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"Changes in Accounting roles and instruments, from double-entry book-keeping to block-chain."

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To Laura.

Table of Contents

Abstract.

This work aims to historically frame the change in accounting, from the point of view of needs and information changes, particularly through the transformation of enterprises in Renaissance times and through the phases of evolution dictated by industrial revolutions and to highlight possible developments in accounting, through the application of new information technologies available (in this specific case the Blockchain) identifying the new possibilities of information management and new methods of data collection, analysis and reporting.

The evolution of new information technologies, both in the sense of system architectures as for Blockchain, both in the sense of integration of interconnected systems, offers new possibilities and new challenges, represented by the capability to quickly and contextually collect the total complex of information produced by the activities of companies and the management of information itself, in the sense of acquisition and reporting and to make the system accountable as a whole.

The times we are living in, are facing the Fourth Industrial Revolution, characterized by economic and social changes driven by new technologies, in a context of continuous climate change, and in presence of increasingly frequent financial, economic, and health crises. In this context of uncertainty, the amount of available information that needs to be analyzed promptly for decision-making purposes is constantly increasing.

In this work, the variation in the amount of information to be recorded and analyzed is identified as a cause of change in accounting, requiring the transition from simple records to double-entry bookkeeping. The need to manage a greater amount of information flows also creates the need to identify criteria to discern information, making it necessary to identify criteria of relevance and materiality. Consistently, early traces of these two principles are identified in Tractatus XI of Summa de Arithmetica, Geometry, Proportionality and Proportionality, printed in Venice in AD 1494 by Franciscan friar Luca Pacioli, an iconic work on the dissemination of the double-entry book-keeping.

Once established the effects that changes in the quantity and quality of the information to be managed have on accounting, considering, the specific context of the fourth industrial revolution in progress. To frame the process of the accounting change, a specific literature review was conducted to identify the historical relationship of change in accounting through preceding industrial revolutions, identifying six main factors of change in accounting both internal and external: variation in firm's complexity, the need of improving profit or efficiency, new management requirements, the change in the relationship between property and management, the change in market conditions and the social environment.

Since almost all the elements of change in accounting identified for the preceding industrial revolutions can also be identified for the fourth industrial revolution, this research has therefore explored the current state of change in accounting and questioned whether the current technological tools, as well as potential agents of change, are already possible application tools. The blockchain technology has therefore been identified as a possible tool for the reduction of moral hazard in the case of non-repayable financial grants, distributed by governments in case of financial or health crisis, as it allows prompt management of a large amount of information in a crisis context. This last result allows, therefore, to recognize the level of adequacy of the new technologies, for the resolution of actual problems where, in particular, non-linear solutions are required.

1. Presentation and research structure

1.1. **Introduction**.

The times we are living in, are facing the Fourth Industrial Revolution, characterized by economic and social changes driven by new technologies, in a context of continuous climate change, and in presence of increasingly frequent financial, economic, and health crises. In this context of uncertainty, new technologies such as Blockchain, the Internet of Things, and Artificial Intelligence are emerging, bringing with them new opportunities, risks, and challenges. These new technologies on the one hand generate an impressive amount of data, increasing with the growth of the Internet of Things. On the other hand, the economic context requires the recognition, management, and analysis of this data readily and responsively, for decision-making purposes. This work is mainly concerned with identifying the relationship between this growing demand to manage information and the changing tools and roles of the accounting, also through the historical contextualization of this process of change.

The objective of accounting is, as is well known, the production and management of the information necessary to make decisions for the conduct of business processes. This process is formalized by the Theory of Rational Administration, according to a cognitive cycle divided into three phases: planning, execution, and control. These three macro phases are interlinked, and the whole process is characterized by the need and creation of knowledge through information flows deriving from decisions, measurement of results, and analysis of variances (Puddu, 2005). By its nature, therefore, accounting is strongly linked to information.

Before its current formalization, accounting has evolved through a long and complex process, always characterized by qualitative leaps. (Coronella, 2014). And it is a long evolutionary process if it is considered that the first known forms of accounting are more than five thousand years ago.

Accounting, conceived as a simple "art of keeping accounts" to keep alive the memory of one's own or others' trade and goods, began to take shape with the establishment of the legal principle of ownership. The affirmation of this principle, capable of giving rise to rights and obligations, posed the need to improve the methods that would facilitate economic relations (D'Atri, 1994). Since the first urbanization, man has hence had to resort to practices of administration of wealth and goods, and the relationship between accounting and the birth of writing is well known, precisely as a tool to administer state finances. Around 3500 BC in the plains of Mesopotamia, in the fertile delta of the Tigris and Euphrates, the administration of vast goods for the gods required priests to invent a system of conventional signs to record income and expenditure (Childe, 1961). In other words, due to the need to keep a record of assets and transactions, accounting was born along with writing.

As it is logical to expect from a phenomenon that has such a long duration, it is the great amount and variety of changes it has undergone over the centuries. This aspect, the change in accounting compared to the variation in complexity and quantity of information, is very topical today. In fact, our society is going through a phase of new and profound change, thanks to new information technologies. The amount of data that our society produces every day was inconceivable only ten years ago, and this phenomenon is constantly growing. But this aspect, which at first glance may seem far from accounting, is actually of interest. More and more companies want to profit from this new information collected, or produce information in their operations and therefore have to manage it. Beyond this change in the production of information, another broader aspect must also be identified. Society as a whole is changing, both from the point of view of social relations and from the point of view of production factors. This change IT-Dirven (Lasi et al., 2014) is today identified as the Fourth Industrial Revolution.

Like every industrial revolution, this one, too, brings with it new potential and challenges, but also risks and criticality to face, making important and current the duality between social and technological innovation (Morrar et al., 2017). Starting from the assumption that companies, being open systems, are open to external exchanges (Ferrero, 1980), it is natural that these technological and social changes

also produce changes in companies (Zhou et al., 2015). Along with the need to manage the new ways of acquiring information, there is also the need to shorten information processes and make them more responsive and smart. This is a process we have already observed in the past. In recent decades, in parallel with the new potential that technology has provided, accounting, where possible, has exploited them, for example with the development of Information and Communication Technology and business intelligence systems. But even in later years, accounting tools have changed under the pressure of new requirements. Without necessarily thinking about the mechanization of writing or the adoption of particular hardware technologies, the instruments have evolved even simply by changing the procedure of data collection and their exposure. If the transition from simple records to double-entry book-keeping is considered, the epochal scope of this change becomes immediately clear. Or if the modification of the calculation procedures is considered, for example for the standard costing, or the creation of the first indicators such as Return of Capital Employed. And it is for this reason that more and more the history of accounting has set itself not only to identify the progression of the technique, but rather, and above all, to identify the new ideas and the underlying theoretics (Costa, 2011). but even if attention was directed only to hardware tools, today those available are no longer sufficient. As we have seen, the production of data today has completely changed, and it is more and more common to have to manage real masses of data until we have to mention precisely Big Data. Once this context of possible change has been framed, possible areas of research emerge, and this work identifies and wants to explore three of them, which are connected to each other.

1.2. Research Area.

First Research Area. The increasing amount of information to be managed leads to the need to identify criteria to determine whether and when the information is relevant. This suggests to questions about the relevance and materiality of information, and how this issue has affected accounting.

Second Research Area. Once the effects that changes in the quantity, and quality of the information to be managed, have on accounting are established, other possible change agents on accounting may emerge. Considering, then, the specific context of the fourth industrial revolution in progress, a historical survey on the relationship between accounting change and industrial revolutions can be carried out.

Third Research Area. After identifying the relationship between industrial revolutions and accounting, it may be questioned whether the current technological tools instruments, as well as potential agents of change, are already possible application tools.

These three related research areas are addressed in the second, third, and fourth chapters of this research, briefly described below.

1.3. First Research Area

The increase in the amount of information raises at least two new issues. The first is the need to be able to process and understand information and the second is the need to identify what information is relevant. The relevance and intelligibility of accounting information, in fact, are two indispensable aspects that have been identified by international accounting standards for a long time (Accounting Standard Steering Commitee, 1975). Moreover, if the accounting information must also be processed automatically, in the presence of a large amount of data it must be possible to discern among which of this information can make the difference to a decision-maker in the decisions made by users. (International Accounting Standards Board [IASB], 2018). The problem of the relevance and intelligibility of information is indeed a very broad problem and its identification has its origins in the more distant past. Approaching the problem, traces of these problems have already been found among skeptics, ancient Greek philosophers, who argued that in case of uncertainty about the degree of truth about information, it should not be taken into account, that is if the information is not certain then it is not relevant, or that if a criterion of absolute truth is not possible, it is possible, however, a criterion

of credibility that allows choosing certain information as more plausible than others (Schutz, 1975). Without considering now the wide theoretical and semiological framework made by Schutz on the problem of relevance, we must however consider the multitude of traces of this problem found in different areas of knowledge and identifiable in ancient times. Considering together these arguments, and above all the wide time line in which these problems have been dealt with, it was concluded that a frame of relevance in accounting should be made in the light of the historical investigation. In the second chapter of this work, early traces of materiality and relevance principles are consequently investigated and found in the very famous Summa de Arithmetica, Geometry, Proportionality and Proportionality of Friar Pacioli.

The research was therefore addressed to the recognition of these principles in the work of the Friar, printed in Venice in 1494. This work was selected as an object of study both for the great impact it had in accounting studies (Coronella, 2014), (Melis, 1950), both for the work of dissemination of the double-entry book-keeping technique and for being the oldest accounting text in which these elements have been identified. After having theoretically framed the principles of relevance and materiality as established today by the IASB, Pacioli's text was then analyzed in the parts inherent to the study of accounting, and the traces found of the two principles investigated were discussed.

To carry out this research and to investigate the causes and origins of the Summa, an analysis has been conducted to place Pacioli's work correctly in its historical context. Within this research, some probable causes were identified that could affect the transition from simple records to double-entry book-keeping, and the causes for which traces of the principles of materiality and relevance in Pacioli's treatise can be discerned. These causes have been identified in the process of the profound transformation of companies from money-lending into commercial capitalism, (Pollard, 1963) with a subsequent strong trade expansion and change in the banking system, and for the need of the Bankers of one clear and unambiguous instruments for the accounts of all debtors and creditors (Sangster, 2016). The changed social and economic context, in the transition between the Middle Ages and the

Renaissance, characterized by the increase in trade, and the increase in accounting information to be managed, has therefore led to a change in accounting.

As a result of this initial research, changes in the market on the one hand and changes in the complexity to be managed on the other, considered in the context of changing society and technology, have been identified as reasons for changing roles and accounting instruments. However, given our current context of change, identified with the fourth industrial revolution in progress, it was questioned whether the causes of change identified in the past had a significance also in other periods characterized by industrial revolutions or in the current context, with a particular historical focus on industrial revolutions in general. This question naturally induced the next area of research. This area of research is therefore to identify, among the factors of change that **characterize** industrial revolutions, those that are agents of change for accounting.

1.4. Second Research Area.

As we have seen, the social and economic change that occurred between the Middle Ages and the Renaissance has been identified as an agent in the change in accounting techniques. To argue what the future changes in accounting may be, it seems logical to try to identify and better specify other possible agents of change. The third chapter, therefore, deals with identifying the reasons for the changes in accounting according to the new requirements. But what can these new needs be? Are the changes in accounting due to changes in technology? To the market? To the change in social relations?

The literature on the changes in accounting in the past times is very wide and diversified. Without wanting to be exhaustive, monographic research can be identified on a historical and theoretical basis, (Coronella, 2014), (Costa, 2011), or transversal by themes and geographical areas (Mattessich, 2003), or they can be of a general nature such as the Routledge Companion of Accounting Histoy. (Edwards & Walker, 2009). In addition to scientific articles, with different orientations, from

micro-history articles that approach in detail a single aspect (Williams, 1999), to the analysis of a single aspect of accounting but analyzed in different contexts (Richard K. Fleischman & Macve, 2002), or on different time-lines (R K et al Fleischman, 1996), on managerial aspects (Ding & McKinstry, 2013), or social (S. Toms & Shepherd, 2017), or based on social-political frameworks (Tepper & Borowiecki, 2015), (R. A. Bryer, 2005) or even religious (Funnell & Williams, 2014), just to show a sample. Considering the great research effort already made previously by the scholars, and that the general thrust given to this research is the fourth industiral revolution, then the chosen direction was to carry out a systematic analysis of the literature, to investigate specifically the role of past industrial revolutions as a cause of the changes in accounting.

Through a progressive selection and analysis of the literature, thirty articles dealing with the change in accounting, during one or more phases of previous industrial revolutions, have been selected. From the analysis of these articles, six clusters of factors affecting the change in accounting have been identified. These identified causes of change were the following *Variation in Firm's Complexity, Improving Profit or Efficiency Management Requirements, Relationship between Property or Property and Management, Social Environment,* and *Changes in Market Condition*, that can be thought of as individual aspects of the industrial revolution. But according to this scheme of thought, also the industrial revolution can be identified as a further indirect cause of change and specialization of the accounting instruments or roles. As a last point of interest, it has emerged that not only the causes of change affect the change in accounting, but also that the accunting itself, once evolved, acts for a retroactive mechanism on the causes. It has been identified in cases where an excessive control role is attributed to the accounting, which in turn generates an increase in the Firm's complexity, and in cases where the introduction of behavioral control tools has an impact on the social environment, both internal and external to the firm.

Once these relations of action, but also of feedback, have been identified among the elements of change that characterized the industrial revolutions in the past, we can then try to understand if at present the causes of change are only present or if accounting is ready for or has already begun to absorb the new elements that

constitute the technical reasons of the fourth industrial revolution. this question addresses the next area of research.

1.5. Third research area.

As already seen, industrial revolutions have been characterized by new technological and socio-economic factors, which have brought benefits, risks, and challenges, and the fourth industrial revolution is not an exception. (Morrar et al., 2017). Almost all the elements of change in accounting, which will be detailed and discussed in the third chapter and just before mentioned, are already identified in the literature also in this industrial revolution. The impact in management and cost reduction (Janovská et al., 2019) can be seen as Improving Profit or Efficiency, according to the classification of causes identified in the fourth chapter. The social aspect of the company, from the point of view of sustainability (Tiwari & Khan, 2020), and the capabilities in controlling people's behavior through the IoT (Al-Hitmi & Sherif, 2018) can be identified as a variation of the social environment. These new technologies also open up new market shares on one hand (Wahl, 2015), with a consequent change in market condition, and certainly vary the business complexity, just to provide samples.

But not only from the literature can be identified elements of the actual change. Concrete examples in the application of blockchain technology can already be found, such as in electricity distribution or e-government practices (Secinaro, 2020).

While these typical factors of the industrial revolution can be identified today, our times, marked by continuous climate change, intercontinental economic and financial crises, and global pandemic, are certainly also characterized by a high level of volatility, uncertainty, complexity and ambiguity (VUCA). Therefore, research was developed to verify whether new technologies were already able to provide accounting solutions for the management of these types of disrupting phenomena. The practical case study was therefore identified as the task of

reducing risk of the moral hazard, in the case of non-repayable financial grants, with extremely long maturities or external guarantees, as intervention by governments or monetary funds to prevent collapse and to guarantee the survival of the economy in general and of firms in particular, in the case of economic or health crises. This practical problem has been selected for the presence of elements such as the large amount of data to observe, and the need to quickly analyze them in crisis contexts.

From the literature, it has emerged that the presence of such contributions of money, in the absence of the principle of *do ut des*, can lead to undesirable behavior, such as improper use, or use different from the purposes intended by the issuing body, or the handling of such sums for longer than is necessary. The cause of these behaviors is identified in the presence of information asymmetry among the actors or as a result of a contractual imbalance. The information asymmetry among the actors is deriving from the fact that the measurement of behaviors could be impossible, due to the excessive number of necessary observations, or due to it is too expensive. As shown in the fourth chapter, the proposed solution to reduce the presence of moral hazard is therefore identified with the possibility of introducing a series of concomitant wide-ranging controls based on blockchain technology and the introduction of smart contracts to automatically and promptly regulate the uses identified as inappropriate.

The last chapter concludes this research work by outlining the conclusions, the limits of this work, and future developments.

2. Early traces of Materiality and Relevance principles in Luca Pacioli's Tractatus XI

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Abstract.

This paper aims to investigate the materiality and relevance principles, as observed from a historical perspective, specifically as shown in the Tractatus XI of Summa de Arithmetica, Geometria, Proportioni et Proportionalità, printed in Venezia in AD 1494 by Franciscan friar Luca Pacioli, a real cornerstone for bookkeeping literature. Materiality and relevance principles are today fundamental to manage information and are discriminating for information acceptance. This research questions about how these principles are present in the Pacioli' treatise. Seven fragments from the Tractatus, within which traces of relevance and materiality can be found, are extracted and analyzed under the IASB theoretical framework and their historical background.

This paper contributes to the literature by investigating the principles through a historical approach, that is selected to explore the topic and to argue about the possible causes for which it is possible to find early traces of relevance and materiality in Pacioli's work. Moreover, this research is a contribution to keep the debate open on the need for the participation of the academic world and practitioner, in the standard-setting process, that is currently lacking.

Keywords: Accounting principles, Relevance, Materiality, Luca Pacioli

2.1. Introduction

This paper aims to investigate the materiality and relevance principles, as observed from a historical perspective, specifically as shown in the Tractatus XI of Summa de Arithmetica, Geometria, Proportioni et Proportionalità, printed in Venice in 1494 AD by the Franciscan friar Luca Pacioli. As well known the Tractatus is a real cornerstone for bookkeeping literature and is considered a powerful and essential instrument for the management of a business and the relevance on commerce. The Summa achieved full success with 2.000 copies probably printed in 1494 (Sangster, 2007), and the friar's work continues to strengthen the world's interest[1]. By adopting a uniform method of bookkeeping the merchants were able to control their business, record transaction, and inventory and audit their books. The Summa has been studied by accountant scholars through six hundred years since for the first time are fully exposed the basis of the double-entry bookkeeping using the Venetian approach. A great deal has been written about the friar's work, but surprisingly an analysis focused on the relevance and materiality principles within the Tractatus XI remains a fully uninvestigated aspect. In the same way, the literature has not revealed and consequently interpreted that Pacioli wrote about materiality and relevance seven times in his Tractatus that is only twenty-six pages long.

Materiality and relevance principles are today fundamental to manage information and are discriminating for information acceptance. For these reasons, they appear as two of the pillars for balance-sheets. Though they are two fundamental and iconic reporting concepts, strictly related to a fair data representation (Edgley, Jones, & Atkins, 2015), little was written about them until the Second World War despite the familiarity and historicity of this concept may easily be overlooked (Edgley, 2014). Nowadays materiality and relevance are both defined in terms of what influences or makes a difference to a decision-maker.

[1] An original copy has been auctioned off by Bolaffi for 530.000,00 € in 2014.

The Accounting Principles, as materiality and relevance, since their first appearance attempted to represent the guidelines to compile financial statements and provide the interpretative keys for it. Through a complex process several entities, as IASB, tried to fix accounting standards aiming to provide for the practitioner's community that guidelines with this interpretative common goal, since the standards have to be clearly based on consistent principles (Dennis, 2008). Analyzing the products of the various committees, it has been noticed that little research has examined the content and structure of accounting standards (Bradbury & Schröder, 2012) and if on one hand, the issue on the principle versus rules in the accounting standards is important and open (Benston et al., 2006), on the other hand sometimes the same accounting principles on which the standards are based on are not completely clear and well defined. (Bradbury & Schröder, 2012).

Since this gap in the literature has been identified, i.e. the lack of a study of the concepts of materiality and relevance within the well-known Tractatus XI, and considering the importance of the concepts of relevance and materiality today, our research question is whether it is possible to identify these two concepts within Tractatus XI for the first time and whether it is possible to identify the reasons why these two concepts emerged. Identifying the origin and possible causes of these two concepts can certainly help to increase their understanding to better adapt them to our current and increasing information management need. We contribute to the literature by investigating the materiality and relevance principles through a historical approach, that is selected to explore the topic and to argue about the possible causes for which it is possible to find early traces of relevance and materiality in Pacioli's work. This research is relevant considering that a debate about the accounting standards is still open, and the need for the participation of the academic world in the standard-setting process, that is currently lacking (Näsi, Saccon, Wüstemann, & Walton, 2010).

The work is developed in the following way. After a brief overview of the two principles investigated, a historical framework of the author's works and context is presented. The historical background will be useful to argue why the principles of relevance and materiality may have emerged under certain conditions and why they are exposed in the Pacioli's treatise. Subsequently, seven fragments in which we

found the early traces of the two principles, will be highlighted from the only primary sources constituted by the Tractatus and will be analyzed under the IASB theoretical framework and the historical background. The last paragraph concludes the work.

2.2. Relevance and Materiality principles. Theoretical framework and IASB definition

Tractatus XI makes explicit reference to the information function and management of information, before going to analyze the fragments of the original text of Pacioli it seems convenient to frame the aspects of relevance, materiality, and recognition of information in the way they are used and conceived today.

During business management activity, it is essential to know to decide. Since any organization, both private or public, can be managed through budgeting statements and reports, accountancy and final balance statement are the key instruments for economic and financial information (Torri, 1987). All the various decision-makers who supply the capital and invest it require information, for valuing alternative investments, to measure the performance and control the management. Even in the absence of external capital providers, companies will design their accounting systems for running their business (Zimmerman, 2015). The truthfulness of the information and, necessarily, the correctness of the balance sheet data became of great importance through the accounting survey, whose object is to study the representation of the evolution of the company's activities using quantitative language (D'Atri, 1994). Moreover, a state of unclearness can be a favorable element for possible frauds or voluntary distortions of data as pointed out by Messier et al. (2005): in particular, the concept of materiality is sometimes abused by companies and their auditors to "manage" earnings (Messier, William, Martinov-Bennie, & Eilifsen., 2005). From the point of view of a Rational Management any organization, both private or public, can be managed through three macro-phases, Planning, Execution and Controlling, that are cyclic and backed by several

documents, in particular budgeting statements and reports, accountancy and final balance statement, that will become the key instrument for economic and financial information. (Rainero, Puddu, Modarelli, & Migliavacca, 2018). During the Execution phase, the recognition takes place, that is the process of capturing for inclusion in the statement of financial position or performance an item, that meets the definition of one of the elements of financial statements, either alone or in aggregation with other items, in words and by a monetary amount (International Accounting Standards Board, 2018).

Given the impact that information has on fair representation, it is essential to consider the quality of incoming information. There are risk factors that need to be taken into account, particularly when influencing the choice of relevant information, for instance, excessive caution or optimism and excessive exposure tightness as important factors that can distort the significance of the information (Hinna, 1986). The principles of relevance and materiality, in their current conception, are related to the capability of information to impact decisions. In this sense, they are two principles strongly incardinated in the decision-making process, which are placed in the broader context of the problem of a true and fair disclosure of corporate facts through the financial statements. In this direction the Accounting Principles, since their first appearance attempted to represent the guidelines to compile financial statements and, on the other hand, the interpretative keys for it. To regulate financial reporting practices, for the sake of their uniformity, intelligibility, and the protection of stakeholders outside the company, the accountant community was faced with the challenge of setting standards of drafting and the principles on which they are based. As a result of this effort, which now spans more than a century, several committees have been formed since the Second World War to determine these standards, such as the Steering Accounting Standard Committee in the UK, the Financial Accounting Standard Board in the USA and the Australian Accounting Association in Australia. As a consequence accounting standards have been increasingly codified, in particular, the meaning of true and fair view and Generally Accepted Accounting Principles (Ó hÓgartaigh, 2008) through a process that appears not particularly influenced by the elite of the firms (Bamber & McMeeking, 2016).

To this end, it is important to underline that the fundamental objective is to communicate economic measurements and information about the resources and performance of the organization useful for those who have a reasonable right to obtain them. Re-connecting today's views with those of the subject matter of this paper in a contemporary key, it is necessary to stress that to be useful and fulfill its fundamental function. Accounting information must have the following characteristics (Accounting Standard Steering Commitee, 1975):

- Relevance
- Intelligibility
- Reliability
- Completeness
- Objectivity
- Timeliness
- Comparability

As seen, the principle of relevance is the first displayed by the Accounting Standard Steering Committee. Nowadays IASB refers to relevance and materiality in terms of what influences or makes a difference to a decision-maker, and materiality is seen as a sub-condition of relevance (Gregoriou & Gaber, 2006).

After having examined the principles of relevance and materiality in relation to business processes, to the collection of information and to the influence on stakeholders, we recall how relevance and materiality are nowadays framed and expressed by the IASB and by the Conceptual Framework (International Accounting Standards Board [IASB], 2018*a*).

In the Conceptual Framework, information is referred to as relevant, if it "is capable of making a difference in the decisions made by users. Information may be capable of making a difference in a decision even if some users choose not to take advantage of it or are already aware of it from other sources" (IASB, 2018*a*).

With regards to materiality, the most recent version of the IFRS Practice Statement, indicates that the definition of Material (Amendments to IAS 1 and IAS 8)) in the following manner:

"Information is material if omitting, misstating or obscuring it could reasonably be expected to influence decisions that the primary users of general purpose financial statements make on the basis of those financial statements, which provide financial information about a specific reporting entity." and "Materiality depends on the nature or magnitude of information or both. An entity assesses whether information, either individually or in combination with other information, is material in the context of its financial statements taken as a whole." (International Accounting Standards Board [IASB], 2018b).

Concerning the last amendments accepted, it is interesting to note that the feedback to previous versions reported that difficulties in making materiality judgments were generally behavioral rather than related to the definition of material, and as consequence, the Board concluded that these difficulties could best be addressed by providing guidance to help entities make materiality judgments. (IASB, 2018a)

Even if materiality might be expressed using thresholds as a percentage of a base amount, a lack of consensus exists in materiality thresholds between auditors, prepares and users, indicating the need for materiality guidelines (Iselin & Iskandar, 2000). The same authors reveal that although in Australia a materiality threshold guideline for financial statements existed, in practice its use was biased by several factors (Iselin & Iskandar, 2000). It's not surprising that the Amendments to the 2018 Conceptual Framework for Financial Reporting added:

"…materiality is an entity-specific aspect of relevance based on the nature or magnitude, or both, of the items to which the information relates in the context of an individual entity's financial report. Consequently, the Board cannot specify a uniform quantitative threshold for materiality or predetermine what could be material in a particular situation." (IASB, 2018*b*).

With regard to the application aspects of the above, it is useful to report for our analysis that" Not recognizing an item that meets the definition of one of the

elements makes the statement of financial position and the statement(s) of financial performance less complete and can exclude useful information from financial statements. On the other hand, in some circumstances, recognizing some items that meet the definition of one of the elements would not provide useful information. An asset or liability is recognized only if recognition of that asset or liability and of any resulting income, expenses, or changes in equity provides users of financial statements with information that is useful" (IASB, 2018*a*).

2.3. Historical Background

To understand an event of the past it is good to place it within its daily structures, thus life is made up of men and things, things and men (Braudel, 1979). To correctly outline the role of the Tractatus XI within the discipline of accounting, it is worth remembering that the years in which Pacioli lived were marked by a strong break, both in the economic, political and ideological sense, since it was a world far from the way we conceive it today. In the transition between 1400 and 1500, there was a strong need to understand and explain nature's phenomena, whether the explanation was provided by science, mathematics philosophy, or even magic. It was the Renaissance, the moment of combining science with practice. It was a period of research and study consumed in the foundations of the shop, of the trade from all over the world, far from the construction that we have made for generations. The Renaissance society was increasingly complex and urbanized, with ever greater resources available and wider markets and it was in the early transformation stage from money-lending into commercial capitalism (Pollard, 1963). This impressive change was made on the basis of the expanding nature of commerce in the 12th and 13th centuries and was based on and allowed by the increasing of banks and their creation and maintenance of a ''bank money'' based cashless economy (Sangster, 2016).

With the changing business and corporate world, we would say today, incoming and outgoing information needs also change. The sizes of data become more

important, the number of transactions increases, as well as the complexity of the market and business combinations, implying an increasing need for information system management and consequently for the evolution of the accounting techniques. This evolution went in the direction of the double-entry book-keeping system, most probably developed by the banks themselves, evolved to maintain a historical record that was accurate, complete, verifiable, and easily controlled. (Sangster, 2016). As proof of the complexity reached by the accounting techniques, many traces of complete writings in double-entry have come down to us. One among all is the "domestic and merchant company of the Barbarigo" (Melis, 1945) in which the analytical double-entry appears in a complete and correct form (Besta, 1932), through an uninterrupted series of notebooks kept since 1430 and for over a century.

In this context, the role of accountants was becoming more important, and the problem of their education and training for specific education in merchant art was recognized. Such formation could be carried out through tutors or within the abacus schools, private or set up by the municipalities themselves. To understand the spread of the phenomenon, it is reported that only in Florence in 1339 AD, on a population of 90,000 inhabitants, there were about 1,200 young students of abacus and arithmetic, divided into six schools (Villani, 1991). Alongside the schools dedicated to education, we find hundreds of Treaties of Abacus[2], Arithmetic, and Mercature, of anonymous or known authors, often written by the same teachers working in the schools (Franci & Toti Rigatelli, 1982). The Treatises of Abacus take shape from the first of them, the Liber Abaci[3] written in 1202 by Leonardo Fibonacci. Fibonacci, above the undoubted merit of exposing the Arabic numbering to the Western world, showed how to perform easily the calculation by the only use of writing itself, actually surpassing the instrument of the Abacus. Curiously, Fibonacci calls his text "The Book of the Abacus", while its contents make it an obsolete instrument. Fibonacci probably calls it in such a way to make the public aware that it is a book about calculations. Without going into details, from

[2] The Abacus was an ancient calculation instrument, made up by a table and several stones to represent numbers and perform operations

[3] The Book of the Abacus

Fibonacci's text onwards, many texts on the art of trade or arithmetic present some or all the same arguments aiming to introduce and solve the typical problems that merchants had to face daily: mathematical problems, setting up of companies, exchanging coins, bartering of goods and so on.

Among the various teachers and authors of treatises certainly emerges the figure of the friar Luca Pacioli. He, went to Venice very young and lived with the merchant Antonio de Rompiasi, being his children's' teacher. In his house, he became familiar with the accounting records and everything related to the merchants' world. He also studied at Domenico Bragadino' s school, a public reader of mathematics. He always taught mathematics, at first in Perugia, in Padova and then in Milan from 1496 to 1499 (Antoni, 1974) where he met Ludovico il Moro, Leonardo da Vinci, and the political establishment of the time (Oelker, 1941). Lately, he became a professor in the papal Archiginnasio in Rome (Antoni, 1974). As well as teaching he was the author of several mathematical books, but his most famous work was certainly the Summa de Arithmetica, Proportione et Proportionalia, printed in Venice in 1494. The Summa de Arithmetica represents the expression of all the mathematical knowledge available at the time of Pacioli and its success was achieved immediately by the Renaissance public. The Summa includes the very famous Tractatus XI that has the undisputed merit of having made the double-entry system known to the public. Even if today it is well known, as we have seen before, that Pacioli was not the creator of the double-entry book-keeping and that Tractatus XI is not the first written text in which it appears, Pacioli certainly deserves the merit of having grasped the importance of divulging the double-entry method through a systematic exposition. For the clarity of his exposition, for the practicality of his work, and for the high profile of the public to whom he addressed himself, the main consequence of Pacioli's efforts to disseminate knowledge of double-entry book-keeping is that it became public knowledge (Lee, 2008), in particular trough merchant class. As mentioned above, the Summa is part of a literary genre of technical and scientific dissemination for the use of merchants, and it was designed specifically for them (Sangster, Stoner, & McCarthy, 2008).

The presence of Tractus XI within the Summa, which was a work of dissemination of mathematical knowledge, suggests that Pacioli felt the need for the men of the

beginning of the Renaissance, for systematic dissemination of the most current and advanced mercantile techniques and business management existing at the time. This knowledge was certainly represented by double-entry book-keeping and advanced Renaissance banking techniques. More in detail, as we will see in the next paragraph, the arguments present in Tractatus XI indicate the degree of maturity of the techniques of that time and show us that the management of information, related to the management of accounts, was a perceived and widespread problem for the Renaissance merchant.

2.4. Traces of Relevance and Materiality in the Summa's Tractatus XI

Pacioli wrote the Tractatus XI, involving the accounting techniques for the preparation of the financial statements obtained through a fair representation of the company events since the "merchant must be a good accountant and ready to compute"[4] (Pacioli, 1494). These financial statements were intended to provide information to the merchant, the stakeholder entitled to the information. In fact, for Pacioli the final purpose of the accounting is to know the variation in the assets of the merchant and his activity: "He has all the matters at his disposal so that he can quickly have the information of each one, whether they're on debit or credit, you don't need to know nothing more" (Pacioli, 1494). This purpose corresponds to a function of information in the interest of the merchant (Ciambotti, Cesaroni, Gamba, & Montebelli, 2010).

Thus accounting consists of data input decisions, a data recording system (book-keeping system), and the provision of useful information to users (Britton, 2013), the problem of the relevance and materiality of the information itself becomes predominant, even for Pacioli. In the light of what has been said so far, let's analyze what we have extracted from his Tractatus.

[4] All quotations from Pacioli's text are freely translated by the authors.

1) – Chapter II “But first it is better to make his diligent Inventory in this way, always recorded on a sheet, or book aside, what you have of furniture and buildings, always starting from the highest value items and most labile to lose”

2) – Chapter XX “And because at a time you will not know precisely the number of ginger baskets that arrive, but it is not a problem, because in the load you make up for what is missing, and what there is more in that of the case will be missing; in the same way recording the packages of sugar because both should be recorded under sugar but you do not record the number of packages or the weight, because you cannot take into account every little straw”

3) – Chapter XXII “Beyond all the things that have been said, you should have in all your books these items, that are: merchandise expenses, ordinary house expenses, extraordinary expenses, entry, and exit item and a gain and loss item. These items are absolutely necessary for every company to be able to always know their capital, and how the business proceeds; and more we will clarify how they should be recorded in books. The item merchandise expenses are held out of respect because not always every scrap can be put immediately in the item of the stuff that you sell or buy”

4) – Chapter XXII “As it happens to pay porters and employees to the weight and packers and expenses of boats and luggage and so on, to whom a penny to whom two ... it would be long to check in detail, and it’s no worth making the effort since de minimis non curat praetor[5] (the praetor does not care about small matters)”

5) – Chapter XXII “When important expenses occur, such as wheat and wine, wood records in books ... while many people are used to recording items for themselves, so that at the end of the year so they can easily know how much they consume. But for small expenses, such as meat and fish, barbers and ferries, you want to keep one or two gold ducats in a separate bag, because it is not possible to keep them in account one by one.”

[5] This reference was quoted in Latin in the original text and was a well known principle since Roman times, used by Pacioli to further emphasize the concept of not dealing with small matters.

6) – Chapter XXXVI "All the jewels and goods that you have earned, inherited, or received as a gift, that you want to estimate in cash, record in the book separately; and you will mark yourself as a creditor for each item. But note that these items have to be greater than ten gold ducats each because small things of little value are not registered in the Book"

7) – Chapter XXXVI "All your household or workshop items recorded ordered and separated, i.e. all iron with iron items, leaving empty spaces for any additions, to mark those that may be lost, or sold, or donated, or broken; but this does not mean small items of little value" (Pacioli, 1494)

Ref.	Pacioli's fragments Synthesis	Our interpretation
1.	Always starting from the highest value items	Indication to record assets according to economic values by descending the hierarchy
2.	Because you cannot take into account every little straw	Indication not to record minimum values
3.	Because not always every scrap can be put immediately in the item of the stuff that you sell or buy	Indication not to record minimum values
4.	Praetor does not care about small matters	Indication not to record minimum values
5.	But for small expenses… you want to keep one or two gold ducats …for it is not possible to keep them in account one by one	Indication not to record minimum values below a threshold
6.	These items are meant not to be at least ten gold ducats each because small things of little value are not registered in the Book	Indication not to record minimum values below a threshold value
7.	But this does not mean small items of little value	Indication not to record minimum values

Table 1. Pacioli's references on non-relevant values.

Once these fragments have been highlighted, it is necessary to proceed with prudence, since it certainly does not seem possible either correct to relate principles described nowadays by the IASB to a 15th-century treatise or to the activities of a

Renaissance merchant. Besides the obvious differences in time, mentality, and technique, it must be surely considered that the IASB has to consider accounting standards towards stakeholders in a highly regulated financial environment, while Pacioli wants to describe an accounting technique aimed at the gathering and rapid retrieval of information for the merchant. Pacioli writes the Tractatus XI, involving the accounting techniques for the preparation of the financial statements. These financial statements were intended to provide information to the merchant, the main stakeholder entitled to the information. Though historically double-entry accounting is seen as the perfect and complete set of interdependent records that offer a global and detailed view of a company, in which all the operations and transactions carried out would take place, without missing even one, no matter how small or insignificant it may be seen (Hernandez Esteve, 2017), the growing number of recordings and the increasing complexity of the activities of the Renaissance business world, and of the merchant, in particular, conflict with the minute recording of all events at the time they occur. The concepts of relevance and materiality emerged to help manage this complexity as established and internalized principles, of the highest theoretical level and ubiquitous in practice. Considering these aspects, and after having highlighted the appropriate differences, we can proceed with the detailed discussion of the extracted fragments.

First of all, it can be considered that the seven fragments above can all be referred to the recognition phase, as intended by the IASB. In the specific case of the second fragment, Pacioli indicates to record items in aggregation with other items.Then, by making a very strong simplification, the decision of a merchant can be reduced to the question of whether he wants to buy certain goods at a certain cost or resell certain goods at a certain price. At this point, remembering that in this context the merchant is the main stakeholder, we can try to use the sense of the IASB standards by simplifying and adapting them to the specific context.

In the first fragment Tractatus XI indicates directly to list values starting from the largest, therefore from the most relevant, to the smallest. In the fragments two, three, four, and seven Pacioli indicates not to record small amounts or of little importance. For the reasoning just made, we can say that in this context amounts of little importance, such as small personal expenses, or ordinary expenses, shipping

or small services related to trading, do not affect the decision of the merchant to buy or sell goods. So, in this sense, we can find in these fragments the sense of the principles of relevance and materiality.

In fragments five and six Pacioli suggests not to report values below a certain threshold. The first time he suggests to bring in a separate bag one or two gold ducats to support the minute expenses and that these should be not recorded. Then Pacioli reports a threshold value of ten gold ducats as the minimum registration value. As mentioned by Sansgter et al., the Summa's selling price was 119 soldi, just under 1 ducato, or about $150 in today's terms (Sangster et al., 2008). It might suggest that the current value of 10 gold ducats is equal to about $1,500. From the point of view of the operational cost, Pacioli suggests not to waste time in recording small value. It assumes importance since the registration operations at the time were done by hand, when economic exchanges occurred during the hectic moments of trade.

Bearing in mind that relevance and materiality are principles connected to the capability of information to influence a decisionmaker, we can conclude how Pacioli wants to underline the importance of dedicating no attention to minimum values and, consequently, of focusing on what is most important, and therefore on what is most relevant, to the point of neglecting what has no value.

At this point, it would be possible to think that Pacioli's approach to relevance may lead the reader to the risk of misrepresentation of the information. Pacioli is indeed very focused on the correct representation of information and we can deduce that from two proofs, one direct and one indirect. The first direct evidence is provided by Pacioli himself when he recommends that the new books on which the records are to be kept must be presented to the tax officers to show their authenticity. He stands against the practice of those who write double books, showing one to the buyer and one to the seller “and on that (the false book)[6], they swear and persuade and they are very wrong” (Pacioli, 1494). The second indirect proof arises from Pacioli’s beliefs. As reported by Barret, Pacioli believed that people should

[6] Note by the authors.

integrate, rather than segregate their business and professional careers with their personal lives and religious convictions (Barrett, 2005). Thus his treatise, which taught the mundane details of bookkeeping, also instructed merchants to "begin their business with the name of God at the beginning of every book and have His holy name in their minds." Pacioli also endorsed as "good custom" the practice "among true Christians," which at that time in Venice meant "Catholics," to mark their accounting books and records with the Sign of the Cross. In considering these two arguments, it is clear how fundamental the correctness of the accounting records was for the friar Pacioli.

Certainly, Pacioli was not and did not intend to be a standard-setter, and again we are not surprised if the simple rules set in Tractatus may seem far from the standards formally set today as the IASB since our financial world is regulated differently from the Renaissance one and there is a profound difference of stake-holders to whom to be accountable. The summa, as was argued, is addressed to the merchant (Sangster et al. 2008) and Pacioli showed how to introduce and teach double-entry bookkeeping in a manner that met and meets the needs of business (Sangster & Scataglinibelghitar, 2010). Considering the audience to which it is addressed, again it is not surprising that Pacioli offers, in the case of information recognition, easy instructions to follow, using pedagogic devices to make even abstract concepts easy to understand. To give an example, stores or accounts were compared to persons (Mattessich, 2003). The problem of giving practical instructions on how to behave is as present for Pacioli as it is for us today. The difficulties in making materiality judgments are generally behavioral, rather than related to the definition of material, so it is concluded that these difficulties could best be addressed by providing guidance to help entities make materiality judgments (International Accounting Standards Board, 2018). So Pacioli not only makes it clear that it does not report minute values but goes as far as to give a practical threshold below which imports are not recorded. In such a way the concepts are expressed operatively and remained clearly expressed, being exposed through a clear guideline and with a precise threshold of application.

As we have seen, Renaissance society is complex and rapidly evolving, with banks, companies, and markets increasing in complexity, and accordingly accounting

records increasing in number. The accounting practice, conceived as a simple "art of keeping accounts" to keep alive the memory of one's own or others' trade, had to evolve to meet the needs of its growing task. The accounting keeping is so required in its most formal aspects, as a chronologically ordered, mechanical and systematic collection of facts. Therefore, the first studies conducted were naturally directed on the research and improvement of the recording methods and this appears formally in line with what was expressed by Pacioli 500 years ago.

2.5. Conclusion

The Tractatus XI of the Summa of Pacioli, a well-known treatise widely studied and cited during more than 500 years, actually contains, besides the famous exposition of the double-entry book-keeping, the first early traces of the principles of materiality and relevance. Within the seven fragments highlighted by the Friar's work, it is indeed possible to see the intention to provide practical advice to help in making materiality judgments. From the point of view of a Rational Management Theory (Rainero et al., 2018), during the Execution phase, when the recognition takes place, following in practice the indications provided by the treatise, it is possible to discern non-relevant information from relevant information, that is information capable of making a difference in the decisions made by users (IASB, 2018*a*).

From what emerged from the analysis of the historical period in which Tractatus XI was written, the reasons why these two principles are exposed within Tractatus XI, even if in an early form, can also be identified,. As we have seen, during the Renaissance period, there was a process of a profound transformation of companies from money-lending into commercial capitalism (Pollard, 1963) with a strong trade expansion and change in the banking system.

Considering also the development of the technique, the ability and willingness of the teacher Pacioli to communicate in a simple way to the merchants the double-entry book-keeping, that was the most advanced account keeping technique then

known, and the widespread propensity at the time to combine practice with theory, it is not surprising identify early traces of relevance or materiality in the seven fragments from the Tractatus XI.

This research contains some limitations. Since in this article, an analysis of the principles of relevance and materiality within Tractatus XI has been conducted in relation to what has been formalized by the IASB in its most recent version, this could represent a limitation of the work. As we have seen, accounting standards in general and materiality and relevance principles, in particular, are not formalized in a unique way and differ according to the entity that formalizes them and the period in which they are formalized. The analysis of the seven fragments was then conducted through comparison with a single theoretical formalization, thus relying on a limited interpretative framework. From the point of view of identifying the causes for which the two principles emerged in a given period of time, the limit of this study can be represented by the use of a single primary source analyzed.

This work may have possible implications for both researchers and practitioners. If in the time of Pacioli the increasing amount of information to be managed has led to the development of special attention regarding the concepts of materiality and relevance, in the current context it is of utmost importance. Today we are experiencing an incredible revolution in terms of dimensional increases in data availability to such an extent that could induce the auditor's role to move from statement-level assurance to data-level assurance (Krahel & Titera, 2015) and will be of crucial importance improve the skills sets in areas such as modeling, statistics, and text mining (Vasarhelyi, Kogan, & Tuttle, 2015). For these reasons, a better understanding of relevance and materiality principles will allow practitioners to better discern the useful data from the worthless information even in the current society, where large information flows and Big Data prevail. the implications for research can also be considered. As seen above, the participation of the academic world in the standard-setting process is currently lacking (Näsi et al., 2010). This historical reading of the two principles can help to integrate the vision of standard setters into a broader historical and interpretative context, also in considering that not all the accounting principles are completely clear and well defined. (Bradbury et al, 2012).

Possible areas of future development of this research could proceed in two directions. On the one hand, the historical aspect of the principles of materiality and relevance can be considered. In this sense, to look for other possible early traces of these two principles, we could proceed through a deep analysis of further texts containing accounting subjects published before the Summa. A comparative study of accounting documents of Renaissance banks or merchants could be conducted to identify the introduction and modification in the application of these principles. It could also be investigated whether and in what way these principles expressed by Pacioli have been accepted by the subsequent technique and literature. On the other hand, the theoretical aspects of these principles can be considered. A more extensive re-reading of these seven fragments could be conducted through the various formalizations of the accounting standards.

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3. Motivations for the Transitions of Accounting roles and instruments, through Industrial Revolutions

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Abstract.

This study aims to identify possible agents of change and evolution of accounting techniques and roles, concerning industrial revolutions, through an analysis of the literature. Nowadays, different and new technologies, such as the Internet of Things, Blockchain, Artificial Intelligence, are bringing profound changes and new challanges, in a context of uncertainaty, and economic and social change. In the past, accounting has changed to respond to the needs that new problems required to be addressed. this article identifies six agents of change, through the phases of industrial revolutions, have changed accounting, in a transition to new roles or instruments.

Key Words: Industrial revolution, Accounting change, Accounting history, Literature review.

3.1. Introduction

This study aims to identify possible agents of change and evolution of accounting techniques and roles, concerning industrial revolutions, through an analysis of the literature. It is well known that accounting has gone through several stages of development, both from a scientific-theoretical point of view and from a technical application point of view. The evolution and changes in accounting evolve from simple registrations, double-entry book-keeping, scientific accounting, to business economics, always proceeding by qualitative leaps (Coronella, 2014). Each of these phases finds its reason for being dependent on the problems it has to face. To give an example, the growth and development of the banking sector in the renaissance, bringing with it an increase in transactions and consequently a difficulty in managing a new multitude of information is one of the causes hypothesized for the genesis of the double-entry book-keeping (Sangster, 2016). If it is perhaps excessive to say that the DEB was born expressly for this cause, we can certainly identify the change in the amount of information to be managed, as a new need that finds in the "new technique" of double-entry book-keeping a natural solution (Rainero et al., 2020). This reasoning of cause and effect, provided by this example, can easily be extended to other changes that have occurred in the accounting, in response to the needs of the people who deal with the business environment.

Nowadays, different and new technologies, such as the Internet of Things, Blockchain, Artificial Intelligence, are bringing a profound change to the everyday life environment. Since the enterprise are open systems (Ferrero, 1980) and absorb the exchange with the external world, it is natural that they have begun to be subject to change by these new elements. As well as it is argued that these new technologies impact both consumers and industries (Edquist et al., 2019), the economic field is also affected by the influence of this complex set of changes, called Industrial Revolution 4.0. (Handoko et al., 2019). This new phase of the industrial revolution, therefore, refers to different IT-driven changes, not only from the point of view of technology manufacturing but also, and above all, change in the products and services offered, therefore changes in the market, organization, and processes, with

a consequent change in business complexity (Lasi et al., 2014), in addition to social changes and new socio-economic issues, with an emphasis on sustainability (Morrar et al., 2017).

As mentioned before, accounting changes and is transformed in the presence of changes and in response to new needs. Facing new social and economic events, driven by new technologies, it is natural to wonder how these changes due to the Fourth Industrial Revolution can also change the techniques and roles of accounting. To try to address this complex issue, we ask what has happened in the past in similar contexts, how and under what conditions accounting has changed through previous industrial revolutions. Since the evolution of accounting has been widely studied in the literature (Coronella, 2014), (Mattessich, 2003), it was therefore considered to explore this specific literature through the phases of the industrial revolution. For this reason, a systematic literature review has been identified as the most suitable tool for this type of research, trying to answer to this specific research question: it is possible to identify motivations of transition from actual to new accounting instruments or roles through industrial revolutions? To answer the research question, this work has focused on the elements and causes of change in accounting, as discussed by the authors analyzed, whether these elements were directly or indirectly expressed.

This study, after clarifying the methodology and the steps performed, proceeds with the classification and analysis of thirty articles in seventeen newspapers, identified as relevant for research purposes, covering a time horizon over four hundred years, seven countries, eleven industrial sectors and different aspects of accounting.

The findings of this study confirm and identify changes in accounting, through the preceding industrial revolutions phases, with a particular focus on the first one, and reveal six motivation for the transition between pre-existing and new roles or tools of accounting, identifying these changes in detail.

The analysis of the literature, by its very conception, should not be considered as a point of arrival but as a platform for future research (Paul & Criado, 2020). For this reason, in the last section of this work, it is possible to find, beyond the limitations

of this research, also possible future developments of the research and forecasts based on findings.

3.2. Research method. A step by step approach.

Since the purpose of this paper is to investigate changes in accounting through the industrial revolutions, and since much literature has been produced on the subject of accounting change by scholars, a systematic literature review methodology has been adopted to review and analyze papers. A literature review, to provide a "robust and consistent" contribution to research and to create the basis for future developments, must be planned, and the whole literature search process must be described in detail (Brocke et al., 2009). To systematically research and review the literature, we have adapted a research protocol with a "step by step" approach. Since the researcher “must overcome the temptation to jump to easy conclusions just because there is some evidence that seems to lead in an interesting direction” (Massaro et al., 2016) we have provided for a recursive corrective action on the research question, allowing the possibility that the research question can be re-addressed to better fit with the analyzed material. The research protocol adopted is described below.

Research Question and Research Key-Words. First of all, from the subject of the research, the research question was clarified: *what relationship can be identified between accounting changes and industrial revolutions*? To form the search key for the Database search, the keywords must be selected from the research question and the logical operators must be selected (Jesson et al., 2011). The words "*Accounting*", "*Industrial*" and "*Revolution*" have been selected from the research question and the and the Boolean operator AND have been selected to connect them to search through Database. The search key then became: "Accounting" AND "Industrial Revolution".

Search for the material and Selection. The search key was uploaded to Elsevier's Scopus on February 21, 2020, obtaining 119 items. From these articles, through the analysis of Title, Abstract, and Key Words, 73 articles have been removed because they were outside the scope of the research.

Classification and Analysis. At this stage, the first systematization of the demography of the articles has been carried out, dividing them by Author(s), Title, Journal, Year of Publication, and Key Words.

On the material thus collected and organized, a systematic analysis of the contents was made, answering questions such as: Is the article about one or more phases of the Industrial Revolution? Does the article relate the industrial relationship phase and accounting? What sources and methodology were used? Having, therefore, achieved a greater degree of awareness of the material being processed, the analysis of the material and the systematic collection of data was carried out: Purpose of the article, Research subject, Methodology, Type of sources used, Coverage of the Study Time Period, Phase(s) of the Industrial Revolution discussed, Accounting Role or Instrumentediscussed, Industrial Sector(s) Analysed. At this point, all the material has been reassessed to verify that it was compliant with the research question. As a result of this in-depth analysis, the research material was further refined, and another 16 articles were identified as not relevant, and have therefore been eliminated. The research basis then became 30 newspaper articles, reported in Table (A). In this progress of the analysis, having thus obtained a clear overview of the available material, the central aspects of the work have clearly emerged, which have been highlighted and classified, making it possible to refine the demand for research.

Re-Adress of the research question. This process of compatibility testing carried out on the material has made it possible to further refine the research application: it is possible to identify motivations of transition from actual to new accounting instruments or roles through industrial revolutions?

In this last stage of analysis, the dominant themes have been identified for each article to answer the readdressed research question: Pre-existing Accounting Role or Instrument, New Accounting Role or instruments, and Motivation of Transitions.

These identified topics have been synthesized, reclassed, and manually coded for each article.

Findings and Implications. In this last phase, following the codification, it has been possible to obtain a synthesis vision of the whole study basis, it has been possible to carry out an analysis of the contents, which is a research process to obtain objectives, systematic and quantitative description of manifest content. Following this last analysis, it was possible to discuss the results obtained, under the light of all the literature analyzed, and it was possible to answer the question of research.

3.3. Classification and Analysis.

From the Database search, 119 journal articles were found and downloaded. From an initial analysis of titles, abstracts, keywords, introductions, and conclusions, all those articles articles that could not provide answers to the research question have been removed. Then a classification work began on this first selected basis, as described above. Following this first phase of analysis, a second group of articles were excluded because they were considered not relevant to the research. This step in two steps, allowed to select 30 articles, chosen among 119 downloaded. From this paragraph onwards the 30 selected articles will be presented, and systematically discussed, and thus become the basis for research. Table I shows the works selected, as the research basis, and cataloged, showing the author, the title of the article, and the year of publication. A reference number has been assigned to each article.

Ref.	Author(s)	Title	Year
1	Pollard	Capital accounting in the industrial revolution	1963
2	McKendric	Josiah Wedgwood and Cost Accounting in the Industrial Revolution	1970
3	Fleischman and Parker	Managerial Accounting Early in the British Industrial Revolution: The Carron Company, a Case Study	1990
4	Fleischman and Parker	The cost-accounting environment in the British Industrial Revolution iron industry	1992
5	Fleischman and Tyson	Cost accounting during the industrial revolution the present state of historical knowledge	1993
6	Fleischman and Tyson	A guide to the historical controversies and organizational contexts fo standard costs	1996
7	Fleischman and Tyson	The evolution of standard costing in the UK and USA	1998
8	Fleischman and Macve	Coals from Newcastle: an evaluation of alternative frameworks for interpreting the development of cost and management accounting in Northeast coal mining during the British Industrial Revolution	2002
9	Boyns, Matthews, and Edwards	The development of costing in the British chemical industry, c.1870-c.194	2004
10	Bryer	A Marxist accounting history of the British industrial revolution: a review of evidence and suggestions for research	2005
11	Bryer	Capitalist accountability and the British Industrial Revolution: The Carron Company-1759 circa. 1850	2006
12	McKinlay	Managing Foucault: Genealogies of management	2006
13	Toms	Calculating-profit: A historical perspective on the development of capitalism	2010
14	Harley	Was technological change in the early industrial Revolution Schumpeterian? Evidence of cotton textile profitability	2012
15	Richard	The dangerous dynamics of modern capitalism from static to IFRS futuristic accounting	2014
16	Toms and Fleischman	Accounting fundamentals and accounting change: Boulton & Watt and the Springfield Armour	2015
17	Zimmerman	The role of accounting in the twenty-first century firm	2015
18	Gervais and Quinn	Costing in the early Industrial Revolution: gradual change to cost calculations at US cloth mills in the 1820s	2016
19	Toms and Shepherd	Accounting and social conflict: Profit and regulated working time in the British Industrial Revolution	2017
20	McLean and McGovern	Costing for strategy development and analysis in an emerging industry: The Newcastle Upon Tyne Electric Supply Company, 1889-1914	2017
21	Zan and Deng	Micro foundations in the Great Divergence debate: Opening up the perspective	2017
22	Edwards, George, and Newell	Cost accounting at Keswick, England, c. 1598-1615: The German connection	1990
23	Hoskin and Macve	Knowing more as knowing less? Alternative histories of cost and management accounting in the U.S. and the U.K.	2000
24	Gutierrez, Larrinaga and Núñez	Cost and management accounting in pre-industrial revolution in Spain	2005
25	Prieto-Moreno and Larrinaga-Gonzàlez	Cost accounting in eighteenth century Spain: the Royal Textile Factory of Ezcaray	2001
26	Carvalho, Lima Rodrigues and Craig	Early cost accounting practices and private ownership: the Silk Factory Company of Portugal, 1745-174	2007
27	Ying Yong Ding and McKinstry	Paper trails: The development of management accounting at Alex. Cowan & Sons Ltd, Penicuik, 1779–1965	2012
28	Nikitin	Setting up an industrial accounting system at Saint-Gobain (1820 - 1880)	1990
29	Warwick and Robert	The religious imperative of cost accounting in the early industrial revolution	2014
30	Brackenborough, McLean, and Oldroyd	The emergence of Discounted Cash Flow analysis in the Tyneside Coal industry c.1700–1820	2001

Table I. Selected articles.

3.3.1. Clasification of Literature

Year of Publication. The articles identified as the basis of the research base were published from 1963 to 2017, with an average of publications of 1.5 articles per year. Figure 1 shows the distribution of articles by year of publication. From 1963, the date of publication of Pollard's famous article, to the year 2000 excluded, 7 of the selected articles have been published. In the decade 2000-2009, 9 articles have been published. In the period 2010-2017, the year of publication of the last article on the research basis, 11 articles were published. These numbers show a light, although steady, growth in the number of published articles. Therefore, 70 percent of the articles analyzed have been published in the last 20 years and about 37 percent in the last ten years.

Journal of publication. Figure 2 shows the distribution of publications for Journal. The set of 30 articles analyzed is spread over 17 journals. 6 journals published two or more articles among those selected and the remaining journals published one article for one. The top three journals in terms of articles published are The Accounting Historians Journal, 5 published articles, Accounting and Business Research, and Accounting, Organizations and Society, 4 published articles *ex-aequo*. About 46 percent of the selected material is therefore covered by these three journals.

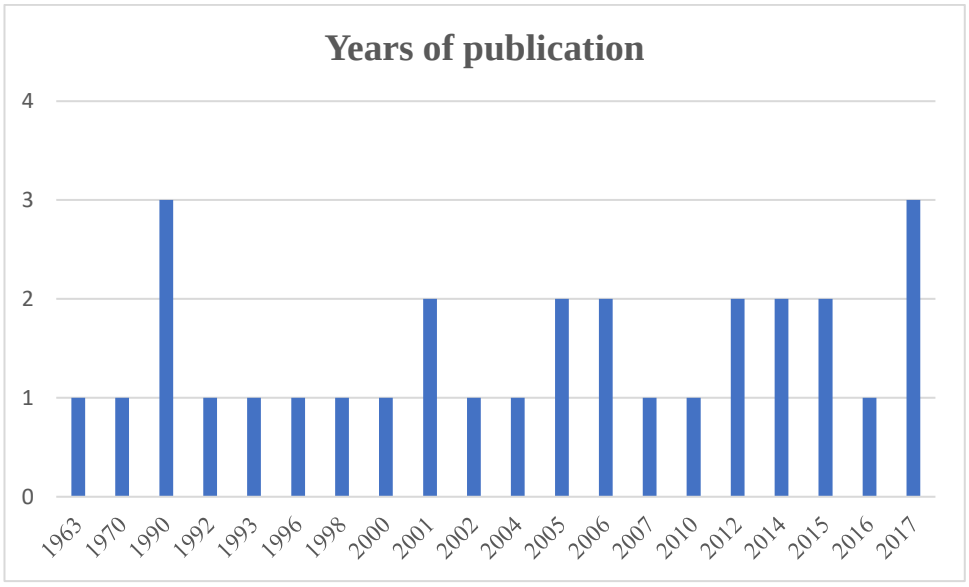

Figure 1. Years of publication.

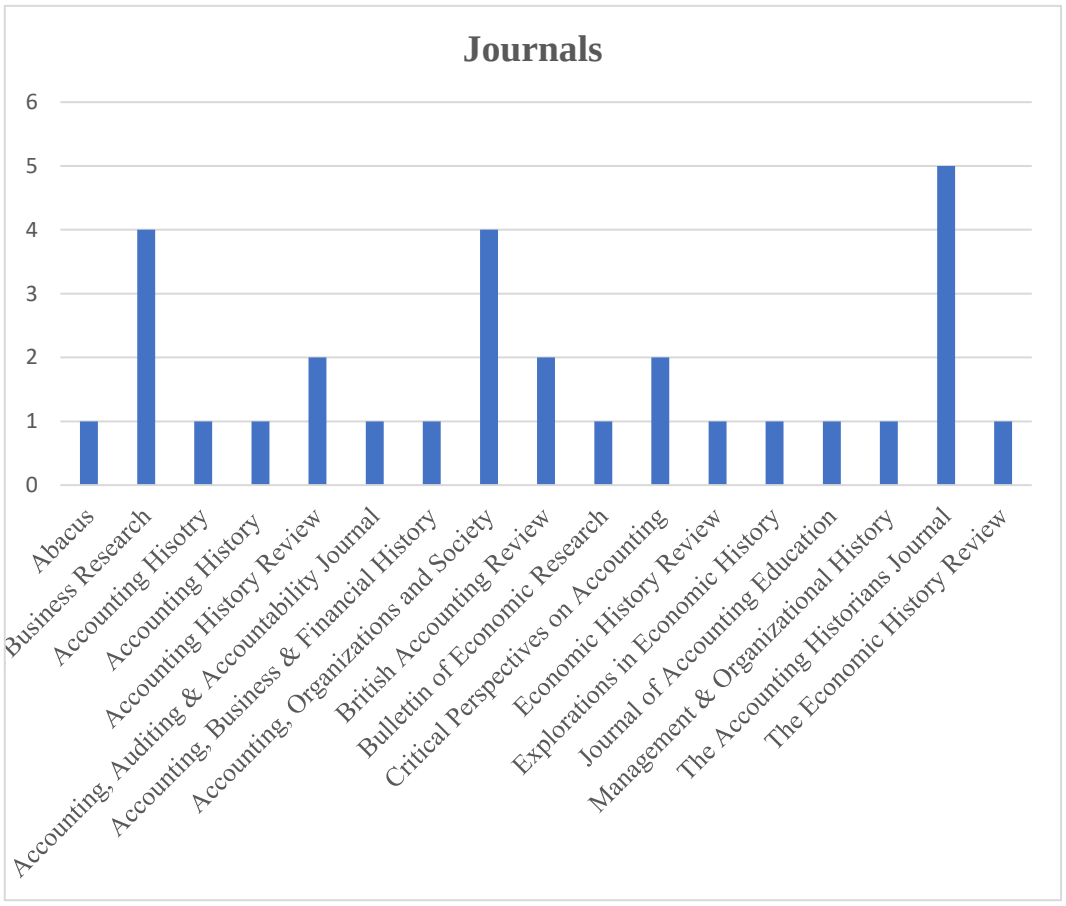

Figure 2. Journals.

3.3.2. Time Period, Countries, Industrial Sectors, and Industrial Revolutions phase coverage.

Time Period Coverage. Facing a cross-cutting study of industrial revolutions, as expected, the temporal coverage of the period covered by the articles was very extensive. It was not possible to derive explicit coverage of the time period in all articles. To obtain this information, if not made explicit by the same article, it has been proceeded to identify the dates relative to the primary sources used by each single study. Two works were excluded from this analysis, from which it was not possible to extract this data, due to the conceptual nature of the studies themselves. The article with the widest coverage covers 400 years, while the less extensive one covers only one year. The average of the years of study for each article is 120 years. 20 articles cover periods of less than a century, with an average coverage of about 36 years per article. Figure 3 shows the time coverage of these articles. The remaining articles, which cover periods over the century have an average of 233 years per article. For the calculation of the averages the two outliers previously identified have been eliminated.

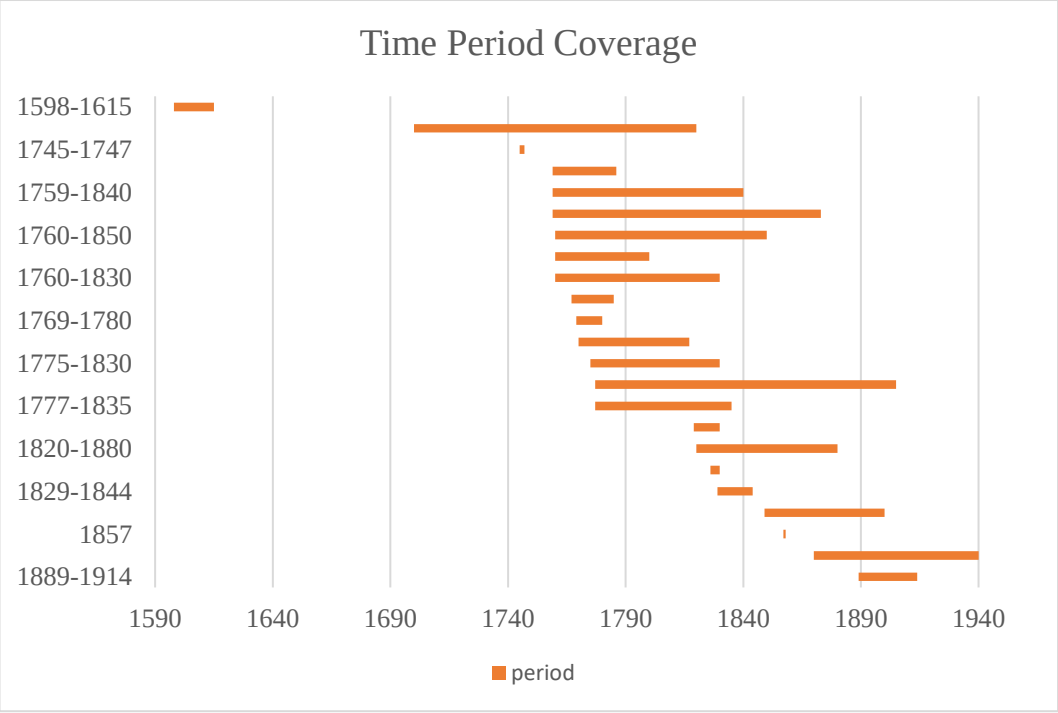

Figure 3. Time period coverage.

Countries. The articles identified can be divided into two categories by coverage of the countries studied. The first group of 22 articles dealing exclusively with one country, and the second group of 8 articles dealing with several countries in a transversal way, including two articles, of a more general nature, which have extended their research to the whole world without restrictions. As shown in Table II and Table III, the countries analyzed by the sample are 7, with the highest representation of the United Kingdom and United States of America.

Country	
UK	16
Spain	2
China	1
France	1
Portugal	1
US	1

Table II. Geographical coverage. Mono-country studies

Country	
UK, US	5
World	2
Germany, Franch, Uk, US	1

Table III. Geographical coverage. Cross-country studies.

Industrial sectors. 23 articles focused exactly on one industrial sector, with the highest prevalence of the Textile sector and the Iron and Hardware sector, which are perhaps the most representative sectors of the first industrial revolution. 3 studies covered several sectors in a transversal way, and 7 studies did not focus on

industrial sectors in a particular way. Table IV shows the study's subdivision by industrial sectors.

Sector	
Chemicals	1
Electricity Supply	1
Glass	1
Iron and Hardware	4
Manufacturing	1
Mechanical	1
Coal Extraction	2
Paper	1
Pottery	1
Shipbuilding	1
Textile	6
All Sectors	3
Not Applicable	7

Table IV. Industrial sector coverage.

Industrial Revolution Phases Coverage. A separate and broader discourse must be made for the phases of the industrial revolution. As has been identified, the timeline of the coverage of the study is very broad. In this sense, we must proceed for a time division by periods. Naturally, in line with the purpose of this work, a subdivision based on the phases of industrial revolutions has been made. To do this, a classical subdivision of the periods has been used based on specific literature (Ashton, 1997), (Cameron, 1982), (Greenwood, 1997) (Mantoux, 2013), (Mokyr, 2004) and (Mokyr, 2003). For the first industrial revolution, the year 1750 has been considered as the starting date also in consideration of the articles under analysis. For the second industrial revolution, the year 1870 was considered as the starting date. For the third industrial revolution, the starting date was set in the year 1950. We then

defined phase 0, or pre-industrial phase, the period before 1750, and, in respect of the literature analyzed, it was considered the year of closing of a phase in the year preceding the beginning of a subsequent phase. Table (E) shows the subdivision of industrial revolutions by phases.

	Period	**4. Years**
0	Pre-Industrial Phase	**5. * - 1749**
1	Firs Industrial Revolutiion	**6. 1750-1869**
2	Second Industrial Revolutiion	**7. 1870-1949**
3	Third Industrial Revolution	**8. 1950 - ***

Table V. Classification of industrial revolutions.

After the subdivision of the articles by the phase of the industrial revolution, two groups of studies have been identified, divided between 23 articles that dealt with a single phase of the industrial revolution, and 7 articles that dealt with two or more phases of industrial revolutions in a transversal way. The sample of articles examined shows that in 63% of the cases there is a concentration of studies on the first phase of the industrial revolution and about 23% of the studies concentrated on the second industrial revolution. An important fact, for our investigation, is that about a quarter of the articles have dealt with more, or all, with the phases of the industrial revolution. Table VI and VII show these subdivisions.

Industrial Revolution Phase	
Pre-Industrial	1
First	18
Second	4
Third	0

Table VI. Studies on a single industrial revolution

Comparative Studies	
Industrial Revolution Phase	
Pre-Inustrial, First	1
First, Second	1
Pre-Inustrial, First, Second	1
First, Second, Third	1
All	3

Table VII. Comparative studies on several industrial revolutions

3.3.3. Sources and Methodologies.

Since most of these articles are based on historical or archival research, the sources take on an important role (Gomes et al., 2011). 22 articles have used primary sources as research bases, and 17 accounting series have been analyzed. For the classification of research methodologies, the following aspects have been highlighted, setting the subdivision on the research work of Ricciardi and Rossignoli (2016): *Type of contribution* (Abstracting description, Context-specific description, Theory building-Theory testing), *Research design* (Case study, Conceptual, Grounded Theory, Literature review), *Time and Distance Lag Strategies* (Comparative, Cross-sectional, Longitudinal), and *Information and Elaboration Methods* (Literature analysis, Data Analysis, Inductive and Abductive Reasoning) (Ricciardi & Rossignoli, 2016).

As would be expected from studies that address the past, almost all of these studies are longitudinal in relation to time and a large part of these studies have been based primarily on primary sources. Table VIII, IX, X, and XI show in detail the methodologies used.

Type of Contribution	
Context-specific desription	14
Abstracting description	10
Theory building-Theory testing	6

Table VIII. Type of contribution.

Research Design	
Case study	12
Grounded theory	9
Conceptual	7
Literature review	2

Table IX. Research design.

Time and Distance Lag Strategies	
Longitudinal	25
Cross-sectional	3
Comparative	2

Table X. Time and Distance Leg.

Information elaboration method	
Literature and data analysis	22
Literature Analysis	6
Inductive Abductive Reasoning	2

Table XI. Time and Distance Leg.

3.3.4. Purposes, Subjects of the research, and Accounting Role Analyzed.

In this last part of the first phase of the analysis of the material, the attention shifted from a general view of the articles under investigation to a more detailed one, going into the focus of the research. At this step, the aims of the articles, and the subjects dealt with were first extracted, and it was identified which aspect of accounting in detail had been investigated. This information was then manually coded, that is, it was reclassified, grouped until classifications were obtained. This kind of analysis allows to analyze large amounts of text without losing touch with focusing on small amounts of the material in considerable depth (Silverman, 2013). The output of this work is described below.

*Purposes and Subjects*The largest category identified, with 15 articles, has been labeled *Genesis, Motivation, and Transaction of Accounting and Managerial Practices*. The articles of this grouping have as a common element the willingness of the authors to identify the origin of certain management or accounting practices or to identify the reasons why they have been introduced or, if present, subsequently modified. The second category by size, consisting of 8 articles, has been identified as *Social Implication*. In these studies the authors had a particular focus in identifying how social dynamics, internal or external to the company, have influenced accounting techniques or vice versa, that is how accounting has influenced the social environment outside the company or, more commonly, has changed the social and organizational dynamics within the company. A third category is labeled *Early Use of Accounting System*. In this class fall the 4 articles that have identified accounting practices in particular historical moments, much

earlier than in other similar ones or before they were formalized. Typically these practices are the result of skills, expertise, and reflections gained within companies to solve certain problems. The last class is labeled as *General Overview*, consisting of 3 articles. Figure 5 shows this classification. Besides, 11 different subject categories have been identified in the research basis. The broadest type of subjects covered is *Cost Accounting*, with 15 articles. This category is particularly wide, because in the structuring of large companies, in the first phase of the industrial revolution, it was one of the first accounting techniques to be developed. 4 articles have as main subject the themes of social relations and have been classified as *SocialTwo other categories, each consisting of 2 articles, are Capital Accounting and Standard Costing.* the remaining subjects, each treated by 1 article, are *Accoutnability*, *Accounting System*, *DCFA* (Discounted Cash Flow Analysis), *East-West divergence*, *Management*, *Profit*, *Strategy*. Figure 6 shows the distribution of subjects.

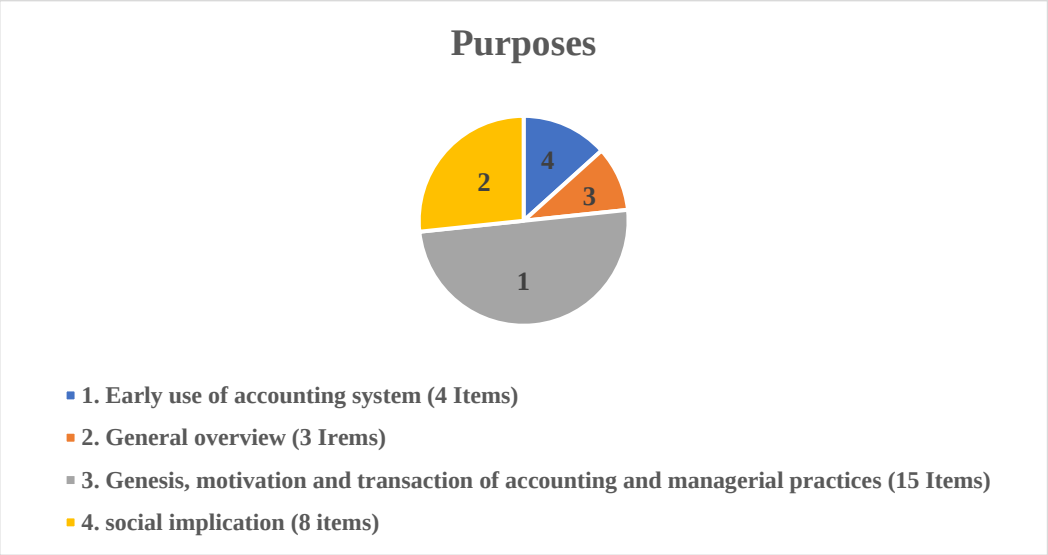

Figure 5. Purposes of the studies.

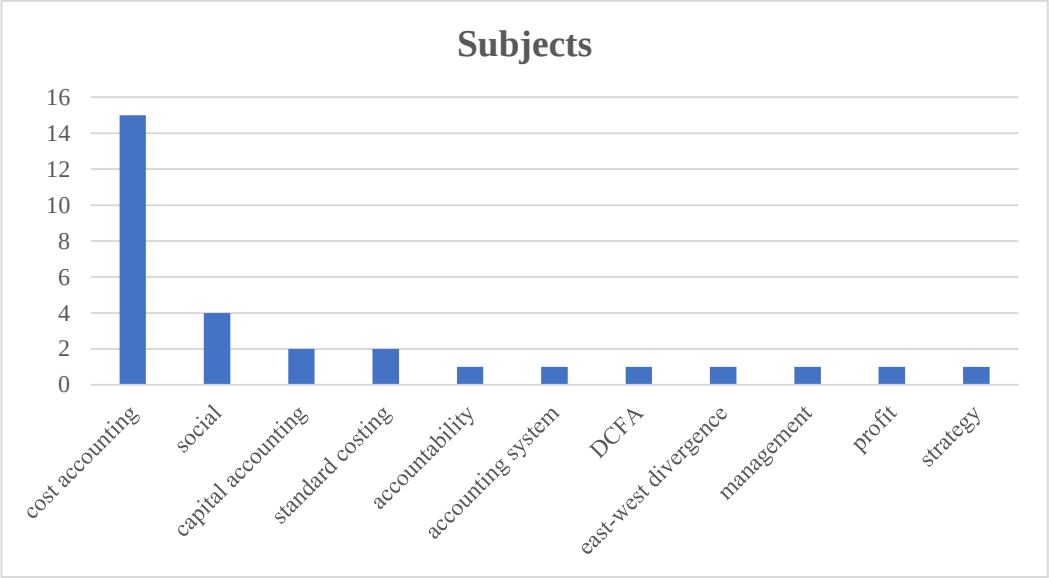

Figure 6. Subjects of the studies.

Accounting Role and Instrument Discussed. Following the analysis of all the material, the last aspect that has been analyzed and classified is the specific role that accounting techniques have been discussed by the articles. Different from scopes and subjects, which are usually explicitly declared by the authors of the articles, this particular type of aspect has been obtained from the analysis of the body of the articles, and, if not the specific object of study of the author, it is not directly explicated. Also because in some cases this specific aspect was secondary or transversal to the subject matter of the analyzed article. In some cases, this specific aspect was secondary or transversal to the article analyzed. The Role of accounting, as investigated by the authors analyzed, rather than the subject or purpose of the article, was identified as central to the purpose of this work. The classification was carried out considering the similarities of themes and functional aspects for the purpose of this research work. As expected from the data previously collected, the Roles of the Mainly Processed Accounting, which have been classified as *Cost Accounting - Cost Managemet*, 13 articles appear. In 4 articles respectively, *Profit Calcualation - Profit Management* and *Price Management* are discussed. In 2 articles the functional role of Strategic Management has been addressed. The other

9 identified cases, which are *Accountability, Balance sheet to show labor condition, Cash flow analysis, Efficiency management, Knowledge, Internal Department comparison, Management,* and *Mercantile purpose Recognition for fixed capital,* have only appeared once. Table XII shows a summary of these categories.

Accounting Role and Instrument Discussed	
Cost accounting - Cost management	13
Profit calculation - Profit management	4
Price management	4
Strategic management	2
Accountability	1
Balance sheet to show labor condition	1
Cash flow analysis	1
Efficiency management	1
Knowledge	1
Internal Department Comparison	1
Management	1
Mercantile purpose	1
Recognition for fixed capital	1

Table XII. Accounting Role and Instrument Discussed

3.3.5. Refining the Research Question.

At this step it was possible to re-address the draft research question, according to the scheme: draft research question, define key concepts, analyze paper, and reassess the research question. (Jesson et al., 2011). Under the new light of all the material analyzed and systematized, the draft research question has been re-evaluated and reformulated as a final research question: it is possible to identify

motivations of transition from actual to new accounting instruments or roles through industrial revolutions*?*

3.4. Findings and Discussion.

The aim of this section is to answer to the (readdressed) research question. In order to do this, following the preliminary analysis carried out, it was possible to perform a content analysis from the articles analyzed, which is the research process to obtain objectives, systematic and quantitative description of manifest content, which made it possible to identify three areas to address the subject under investigation. Since the articles, which form the basis of the study, were selected if it was possible to identify a process of change in accounting, these three areas were divided between precedent, consequence, and cause. In the class labeled *Pre-Existing Accounting Roles or Instruments*, 10 types of roles or accounting techniques have been identified. These aspects are included in this class if they have been the subject of study and discussion by the authors analyzed, before the change. In the *New Accounting Roles or Instruments* class, 19 types of new accounting roles or techniques have been identified. This group, considered to be the study basis for 30 articles, is very wide. However, the size of this category is reasonable considering the great variety of accounting techniques and roles that are present and recognized today. In order not to lose this information, it was preferred to maintain the width of the category, rather than reducing it by operating sub-groups in fewer, larger classes. These two areas are shown in the Tables XIII and XIV. As can be observed in the Tables, the total number of roles, new or pre-existing, is greater than the number of articles. The reason is that in two articles two different roles have been identified and discussed for the accounting, and this aspect has been taken into account.

Pre-Existing Accounting Roles or Instruments	
Balance sheet	1
Control	1
cost accounting	19
DEB	4
efficiency control	2
knowledge instrument	1
output costing	1
Quality control	1
simple records	1
standard costing	1
Total	32

Table XIII. Pre-Existing Accounting Roles or Instruments.

New Accounting Roles or Instruments	
Capital Accounting	1
Cost Accounting	1
Cost control by Measuring Waste and Inefficiency	1
DEB	1
Decision Making and Strategic Management	4
Discipline and Behavioural Control	2
Discouted Cash Flaws Analysis	1
Ifrs Principles	1
Informative Role	1
Integration of Financial and Management Accounts	2
Management Evaluation	1
Moral and Social Role	1
Ooverhead Cost Accounting	1
Output Costing	1
Planning and Control	5
Planning and Control, Decision Making and Strategic Management	3
Return of Capital Employed	2
Standard Costing	2
Unit Cost calculation	1
Total	32

Table XIV. New accounting roles or instruments.

3.4 Motivations of Transition.

Finally, from the studies examined, it was possible to identify the causes of transition between prior and subsequent, labeled as *Motivation of Transitions.* From the articles analyzed it was possible to identify 6 causes of change in the techniques or in the role attributed to accounting in companies, which were divided into the following classes: *Variation in Firm's Complexity, Improving Profit or Efficiency, Management Requirements, Relationship between Property or Property and Management, Social Environment* and *Changes in Market Condition*. These causes can be further grouped into two sub-categories: *Internal Factors*, causes of change that can be identified within the firm, and *External Factors*, external factors of change. The Table displayed the articles in which the identified causes could be found. Since these 6 causes are the subject of this work, they will be discussed in detail. For each of them, the phases of the industrial revolution will be highlighted in relation to the period in which they were treated, and at the bottom of each subparagraph, a table will be inserted to show synoptically the antecedents, the cause of transition and the consequent.

Motivation of Transtions			
Internal Factors			
Variation in Firm's Complexity	Improving Profit or Efficiency	Management Requirements	Relationship between Property or Property and Management
Article n.	Article n.	Article n.	Article n.
1,9,14,15,24,27	2,12,13,16	5,7,8,20	11,17,25,26,30

Table XIV. Motivation of transitions. Internal Factors

Motivation of Transtions	
External Factors	
Social Environment	Changes in Market Condition
Article n.	Article n.
6,10,19,23,29	2,4,18,22,28

Table XV. Motivation of transitions. External Factors

3.4.1 Motivation of Transition. Internal Factors.

Variation in Firm's Complexity. The first of the causes identified as having an impact on changing roles and accounting techniques is the change in the degree of complexity of a company. This aspect has been identified in articles that dealt with both the first and the second phase of the industrial revolution, as well as in articles that dealt with several phases at the same time. It has been identified in a transversal way with respect to the various phases of the industrial revolution. Among the possible types of changes in complexity were identified the change in the activity carried out by the company, for example the change from money-lenders to commercial companies with the consequent number of transitions that must be kept track of (Pollard, 1963), or the change in the mode of investment financing (Richard, 2015), the increase in company size or the introduction of more complex production technologies (Boyns et al., 2004), (Harley, 2012), (Ding & McKinstry, 2013) or for the increase of internal bureaucratization (Gutiérrez et al., 2005). Since the increase in business complexity is a phenomenon independent of the phase of the industrial revolution analyzed, it is reasonable and not surprising that this aspect has been identified through all phases of the industrial revolution. With regard to this factor of change, it has not been possible to identify compact clusters of instruments or accounting roles, both before and after the change. This fact can be interpreted

because, as mentioned above, of the intrinsic heterogeneity of the change agent, which allowed neither a temporal phase nor an intrinsically univocal change agent to be fixed. From the articles analyzed in this section, it appears that the roles or techniques aimed at controlling and managing costs and efficiency are redirected to a more defined role of decision making and business planning in the medium and long term due to the needs arising from the increase in complexity. The articles that specifically observed the aspects related to accounting techniques show that the need to manage increasing complexity leads to further technical progress (e.g. from simple records to double-entry book-keeping) for example observed in Pollard (1963) or towards normative progress, as in the case of the introduction of the IFRS principles (Richard, 2015).

Industrial Revolution Phase	**Pre-Existing Accounting Roles or Instrument**	**Motivation of Transition**	**New Accounting Roles or Instruments**
1	Cost Accounting	Variation in Firm's Complexity	Decision Making and Strategic Management
1	Efficiency Control		Planning and Control
2	Efficiency Control		Decision Making and Strategic Management
A	DEB		Capital Accounting
A	DEB		Ifrs Principles
A	Cost Accounting		Planning and Control
A	Simple Records		DEB
A	Standard Costing		Output Costing

Table XV. Motivation of transitions. Variation in Firm's Complexity

Improving Profit or Efficiency. The second cause of the change in accounting techniques or roles has been identified in the need to evaluate, manage or improve the company's performance or, in general, to improve the level of business efficiency by managers or property. This aspect was also identified in articles that dealt with the first, second, or more phases of the industrial revolution in a cross-cutting manner. In this category of causes, the need to know the Return of Capital Employed has been identified, (Richard K. Fleischman & Parker, 1990), the need

of securing adequate partnership capital, attaining profitability, and maintaining liquidity (McKinlay, 2006), the need for ownership to evaluate and act on management performance (J. S. Toms, 2010), and improve efficiency by monitoring the return on investments made (S. Toms & Fleischman, 2015). Also in this case there is no clear concentration of these aspects in a particular phase of the industrial revolution. The interest of corporate bodies to manage aspects of profit or efficiency have led, in two cases highlighted by the literature, to a change in the technique of cost accounting, developing, on the one hand, the technique in the direction of Overhead Cost Accounting and on the other the development of indicators such as ROCE. McKinlay (2006) identified how the informative role of accounting is redirected to a planning and control role under the impetus of corporate profit management. The last interesting aspect is the work of S. Toms & Fleischman (2015). In this article it is possible to identify how the role of recording techniques, in this specific case double-entry book-keeping, becomes a tool to control people's behaviours, thus assuming a disciplining role for people.

Industrial Revolution Phase	**Pre-Existing Accounting Roles or Instrument**	**Motivation of Transition**	**New Accounting Roles or Instruments**
1	Cost Accounting	Improving Profit or Efficiency	Ooverhead Cost Accounting
1	Cost Accounting		Return Of Capital Employed
2	Knowledge Instrument		Planning and Control
A	DEB		Discipline and Behaviural Control

Table XVI. Motivation of transitions. Improving Profit or Efficiency

Management Requirements. This category includes the need to manage certain particular aspects of the company's activities and operations. As in the two previous cases, also in these cases, the articles examined dealt with both the first, the second, and several phases of the industrial revolution at the same time. The management needs, which were identified as possible causes of the change in accounting techniques, had only the cost accounting technique as the only antecedent. The first

two reasons for transition identified in this section are the need to set up the accounting information to entrepreneurs' managerial needs (Richard K. Fleischman & Tyson, 1993), and the specific need of managing contractual relationships between firms and suppliers (Richard K. Fleischman & Macve, 2002). Entrambe queste motivazioni sono state individuate come agenti di cambiamento dalla tecnica del cost accounting ai ruoli di Planning and Control, e sia di Decision Making and di Strategic Management. The request for a change in strategic direction has been identified as a key to change purpose in accounting (McLean & McGovern, 2017). In this study, the development of costing techniques was identified as the reason for the change in strategic direction, taking on a new informative role. In the last article of this category, the need for decision making and control by management is identified as a reason for refining the cost accounting technique towards Standard Costing. The cost accounting technique appears in all four cases as an antecedent to the change. This is not surprising if we consider on the one hand that cost accounting is one of the first techniques developed, already before the first industrial revolution and, on the other hand, several rudimentary attempts at standard costing were made by entrepreneurs already in the first phase of the industrial revolution, long before the introduction of "scientific management". (Richard K. Fleischman & Tyson, 1998).

Industrial Revolution Phase	Pre-Existing Accounting Roles or Instrument	Motivation of Transaction	New Accounting Roles or Instruments
1	Cost Accounting	Management Requirements	Planning and Control, Decision Making and Strategic Management
1	Cost Accounting		Planning and Control, Decision Making and Strategic Management
2	Cost Accounting		Informative Role
A	Cost Accounting		Standard Costing

Table XVII. Motivation of transitions. Management requirements.

Relationship between Property or Property and Management. The last of the causes identified among the external factors, for the transition of accounting roles, from the articles analyzed, is the need to manage the relationships between the different members of the ownership of companies or between the ownership and management. This change agent was identified in 4 articles. In all the articles analyzed in this section, the only antecedent identified is the cost accounting technique. The first three articles focus on the first industrial revolution. In the first of these, the cause identified is the need to manage the relationship between ownership and management. From the particular situation analyzed emerged the study and presentation of costs seem to be aimed by managers at obtaining funds from the property, shareholders, and bondholders. Consequently, the need was to make managers accountable for property. This need acted in order to develop a form of Standard Costing technique on the one hand and to develop a Planning and Control function on the other hand. (Prieto-Moreno & Larrinaga-González, 2001). In the second and third article, the change agent is the need to manage the internal relations of the company property, to hold the propriety accountable to each other, directing the cost accounting towards the Integration of Financial and Management Accounts in one case (Bryer, 2006) and the need for owners to evaluate and trade company's shares among themselves by pushing the accounting technique in the direction of Discounted Cash Flaws Analysis. (Brackenborough et al., 2001). In the last article in this section, the temporal focus was more extensive, having covered a time horizon across all phases of the industrial revolution. Again here the transition agent is identified in the need to manage the relationship between ownership and management and, more in detail, to control and manage the conflict of interest between debt and equity providers and between owners and managers, from a typically stewardship point of view. This need has finally brought accounting in a direction of control and strategic management. (Zimmerman, 2015).

Industrial Revolution Phase	Pre-Existing Accounting Roles or Instrument	Motivation of Transition	New Accounting Roles or Instruments
1	Cost Accounting	Relationship between Property or Property and Management	Standard Costing
1	Cost Accounting		Planning and Control
1	Cost Accounting		Discouted Cash Flaws Analysis
1	Cost Accounting		Integration of Financial and Management Accounts
A	Cost Accounting		Strategic Management

Table XVIII. Motivation of transitions. Relationship between Property or Property and Management

3.4.2. Motivation of Transition. External Facotrs.

Social Environment. In addition to the internal causes within the company, which can be identified as possible agents of change, exogenous causes have also been identified from the analyzed literature basis. The first grouping of this type of cause is classified as Social Environment and evidence of it has been found in 4 articles. The first 3 articles of this group had a temporal focus on the first phase of the industrial revolution, while the fourth is focused on the second phase. In the first article of this group, the antecedent is generically identified by Balance Sheets and the consequent is a Moral and Social role, as Balance Sheets are used as proof of too long working hours in factories and for, to show moral and health consequences of factory work outside the company acting on social awareness. The agent-cause of this subsequent role of accounting is identified as the need for social reforms. (S. Toms & Shepherd, 2017). Even a religious doctrine, if its values are strongly focused on the discipline and if it is strongly rooted and widely spread in the community to which the company refers, is identified as a motiavation of transiction. In this case, it has been possible to identify as an agent of change of the cost accounting technique towards a role of Discipline and Behaviural Control (Funnell & Williams, 2014). The change in the social relations of production, during the transition from feudal to capitalistic mentality, is identified as a cause of

change in the shift towards the identification of an indicator such as the Return of Capital Employed (R. A. Bryer, 2005). In the last article classified in this cluster, the focus was on a disciplinary environment, internal to the company, where all individuals are subject to ever-increasing internal and public accountability (Hoskin & Macve, 2000). This type of highly disciplined environment has been identified as the cause of the transition from cost accounting to a control role.

Industrial Revolution Phase	Pre-Existing Accounting Roles or Instrument	Motivation of Transition	New Accounting Roles or Instruments
1	Balance sheet	Social Environment	Moral and Social Role
1	Cost Accounting		Return of Capital Employed
1	Cost Accounting		Discipline and Behaviural Control
2	Cost Accounting		Planning and Control

Table XIX. Motivation of transitions. Social environment.

Changes in Market Condition. This last section describes the cluster of change agents on accounting external to the company, which are related to changes in market conditions, whether in the sense of development, contraction, or change in complexity, in which the company operates. This aspect has been identified in 4 articles that dealt mainly with the first phase of the industrial revolution, both in an article that dealt with the pre-industrial phase. Among the possible types of market variations, low-profitability, a reduction in trade due to economic crisis factors, and the emergence of the new competition were identified. Low-profitability was identified as a cause for change in an article focused on the pre-industrial phase, underlining how the cost-consciousness of industrialists was heightened at times of low profitability. This factor was identified as the agent of change of the cost accounting technique towards an early Unit Cost Calculation technique. (Edwards

et al., 1990). Low profitability was identified in two other articles related to the first phase of the industrial revolution. The low profitability has been associated with the transition of cost accounting to a strategic management role. (Richard K. Fleischman & Parker, 1992), the variation in periodic profitability and the difficulty of access to resources has been associated with the change of cost accounting towards a planning and control role and a first rudimentary standard costing technique. (McKendrick, 1970). The slackening of trade has instead been identified as a transition agent in the transition from double-entry book-keeping to a decision making role (Nikitin, 1990), and the emergence of competition has been associated with a transition of the accounting used in its quality control role to a cost accounting function, and specifically to unit cost calculation, and it is underlined that this gradual change was a result of external pressures (Gervais & Quinn, 2016).

Industrial Revolution Phase	Pre-Existing Accounting Roles or Instrument	Motivation of Transition	New Accounting Roles or Instruments
0	Cost Accounting	Changes in Market Condition	Unit Cost calculation
1	Quality control		Cost Accounting
1	DEB		Decision Making and Strategic Management
1	Cost Accounting		Planning and Control
1	Cost Accounting		Decision Making and Strategic Management

Table XX. Motivation of transitions. Changes in market conditions..

3.4.3. Discussion

This study carried out on the search for reasons for the change in accounting techniques through industrial revolutions, turned out, as logical to expect, to be extremely transversal both in terms of timeline, geography, and specific accounting topics taken into consideration. The database analyzed, as a consequence of the search keys used, has been consistent with the topic. All the journals employed, in

fact, are strongly focused on accounting, organization, or business issues and almost half of them have a historical address. As no specific limits were imposed, the timeline covered was very long, while from a geographical point of view the areas most affected were the United Kingdom and the United State of America, being the geographical areas most interested and studied in relation to industrial revolutions. Even among the eleven industrial sectors analyzed, a specification can be identified by the predominance of the Textile and Steel sectors. This specialization of the results, however, does not constitute a particular bias for this work if it is considered the central role that Great Britain has played in the industrial revolution. (R. A. Bryer, 2005) and the important role that the textile sector (Falkus, 1969) and heavy industry (S. Toms & Fleischman, 2015) played in the industrial revolution. Even the purposes, subjects, and Accounting Roles and Instruments discussed are consistent with the research question, with a predominance of Cost Accounting, Profit, and Price management.

Instead, attention must be paid to the predominance of studies focused on the first industrial revolution. This has been considered, directly or indirectly, in 25 articles on the basis of the thirty analyzed, while the second industrial revolution has been considered in ten articles, leaving little space for the pre-industrial period or for the third industrial revolution, which has been considered only in transversal articles, which dealt with two or more phases of the industrial revolutions. This fact can be observed from two points of view. The predominance of the first phase of the industrial revolution, which emerged in this research, can be explained by the fact that many accounting techniques began to be used before they were formalized. First attempts of standard costing before formalization (McKendrick, 1970) or early forms of cost accounting can be founded in the pre-industrial period, for example in Germany at the beginning of the 1600s (Edwards et al., 1990). The modern ideas of accounting will begin to be formalized towards the end of the second half of the 19th century. In fact, excluding books on doube-entry book-keeping or simple writings, which were the only publications of the period, such as the publication of the Jones method in 1796 (Coronella, 2014), and the first texts about costing in Uk are indicated in the texts (Boyns et al., 2004). More in general, it must be kept in mind that the scientific managemet is attributed to Taylor's text published in 1880

and that, in any case, the other specific texts before the year 1870 appear fragmentarily (Coronella, 2014). If it si considered, then, that the practice of accounting comes before its theoretical arrangement, (Richard K. Fleischman & Parker, 1992), it's not surprising that a lot of attention was paid to the scholars at that time. On the other hand, it is necessary to frame the moderate presence of articles focused on the second industrial revolution or the reduced presence of articles on the pre-industrial phase or the third. The lack of representation of the pre-industrial phase is easy to identify if we consider that in fact little real evolution can be found in the accounting techniques from the genesis and double-entry book-keeping divulgation with the Summa of Pacioli (Sangster, 2016) until around the mid-19th century (Amaduzzi, 2004) and that a study of textbooks of accountancy and account books over that period 1494-1840 revealed remarkably little change (Pollard, 1963). With regard to the second and especially the third industrial revolution, it must be considered that the development of accounting has been partially replaced by the development of business economics by a high and other scientific areas of research on the other, such as management and business organization, so that part of the research should also be extended to other areas outside accounting. Findings of the literature analysis show that at least six clusters of motivations, both external and internal to the company, acting on the transition from pre-existing to new accounting roles or instruments can be identified. Given what has been said about the predominance of some phases of the Industrial Revolution over others, with reference to the articles analyzed, it appears that these six identified causes are much more relevant to the changes in accounting than the historical period in which they occur. Or rather, also the historical period of the Industrial Revolution and its specific context act on the causes of transition. If, for example, in a given historical period there is a need for social reforms, this need will lead to the emergence of a new moral and social awareness function for the balance sheets, which otherwise would have had a mere informative role within the company. (S. Toms & Shepherd, 2017). Or, if in a given historical period, new production technologies make the competition more intense, increasing production capacity and consequently reducing prices and profitability, this new external cause will act in such a way as to modify the accounting to manage the new needs of

managers and entrepreneurs, And this has been seen to happen even before the formalisation of these techniques, in the absence of specific literature on the subject (Richard K. Fleischman & Tyson, 1993). In this sense then the phase of the Industrial Revolution may be considered as a further indirect external cause, as it represents a complex set of new factors of change.

The last point of reflection on what has been analyzed, it can be considered that if on the one hand, the needs act on the changes in accounting, on the other hand, there can also be a retro-action effect that the new roles or techniques of accounting have on the transition agents. In this sense, two elements have been identified. First, the introduction of more advanced roles or control and planning tools can degenerate into an excessive bureaucratization of company procedures, contributing to a further increase in the level of complexity of the company. The second aspect is the impact that the introduction of behavioral control tools, for example, the process of writing, examining and grading employees' actions (Hoskin & Macve, 2000) has on the social environment, both in the relationship between company and workers and in the sense of social wealth considered more broadly.

3.5. Conclusions.

From the analysis of the literature conducted it was, therefore, possible to highlight six clusters of motivations for the transition of roles or techniques of accounting, in the specific and complex set of changes that characterize industrial revolutions. These six clusters can be divided into external and internal causes. The internal causes within the company are the change in the level of complexity of a firm, the need to manage profit or the level of efficiency, the need to manage internal ownership or relationships and conflicts of interest between ownership and management, the changes in the requirements of the management of the company, either in the sense of information or operational needs. The external transition motivations of accounting are the particular conditions of the social environment,

for example, the need for social change or the presence of particularly diciplinary environments, or changes in market conditions.

A second interesting conclusion is that even a phase of the industrial revolution, intended as a complex set of social, economic, and technological changes (Morrar et al., 2017) can be considered as an indirect reason for the transition to accounting. The last conclusion that can be deduced is that the same changes in accounting can have a retro-action effect on change agents.

The most important limitation of this work is the predominant presence of the first phase of the Industrial Revolution, despite the minor representation of the second and third industrial revolution in the analysed literature. To overcome this limitation, further research on changes in accounting should be carried out focusing on a time limitation compatible with the second and third industrial revolution, and starting from the research on the transition motivations already identified.

The results of this work also represent an advancement in research. First of all, this study makes explicit the action that the transition causes of accounting identified, within the research basis, actually have on the role or instrument, even in those journal articles where this aspect is not directly expressed. Secondly, while a great body of literature has been produced on the change in individual aspects of accounting, whether or not in consideration of one or more phases of industrial revolutions, no systematic approach has been identified to the effect that the set of causes connected to industrial revolutions have on the evolution of accounting, considered as a single body of knowledge. This consideration opens up new opportunities for future research. One way could be to identify a minimum set of sub-causes that would bring about a change in a specific area of accounting. A second area that could be further investigated is the retro-action mechanism that accounting operates on the causes of change.

As pointed out in the introduction, the Fourth Industrial Revolution, which is the area of interest that has driven this research, is a current context of change. In this sense, some considerations and forecasts can be made. The presence of a new, but isolated, particular accounting technique does not provide the motivation for a

transition towards new roles or instrument or even for its own adoption. The DEB, for example, does not alone provide the elements to reach the unit cost calculation, nor can it alone provide elements of a disciplinary or strategic direction. And even though the DEB was widely disseminated, there are countless examples of accounts in which the DEB is not used, even in recent times. From what has been analyzed, it is clear instead that it is the need for a particular aspect of accounting that makes it emerge, even in the extreme case that this aspect originally did not exist. This suggests that it is not only the presence of new technologies, such as IoT, Bloc-chain, or artificial intelligence, that is preparing the integration with accounting techniques. Rather, it is the coexistence of new techniques and the need to use them. But if from what we are learning, the Fourth Industrial Revolution brings with it market, social, organizational or socio-economic changes (just think of the fact that sustainability reporting, even if not required by law, is becoming almost a moral obligation for large companies or the non-profit sector) new changes in accounting can be expected. Applying the causes of transition that we have individuated, we can go so far as to think that the need for ever-faster organizational responses can lead in the direction of real-time accounting, as well as the block-chain can become a technological support for the collection and management of corporate information, to the point of assuming that the same Artificial Intelligence can go to contribute to the drafting of financial statements. As already argued, the future role of the accountant could shift from statement-level assurance to data-level assurance. (Krahel & Titera, 2015)

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4. Accounting for pandemics and economic crises management: moral hazard, blockchain, and smart-contracts

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Abstract:

During economic crisis, sovereign states and central banks adopt a range of supporting measures for economy and firms, such as the allocation of subsidies to enterprises and citizens. The sudden availability of money without the need for any consideration by the recipient leads the way to inappropriate conduct known as moral hazard, such as diversion or improper use of funding. The moral hazards arise from the individual tendency to rational behavior when in the presence of information asymmetry, inadequate controls, or favorable contractual positions. This paper proposes accounting and reporting as a solution to information asymmetry during crises (such as economic ones or pandemics), based on the use of blockchain and smart contracts technologies.

Keywords: Accounting, Pandemic, Economic, Crises, Moral Hazard, Blockchain.

4.1. Introduction

The last thirty years of our Planet history, in a context of continuous climate change, have been strongly marked by intercontinental economic and financial crises, such as the Mexican financial crisis of 1994, the collapse of the currencies that marked the Asian financial crisis in 1997–98, the Argentina and Turkey crisis toward the end of 2000 (Desai, 2003) and the subprime crisis of 2008. During these years, the economy and enterprises have been raddled by financial distress, and it required countries and governing bodies to issue assorted rescue measures on a large scale, including loans and/or subsidies to firms and citizens.

The typical feature of these crises is not only its global reach but also the heterogeneity with which it affected different countries, both among advanced economies as well as among emerging market economies (Fratzscher, 2012). The effects of these crises naturally spread to the banking system as well, modifying the banks' ability to sustain lending in the wake of financial shocks, to a greater or lesser degree depending on their relationship with the market, the quantity, and quality of their capital and the assistance programs of governments (Kapan & Minoiu, 2018).

Among the various global economic crises, the current economic crisis, which has now become the new norm for the entire planet, has been further worsened by the first true global pandemic of the digital age, caused by the SARS-CoV-2 virus and the so-called COVID-19 infection. This type of economic-social situations, which are becoming cyclical normality due to future pandemics or environmental or economic phenomena of high impact, cause a total worldwide blockage of production and economic activity, with the need for the reaction of society as a whole, and the public sector, in particular, to provide relief tools for the survival of companies, small entrepreneurs and nonprofit organizations.

In the particular case of the current health crisis, almost the entire economic system has been forced to reduce to a minimum, if not to suspend totally, its activities and, therefore, trade and financial exchanges, for more or less long periods, dictated by the health needs of the country that orders the "lockdown". All firms, considered as

instruments of the human operating in the economic activity (Ferrero, 1968), aimed at satisfying human needs (Zappa, 1950), must be able to sustain and carry out the production and consumption of wealth (Zappa, 1957). To prevent collapse, and to guarantee the survival of the economy in general and of firms in particular, in the light of this externally imposed blocking, the economic system must be supported by central banks, money emitters, sovereign states, through the increase of their debt for the financing and emergency support of the national economy, with the emission of non-repayable grants, unemployment benefits, welfare enhancement, and guaranteed financing.

In these situations, therefore, the IMF, the Central Banks, and the Sovereign States respond to the crisis by providing programs of large-scale lending packages, in combination with the implementation of macroeconomic and structural reform. These programs are intended to offer bridging finance to the debtor and to help catalyze private sector capital flows, but official lending on this scale may also generate a moral hazard risk. Under this light, it is the behavior of the official financial institutions that engender moral hazard, and so do more harm than good (Haldane & Kruger, 2001) and therefore it can be stated that moral hazard is an important element of many financial crises (Dow, 2000).

The provision of these sources of financing, whether non-repayable or with extremely long maturities or external guarantees, generates the issuance of new money mainly through institutions outside the company, without any economic return for the cash flow. Thus, the intervention tends to provide beneficiaries with the availability of money that is not offset by any consideration from the recipient. This can lead to misbehaving such as the incorrect use of money, such as improper use, or in general different from the purposes intended by the issuing body, or the handling of such sums for longer than is necessary. In this way, the *do ut des* principle, on which the market-based economy is based, is no longer applied.

These undesirable behaviors represent a moral hazard and arise in the presence of information asymmetry. For this reason, there is a need for careful monitoring by multiple actors to avoid the emergence of moral hazard situations (Pauly, 1968), (Hölmstrom, 1979), in which the beneficiaries use the money acquired for purposes

other than those set by the lender (over-insurance), or do not access the available instruments because they underestimate liquidity risks (under-insurance).

Because of the wide economic scale of crises, the cyclicality of these phenomena, and the large number of firms involved, the topic of research is certainly relevant.

This article is explorative and inspects whether recent information technologies and in particular blockchain and smart-contracts, can help reduce this type of phenomena. The research question of this article is: "*Is it possible to find a technical solution to the problem of moral hazard in case of extraordinary loans to support the economy in crisis occurrence?*".

This possible solution is looked for among the applications of new technology available to accounting, with a particular focus on blockchain and smart-contracts to reduce the information asymmetry between the emitter(s) and recipients. The approach of this work is theoretical and proposals, suggesting a new direction of solutions to the problem under investigation.

The paper is structured as follows: in the second chapter, the literature on moral-hazard is analyzed, shifting its framework, which is originally of the insurance world, to the economic one. In particular, it is highlighted that the moral-hazard is generated by the tendency of the actors, in the presence of information asymmetry, to adopt economically rational behaviors. The third chapter frames the problem of information asymmetry and contractual problems between debtors and money lenders under the light of Rational Management Theory. The fourth chapter introduces the concepts of blockchain and smart-contracts and proposes a technical solution based on these technologies. The last chapter concludes.

4.2. A scoping literature review on Moral Hazard

Moral hazard is a type of risk related to behavior, whose original identification is linked to the insurance world, and can be defined as the intangible loss-producing propensities of the individual assured. (Grubel, 1971). Every insurance contract

possesses some degree of moral hazard and its effects are sometimes hard to detect even though anecdotal evidence of the importance of moral hazard is widespread..(Haldane & Kruger, 2001). It is already clear that the case of moral hazard in insurance is a very general one, arising whenever behavior is unobservable, but its consequences are observable (Mirrlees, 1999). Just to give some examples of this kind of behavior, not arising from the insurance world, it is possible to think of the possibility that individual traders will take actions, specifically, excessive risk-taking, at the expense of the firm as a whole, the possibility that bank management will not act in the shareholders' interests or the recurrent problem of excessive risk-taking in bank loan portfolios, that is often a moral hazard problem (Dow, 2000).

Dow identifies four particular situations that lead to moral hazard. The first is the case of excessive risk-taking or fraudulent behavior by individuals or groups of individuals who have a disproportionate amount of discretion together with a failure of management control that fails to detect them. The second case stems from an aggressive profit tendency, i.e. the focus on profitability is so strong to take excessive risks to enhance short-term profitability. The third case represents the classic problem of moral hazard, where a passive attitude together with the presence of strong incentives may encourage risky or suboptimal actions. Incentives that are too advantageous lead the individual, or group of individuals, to try hard to make large profits but without giving enough weight to the consequences of failure. Also in this case a lack of control contributes to the occurrence of unwanted behavior. The last case occurs in the presence of a collective overexposure when a large group of individuals is collectively exposed to the same risk and no one has the incentive to correct the problem (Dow, 2000).

From the economist's point of view, one of the most interesting aspects of the moral hazard phenomenon is its ultimate cause. The search for additional services in the presence of insurance if no constraints are imposed, the tendency to exaggerate the size of losses, the tendency to seek services or benefits at a lower price where liable, are actually expected actions. (Grubel, 1971). In other words, if the "moral" aspect is disregarded, it must be observed that this behavior is the result of economically rational behavior (Pauly, 1968). From a management point of view, however, the

situation is complicated by the presence of expected behavior, as we have seen, widespread and rooted in individuals whose measurement can only take place after the behavior has taken place. In other words, at present, there appear to exist no systematic measures of moral hazard. The measurement can be made through multiple regression techniques based on the measurements of the phenomenon from data available.

In the specific case of recent policy measures to facilitate international financial rescues, a large amount of literature has wondered if these programs have influenced debtors' reliance on official sector resources. Authors have tried to identify the extent of the phenomenon for which certain debtors tend to consider exceptional funding as “part of the furniture”, leading to an increase in purchases classifiable as a moral hazard (Haldane & Kruger, 2001).

In response to the crisis, new regulations were imposed on sovereigns and banks, as the creation of a banking union in the Eurozone or new directives on capital regulation. The goal of these new regulations is to introduce more discipline both for sovereigns and banks, decrease the public support to banks, and strengthen the resiliency of financial institutions or, in other words, to reduce the moral hazard resulting from widespread support to the financial system (Allen et al., 2015). The analysis shows that in a large number of cases the problems related to the moral hazard arose within the financial sector and individual firms, and this led to the discussion of the role of moral hazard in financial crises (Dow, 2000).

In this specific context, moral hazard can be identified on both the creditors' and debtors' side. The moral hazard of creditors, who on the one hand mitigate the control and risk management policies and on the other hand provide loans, encouraging capital flight. On the other hand, the moral hazard of debtors who improperly use resources, require loans beyond their needs or keep them for too long In both cases, it goes in the opposite direction to the needs of the provider, who wants the livelihood of the subjects in a context of health and economic-social crisis. For example, there would be moral hazard for companies if the funds received were used for the remuneration of equity capital or purposes other than the re-establishment of the company and economic activity in a pre-crisis situation;

there would be moral hazard if the company believed that it could sustain itself and subsequently went bankrupt, causing a worsening of the crisis. In these cases, moreover, the principle of "moral hazard" generates the risk that rescue programs encourage to engage in risky transactions, because institutions, firms, and individuals foresee being bailed out (Schoen, 2017). There must be greater clarity in the rescue programs dedicated to financial crises. And the respective responsibilities of the private and official sectors must be more clearly defined. It is essential that the official sector decides how much official finance will be made available and on what conditions (Haldane & Kruger, 2001). The meaning of moral hazard is that attempts to reduce the consequences of bad behavior can encourage such behavior. The general lesson of moral hazard is that less is more (Baker, 1996).

Reducing these behaviors *ex-ante*, to avoid the consequences of moral hazard, is difficult, since the relationship between action, incentive, and undesirable behavior should be carefully assessed, which can be very complex and with results far from those expected. Moreover, it must be considered that the source of moral hazard is an asymmetry of information among individuals, resulting because actions cannot be observed and hence immediately contracted upon (Holmstrom, 1979).

An example of solutions found in the insurance industry to reduce moral hazard is to link payments in a proportional way to expenditures, with individuals choosing their expenditures to suit themselves. In this sense lending limitations or constrains can help to reduce the phenomenon (Haldane & Kruger, 2001), (Mirrlees, 1999). Another possible direction for the resolution of the phenomenon is monitoring the actions and use this information to draw up contracts. Obviously, if in simple situations complete monitoring may be possible, in the more general case a full observation of actions is either impossible or prohibitively costly. The indication, therefore, is that of using estimators of action or casual observations, that are extensively used in practice to alleviate moral hazard, as in the supervision of employees or in various forms of managerial account (Holmstrom, 1979).

It can, therefore, be briefly summarised that moral hazard is a behavior that occurs in the presence of contracts that provide incentives in favor of certain actions. These actions are typically determined by an excessive propensity to risk-taking, by an

excessive tendency on profitability or by a passive attitude to underestimate the possible consequences of their own actions. The lack or inefficiency of controls also contributes to the occurrence of undesirable behavior.

This type of unwanted behavior is extremely rooted and widespread in individuals since it is rational economic behavior. Moral hazard is a consequence of information asymmetry among the actors, deriving from the fact that the measurement of behaviors is impossible (because of the excessive number of necessary observations) or because it is too expensive. This statement is particularly true in the case of international financial rescue programs, where the number of actors and actions is very high.

The reduction of moral hazard can be pursued in several ways:

- Reduction of information asymmetry from the information issuer by requesting more mandatory information: this solution can transfer information between the actors, leveling out the available knowledge for decision making;
- Reduction of information asymmetry by granting more controlling power or rights: this solution can increase the awareness by the user of the information or by the controller;
- Introduction of limitations and covenants within the contracts between actors, that can prevent the onset of moral hazard situations by providing for compensation in case of misbehaviors.

The problem of all of the proposed solutions is that information, in particular economic one, can be gatekept is subjectivized and derives from evaluation and estimation processes. Thus the complexity (and costs) for implementation of mandatory information and the controlling and monitoring activities can be massive and daunting.

Accounting and reporting serve at least the purpose of rationalizing and processing information in a convenient and transferrable way, at least when it follows generally accepted principles and it is implemented rationally to prevent gatekeeping and omissions.

This property of accounting is given by its capabilities of creating an informed space, that actors inhabit, of awareness of the results of the management and the operations (*territorializing*), of providing an external-communication-function (*mediating*) and the possibility of evaluating the performance of individuals and organizations (*adjudicating*) and of allowing control by the competent authorities (*subjectivizing*) (Miller & Power, 2013). In particular, the mediation of information can reduce information asymmetry, and subjectivizing information can enhance control and monitoring capabilities by information users.

To overcome the obstacle of complexity of implementation, and to reduce considerably both time and human resource consumption, new technologies can automate part of the process and make information accessible, reducing asymmetry. The use of technologies such as blockchain-based accounting and smart contracts can also foster the use of artificial intelligence to prevent or highlight misbehaviors and, thus, to reduce moral hazard.

3.4. Accounting under Rational Management Theory and reduction of information asymmetry

The management of any organization, whether it is private or public, small or big, profit-oriented or not for profit, is conceived through a complex process of continuous implementation of decisions and policies. Each of the single decision is built up through a sub-process, that is known as Rational Management based on financial statements (Puddu, 2010), (Migliavacca, 2020)that can be divided into three separate macro phases, “Planning”, “Execution”, “Controlling”, cyclic and backed by several documents, in particular budgeting statements and reports, accountancy and final balance statement, that will become the key instrument for economic and financial information (Torri, 1987).

In the first phase, the decision is conceived based on prospective and retrospective data, through financial and non-financial resources allocation forecast. This phase of Planning is aimed to define the vision and the mission of the organization and,

more specifically, defining the target and the related budget (Bhushan and Rai, 2007). In the public sector management, in particular, in this phase, the policymakers attempt to enhance the accountability of the decision-makers and operators and lays the foundations for any resource consumption. In particular, none of the resources that is not allotted can be consumed, and each consumption must correspond to an authorization (Potter and Diamond, 1999). To achieve this accountability and the capability of authorization, a perspective financial statement (or budget) must be generated. In this financial statement, any resource allocation is indicated and defines the maximum resources that can be used for organization management.

The second macro phase, naturally following the planning one, consists in the execution of the forecasted activities. This phase of Execution is grounded on the budget allocations and is composed of a continuous process of unitary decisions that must generate continuous recording for actual resource consumption. The orderly, continuous, and thorough recording is called accounting and permits to generate timely, precise, and effective data prospectuses to enhance further decisions and gap analyses. In particular, several accounting systems have been created and developed for the public sector, and almost all of them lay their foundations on the double-entry accounting system of financial, economic data recorded on accrual basis (even if some of the applied systems are still only financial-data-driven and on a cash basis). The use of a shared accounting system can enhance the decision making, the stakeholder-driven disclosure, and the comprehensibility of the organization's activity, namely leading to a lower information asymmetry level and allowing other organizations to generate synergies through linked policies.

The third step of decision making is represented by a phase of Controlling. In this phase, any organization must take into consideration what the budget forecasted and conduct gap analyses on the deliverables expected from the budget statement with the actual execution results recorded in accounting. This phase, generally crucial for the private sector and its stakeholders' information requirements, is way less considered in the public sector, despite being it really important for better decision making and proper accountability of the policymakers. The control phase

generally exploits financial statements and accounting prospectus to achieve a better comprehension of what caused differences between the forecasted and the actual performance of the organization.

Rational Management Theory acknowledges the three phases and the related documentation to be produced for accountability and better policymaking in a circular vision and is repeated on the whole at least yearly. This process enhances the potential efficiency and effectiveness of an organization and contributes to the creation of a clearer map of the actual value generation through the organization's activity. Thus, Rational Management is always focused on people and their requirements (Puddu, 2010) and the value generation can be considered both under the economic/financial dimension and the non-financial one, to maximize all the results and meet all the stakeholders' requirements and needs.

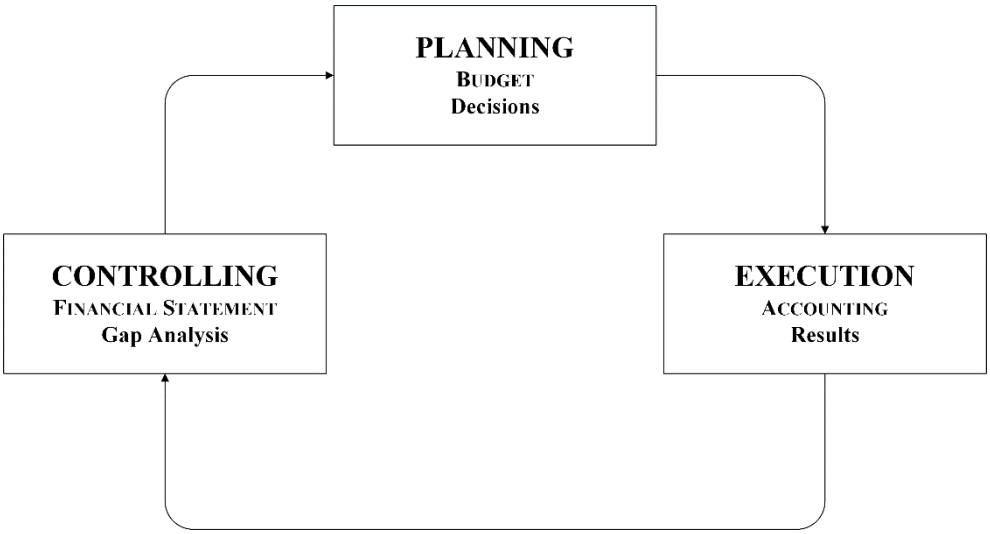

Figure 1 - RMT cycle - source: Puddu 2010

In the case of financial crisis rescue by providing programs of large-scale lending packages, our research question concerns in particular the possibility of reducing moral hazard on the debtors' side. When rescue programs have already been planned and implemented, unwanted behavior is present in the possibility that the contractors will take advantage of sums to which they are not entitled and/or improperly use them. For this reason, the question must be looked at during the three Planning, Execution, and Controlling phasis. In line with the literature on moral hazard, the possibilities to reduce the phenomenon are related to the introduction of limits in the contractual phase, and the implementation of a control system (Execution and Control). In particular, this last function can be considered as part of the Miller and Power (2013) framework, as the *Subjectivizing* function.

To be able to reduce moral hazard behavior, a system capable of actively operating on contracts is logically necessary, so as to be able to limit and possibly withdraw from the contract promptly, and to reduce the information asymmetry because moral hazard arises in conditions of uncertainty. Improving information can reduce costs and produce a more accurate performance evaluation(Guadalupe & Pérez-González, 2006). By reducing or eliminating the information asymmetry between the various actors involved, operating the appropriate controls, it is possible to make the debtors liable to Subjectivizing, and therefore be able to promptly intervene on their work. In this light, it appears how important is the accuracy of the information, because if debtors are required to report, there could always be a risk of data distortion or tampering. In the next section will be shown if and how technology can then overcome the difficulty of operating controls in real-time among a multitude of subjects.

3.5. Blockchain and AI, a technical solution to reduce moral hazard

In the case of financial crisis rescue by lending, the two areas on which to intervene to reduce moral hazard are the contractual aspect and the control aspect, to reduce the information asymmetry between debtors and money lenders. In specific, the control aspect is complicated by the fact that such controls must be carried out on

real-time, that data entry must not be left to the debtors to avoid tampering or distortion, and that control over multiple subjects can be costly or complex due to the presence of a massive amount of data.

In the area of data processing and management, Information Technology has made a lot of progress, particularly in recent years. The literature has already analyzed the use of new technologies, especially blockchain technology, also in the context of the public sector and in the case of e-government, for instance in the case of management of voting and management of payments, or to reduce the cost of managing tax, often eliminating government intermediation and changing the actors in the management. Information Technology has also made changes at the accounting level to audit and verify scripts through blockchain algorithms designed to identify the application of the law to the records (Secinaro, 2020). In this sense, it is already known that in the future the accountant's skill will improve in areas such as modeling, statistics, and text mining (Vasarhelyi et al., 2015), while the auditor's role will move from statement-level assurance to data-level assurance (Krahel & Titera, 2015).

The blockchain is technically a list of records, where each new recording is maintained and added to the previous ones. Once a new record is introduced, it is no possible to delete or modify it. The validation of records is implemented through simultaneous communication of the records to all who have access to the data. The security of the system is based on the use of a cryptographic system to add new registrations to the previous ones in a secure and tamper-proof way. (Lynn et al., 2019). The blockchain is a distributed ledger, stored on an unbounded number of computers, in which the data cannot be tampered with, altered, or stolen (Coyne & McMickle, 2017). From an operational point of view, it is important to underline that data is updated in real-time and there is no limit to the number of records to be processed. In addition to the above, it should be noted that the potential of the blockchain lies in its ability to record anything, and therefore not only in the recording of payments. (Böhme et al., 2015).

Using blockchain technology is therefore possible to implement a storage system with the characteristics of *transparency*, data is accessible to all those who have the

permissions, *security*, can not tamper with the data, *reliability*, the recording system is distributed. In the specific case of records of expenses incurred by debtors by using the money loaned, there may still be a risk of incorrect or distorted communications by debtors. This problem can be solved if the expense statement is automatically collected at the same time as the payment is made. By using blockchain technology to automatically record payments made as a result of loaned amounts, it is, therefore, possible to implement a real-time and wide-ranging control system. If in the past the role of controller, and therefore of guarantor of trust, was attributed to a physical person, now this role could be played by the blockchain.

If, as seen above, the block-chain can perform the control function, it is still necessary to intervene on the contractual side. If the use of the loaned monies is not compliant with the creditor's policy, and therefore in the event of irregular conduct ascertained by the block-chain, the contractual conditions must be applied promptly and automatically, so that the amounts loaned can be returned, the loan is modified in the conditions of disbursement, or further and stricter controls must be activated. This can be achieved by using smart-contracts.

Smart contracts are self-executing contracts, based on computer programs that, within the block-chain, disconnect the contractual parties from third parties. (Allam, 2018). Since in these programs the evaluation of the inputs is left to algorithms, deterministic control is obtained, that is to say, that in the presence of the same inputs the same outcomes are obtained (Christidis & Devetsikiotis, 2016).

A combined system of block-chain and smart-contracts could, therefore, perform the dual role of control and automatic execution of contractual rules. Below is proposed an illustrative scheme of the system architecture.

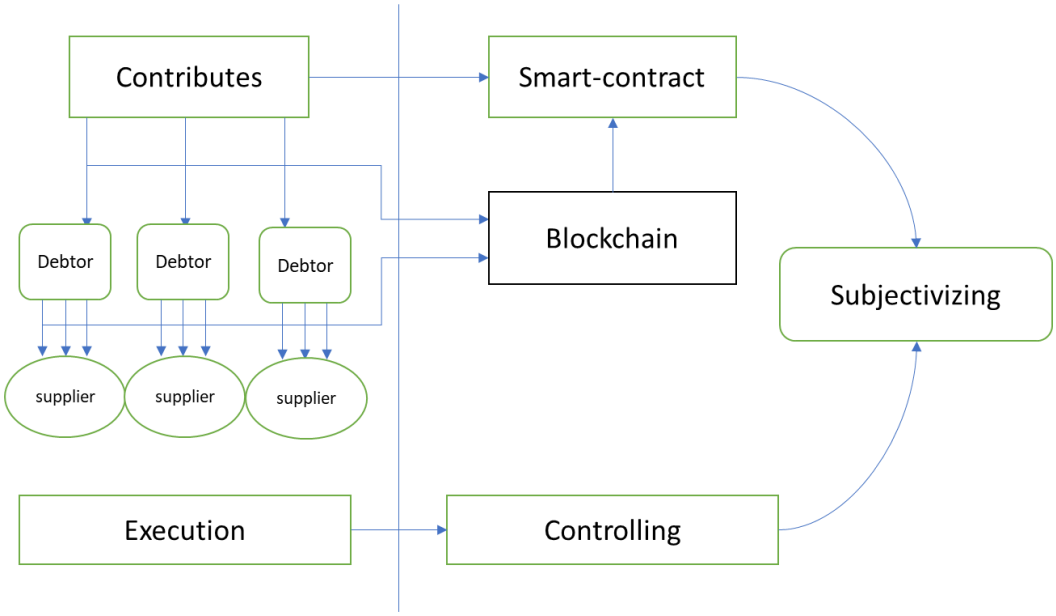

Figure 2 - System architectures with blockchain and smart contracts

In the case of large contributions, following verification of the debtors' eligibility requirements for access to the funds, the sums are released. Starting from this moment, through the blockchain, smart-contracts are activated, and all money movements are tracked. The tracking of these transitions, in all those countries where electronic payments have already been implemented, is certainly already possible. During the execution phase of the company's activities, (Execution), the recognition takes place, which is the process of capturing information for inclusion in the statement of financial position (International Accounting Standards Board, 2018). The recognition, as we have seen, takes place automatically through the tracking of money movements, and goes to collect information on the date of spending, how the sums were used, and to who were given. This data gathering takes place without the intervention of debtors, who therefore have no way of hiding or tampering with the data for fraudulent purposes. Simultaneously with the collection of this information. The data is stored indelibly and tamper-proof in the blockchain and evaluated using the algorithms of the smart-contract. In this way, control is performed (Controlling), by an algorithm and not by a natural person, so

that the control is exercised by an entity outside the company. The algorithms, at this point, can assess the presence of gaps between the policy lines of the lenders and the use of the loans, automatically recognizing whether there has been total or partial contractual fulfillment, thus being able to activate accessory clauses such as the payment of interest at a higher rate, or if there is a total breach of contract so that the debtors must return the total amount lent and are subject to further controls and acceptance by the competent authorities.

From the point of view of the Rational Management Theory, controls are then implemented automatically and concomitantly in the Execution phase, and the Controlling phase is exercised automatically and externally whenever there is a payment. This whole system, therefore, leads to complete asseveration of control by the competent authorities, thus allowing the Subjectivizing of the debtor's actions (Miller et al., 2013)

3.6. Conclusions

In the concrete hypothesis of a future affected by a growing number of financial crises, due to catastrophic climatic and economic events, health emergencies, wars caused by the exploitation of economic and human resources, the possibility of economic interventions by governments and central banks will be increasingly common. The possibility for firms to have access to economic resources at little or no cost brings with it a high risk of moral hazard (Haldane & Kruger, 2001) with the consequence of distracting this aid from where it was needed.

The possibility to combine blockchain technology, with its capability of interaction among different actors in a trustless, auditable manner, in combination with smart-contracts, brings with it the potential of automating complex multi-step processes (Christidis & Devetsikiotis, 2016). These powerful new possibilities, applied to the control of business processes, can significantly reduce the information asymmetry,

through the strengthening of controls, and make loan contracts rapidly expire, mitigating, and in theory reducing, the causes identified for the occurrence of moral hazard phenomena.

This paper is explorative and proposes an answer to urgent problems, having identified from the literature the causes of moral hazard, highlighting a possible solution intervening on these causes, based on a system architecture that has yet to be tested. This type of research is certainly important since opens up pathways of study that have not yet been explored, but at the same time represent the limit of this work.

The possible areas for future research are mainly two. On the one hand, a study should be carried out to measure the impact of improved controls and contractual actions on the reduction of moral hazard behavior. On the other hand, the technical solution, based on the blockchain, must be implemented and tested. This current, and very broad, field of research, which is part of the much broader real-time accounting, is a science still in the making (Trigo et al., 2014), which gives ample space for both researchers and practitioners to work.

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5. Conclusions

5.1. Summary of findings.

This research work has been an opportunity to take a journey through 500 of accounting history. The method to base the research activity on a historical basis is a widespread practice in accounting research (Coronella, 2014). But this work has also looked at the present, especially in identifying new opportunities offered by new technologies, which for accounting are not relevant under the technological aspect, but under the functional aspect. In this sense, being able to understand how in the past new technologies have impacted and merged with accounting, may induce a greater understanding of current phenomena.

The general aim of the work was therefore to identify, in the areas of research investigated, where and how the extensive social, economic, and technological changes, which mark the transition between different historical periods, including the present one, are linked to the change in accounting. This understanding is based on the following findings.

The first result is based on the identification of the appearance of the principles of materiality and relevance, since the first complete exposition of the double-entry bookkeeping method, the Tractatus XI of the Summa de Arithmetica, Geometry, Proportionality and Proportionality, by the Franciscan friar Luca Pacioli, in 1494.

The growth of the amount of information has led first to the transition from simple records to double-entry book-keeping (Sangster, 2016) and then to the need to identify criteria to distinguish easily and operatively the information relevant from those not relevant, and this explains the presence of the principles of relevance and materiality in Pacioli's work, even if they are expressed in a very early form. This change in accounting, motivated by the increase in complexity and quantity of

information to be recorded, has addressed the further research and led to the second conclusion.

Through the analysis of specific literature on accounting, it has been possible to identify relationships of cause and effect between the typical features and changes of the industrial revolutions, and accounting. Six motivations have been identified for the transition of roles or techniques of accounting, in the specific and complex set of changes that characterize industrial revolutions. This set of causes is made up of the need to manage profit or the level of efficiency, the need to manage internal ownership or relationships and conflicts of interest between ownership and management, the changes in the requirements of the management of the company, either in the sense of information or operational needs, the change of the social environment and the changes in market conditions. If on the one hand some causes can be considered common to the normal conduct during the existence of a firm, such as stewardship management or new needs by management, other causes, such as the change of the social environment or market conditions or the need to manage the increasing firm complexity, can be identified as particularly peculiar to a period of revolution, especially if these changes occur at the same time. In addition to this cause and effect relationship, a retro-action effect on the causes of change has also been identified. In fact, the introduction of more advanced control and planning tools can degenerate into an excessive bureaucratization of company procedures, contributing to a further increase in the level of complexity of the company, and the introduction of behavioral control tools, affects on the social environment, both in the relationship between company and workers and in the sense of social wealth, considered more broadly.

The conclusion that can be drawn from the second and the third chapters, comes from the understanding of the relationship of change of enterprises, a change that is reflected in a greater specification of management needs and therefore in accounting techniques, depending on the changes that the company has to face, first of all, the greater contribution of information to be managed, both for the amount of information input and variety of elaborations in output.

Precisely it must be highlighted that are not the new technologies, both in terms of hardware and new know-how, that determine the change, but that the main cause of the change is the change of reality *as a result* of new technologies. This understanding makes us more aware of the factors that require changes in the gathering and structuring of economic information.

The awareness that the relationship of new technologies with the surrounding environment is the main cause of change, helps to focus only on the functional aspects and to disregard the technical aspects of new technologies. This has allowed to reach the last result of this work, which is the identification of a new technology, the blockchain, as a technical tool as a possible instrument to reduce a risk agent, the moral hazard, in a context of volatility, uncertainty, complexity and ambiguity, such as a global health crisis.

The problem of moral hazard, relating to the misuse of funds granted by governments in global emergencies, is a perfect application case in light of what has been learned. New factors for change coexist in this problem. Recent crises have global and not local characteristics, the funds for the rescue of companies involve large amounts of information to manage, in the context of social and market change that is typical of the current industrial revolution. The new technologies, in this case, blockchain and smart contracts, therefore show themselves as a new accounting tool, allowing the automatic recording and analysis of the large amount of information, in a precise and timely manner, in a VUCA context. This last result allows, furthermore, to recognize the actual level of adequacy of the new technologies, for the resolution of current problems where, in particular, non-linear solutions are required.

5.2. Limitation of research.

As highlighted in each chapter, this work has some limitations.

The materiality and relevance of Pacioli's Summa have been analyzed exclusively in light of the theoretical framework set by the IASB. The accounting standards in

general, and materiality and relevance principles, in particular, are not formalized in a unique way and are differing according to the entity that formalizes them and the period in which they are formalized. The analysis of the seven fragments, about the two principles involved, was then conducted through comparison with a single theoretical formalization, thus relying on a limited interpretative framework. Given the importance the IASB accords to the two principles of relevance and materiality, further consideration could be made to the text of Pacioli.

For the topics discussed in the third chapter, the relationships of cause and effect between agents of change and the development of accounting through industrial revolutions, the following has already been observed the predominant presence of the first phase of the Industrial Revolution, despite the minor representation of the second and third industrial revolution in the analyzed literature.

From the point of view of the evaluation of the maturity of the new technologies, involving their use in accounting, this aspect has been deepened for the blockchain and smart contracts, while it has not been deepened in a systematic way for the other new technologies that characterize the fourth industrial revolution.

A further reflection can be made considering the work as a whole. Nowadays changes, as a result of globalization, occur with rapidity and diffusivity completely unknown in the past. If it is considered the management of the global health crisis, caused by the SARS-CoV-2 virus, the most surprising aspect is the amount of information that has been collected and distributed worldwide and the need for the rapidity with which far-reaching decisions had to be taken, such as the lock-down of entire countries, the imposition of compulsory closing of borders and the reconversion of factories for the production of sanitary materials, just to give some examples. In this light, the need for greater promptness in the collection and processing of information, therefore, appears as an additional factor of change. This aspect has been treated only partially, in the study of the use of blockchain technology, while it has not been considered in the other chapters of this work.

5.3. Future research.

As previously mentioned, the principles of relevance and materiality could be further elaborated. A comparative study of accounting documents of Renaissance banks or merchants could be conducted to identify the introduction and modification in the application of these principles. It could also be investigated whether and in what way these principles expressed by Pacioli have been accepted by the subsequent technique and literature.

One aspect of attention, which emerged from the analysis of the literature on the reasons for the change in accounting, is the retro-action mechanism that changes in accounting act on the causes of change. This aspect is certainly to be analyzed, especially given the wide range of potential changes in new technologies.

The six reasons identified for accountancy change could also be used for an in-depth analysis of the current context to identify possible future areas of development of IT-driven accounting.

The main topic of development for future research, however, is originated by the growing need for rapid collection and processing of information. From what has been learned from this work, the effect of new technologies and changes in the environment, act as a lever for the change of accounting instruments and roles. Some of the current new technologies, as seen in the case of the blockchain, are ready to be integrated with accounting techniques. The natural development of this research will, therefore, be to understand how new technologies, starting with blockchain, can be integrated into what will become a real-time accounting. Reflecting on the intricate relationship that connects the three main chapters of this work, it is possible to realize that the missing piece is time. The time of change, the time of data collection, the time of programming, execution, and control. Under this light, the Theory of Rational Administration is even more actual, but the technical support tools must change to make it feasible in our rapidly changing environment.

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