XIX dedicaram especial atenção às "excursões fotográficas". Empresas especializadas contratavam fotógrafos profissionais que giravam o mundo produzindo imagens que depois seriam processadas em massa e colocadas à venda, em formato de cartão postal ou de cartão estereoscópico. Assim, o turismo passa a ser um tipo de linguagem visual típico da estereoscopia. Dentre variados assuntos, o turismo estereoscópico foi, sem dúvidas, uma das temáticas mais usadas neste tipo de fotografia, não só pelas empresas especializadas, mas também pelos fotógrafos amadores.

> In the second half of the nineteenth century, the successful deployment of stereoscopy was mainly ascribed to its realistic reproduction of the world (Holmes, 1859). Thanks to its quality, this visual medium was used not only for entertainment, but also for information and education (Darrah, 1964; Darrah, 1977; Silverman, 1993). During the stereoscopic-crazed entertainment boom, stereoviews entered American schools and were used for educational purposes to teach social studies, science, history, reading and geography (Apthorpe, 1908 174; Bak, 2012; Ent, 2013).
>
> *Knowledge of the world was a favoured topic. Many societies and foreign countries were represented though stereoviews with the purpose of introducing different cultures* (Malin, 2007; VanderKnyff, 2007). Although there was a long tradition of travelling while staying in one place thanks to books and images (Stiegler, 2013), the stereoscope was introduced as the perfect device for the *armchair traveller*. (PARMEGGIANI, 2016: 35)

Havia uma estética comum entre as fotografias turísticas produzidas para o consumo em massa, sendo possível detectar uma linguagem "profissional" em cada uma delas. Geralmente elas apresentavam claramente o objeto fotografado, através de composições cuidadosas e iluminação homogênea. Os fotógrafos lançavam mão de recursos que já constituíam linguagem consolidada no início do século XX, típicos do registro de arquitetura no século XIX, onde a fotografia concorria para reforçar os efeitos do majestoso, do opulento ou do monumental nas arquiteturas dos edifícios religiosos e seculares. (ADAMS, 2004:27)

Podemos citar como caso exemplar da estereoscopia turística, as vistas de Paris produzidas pela empresa francesa *Maison Richard* no início do século XX. Tais vistas privilegiam edificações individuais, em

detrimento das tomadas panorâmicas ou de aspectos gerais da cidade. O contexto urbano é reduzido ao essencial de modo que raramente aparece como elemento ativo da composição. A figura humana também é elemento raro, aparecendo somente no contexto da rua. O edifício monumental e não a cidade, é o foco dessas fotografias, como podemos notar na figura 1.

Essa preocupação estética também pode ser observada nas coleções estereoscópicas da estadunidense *Underwood & Underwood*, que na virada para o século XX colocou no mercado coleções como a *Italy through the stereoscope,* entre outras do mesmo gênero. Séries de vistas deste tipo possibilitaram para as classes menos abastadas uma opção mais barata e viável de lazer que o tradicional *Grand Tour,* praticado apenas pela aristocracia e alta burguesia até então. Além das fotografias, a coleção vinha acompanhada de mapas e textos que funcionavam como verdadeiros guias de turismo.

Assim, uma característica específica do turismo estereoscópico é o efeito de imersão virtual que as vistas produzem no observador. O ponto de vista torna-se um lugar de ser, onde o espectador poderia se tornar um "viajante de poltrona" e mergulhar em um país virtual e exótico. Conjuntos desse tipo caracterizam-se, portanto, não apenas pela ilusão de profundidade que provocam em quem as observa, mas também pela ideia de que o observador deveria desempenhar um papel ativo nas imagens visualizadas (como na realidade virtual). Dirigido pelas palavras do texto, o visualizador é solicitado a mover-se na cena, seguindo uma classe superior de guias de viagem virtuais. (PARMEGGIANI, 2016: 36)

A compra de estereoscopias turísticasera feita também durante a própria viagem do colecionador, como um *souvenier*. Na condição de consumidor-turista, alguns estereoscopistas amadores terão o privilégio de selecionar as vistas que viriam a compor seu museu privado. O turista estereoscópico, na fruição doméstica de sua coleção, apropria-se da linguagem da fotografia arquitetônica. Dentro deste universo visual, o observador "flutua", percorrendo os volumes e recessos previstos pelo arquiteto. Ao contrário da coleção da *Underwood & Underwood*, as vistas *Richard* não vinham acompanhadas de texto explicativo em anexo, mas de legenda entre as vistas, o que acredita-se ser fundamental para que o observador tenha um papel mais ativo na exploração do espaço "estereoscopicamente restituído". (Adams, 2004: 44)

A tangibilidade proporcionada pela estereoscopia, portanto, acabou por fazer prevalecer a temática da paisagem neste tipo de fotografia, fosse ela direcionada à educação de crianças e jovens na estereoscopia pedagógica[2] ou ao "turismo de sofá".

W.J.T. Mitchell procura desmistificar alguns fatos reproduzidos pelo senso comum a respeito da Paisagem nas artes visuais. Para o autor, Paisagem é uma mídia/meio no mais completo sentido da palavra. É um significado material como a linguagem ou a pintura, embebida numa tradição de significação e comunicação cultural, um corpo de formas simbólicas capaz de ser invocada e reformulada para expressar significados e valores. Como um meio para expressar valor, possui uma estrutura semiótica tanto quanto o dinheiro, funcionando como um tipo especial de *commodity* que interpreta um papel simbólico único no sistema de troca-valor.

> At the most basic, vulgar level, the value of landscape express itself in a especific price: the added cost of a beautiful view in real state value; the price of a plane ticket to the Rockies, Hawaii, the Alps, or New Zealand. Landscape is a marketable commodity to be presented and re-presented in "packaged tours," an object to be purchased, consumed, and even brought home in the form of souvenirs such as post cards and photo

[2] Um outro tipo de estereoscopia muito popular entre os séculos XIX e XX foi a estereoscopia pedagógica, ou seja, a fotografia tridimensional com usos e funções educativas. Foram produzidas diversas coleções pedagógicas das mais diversas áreas do conhecimento como Arte, Arqueologia, Geologia, Geografia, Botância e etc. A Keystone View e a Pestalozzi foram as empresas mais conhecidas do ramo que vendiam suas coleções estereoscópicas para escolas acompanhadas de textos, mapas e guias. Muitas vezes as coleções pedagógicas se utilizavam de vistas do turismo estereoscópico. Para mais informações sobre o assunto ver: PEIXOTO, 2017.

> albums. In its double role as commodity and potent cultural symbol, landscape is the object of fetishistic practices involving the limitless repetition of identical photographs taken on identical spots by tourists with interchangeable emotions. (MITCHELL, 2002: 14)

O uso da paisagem como *commodity,* nesse sentido, será o grande trunfo das empresas que produziam e comercializavam fotografias estereoscópicas. A criação de um largo e definido mercado para fotografias de paisagem têm início na metade final da década de 1850 - justamente o período em que as vistas estereoscópicas começam a ser comercializadas em larga escala. As fotografias de paisagem do final do século XIX, não escaparam das convenções da pintura, mas as adotaram e as reformularam. Desse modo, é possível identificarmos na fotografia de paisagem daquele período - e consequentemente nas estereoscopias do gênero – as categorias que tradicionalmente caracterizam este tipo de imagem: o Belo, o Pitoresco e o Sublime, distinções baseadas nos tipos de objetos e espaços visuais representados na pintura.

Mitchell chama atenção para o fato de que há certamente um gênero da pintura conhecido como "paisagem", definido com uma certa ênfase nos objetos naturais. O que tendemos a esquecer é que este assunto não é um simples material bruto a ser representado na pintura, mas é também uma forma simbólica nela mesma. Assim, a Paisagem pode ser representada pela pintura, desenho, gravura, fotografia, filme, cenário teatral, literatura, discursos e até mesmo pela música e outros "sons imagéticos". Antes de todas essas representações secundárias, no entanto, a Paisagem é, ela mesma, um meio multissensorial e físico (terra, pedra, vegetação, água, céu, som e silêncio, luz e escuridão, etc.) em que significados culturais e valores são codificados, mesmo que sejam ali colocados por uma transformação física de um lugar - em paisagens de jardins e de arquitetura- , ou encontrados em lugares formados pela natureza. É justamente essa "multissensorialidade" da paisagem que acreditamos ter casado tão bem com a singularidade do aparato estereoscópio. As vistas estereoscópicas ampliam a visualização tátil e incorporam a participação corporal do espectador na imagem-espaço, causando nele a sensação de realismo, presença e bem-estar.

Podemos utilizar os conceitos de "ponto de vista" e "ponto de estar" (De Kerckhove & De Almeida, 2014) para entender as características que distinguem a fotografia estereoscópica da fotografia comum. O ponto de vista posiciona a pessoa em uma relação espacial com o meio ambiente de um ângulo específico para avaliá-lo e julgá-lo. Já o ponto de estar é uma condição imersiva total. As vistas estereoscópicas estariam, desse modo, situadas entres estes dois polos. Não são uma mídia eletrônica e digital que nos colocam numa situação de total imersão, mas dão ao espectador a sensação de estar em uma cena representada. Logo, ao mesmo tempo em que representam uma superação da perspectiva renascentista (Crary, 2012) podem ser consideradas uma espécie de antecipação da "realidade virtual" que conhecemos atualmente. (PARMEGGIANI, 2016) O grande diferencial que a fotografia estereoscópica proporciona ao seu observador, portanto, é a interação profunda entre visão e tato, e entre visão, postura e propriocepção para conscientemente representar o espaço.

Devemos estar atentos, no entanto, para o fato de que tais questões técnicas, psicológicas e sociais relacionadas à percepção visual nem sempre produzem uma sensação de presença, mas no contexto histórico e cultural da segunda metade do século XIX e primeira metade do XX, é inegável que as estereoscopias representaram um novo fator sensório-comunicativo.

III. A COLEÇÃO DO IMPERADOR

Krzysztof Pomian afirma que as coleções são criadas para serem expostas ao olhar. O conceito de objetos semióforos desenvolvido pelo autor defende que alguns objetos são desprovidos de valor utilitário, com a função mediadora entre o visível e o invisível. (POMIAN, 1984) Uma vez que é o colecionador quem atribui valores e significados aos objetos, o colecionismo está atrelado à necessidade do indivíduo de se

posicionar socialmente por meio deles como suportes de memória, traçando sua relação entre o grupo e entre presente e passado.

> Um colecionador traz consigo o desejo de possuir e de ser representado a partir dos objetos que coleciona. O que o motiva torna suas coleções únicas. Busca sempre um significado especial no objeto, e esse significado é a motivação que o leva a atribuir-lhe valor. "Todo item colecionado é, em certa medida, um totem." (BLOM, 2003:193). Dessa forma, podemos entender os objetos de coleção como uma representação de seus colecionadores, uma vez que estes lhes atribuem valores e ressignificações, reordenando seu próprio mundo. Uma determinada coleção diz mais sobre o colecionador do que sobre os objetos em si. (FERRAZ, 2016)

Banido do Brasil após a proclamação da República, d. Pedro II foi conduzido para o exílio à 17 de novembro de 1889. "Perfeitamente cônscio do interesse que a permanência de sua biblioteca e de suas coleções poderia ter para o futuro desenvolvimento do país, o imperador doou todo seu acervo pessoal à nação brasileira". (VASQUEZ, 2002: 42) Desse modo, seu vasto patrimônio material foi distribuído entre várias instituições do país, cabendo aos cuidados da Biblioteca Nacional sua coleção de fotografias, que reúne mais de 20 mil imagens produzidas por grandes mestres da fotografia, nacionais e estrangeiros.

Neste acervo compõe-se o esforço de construção e perpetuação de determinada memória nacional. (SCHWARCZ, 1998) Trata-se não de um amontoado de imagens, mas de uma "coleção" feita de muitas lembranças e de várias lacunas. Ela carrega imagens do imperador e de sua família, mas também grandes temas do século XIX – artes, urbanismo, botânica, mineração, saúde pública –, os eventos mais importantes da época e retratos da gente brasileira.

As imagens do imperador distinguem-se por suas técnicas – xilogravura e litogravura, pinturas a óleo, aquarelas nanquim e carvão, caricaturas e, a partir dos anos 1860, fotografias. É nítido, entre os inúmeros retratos presentes, a quantidade de imagens que vinculam d. Pedro II à cultura, fato que parece destacar uma política intencional. Desse modo, através deles, o imperador associa-se à modernidade ocidental idealizada com símbolos de progresso."Nessas imagens o rei esquece o ritual majestático e se apresenta como um cidadão do mundo, emancipado pela cultura." (SCHWARCZ, 1998: 50) É o que vamos denominar de "monarca-cidadão".

Essa coleção poderia resumir, segundo Pedro Vasquez, a história da fotografia brasileira oitocentista, período que por sua vez foi marcado por profundas transformações nos regimes de visualidade e subjetividade, com um "progresso técnico avassalador percorrendo todo o processo de intensas transformações sociais e urbanas vivido pelo mundo ocidental". (VASQUEZ, 2002: 42) O recurso à fotografia é em si uma originalidade do monarca tropical, uma vez que os monarcas europeus preferiam ser retratados em pinturas a óleo, deixando de lado a "imagem burguesa" proveniente da fotografia.

No empreendimento de construir a identidade nacional, a dicotomia Civilização e Natureza se traduzia em elementos constitutivos da nova nacionalidade. De um lado o Estado monárquico, portador e impulsionador do projeto civilizatório, e do outro a natureza, como base territorial e material deste Estado (SALLES, 1996: 98). No duplo projeto de dar conta da gênese da nação brasileira, inserindo-a numa tradição de civilização e progresso (GUIMARÃES, 1998), considerava-se que a imagem do país no exterior e a representação que este fazia de si mesmo, tanto interna quanto externamente, eram parte fundamental do processo de construção de seu futuro enquanto nação, especialmente no campo simbólico. Sublinhada pela ideologia do progresso, era com as luzes da Europa que o país se iluminava, especialmente com o brilho da França, principal influência dos intelectuais da corte brasileira. (TURAZZI, 1995).

A expansão da fotografia fez parte deste amplo processo de intercâmbio com as nações europeias. D. Pedro II esteve atento a este aspecto quando investiu na produção e divulgação de imagens

sobre o Brasil. Diante da visível expansão dos negócios ligados ao setor, o governo imperial apressou-se em regulamentar a atividade, a fim de extrair impostos desse novo ramo industrial e comercial.

Um investimento de peso foi feito também no âmbito das exposições internacionais. Nestes espaços, as nações participantes podiam se inserir numa espécie de hierarquia do progresso e aí a fotografia encontraria uma função incontestável. Mais do que qualquer outra mídia, era capaz de concentrar representações supostamente objetivas dos mais longínquos e estranhos lugares do mundo. A história do desenvolvimento da fotografia no Brasil relaciona-se, desse modo, com a história das exposições nacionais e internacionais das quais participou. Inseridas num processo mais amplo de construção e afirmação de uma "identidade brasileira", essas duas histórias estão ligadas a um tipo de leitura da "história nacional", tipicamente oitocentista que objetivava reproduzir fielmente o presente e elaborava as imagens de seu futuro. No Brasil, era grande a empolgação do imperador com as exposições e, por esta razão, em 1861, ele abre a primeira Exposição Nacional do país.

O interesse do imperador pela fotografia denota mais do que o objetivo de promover uma imagem do Brasil enquanto nação inserida no processo civilizatório, mas a promoção da auto-imagem do monarca enquanto símbolo desta "linguagem civilizatória". A imagem de Pedro "amante das letras e das artes" difundida pelos fotógrafos reais, foi igualmente importante para o processo de construção da nacionalidade brasileira. Conforme aponta Mauad, "enquanto a imagem da corte era uma imagem não somente pública, mas publicada nos jornais e nas exposições universais, a imagem do Império ainda tinha como modelo a família imperial." (1997:185)

Por esta razão, a família imperial foi amplamente fotografada pelos mais consagrados fotógrafos e das mais diferentes formas. Em fotopinturas, fotomontagens, em estúdios simulando ambientes naturais, situaçõe solenes ou informais e, como não poderia deixar de ser, em retratos estereoscópicos.

3.1 As estereoscopias da Coleção do Imperador: o Brasil e o Mundo

Podemos classificar as fotografias estereoscópicas que compõem a Coleção do Imperador em dois tipos principais: as estereoscopias produzidas no Brasil e as estereoscopias produzidas fora do país. Em grande maioria na coleção, destacam-se as estereoscopias produzidas no Brasil pelo fotógrafo alemão Revert Henry Klumb (1830-1866).

Instalando-se na sede da corte a partir de 1855, Klumb foi o primeiro a realizar uma ampla e sistemática documentação da paisagem carioca e também um dos primeiros a produzir fotografias sobre papel na cidade do Rio de Janeiro. Fotógrafo da corte imperial até 1880, seu trabalho focaliza os principais monumentos e logradouros públicos da época. Sua obra possui valor excepcional pelo pioneirismo técnico e pela documentação histórica da cidade e da província do Rio de Janeiro, de cidades da província de Minas Gerais, além dos retratos da família imperial brasileira. Condecorado com o título de *Fotógrafo da Casa Imperial* em 1861, sua produção foi realizada majoritariamente em vistas estereoscópicas, técnica que muito provavelmente o fotógrafo introduziu no Brasil.

> Até prova em contrário, essas vistas são as mais antigas estereoscopias cariocas, pois Klumb foi provavelmente o primeiro a utilizar o processo estereoscópico no Brasil, antes mesmo que este se tornasse uma coqueluche mundial na década de 1860, quando a London Stereoscopic Company chegou a vender em média um milhão de vistas estereoscópicas por ano. (...) Como se considera que as primeiras estereoscopias em papel foram calótipos produzidos entre 1850 e 1851, os primeiros exemplares feitos em papel albuminado produzidos por Klumb no Rio de Janeiro, Petrópolis e Juiz de Fora, entre 1855 e 1862, estariam entre os primeiros exemplos do gênero em todo mundo. (VASQUEZ, 2001: 35)

A predileção de Klumb pela técnica da estereoscopia fica clara quando analisamos o acervo do fotógrafo pertencente à Coleção do Imperador. Das 315 fotografias de sua autoria,

255 são estereoscopias. Dentre retratos da família imperial e de pessoas escravizadas, destacamos as vistas da cidade do Rio de Janeiro. São panorâmicas da Floresta da Tijuca, do Morro do Castelo, da Praça XV, dos bairros da Glória, da Lapa, da Rua do Ouvidor, entre outras vias comerciais e residenciais do centro da cidade. Não foram esquecidos os detalhes de cada um destes logradouros, como a famosa fonte do Mestre Valentim[3] no Largo do Paço (atual Praça XV de Novembro). Destaca-se no todo da coleção, a série produzida no Jardim Público do Rio de Janeiro (atual Passeio Público). São cerca de 40 vistas estereoscópicas que abarcam os aspectos arquitetônicos do jardim, suas características paisagísticas, seus visitantes, seus monumentos e suas espécies vegetais.

As fotografias produzidas por Klumb inserem-se nas novas exigências colocadas pela visualidade moderna, seguida pelos demais fotógrafos daquele período. Sem desconsiderar os códigos de representação da pintura, Klumb apoiava-se na exatidão da forma e na fidelidade do registro, colaborando para a instituição de uma nova maneira de olhar para a natureza, indo ao encontro do movimento que tira o observador do papel de contemplador passivo ao colocá-lo como interventor da cena. Este novo olhar envolve uma mudança de perspectiva em relação à história.

> No Brasil, o esquadrinhamento do território pela fotografia, assim como pela geografia, geologia ou botânica, além de ser matéria de interesse científico, é também uma necessidade política de consolidação do Estado imperial: vistas e panoramas fotográficos são reconhecidos como enquadramentos do país que tipificam cenários, costumes e gentes da terra, elegendo-os como atributos singulares de uma identidade nacional em construção, consubstanciada na variedade e exuberância dessas imagens. (TURAZZI, 2000: 14)

Na obra de Klumb, esse esquadrinhamento do território apontado por Turazzi, passa obrigatoriamente por sua "mirada estereoscópica", ou seja, pela "operação visual, que envolve o alinhamento de um corpo observador em relação a um aparato de visualização e um tipo particular de concentração para a produção da sensação de volume a partir de duas imagens díspares". (ADAMS, 2004: 3) Ou, nas palavras de Parmeggiani, pela produção do "ponto de estar" que cria no espectador a sensação de imersão na cena e uma espécie de convite a participar dela.

Nesse sentido, ainda que as estereoscopias de Klumb não tenham sido produzidas para uma comercialização em massa - como as de empresas estadunidenses como Underwood & Underwood ou Keystone View -, nelas já podemos perceber a presença da linguagem do turismo estereoscópico e o uso da multisensorialidade da paisagem carioca como *comodity*. Ou seja, a estética turístico -pedagógica já estava presente nas vistas produzidas especialmente para a fruição do imperador e de sua família.

Em número menor, encontram-se na coleção as fotografias estereoscópicas produzidas no exterior. São 147 estereoscopias de fotógrafos e empresas especializadas, que datam aproximadamente de 1860 a 1880.

O comércio de vistas estereoscópicas na Corte brasileira teve início provavelmente em 1854. Excetuando-se as casas dirigidas por fotógrafos, a maioria dos estabelecimentos comercializavam vistas importadas. Em alguns anúncios publicados no *Jornal do Commercio* e no *Almanak Laemmert* entre os anos de 1854 e 1888, pudemos encontrar diversas referências que apontam esta tendência.

Já em dezembro de 1854, a loja *Imperial Imprensa de Música de Filipone C.* Destacava: "(...) sterocopos com muito lindas vistas, de Paris, de Roma e de diferentes lugares, divertimento próprio para uma reunião de famílias, para o qual convida-se os senhores amadores de vir ver o effeito que produz; (...)".[4] (Grifo nosso) Do mesmo modo, a casa *As vistas de Pariz*, como o próprio nome deixava crer, anunciava: "(...)stereoscopo e vistas para ditos dos palácios mais afamados da

[3]Valentim da Fonseca Silva (1745-1813) foi um dos principais artistas do Brasil colonial. Atuou como escultor, entalhador e urbanista.

[4] Jornal do Commercio, 14 de dezembro de 1854. P.3.

França, illuminados e transparentes"[5]. Também o estabelecimento da Rua do Ouvidor, número 102, anunciava: "STEREOSCÓPIOS com vidros de crystal. Vistas de vidro, modernas, para STEREOSCÓPIOS. Ditas transparentes, represemntando scenas familiares, bailes, combates, etc. Grande variedade de vistas de Pariz."[6] (Grifo nosso)

José Maria dos Reis, óptico reconhecido na cidade e provavelmente o primeiro a comercializar vistas estereoscópicas na corte, recebia encomendas do imperador, que mencionou em seu diário uma das visitas ao estabelecimento:

> Vi instrumentos curiosos, sobretudo um espectroscópio de Bunsen, e outro de Soleil, para medir os ângulos dos eixos dos cristais. Reis ficou de mandálos para cá para eu examiná-los detidamente. Há muito instrumento que ele decerto não vende. (...) Trouxe-me um catálogo dos nomes apenas dos instrumentos que há na loja. Os vidros são lapidados na Europa. (...). Mostrou-me a mesa onde trabalhava o Maia (...). Notei fotografias obscenas para esteroscópio; devia ao menos tirá-la do mostrador.[7]

Enquanto cliente de José Maria dos Reis, é muito provável que o imperador tenha adquirido com o óptico algumas fotografias para estereoscópio. Entretanto, acreditamos que boa parte das estereoscopias estrangeiras presentes em sua coleção foram adquiridas por d. Pedro II em suas viagens ao exterior, como *souveniers*.

3.2 As viagens do Imperador

D. Pedro II realiza sua primeira viagem ao exterior no ano 1871. Até a década de 1870, o imperador não havia saído do Brasil, mas já conhecia parte significativa do território brasileiro. As viagens ajudariam-o na demarcação simbólica das fronteiras de seu grande Império, além de contribuir para alargar a recepção da imagem da monarquia interna e externamente. Nas viagens domésticas o monarca tomava posse e unificava a representação do país. Nas viagens internacionais, delineava sua imagem de monarca-cidadão e cosmopolita. Em todas as excursões que o imperador passará a empreender, a fotografia o acompanha de perto. (SCHWARCZ, 1998: 370)

Em 1845, Pedro tinha se aventurado a ir às províncias de Santa Catarina, Rio Grande do Sul e São Paulo, ausentando-se da corte por seis meses. Em 1847 foi a vez de percorrer a província fluminense e se hospedar nas casas de fazenda da região. Pedro conheceu as milagrosas águas termais de Poços de Caldas em 1861, e em 1865 passou por Juiz de Fora, ambas cidades da província de Minas Gerais.

A partir da década de 1860, algumas viagens realizadas pelo imperador foram registradas por Klumb. É o caso da visita realizada à propriedade de Mariano Procópio Ferreira Lage. Na ocasião, o imperador e sua comitiva foram retratados à beira do Rio Paraibuna, que margeava a quinta dos Ferreira Lage em Juiz de Fora. Na ocasião da visita, Klumb também produziu uma série de imagens da região, dando destaque à sua paisagem bucólica, em detrimento às figuras humanas (Figuras 2 e 3) O registro da construção da Estrada União e Indústria, primeira rodovia pavimentada da América Latina, também ganha destaque nessa viagem. Tal fato confirma a intencionalidade do uso da fotografia pelo imperador como um instrumento de propaganda do seu governo, ainda que num primeiro momento, essas fotografias circulassem apenas em âmbito privado.

No interior da província fluminense o "turismo estereoscópico" de Klumb pode ser constatado em cidades como Campos dos Goytacazes e Magé. Nessas imagens a paisagem natural, mas sobretudo a intervenção humana sobre ela, são valorizadas de modo que o binômio "Civilização e Natureza" pode ser contemplado em construções arquitetônicas, pórticos, pontes, em conjunto com cadeia montanhosas, rochas, rios e lagos . (Figura 4)

Pedro II realizou sua primeira viagem para fora do Brasil quando já havia completado seus 45

[5] Jornal do Commercio, 03 de junho 1860. P.3.
[6] Jornal do Commercio, 09 de junho de 1872. P.4.
[7] Diário do Imperador D. Pedro II/ 1840-1891. Museu Imperial/ IPHAN / MINC. Vol. 9; 22 dez. 1862.

anos de idade. Na ocasião, ele visitou diversos países da Europa e regiões do Oriente Médio. Em 1876 realizou uma segunda viagem internacional, dessa vez passando também pelos Estados Unidos da América.

Em sua primeira viagem, Pedro inicia sua excursão por Portugal, segue para a Alemanha e, da Itália, parte para o continente africano. Grande admirador da cultura árabe, visitou o Egito, a Ásia Menor e a Palestina; "O imperador volta à Europa carregado de imagens do velho Oriente, que tanto estudara nos livros" (SCHWARCZ, 1998: 784) e, antes de se despedir do Velho Mundo, faz uma visita à França. Na Itália, provavelmente adquiriu uma série composta de oito vistas de sítios arqueológicos e turísticos do país, como as ruínas do anfiteatro de Verona, a Praça de São Marcos em Veneza e a Catedral de Milão (Figura 5). Da Europa, constam ainda séries de estereoscopias turísticas produzidas, na Espanha, na Irlanda e na Inglaterra na ocasião da Exposição Universal de Londres de 1862.

> Em 1876, (...) [d. Pedro II] planejava sua segunda viagem ao exterior. (...) Partiria em maio e, após a visita oficial à Exposição Universal da Filadélfia, levaria a imperatriz às águas de Gastein para um tratamento. Depois iria até Jerusalém. Planejada com o mesmo cuidado que a anterior, a viagem incluiria, em doses equilibradas, Estados Unidos, Canadá, um pouco de Ásia, parte da África, Europa (Alemanha, Dinamarca, Suécia, Noruega, Rússia, Turquia, Grécia, Áustria, Bélgica, Holanda, Suíça e Portugal) e especialmente seis semanas em Paris. (SCHWARCZ, 1998: 793)

No Líbano o imperador permaneceu de 11 a 15 de novembro de 1876, acompanhado de sua esposa, Thereza Christina Maria, e de uma comitiva de cerca de 200 pessoas. Após atravessar o vale de Chtaura e passar por Zahle e outras cidades, chegou a Baalbeck em 14 de novembro e redigiu em seu diário: "A entrada nas ruínas de Baalbeck, à luz de fogaréus e lanternas, atravessando por longa abóbada de grandes pedras, foi triunfal e as colunas tomavam dimensões colossais". No dia seguinte, visitou os templos de Baco, Júpiter e Vênus. De lá, trouxe consigo uma interessantíssima série de dez vistas estereoscópicas. (Figura 6)

> Saindo de Baalbeck, onde deixei meu nome com a data na parede do fundo do pequeno templo, está cheio de semelhantes inscrições, lendo-se logo depois da entrada estas palavras - "Comme le monde est bête!!! (...) A noite passada encheram-se os cabeços dos montes de neve e que belo efeito produziram, vistos do fundo do grande templo [o templo de Júpiter] ou por entre as seis colunas.[8]

Além da série de imagens do Líbano, a viagem aos Estados Unidos também rendeu ao imperador uma quantidade significativa de estereoscopias.[9] Partindo em maio para o país, usou como pretexto a visita oficial à Exposição Universal da Filadélfia e o estado de saúde de sua esposa, que aproveitaria a ocasião para um tratamento nas águas termais do país. Nesta, como em outras viagens, Pedro teria a chance de exercer sua vocação de "monarca-cidadão". (SCHWARCZ, 1998: 793) Era a primeira vez que um monarca pisava em território estadunidense, nação independente e republicana.

A maioria das vistas que compõem esta série retratam o Estado de Nova Yorque, onde imperador e imperatriz desembarcaram. Lá visitaram o Niagara Falls State Park, de onde trouxeram pelo menos oito vistas editadas pela *E. & H. T. Anthony and Co*. Também posaram para fotografias, como podemos ver na Figura 7."O monarca maravilhou-se de tudo o que viu, e se fez fotografar e retratar sempre que pôde, mas era a Exposição da Filadélfia que mais lhe interessava." (SCHWARCZ, 1998: 389) Com início no dia dez de maio, o imperador foi um dos primeiros a adentrar o local da exposição. Inaugurou a feira junto com o presidente estadunidense e portou-se como um "cientista interessado".

[8] Diário do Imperador D. Pedro II / 1840-1891. Museu Imperial / IPHAN / MINC. Vol. 9; 22 dez. 1862.

[9] Para mais informações sobre a viagem de Dom Pedro II aos Estados Unidos ver: https://www.bn.gov.br/acontece/noticias/2020/06/viagem-d-pedro-ii-aos-estados-unidos1876-nova-iorque

Fazendo visita a escolas, instituições, museus e intelectuais destacados, a ocasião também rendeu para sua coleção, estereoscopias da Região Petrolífera da Pensilvânia. São 19 vistas da série *Frank Robbin's Stereoscopic Views, of the Pennsylvania Oil Region, Oil City: Views of the Penna,* que reproduzem com detalhes a grandiosidade e modernidade da produção de petróleo da região. Desse modo, o que podemos perceber nas estereoscopias estadunidenses de d. Pedro II é um claro instrumento de propaganda daquela república que comemorava em 1876, seu primeiro centenário de independência. As vistas da *E. & H. T. Anthony and Co.* e da *Frank Robbin's,* mostram uma nação em ascenção, que orgulhava-se de suas riquezas naturais, mas principalmente das tecnologias responsáveis por seu progresso. (Figura 8)

Em julho, d. Pedro e sua comitiva partem dos Estados Unidos, passam por Londres, em Bruxelas, e em Gastein deixam a imperatriz, enquanto se dirigem aos países bálticos. Em setembro de 1876 o imperador chega à Grécia. Recebido como um monarca tropical, Pedro surpreendia ao portar-se como um imperador civilizado. Em novembro de 1876 alcançam o Oriente, onde encontram, novamente, a imperatriz e sua comitiva. É no Egito que Pedro e sua comitiva se faz fotografar, tendo como cenário a esfinge e as pirâmides de Gizé. De volta ao Velho Mundo, passa por Roma e Viena e termina sua viagem em Paris, onde faz questão de conhecer e trocar fotografias com Victor Hugo. Como relatou Schwarcz:

> Mais uma vez, nesse movimento da memória histórica que seleciona, lembra e esquece, é o encontro com um grande intelectual que será largamente reproduzido nos relatos dessa viagem. Imbuído de seu papel, d. Pedro leva a casaca, e mesmo diante da negativa do famoso intelectual francês a recebê-lo, abre mão do protocolo e vai ele próprio à morada de Victor Hugo. (SCHWARCZ, 1998: 804)

3.3 O Turismo de Sofá

Outra série muito interessante encontrada na coleção é composta de fotografias planas e estereoscópicas do arqueólogo e fotógrafo britânico-americano Augustus Le Plongeon (1825-1908) nas ruínas de Uxmal em Yucatán, no México. Não consta na biografia do imperador nenhuma visita ao país da América do Norte, ainda que seu primo-irmão, Maximiliano de Habsburgo-Lorena (1832-1867) tenha sido declarado Imperador do Segundo Império do México entre 1864 e 1867.

A série Yucatán pode ter sido adquirida durante a última viagem de Pedro, na Europa ou nos Estados Unidos, pode ter sido um presente, ou uma encomenda feita pelo imperador enquanto estava no Brasi, ou uma compra realizada em uma das casas especializadas da corte. Mais do que entender por quais meios essas vistas chegaram ao monarca, penso ser interessante refletirmos acerca dos significados de sua presença em seu acervo pessoal.

Em 1873, Le Plongeon e sua esposa viajaram para o México a fim de estudar os sítios arqueológicos dos povos Maias. O casal foi um dos primeiros a fotografar e estudar os Chicen Itza. (DESMOND, 1988) Seu trabalho fotográfico era bastante metódico e sistemático, de modo que produziram interessantes fotografias bidimensionais e estereoscópicas das ruínas mexicanas e do trabalho arqueológico realizado por ele e sua equipe.

A presença de tais fotografias na Coleção do Imperador atestam seu interesse pelo avanço da ciência e descobertas arqueológicas. Ainda que não tenha conhecido aquele sítio pessoalmente, a guarda de tais fotografias mostram o desejo do imperador de "possuir" aquele passeio e de ser representado por aquelas imagens. Se não era possível conhecer pessoalmente as ruínas de Uxmal, que pudesse desfrutar delas através do visor estereoscópico.

IV. CONCLUSÃO

Como vimos, é o colecionador quem atribui valores e significados aos objetos que coleciona. As estereoscopias turísticas presentes na Coleção do Imperador d. Pedro II representam o papel que a fotografia estereoscópica teve na divulgação de uma certa imagem de mundo no oitocentos, mas também na divulgação de uma imagem específica

que o imperador buscava construir sobre ele próprio. O colecionismo estereoscópico de Pedro está atrelado à sua necessidade de se posicionar socialmente por meio de tais imagens como suportes de memória, traçando sua relação entre eles e seus súditos, mas também entre o presente e o passado de seu reinado, criando ainda imagens para o futuro.

Com uma ampla maioria de vistas produzidas por agências especializadas e com temáticas claramente turístico-pedagógicas, a coleção apresenta imagens que atuaram como repositórios de um mundo particular que se pretendia veicular pelas nações no auge da corrida imperialista. Um instrumento político de estabelecimento e perpetuação de um poder de uma classe dominante europeia ou estadunidense sobre uma população dominada, constituída pelos afro-americanos, considerados primitivos, no qual o império brasileiro se incluía.

Assim, um número significativo de imagens representam o domínio ocidental sobre o oriente. As estereoscopias que retratam o continente europeu exibem, em geral, as maravilhas do mundo moderno ou das obras monumentais realizadas pela civilização do Velho Mundo. O mesmo se repete nas estereoscopias estadunidenses, em que encontramos as belezas naturais da América do Norte, mas sobretudo a grandiosidade de sua infraestrutura.

Por outro lado, as vistas do Oriente Médio representam as glórias de um passado longínquo, que ficou na antiguidade e não pode mais se repetir. Também as vistas produzidas no México, mostram o trabalho de dois cientistas de origem ocidental que realizavam naquele país uma pesquisa arqueológica e documental sobre uma cultura que há séculos havia sido dizimada pelos colonizadores europeus. São, portanto, imagens cuja função principal era alimentar os desejos dos observadores por paisagens longínquas e exóticas.

O mesmo sentido turístico-pedagógico podemos constatar nas fotografias produzidas no Brasil por R.H.Klumb. Ainda que o objetivo do fotógrafo não fosse produzir estereoscopias para a venda em massa e sim para o museu privado do imperador, percebemos que muitas delas encarnam a função turística, especialmente aquelas produzidas em outras cidades além da corte. Mas, mesmo nas imagens que retratam a cidade do Rio de Janeiro, podemos notar a preocupação do fotógrafo em registrar seus monumentos e seus aspectos exóticos. Estão presentes, portanto, elementos da dicotomia de um império que mirava na civilização europeia, mas que não conseguia se libertar de seu passado colonial ao não abrir mão do sistema escravista.

O que podemos concluir através desse conjunto de imagens, é a preocupação do monarca tropical em, através de sua coleção de fotografias, construir uma imagem de si mesmo. Essa imagem estava relacionada à do "monarca-cidadão", ou seja, aquele que mesmo sendo um soberano, se interessava pelo conhecimento, pelas ciências, pelo progresso e pelas diferentes culturas ao redor do mundo. Nas estereoscopias de sua coleção, o monarca-cidadão encarna também o consumidor-turista, cujo objetivo era não apenas criar memórias para si, mas também difundir símbolos da linguagem civilizatória, possuir e ser representado por essas imagens.

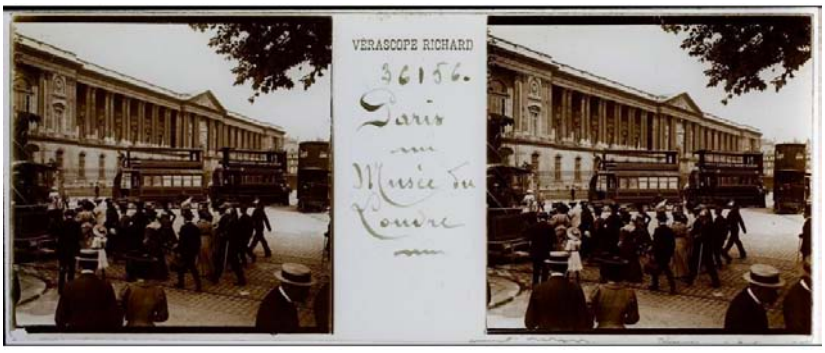

Figura 1: Verascope Richard - Paris, Museu do Louvre, sem data. Instituto Moreira Salles

Figura 2: R.H.Klumb - Família Imperial na quinta de Mariano Procópio Ferreira Lage em Juiz de Fora, Minas Gerais, 1861 - Fundação Biblioteca Nacional

Figura 3: R.H.Klumb - Residência dos Ferreira Lage em Juiz de Fora, Minas Gerais, 1861 - Fundação Biblioteca Nacional

Figura 4: R.H.Klumb - Campos dos Goytacazes, Rio de Janeiro, [1861] - Fundação Biblioteca Nacional

Figura 5: Dôme de Milano – sem data - Fundação Biblioteca Nacional

Figura 6: Templo de Júpiter, Ruínas de Baalbeck, Líbano, sem data - Fundação Biblioteca Nacional

Figura 7: [D. Pedro II, Tereza Cristina Maria e outras pessoas em Niagara Falls] – 1876 - Fundação Biblioteca Nacional

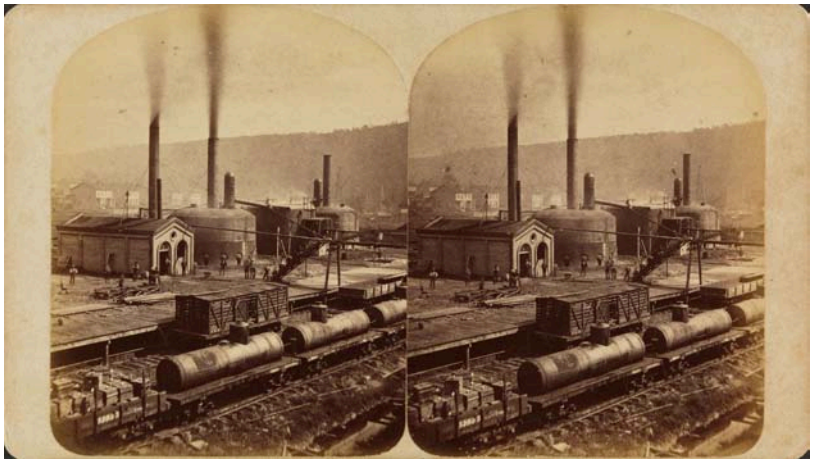

Figura 8: Views of the Penna. Oil Region:refining oil – [1875] - Fundação Biblioteca Nacional

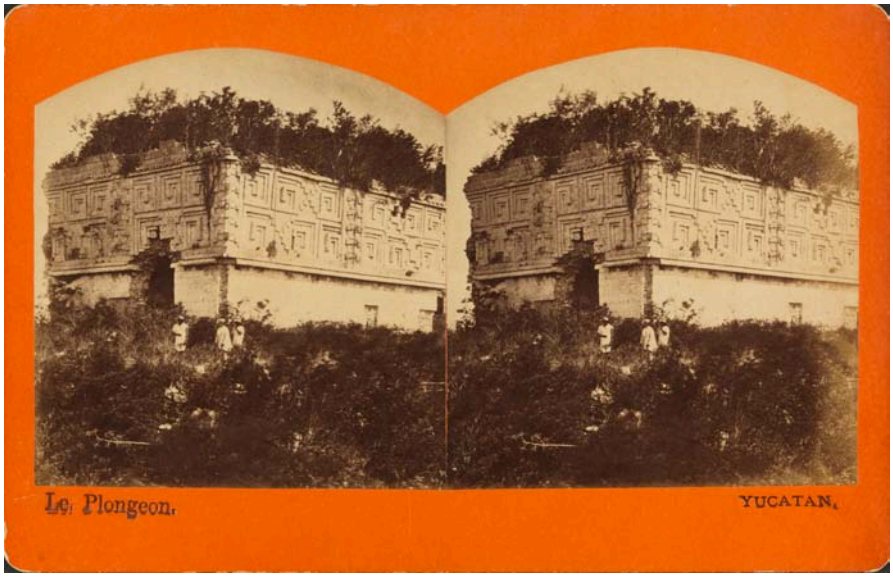

Figura 9: Le Plongeon - Ruins of Uxmal:North end and West façade of the Governor's House – [1873] - Fundação Biblioteca Nacional

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Multiple Contracts: The Case of Periodic Balloon Payments: Constant Installments

Clovis de Faro & Gerson Lachtermache

ABSTRACT

In a pioneering contribution De-Losso et al. (2013) introduced the idea of substituting a single contract by multiple contracts. The article considered only the usual case of a loan that must be reimbursed by n periodic constant payments. In this paper it will be examined the case where, besides the n periodic payments, the borrower has also to pay a sequence of ℓballoon payments, with periodicity m.

This may be very interesting in the case of Brazil. Since, by law, every employer must pay, to each registered employee, thirteen monthly payments per year. The thirteenth one being known as the "décimo terceiro salário" (the thirteenth wage), which is usually paid during the month of December.

As will be shown, the financial institution is also better off if a single contract is substituted by multiple contracts in this new case.

Keywords: constant payments amortization method; balloon payments; compound interest capitalization.

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I. INTRODUCTION

In a pioneering contribution De-Losso et al. (2013) introduced the idea of substituting a single contract by multiple contracts. Specifically, considering a loan of $\boldsymbol{F}$units of capital, with a term of n periods, at the periodic rate i of compound interest, which has to be reimbursed by periodic constant payments, the usual practice is that the financial institution providing the loan requires the borrower to sign a single contract.

Alternatively, the financial institution may require the borrower to sign n contracts. One for each of the n payments of the single contract. The reason for this procedure is that, considering its cost of capital, the financial institution may have a reduction, in terms of present values, of the amount of taxes it must pay.

In the above-mentioned contribution, it was considered only the usual case of a loan that must be reimbursed by n periodic constant payments. In this paper it will be examined the case where, besides the n periodic payments, the borrower has also to pay a sequence of ℓ balloon payments, with periodicity m.

This may be very interesting in the case of Brazil. Since, by law, every employer must pay, to each registered employee, thirteen monthly payments per year. The thirteenth one being known as the "décimo terceiro salário" (the thirteenth wage), which is usually paid during the month of December.
As will be shown, the financial institution is also better off if a single contract is substituted by multiple contracts in this new case.

II. THE CASE OF A SINGLE CONTRACT

Suppose that, besides the n constant equal payments p, the borrower has also to pay a sequence of ℓ balloon payments. Each one of them with the value P, with periodicity m, where $m = n / \ell$, and the first balloon payment at epoch m.

Denoting by i_m the equivalent rate of compound interest relative to m periods, so that

$$i_m = (1+i)^m - 1 \tag{1}$$

the assumption of n constant payments with value p, and additional ℓ payments with value P, with periodicity equal to m, implies that the following equation must be satisfied:

$$F = \frac{p \times \left\{1-(1+i)^{-n}\right\}}{i} + \frac{P \times \left\{1-(1+i_m)^{-\ell}\right\}}{i_m} \tag{2}$$

Therefore, once the value P of the ℓ balloon payments has been established, the value p of the n periodic constant payments will be equal to:

$$p = \frac{i}{1-(1+i)^{-n}} \times \left\{ F - \frac{P \times \left[1-(1+i_m)^{-\ell}\right]}{i_m} \right\} \tag{3}$$

Noticing that the k^{th} payment, p_k, is such that

$$p_k = \begin{cases} p, \text{ for } k = 1,2,m-1,m+1,\ldots,2m-1,2m+1,\ldots,n-1 \\ p+P, \text{ for } k = m,2m,\ldots,\ell \times m = n \end{cases} \tag{4}$$

it follows that, denoting by S_k the outstanding debt at epoch k, just after the k^{th} payment p_k, by J_k the parcel of interest, and by A_k the corresponding parcel of amortization of p_k, we have:

$$S_k = (1+i) \times S_{k-1} - p_k \quad , k = 1,2,\ldots,n \tag{5}$$

with $S_0 = F$ and $S_n = 0$ and

$$J_k = i \times S_{k-1} \quad , k = 1,2,\ldots,n \tag{6}$$

$$A_n = p_k - J_k \quad , k = 1,2,\ldots,n \tag{7}$$

As a simple numerical illustration of a single contract, consider the case where F=\$100,000.00, n = 12, ℓ = 4, m = 3, P = \$10,000.00 and i = 1% per period. In this case, the solution of equation (3) implies that, besides the 4 balloon payments of \$ 10,000.00, 12 periodic payments of \$ 5,584.66 will be necessary. Table 1 presents the evolution of debt.

Table 1: Evolution of the debt in the case of a single contract

k	J_k	A_k	p_k	S_k
0				100,000.00
1	1,000.00	4,584.66	5,584,66	95,415.34

2	954.15	4,630.50	5,584,66	90,784.84
3	907,85	14,676.81	15,584,66	76,108.03
4	761.08	4,823.58	5,584,66	71,284.45
5	712.84	4,871.81	5,584,66	66,412.64
6	644.13	14,920.53	15,584,66	51,492.11
7	514.92	5,069.74	5,584,66	46,422.37
8	464.22	5,120.43	5,584,66	41,301.94
9	413.02	15,171.64	15,584,66	26,130.30
10	261.30	5,323.35	5,584,66	20,806.94
11	208.07	5,376.59	5,584,66	15,430.35
12	154.30	15,430.35	15,584,66	0.00
∑	7,015.89	100,000.00	107,015.89	

III. THE CASE OF MULTIPLE CONTRACTS

Instead of a single contract, the financial institution providing the loan has the option of requiring the borrower to sign n individual contracts - one for each of the n payments that would be associated with the case of a single contract. With the value of the loan of the k^{th} subcontract being the present value, at the same interest rate i , of the k^{th} payment of the single contract.

That is, the value of the principal of the k^{th} subcontract, denoted F_k , is:

$$F_k = \frac{p_k}{(1+i)^k} \quad ,k = 1,2,...,n \tag{8}$$

In this case, the parcel of amortization associated with the k^{th} payment, denoted as A'_k will be:

$$A'_k = F_k = \frac{p_k}{(1+i)^k} \quad ,k = 1,2,...,n \tag{9}$$

Namely, the parcel of amortization associated with the k^{th} subcontract is exactly equal to the value of the loan of the k^{th} subcontract.

On the other hand, from an accounting point of view, it follows that the parcel of interest associated with the k^{th} subcontract, which will be denoted by J'_k wherein:

$$J'_k = p_k \times \left[1 - \frac{1}{(1+i)^k}\right] \quad ,k = 1,2,...,n \tag{10}$$

It should be especially noted that, although from the strict point of view, not taking into consideration the costs that may be associated with the bookkeeping and registration of the n subcontracts, the total of interest payments is the same in both cases. That is:

$$\sum_{k=1}^{n} J_k = \sum_{k=1}^{n} J'_k \tag{11}$$

However, in terms of present values, and depending on the financial institution cost of capital, it is possible that the financial institution will be better off if it adopts the multiple contracts option. As will be illustrated in the case of our simple example.

Table 2 presents the values of the sequence of payments p_k, the sequence of the parcels of interest J_k in the case of a single contract, and the sequence J'_k of the parcels of interest in the case of the adoption of the option of multiple contracts. As well as the sequence $F_k = A'_k$ of principals and the sequence of amortization components of the subcontracts. Additionally, Table 2 presents also the sequence of differences, d_k, and the sequence of accumulated values of d_k, denoted as Δ_k, given by:

$$d_k = J_k - J'_k \quad ,k = 1,2,...,n \tag{12}$$

$$\Delta_k = \sum_{\ell=1}^{k} d_\ell \tag{13}$$

It is interesting to note that the sequence of the values of d_k has more than one change of sign. However, adapting the proposition in Norstrom (1972), as the sequence of accumulated values of d_k, does not change sign, it follows that d_k has a unique internal rate of return. Which is, in this case, null. Since present values of the interest sequences of both cases, single V_s and multiple V_m, at interest rate ρ, that denotes the financial institution cost of capital, are $V_s(\rho)=V_m(\rho)=0$. With ρ being relative to the same period as the financing rate i. With:

$$V_s(\rho) = \sum_{k=1}^{n} J_k \times (1+\rho)^{-k} \tag{14}$$

$$V_m(\rho) = \sum_{k=1}^{n} J'_k \times (1+\rho)^{-k} \tag{15}$$

Table 2: Multiple Contracts

k	$F_k = A'_k$	J'_k	p_k	J_k	$d_k = J_k - J'_k$	Δ_k
1	5,529.36	55.29	5,584.66	1,000.00	944.71	944.71
2	5,474.62	110.04	5,584.66	954.15	844.11	,788.82
3	15,126.32	458.34	15,584.66	907.85	449.51	,238.33
4	5,366.75	217.91	5,584.66	761.08	543.17	2,781.49
5	5,313.61	271.05	5,584.66	712.84	441.80	3,223.29
6	14,601.45	903.21	15,584.66	644.13	- 239.08	2,984.21
7	5,208.91	375.75	5,584.66	514.92	139.17	3,123.39
8	5,157.34	427.32	5,584.66	464.22	36.90	3,160.29
9	14,249.67	1,334.98	15,584.66	413.02	- 921.97	2,238.33
10	5,055.72	528.94	5,584.66	261.30	- 267.64	1,970.69
11	5,005.66	579.00	5,584.66	208.07	- 370.93	1,599.76
12	13,830.59	1,754.07	15,584.66	154.30	- 1,599.76	0.00
∑	00,000.00	7,015.89	107,015.89	7,015.89	0.00	

As previously noted, the first point that should be observed is that, although the sum of the parcels of interest are the same in the case of a single contract and in the case of multiple contracts, the timing and the values of their respective payments are not the same.

Considering the period of i and ρ one month, Table 3 shows, for our example, the present values of the interest sequences for several values of the cost of capital, in annual terms, ρ_a.

Table 3: Present values of $V_s(\rho)$and $V_m(\rho)$

ρ_a	ρ	$V_s(\rho)$	$V_m(\rho)$	%(difference)
5%	0.40741%	6,879.47	6,776.37	1.52142%
10%	0.79741%	6,752.80	6,556.52	2.99373%
15%	1.17149%	6,634.79	6,353.91	4.42046%
20%	1.53095%	6,524.48	6,166.52	5.80477%
25%	1.87693%	6,421.07	5,992.62	7.14949%
30%	2.21045%	6,323.86	5,830.75	8.45713%

Therefore, in the case of our simple numerical example, we have $V_m(\rho)<V_s(\rho)$, if $\rho > 0$. Consequently, the financial institution providing the loan should prefer to implement the multiple contracts option.

A Particular Case – 13 Payments per Year

Although a more general analysis should consider the case where the periodic balloon payments P can assume any value, as long $P < F \times i_m / \left\{1-\left(1+i_m\right)^{-\ell}\right\}$, otherwise p would either be null or negative, we are going to focus attention on the case where $P=p$. Since this is the case that better contemplates the Brazilian peculiarity of thirteen yearly wages of the employees.

In this case, it follows, from equation (2) (see appendix A for demonstration), that the value of the periodic and balloon payments, p, will be such that:

$$p = \frac{F \times i \times i_m \times (1+i)^n}{\left[(1+i)^n - 1\right] \times (i + i_m)} \tag{16}$$

As a numerical illustration, consider the case where F=\$100,000.00 , i=1% per period, n=24 and ℓ=2. Observing that we will have 24 periodic payments equal to p=\$4,363.31, plus the two payments of the same value at epoch 12 and epoch 24. Table 4 presents the evolution of the debt of a single contract of this case and Table 5 the corresponding multiple contracts.

Table 4: Evolution of the debt Single contract – "thirteenth wage"

Epoch (k)	J_k	A_k	p_k	S_k
0				100,000.00
1	1,000.00	3,363.31	4,363.31	96,636.69
2	966.37	3,396.94	4,363.31	93,239.76
3	932.40	3,430.91	4,363.31	89,808.85
⋮	⋮	⋮	⋮	⋮
11	648.12	3,715.18	4,363.31	61,097.20
12	610.97	8,115.64	8,726.61	52,981.56
13	529.82	3,833.49	4,363.31	49,148.07
⋮	⋮	⋮	⋮	⋮
22	170.67	4,192.63	4,363.31	12,874.77

23	128.75	4,234.56	4,363.31	8,640.21
24	86.40	8,640.21	8,726.61	0.00
∑	13,445.95	100,000.00	113,445.95	

Table 5: Multiple contracts – "thirteenth wage"

k	$F_k = A'_k$	J'_k	p_k	J_k	$d_k = J_k - J'_k$	Δ_k
1	4,320.10	43.20	4,363.31	1,000.00	956.80	956.80
2	4,277.33	85.97	4,363.31	966.37	880.39	1,837.19
3	4,234.98	128.32	4,363.31	932.40	804.07	2,641.26
⋮	⋮	⋮	⋮	⋮	⋮	⋮
11	3,910.93	452.37	4,363.31	648.12	195.75	6,334.33
12	7,744.42	982.19	8,726.61	610.97	-371.21	5,963.12
13	3,833.87	529.43	4,363.31	529.82	0.38	5,963.50
⋮	⋮	⋮	⋮	⋮	⋮	⋮
22	3,505.46	857.84	4,363.31	170.67	-687.17	2,531.23
23	3,470.76	892.55	4,363.31	128.75	-763.80	1,767.43
24	6,872.78	1,853.83	8,726.61	86.40	-1,767.43	0.00
∑	100,000.00	13,445.95	113,445.95	13,445.95	0.00	-

Although the sequence d_k also has more than one change of sign, the sequence of its accumulated values Δ_k has no change of sign. Therefore, the sequence of differences d_k has a unique internal rate of return. Consequently, we are assured that $V_m(\rho)<V_s(\rho)$ for all $\rho > 0$ Table 6 shows the values of $V_s(\rho)$ and $V_m(\rho)$

Table 6: Present value of interest sequences. – Constant Installments

ρ_a	ρ	$V_s(\rho)$	$V_m(\rho)$	%(difference)
5%	0.40741%	25,111.16	24,720.56	1.58007%
10%	0.79741%	23,553.18	22,826.50	3.18346%
15%	1.17149%	22,180.97	21,163.52	4.80757%
20%	1.53095%	20,965.03	19,694.71	6.45002%
25%	1.87693%	19,881.53	18,390.32	8.10863%
30%	2.21045%	18,911.09	17,226.13	9.78142%

That is, at least in the case of our simple numerical example, with n equal to 24 periods (24 months and 2 years), the financial institution should choose to implement the multiple contracts option.

4.1. Reduction in the value of the installments

Given that, considering a contract with a term of n years, the effect of the "thirteenth wage" is to imply the value of the monthly payments to be reduced, as compared to the case of no "thirteenth wage", it is interesting to give a numerical illustration of the size of the reduction.

For instance, considering the constant installments methods, if the contract has a term of n = 20 years, with i = 1% per month, with and without the "thirteenth wage", it follows that the value of the monthly payment will be p = $ 1,101.09. While in the case of the "thirteenth wage", the value of the resulting

monthly payment will be p'=$1,020.61. That is, we will have a reduction of 7.31% in the value of the monthly payment.

However, as shown in Table 7, the resulting reduction decreases when the value of the financing interest rate i is increased. Furthermore, for every value of i, the resulting reduction does not change with the value of the term n.

Table 7: Percentual reduction of installments

	120 months			240 months		
Int. Rate	Original	13Wages	Δ%	Original	13Wages	Δ%
0.50%	1,110.21	1,026.95	-7.499%	716.43	662.71	-7.499%
1.00%	1,434.71	1,329.85	-7.309%	1,101.09	1,020.61	-7.309%
1.50%	1,801.85	1,673.53	-7.122%	1,543.31	1,433.40	-7.122%
2.00%	2,204.81	2,051.83	-6.939%	2,017.41	1,877.43	-6.939%
2.50%	2,636.18	2,458.01	-6.759%	2,506.69	2,337.27	-6.759%
3.00%	3,088.99	2,885.66	-6.582%	3,002.49	2,804.86	-6.582%

IV. GENERAL ANALYSIS

A comprehensive analysis would have to consider different values of the periodicity m of the balloon payments. However, given that De-Losso et al. (2013), did not address the behavior of what can be defined as the fiscal gain δ, given by:

$$\delta(\%) = \left[V_s(\rho)/V_m(\rho) - 1\right] \times 100 \tag{16}$$

We are going to focus on only two cases. The one with no balloon payments and the one with the "thirteenth wage".

5.1. The case of periodic payments only

In Tables 8 to 13, a comparison of single and multiple contracts values of δ are presented. In terms of the annual cost of capital value ρ_a, for different values of the monthly interest rate i, for contracts with term n ranging from 5 to 30 years.

Table 8: Fiscal Gain Comparison – monthly interest rate i=0.5% p.m.

Constant Installments - Single vs. Multiple Contracts						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	7.8844	15.9577	24.1931	32.5645	41.0469	49.6169
10	15.6432	32.6397	50.8269	70.0162	90.0068	110.5986
15	23.0441	49.2608	78.1367	109.0285	141.2650	174.2288
20	30.0078	65.3012	104.6218	146.4624	189.4352	232.4757
25	36.4748	80.3036	128.9813	179.8554	230.9162	280.9682
30	42.4060	93.9206	150.3444	207.9367	264.4861	319.0548

Table 9: Fiscal Gain Comparison – monthly interest rate i=1.0% p.m.

Constant Installments - Single vs. Multiple Contracts						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	7.4709	15.0921	22.8383	30.6852	38.6100	46.5914
10	14.0198	29.0432	44.9101	61.4475	78.4809	95.8444
15	19.5047	41.0777	64.2314	88.4350	113.1899	138.0765
20	23.9956	50.9828	79.8946	109.6788	139.5020	168.8095
25	27.6074	58.8032	91.7529	124.9283	157.3894	188.6977
30	30.4732	64.7578	100.2201	135.1035	168.6416	200.6545

Table 10: Fiscal Gain Comparison – monthly interest rate i=1.5% p.m.

Constant Installments - Single vs. Multiple Contracts						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	7.0804	14.2775	21.5676	28.9286	36.3396	43.7814
10	12.5912	25.9196	39.8353	54.1847	68.8199	83.6058
15	16.6379	34.6202	53.5221	72.9240	92.4622	111.8538
20	19.5387	40.7879	62.9157	85.2034	107.1470	128.4546
25	21.5953	44.9934	68.9223	92.4864	115.2285	136.9947
30	23.0520	47.7821	72.5546	96.4879	119.3078	141.0251

Table 11: Fiscal Gain Comparison – monthly interest rate i=2.0% p.m.

Constant Installments - Single vs. Multiple Contracts						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	6.7127	13.5130	20.3792	27.2909	34.2293	41.1772
10	11.3444	23.2246	35.5046	48.0510	60.7398	73.4620
15	14.3369	29.5463	45.2718	61.1867	77.0260	92.5980
20	16.2431	33.4752	51.0616	68.5062	85.4967	101.8767
25	17.4684	35.8643	54.2986	72.2220	89.4012	105.7919
30	18.2744	37.3076	56.0386	73.9866	91.0552	107.2993

Table 12: Fiscal Gain Comparison – monthly interest rate i=2.5% p.m.

Constant Installments - Single vs. Multiple Contracts						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	6.3673	12.7974	19.2702	25.7672	32.2715	38.7677
10	10.2616	20.9078	31.8173	42.8755	53.9793	65.0411
15	12.4920	25.5477	38.8727	52.2124	65.3724	78.2212
20	13.7799	28.1330	42.5733	56.7506	70.4649	83.6319
25	14.5535	29.5831	44.4504	58.8007	72.5100	85.5775
30	15.0423	30.4135	45.3891	59.6855	73.2758	86.2199

Table 13: Fiscal Gain Comparison – monthly interest rate i=3.0% p.m.

Constant Installments - Single vs. Multiple Contracts						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	6.0437	12.1289	18.2372	24.3519	30.4578	36.5415
10	9.3237	18.9184	28.6775	38.5028	48.3090	58.0256
15	11.0061	22.3717	33.8545	45.2545	56.4275	67.2821
20	11.9057	24.1377	36.3187	48.1948	59.6342	70.5915
25	12.4241	25.0787	37.4909	49.4210	60.8012	71.6479
30	12.7459	25.6036	38.0551	49.9222	61.2064	71.9629

Additionally, fixing the financing interest rate i, on 1% per month, Figures 1 and 2 depict the behavior of the fiscal gain, respectively for the cases where the opportunity cost varies from 5% to 30% per year, and when the length of the contract varies from 5 to 30 years.

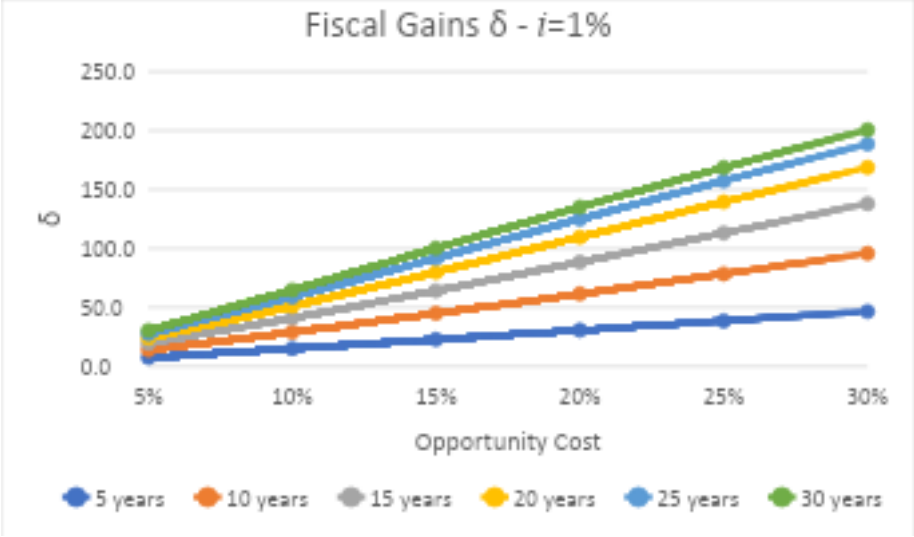

Figure 1: Fiscal Gains x Opportunity Costs

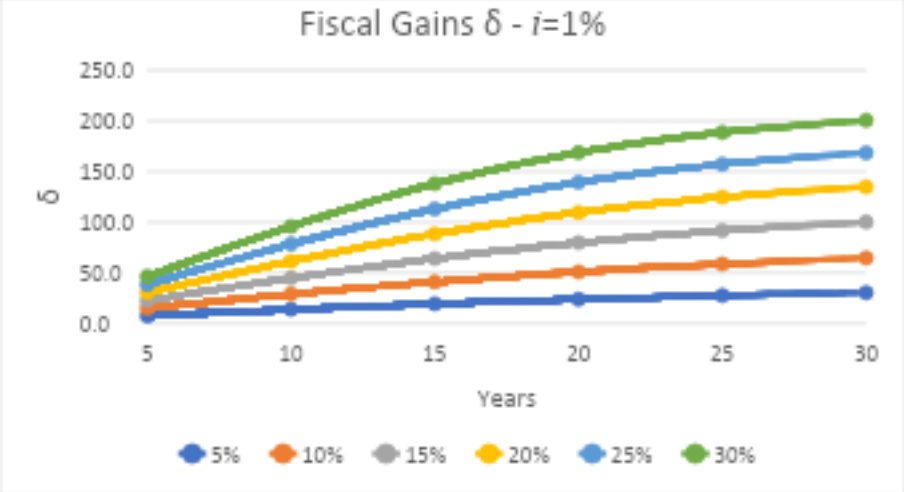

Figure 2: Fiscal Gains x Financial Terms

As shown, in all cases the fiscal gain is substantial. Which implies that the financial institution providing the loan should always choose the option of implementing multiple contracts.

5.2. The case of the "thirteenth wage"

Analogously, Tables 14 to 19 present the value of the fiscal gain δ , in terms of the annual value ρ_a for different values of the monthly interest rate i, for contracts with length n of 5 to 30 years.

Additionally, fixing the financing interest rate i at 1% per month, Figures 3 and 4 depict the behavior of the fiscal gain, respectively for the cases where the opportunity cost varies from 5% to 30% per year, and when the length of the contract varies from 5 to 30 years, for the case of thirteen wages.

Table 14: Fiscal Gain Comparison 13 Wages – monthly interest rate i=0.5% p.m.

Constant Installments - Single vs. Multiple Contracts – 13 Wages						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	7.9499	16.0955	24.4096	32.8657	41.4385	50.1043
10	15.7020	32.7705	51.0423	70.3276	90.4246	111.1317
15	23.0986	49.3869	78.3498	109.3411	141.6869	174.7680
20	30.0583	65.4209	104.8252	146.7593	189.8330	232.9811
25	36.5212	80.4147	129.1682	180.1247	231.2740	281.4229
30	42.4484	94.0214	150.5109	208.1736	264.8009	319.4594

Table 15: Fiscal Gain Comparison 13 Wages – monthly interest rate i=1.0% p.m.

Constant Installments - Single vs. Multiple Contracts – 13Wages						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	7.5300	15.2162	23.0327	30.9551	38.9602	47.0264
10	14.0668	29.1469	45.0793	61.6900	78.8037	96.2536
15	19.5431	41.1647	64.3755	88.6429	113.4669	138.4274
20	24.0268	51.0542	80.0123	109.8471	139.7251	169.0926
25	27.6326	58.8604	91.8460	125.0606	157.5658	188.9256
30	30.4934	64.8031	100.2929	135.2076	168.7842	200.8451

Table 16: Fiscal Gain Comparison 13 Wages – monthly interest rate i=1.5% p.m.

Constant Installments - Single vs. Multiple Contracts – 13Wages						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	7.1337	14.3891	21.7423	29.1706	36.6531	44.1701
10	12.6290	26.0020	39.9688	54.3750	69.0718	83.9237
15	16.6652	34.6812	53.6218	73.0666	92.6515	112.0934
20	19.5585	40.8324	62.9884	85.3072	107.2857	128.6328
25	21.6098	45.0260	68.9755	92.5634	115.3343	137.1359
30	23.0629	47.8065	72.5949	96.5486	119.3953	141.1473

Table 17: Fiscal Gain Comparison 13 Wages – monthly interest rate i=2.0% p.m.

Constant Installments - Single vs. Multiple Contracts – 13Wages						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	6.7608	13.6135	20.5362	27.5082	34.5103	41.5252
10	11.3747	23.2906	35.6110	48.2020	60.9392	73.7132
15	14.3567	29.5902	45.3434	61.2890	77.1622	92.7714
20	16.2563	33.5050	51.1106	68.5772	85.5934	102.0036
25	17.4777	35.8855	54.3342	72.2754	89.4773	105.8967
30	18.2813	37.3235	56.0666	74.0310	91.1220	107.3949

Table 18: Fiscal Gain Comparison 13 Wages – monthly interest rate i=2.5% p.m.

Constant Installments - Single vs. Multiple Contracts – 13Wages						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	6.4107	12.8880	19.4115	25.9625	32.5239	39.0801
10	10.2863	20.9611	31.9032	42.9972	54.1399	65.2436
15	12.5068	25.5806	38.9265	52.2897	65.4762	78.3547
20	13.7894	28.1546	42.6095	56.8043	70.5398	83.7323
25	14.5601	29.5987	44.4775	58.8431	72.5723	85.6649
30	15.0473	30.4257	45.4117	59.7228	73.3331	86.3026

Table 19: Fiscal Gain Comparison 13 Wages – monthly interest rate i=3.0% p.m.

Constant Installments - Single vs. Multiple Contracts – 13Wages						
	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	6.0829	12.2107	18.3647	24.5279	30.6851	36.8226
10	9.3439	18.9622	28.7480	38.6028	48.4412	58.1926
15	11.0175	22.3974	33.8968	45.3161	56.5111	67.3909
20	11.9130	24.1546	36.3477	48.2389	59.6969	70.6771
25	12.4293	25.0912	37.5136	49.4576	60.8559	71.7255
30	12.7499	25.6139	38.0750	49.9557	61.2583	72.0381

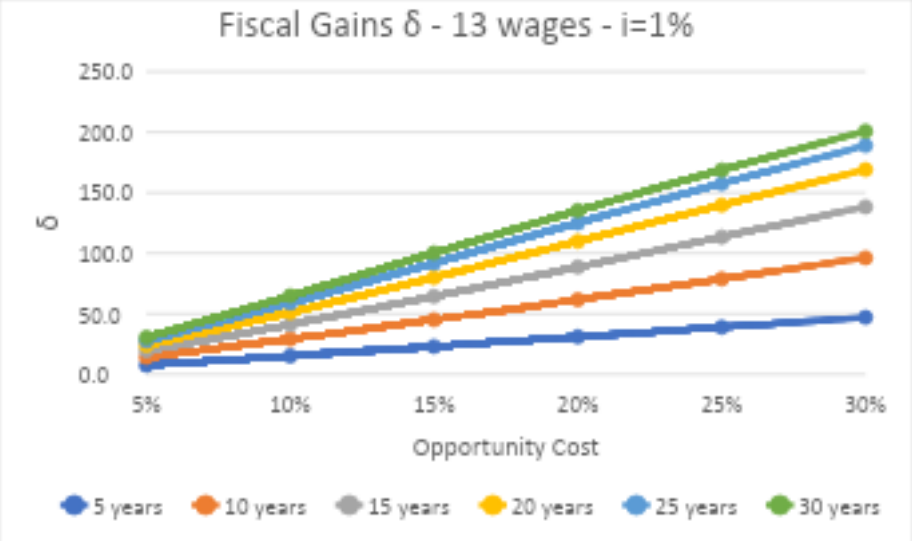

Figure 3: Fiscal Gains x Opportunity Costs – 13 Wages

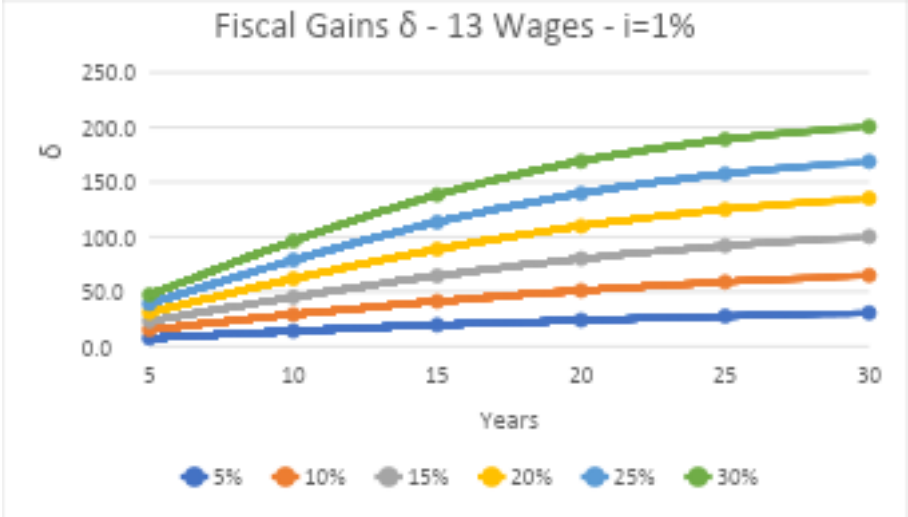

Figure 4: Fiscal Gains x Financial Terms – 13 Wages

As shown, in all cases fiscal gain is very substantial. Therefore, given that implementing the policy of considering the "thirteenth wage" is beneficial to the borrower, the financial institution providing the loan, should also prefer to adopt the option of substituting a single contract by multiple contracts.

V. CONCLUSIONS

As shown in the other cases previously analyzed, cf. De-Losso et al. (2013), for the case of constant payments, de Faro (2021), for the case of periodic payments only, de Faro (2022), for the case of the constant amortization, de Faro and Lachtermacher (2023b), for the case of the an alternative version of the SACRE, and de Faro and Lachtermacher (2024), for the case of the German system of amortization, it always better for the financial institution providing the loan to implement the policy of multiple contracts.

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Appendix A

$$F=\frac{p\times\left\{1-(1+i)^{-n}\right\}}{i}+\frac{p\times\left\{1-(1+i_m)^{-\ell}\right\}}{i_m}$$

$$F=p\times\left[\frac{\left\{1-(1+i)^{-n}\right\}}{i}+\frac{\left\{1-(1+i_m)^{-\ell}\right\}}{i_m}\right]=p\times\left[\frac{i_m\left\{1-(1+i)^{-n}\right\}+i\left\{1-(1+i_m)^{-\ell}\right\}}{i\times i_m}\right]$$

$$p=\frac{F\times i\times i_m}{i_m\left\{1-(1+i)^{-n}\right\}+i\left\{1-(1+i_m)^{-\ell}\right\}}=\frac{F\times i\times i_m}{i_m\times\left\{1-\frac{1}{(1+i)^n}\right\}+i\times\left\{1-\frac{1}{(1+i_m)^{\ell}}\right\}}$$

$$p=\frac{F\times i\times i_m}{i_m\times\left\{\frac{(1+i)^n-1}{(1+i)^n}\right\}+i\times\left\{\frac{(1+i_m)^{\ell}-1}{(1+i_m)^{\ell}}\right\}}=\frac{F\times i\times i_m\times(1+i)^n\times(1+i_m)^{\ell}}{i_m\times(1+i_m)^{\ell}\times\left[(1+i)^n-1\right]+i\times(1+i)^n\left[(1+i_m)^{\ell}-1\right]}$$

since

$$(1+i)^n-1=(1+i_m)^{\ell}-1\Rightarrow(1+i)^n=(1+i_m)^{\ell}$$

$$p=\frac{F\times i\times i_m\times(1+i)^n\times(1+i_m)^{\ell}}{i_m\times(1+i_m)^{\ell}\times\left[(1+i)^n-1\right]+i\times(1+i)^n\left[(1+i_m)^{\ell}-1\right]}=\frac{F\times i\times i_m\times(1+i)^n}{i_m\times\left[(1+i)^n-1\right]+i\times\left[(1+i_m)^{\ell}-1\right]}$$

$$p=\frac{F\times i\times i_m\times(1+i)^n}{i_m\times\left[(1+i)^n-1\right]+i\times\left[(1+i)^n-1\right]}=\frac{F\times i\times i_m\times(1+i)^n}{\left[(1+i)^n-1\right]\times(i+i_m)}$$

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A Simple Proof of Ergodic Theorem for Recursive Decision

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Zhejiang University of Finance & Economics.

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Highlights

Recursive decision systems are dynamic systems that represent the asymptotic behavior of decision makers.

Rational choice on recursive decision under measure preserving transformation can lead to asymptotic behavior in a stationary environment.

The ergodic theorem provides sufficient conditions for recursive decision systems to possess ergodic properties, that is, for sample averages to converge to an invariant limit.

I. INTRODUCTION

People frequently modify their behavior and We do observe behavioral anomalies that deviate from the rational choice model use in economics, expected utility maximization combined with Bayes' rule. Nevertheless, if sample averages converge for a sufficiently large class of measurements, i.e., ergodic behavior or average behavior, is there a behavior related to arbitrary choice sets under the dynamical system on a set of full measure has either measure 0 or full measure? This paper show that rational choice on recursive decision under measure preserving transformation can lead to asymptotic behavior in a stationary environment. I mean by asymptotic behavior choice sequences that time averages converge to the space average.

The property of ergodicty for recursive decision systems with an invariant probability measure have been put to describe, formulate and analyze the average behavior of various economic sectors and dynamic economic theories. asymptotic behavior of the type under investigation here was shown to sample path properties of economic dynamics by Kamihigashi and Stachurski(2016), recursive equilibrium in dynamically incomplete markets by Cao(2020), ergodicty in economic decisions by Peters(2019), existence conditions for stationary ergodic Markov equilibrium by Ma(1993), the ergodic behavior of stochastic processes of economic equilibria by Blume(1979). Applications in dynamic macro model followed in the work of Benhabib and Day(1981), Day and Shafer(1987), Nishimura et al(1994), Araujo and Maldonado(2000), Huang(2001). With the advancement of artificial intelligence and algorithmic game theory, more issues central to recursive decision systems that model human recursive reasoning and involve interactions between multiple agents, this paper contributes to understanding the asymptotic behavior of human decision-making and interaction.

In this paper, rather than focusing on a specific model, I attempt to derive conditions under which recursive decision models will give asymptotic convergence. The two behavioral assumptions I require are that choice sets need not be convex and that the decision making process is characterized by learning. The recursive decision systems refers to the model configuration of Day and Kennedy(1970).In the proofs of my results I rely on the ergodic properties for dynamical systems given by Aaronson(1997), Gray(2009), Pollicott and Yuri(1998), and the implications of average behavior for rational choice are similar to those discussed by Hammond(1976), Blume(1979), Elton(1987), Canning(1992), Carlsson(2004).

Section 2 contains necessary assumptions and definitions. Section 3 proves some lemmas and the ergodic theorem for recursive decision systems. The final section is a brief discussion of the theorem.

II. ASSUMPTIONS AND DEFINITIONS

Let (Ω,B,μ) be a probability space that represents the space of the states of the world. Ω is the set of all possible states of the world, $\omega\in\Omega$ shall be call an information; B is a σ-algebra of events which, in the case where Ω is finite, is simply the set of subsets of Ω.Then an event is a subset of Ω, and μ is a measure of probability over the events of B. Let $f:\Omega\to R$ be a measurable mapping of (Ω,B,μ) into a space of outcomes which an observable for an economical quantity.

ASSUMPTION 1. $f\in L^1(\Omega,B,\mu)$ the space of all linear integrable functions.

A recursive decision system is a function T defined on a set Ω, a transformation $T:\Omega\to\Omega$ is the law of motion which prescribes that if the decision system is an state ω at time $n\in Z$, then it will evolve to state $T(\omega)$ after one unit of time, and is measure-preserving if $\mu\left(T^{-1}(B)\right)=\mu(B)$ for every $B\in B$. The successive iterates of the map are defined by induction $T^n:=T\circ T^{n-1}$, the transformation associates with the initial sets of possible information depending on the studied time scale, and the orbit $\{T^n(\omega)\}$ is a sequence of the time evolution for a recursive decision system returns to all accessible states with equal probability.

ASSUMPTION 2. An orbit set is compact.

DEFINITION 1. The time average or sample average of f, if it exists, is defined by:

$$f^*(\omega)=\frac{1}{N}\sum_{n=0}^{N-1} f(T^n(\omega)),\ \omega\in\Omega,\ n\in Z^+.$$

DEFINITION 2.The space average is defined, if it exists, as:

$$\overline{f}(\omega)=\int_{\Omega} f(\omega)d\mu.$$

this statement is often referred to as iterated expectation since it shows that the expectation of f can be found in the conditional expectation given a class of measurements and then integrate the conditional expectation.

Ergodicity property with respect to a measurement f is to describe the average behavior of $T^n(\omega)$ as $n\to\infty$.

DEFINITION 3. Given a *measure-preserving* recursive decision *system is called ergodic if for* every $B\in B$ with $T^{-1}(B)=B$ have that either $\mu(B)=1$ or $\mu(B)=0$.

DEFINITION 4. A *measure-preserving* recursive decision *system is said to be invariant or stationary if* $\mu\left(T^{-n}(B)\right) = \mu(B)$, all events B, all $n \in Z^{+}$, and let set I_T={ $B \in B \mid T^{-1}(B) = B$} denote the σ-algebra of T-invariant sets.

III. MAIN RESULTS

The following lemmas gives a characterization of ergodic measures.

LEMMA 1. T is ergodic with respect to μ iff whenever $f \in L^1(\Omega,B,\mu)$ satisfies $f = f \circ T$ then f is a constant function.

Proof. See Gray(2009).

LEMMA 2. Given any continuous transformation T: Ω→Ω there exists at least one T-erodic probability measure μ.

Proof. Let Φ denote the set of invariant probability measures on Ω, there is a weak-star topology such that a sequence $\mu_k \in \Omega$ converges to $\mu \in \Omega$ iff $f \in C^0(\Omega)$. Choose a dense set of functions $f_k \in C^0(\Omega)$, there exists $\Phi_k = \{\varphi \in \Phi_{k-1} | \int f_k d\varphi = sup_{\varphi\in\Phi_{k-1}}\{\int f_k d\mu\}\}$, $k \in Z^{+}$, and shows nested sequence $\Phi_k \subset \Phi_{k-1} \ldots \subset \Phi$ is closed and non-empty. Assume that $\mu \in \Phi$ is convex, it suffices to see that $sup_{\varphi\in\Phi}\{\int f_k d\varphi\} = \int f_k d\mu = \int f_k d\alpha\mu_1 + \int f_k d(1-\alpha)\mu_2$, where $\mu_1, \mu_2 \in \Phi_k$.The proof show that probability measure μ is ergodic.

Lemma 2 ensures that for transformation T generates a well-defined probability measure on the set of orbits.

THEOREM. Let (Ω,B,μ) be a measure space for which $\mu(\Omega) < \infty$,If $f \in L^1(\Omega,B,\mu)$ and the measure μ is ergodic then for almost all$\omega\in\Omega$ recursive decision *systems have that the* time average converge to the space average.

Proof. Set $F_N f(\omega) = \frac{1}{N}\sum_{n=0}^{N-1} f(T^n(\omega))$. For $\varphi \in L^1(\Omega,B,\mu)$, set

$$G_N\varphi = \max\{\sum_{m=0}^{p-1} \varphi \circ T^m : 1 \le p \le N\},$$

and $F_N\varphi \le \frac{1}{N} G_M\varphi$. Set

$$A = A(\varphi) = \{\omega \in \Omega | sup_N G_M\varphi(\omega) = \infty\} \in I_T.$$

For $\forall\omega \in F^c$, there is

$$sup\, A_N\varphi(\omega) \le 0.$$

$G_M\varphi$ is the increasing function sequence, and

$$G_N\varphi(T(\omega)) = \max\{\sum_{m=1}^{p-1} \varphi(T^m(\omega)) : 2 \le p \le N+1\}.$$

So

$$G_{N+1}\varphi(\omega) - G_N\varphi(T(\omega)) = \varphi(\omega) - \min\{0, G_N\varphi(T(\omega))\} \ge \varphi(\omega).$$

Therefore, on the set A, the sequence $G_{N+1}\varphi(\omega) - G_N\varphi(T(\omega))$ gradually decreases and converges to φ, and for Lebesgue's dominated convergence theorem,

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$$0 \leq \int_A (G_{N+1}\varphi - G_N\varphi)d\mu \leq \int_A (G_{N+1}\varphi - G_N\varphi \circ T)d\mu \to \int_A \varphi d\mu.$$

Set $\varepsilon > 0$, and $\varphi = f - f^* - \varepsilon$. For $A=A(\varphi) \in I_T$, there is $\int_A f d\mu = \int_A f^* d\mu$, so

$$\int_A \varphi d\mu = \int_A (f - f^* - \varepsilon)d\mu = -\varepsilon\mu(A) \leq 0.$$

Further $\int_A \varphi d\mu = 0$, and $\mu(A(\varphi)) = 0$. Therefore $sup\, A_N\varphi(\omega) \leq 0, \forall\omega \in \Omega$ a.e.. Since f^* is T-invariant, and $A_N\varphi = A_N f - f^* - \varepsilon$, then lead to $sup\, A_N f(\omega) \leq f^* + \varepsilon$. Finally, the same can be said about $-f$, $sup\, A_N f(\omega) \geq f^* - \varepsilon$.

IV. CONCLUSION

I providing sufficient conditions for recursive decision systems to possess ergodic properties from its stationary mean, a recursive decision system is asymptotically dominated by measure preserving transformation. In fact, arbitrary choice set contains multiple distance between measures, the theorem fails to explain how such distances affect their respective ergodic properties; on the other hand, the ideas can be extended to the possibility of asymptotic behavior for a wide variety of rational decision involving dynamic economic model.

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