Toward a Continuous Measurement Model

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***Abstract*— The business and Enterprise Resource Planning (ERP) system data for accounting and auditing is close to continuous, but the accounting and auditing work is interval-based and loses the close to continuous characteristic of the business measurement process. A series of proxies for more frequent measures have emerged in the increasingly desperate attempt to have very short time market trading superiority. Our objective in this paper is to propose a continuous measurement framework in critical areas of business.**

Keywords- continuous measurement; continuum paradigm; business reporting; cybersecurity; sustainability; ESG.

I. INTRODUCTION

The current accounting and reporting model derives from first mainly legal oriented records of the 12th and 13th centuries from traders from Florence and then more analytic double entry records formalized by Pacioli in late 1400s [4]. At that time, trading was manual, and the determinants for the success of a business were reporting assets and capital structure. Consequently, the traditional accounting and reporting mechanisms worked well for the purposes of record keeping, asset management, supply chain management, loan recording, and profit distribution. However, trading nowadays is real-time, volumes are enormous, and the business environment changes fast. Only relying on annual or quarterly financial reporting is not enough for the algorithms / decision-makers to make good decision [22]. As [11] states:

> *"Over the last few decades, the relationship between market values and traditional financial information has become substantially weaker. [32] had found that income reflected 50% of information in the market while current market studies show relationships in the 5-7% range… [6] has shown that over the years this relationship is less and less relevant and that the inclusion of more firm-specific measures outside of the core four accounting statements, such as intangibles [7] and R&D [8] may provide better matching between market and accounting metrics."*

The progressive adoption of automatic trading by investors, which could entail even close to 70% of daily trading in the markets, as well as index fund trading by algorithms aiming at maintaining these funds representative of their indexes [1] adding probably another 15% of the volume. Financial information is provided today by anachronistic reports published at best once every quarter, trading algorithms [17]. Consequently, trading algorithms must resort to other forms of information as triggers of market actions. Although the rules of trading actions are held very private, it appears that trades tend to focus on very short time frame price changes, volume levels, peer stock behavior, and a series of other factors. These other factors may include market changes relative to the particular equities, and more recently exogenous variables such as social media, weather, internet of things, etc. (see Figure 1). A series of proxies for more frequent measures such as parking lot usage [14], electricity consumption [36] have emerged in the increasingly desperate attempt to have very short time market trading superiority. Many other unorthodox proxy measurements will emerge over time.

These factors largely account for 80 or 90 percent of stock trading leaving traditional stock trading a minor effect and consequently, much of prior research on stock trading and financial reporting by and large obsolete. Furthermore, the very important function of business measurement and reporting principles, which trace back to the Securities Acts of 1933 and 1934 as agent accountability, is being measured by increasingly obsolete and anachronistic rules and measurements.

The Enterprise Resource Planning (ERP) system data for accounting and auditing is close to continuous, but the accounting and auditing work is interval-based and loses the close to continuous characteristic of the business measurement process. If the measurement interval is changed, close to continuous reporting is also possible.

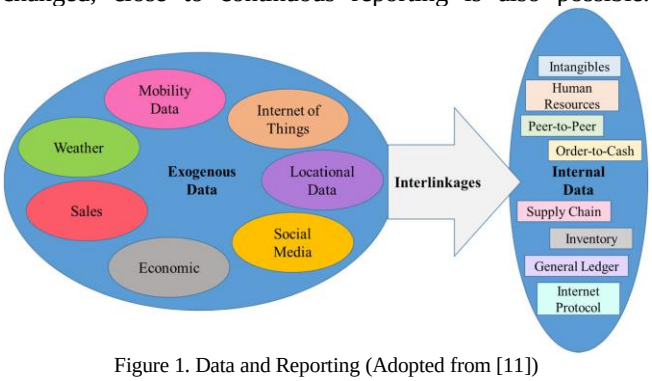

Figure 1. Data and Reporting (Adopted from [11])

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However, companies, for obvious reasons, are very hesitant if not mandated, to disclose day-to-day or second-to-second details of their operation even if automatic traders and the modern real-time-economy needs so [26]. Automatic trading algorithms and other modern business issues need real time information, the accounting world is not providing so, consequently new mechanisms are needed [7].

It is not only trading that can benefit of a more continuous schema of measurement, just-in-time production has long been the objective of supply chains where inventory carrying costs tradeoff with periodical ordering and delivering costs.

Although automatic trading is a natural driver for frequent measurement and query-based reporting many processes in the business ecosystem can benefit or demand different methods of measurement, alternative forms of reporting, improved approaches for verification (audit), and automatic actioning algorithms. However, the acceleration and "ad-hoctization" of these processes is not always necessarily desirable. [5] has shown that daily data measurements create instability in models and therefore for certain types of prediction and modeling they are not the most desirable. The objective in this study is to propose a continuous measurement framework that can provide appropriate timely information for both internal and external stakeholders in some business areas that we think are critical.

This paper is structured as follows. Section II summarizes some related literature. Section III elaborate the idea of continuous measurement metrics for critical business areas, and Section IV, classifies and discusses the advantage and disadvantages of both the traditional and proposed measurements.

II. LITERATURE REVIEW

The double entry method for business recording or measurement originated from 12th and 13th centuries [1]. On of the first attempts for a continuous paradigm in accounting and auditing was proposed by Vasarhelyi and Halper at Bell Labs [25]. Later, the Canadian Institute of Chartered Accountants defined continuous auditing as "*a methodology for issuing audit reports simultaneously with, or a short period of time after, the occurrence of the relevant events [9]*". The continuum paradigm covers a wide range of interrelated activities, such as continuous reporting, continuous monitoring, continuous auditing, continuous assurance and so on.

The traditional approach to information technology applications in auditing are characterized by a predominant focus on a singular tool for a singular problem. While a small number of papers focus on a more holistic approach. However, auditing is an evolving process. [13] argue that Continuous Auditing can be represented as a maturity model that consists of five maturity levels and four factors. The progressive maturity levels that can be used in auditing are: 1) initial approach, 2) ad hoc approach, 3) defined approach, 4) managed approach, and 5) optimized approach. The four capabilities are: A) systems, B) data, C) organization, and D) people [13]. That study fills a gap in the literature concerning a more holistic approach on auditing, and it answers the call for more practical oriented research on Continuous Auditing (CA).

Substantial changes in technology, regulation, and business environment led to increased demand for continuous auditing and facilitated the development of a continuous auditing framework [27]. For example, [34] argues for the necessity to provide a reliable real-time monitoring of financial activities resulting in the need for continuous auditing. Emerging technological capabilities also facilitates the usage of other proxy measurements. For example, search volume can be used in firm valuation [31][37], the number of cars in the retailer's parking lots can be a proxy for a timely measure of store performance [19],electricity consumption could detect firm financial misreporting [20], etc.

III. POTENTIAL APPLICATIONS OF CONTINUOUS MEASUREMENT

In the following sections, we discuss how continuous measurement can be used in three critical areas of the enterprise: business reporting, financial and non-financial information related to ESG, and cybersecurity.

A. Continuous Measurement for Business Reporting

Traditional annual business reporting can only provide limited information and is outdated in the real-time economy [24]. Continuous measurements of real-time processes are needed. The emergence of various forms of exogenous data as proxies for business process measurement provides potential sources for state-to-art business reporting. Existing successful applications indicate that business processes and Key Performance Indicators (KPIs) can be used not only to measure but also to improve business performance [35]. Instead of measuring the periodic financial data, we propose a process-based continuous performance measurement framework (PCPM) to measure the business performance. This framework consists of three stages. First, the company needs to construct a business process model; then KPIs will be designed for each process; finally, a continuous monitoring dashboard will be built to monitor all KPIs in real-time.

1) Construct a process model

Each company is a collection of activities that are applied to produce, design, market, deliver, and support its production [30]. But the activities and process models vary from company to company, thus the construction of the process model should follow the company's operational characteristics. [30] provides a value chain model that classifies the company's activities into primary activities and supporting activities. Consequently, the measurements

Figure 2: PCF levels explained (adopted from [2])

based on these value activities can provide valuable information to stakeholders. However, these valued activities might be too general for company valuation, thus, a more detailed process model might be needed. The American Productivity & Quality Center (APQC) regularly issues the Process Classification Framework (PCF) [2] for different industries. These frameworks usually have five levels (Figure 2), and for each level, it has detailed activities and evaluation metrics. Companies can construct their specific process model based on this framework.

2) Construc KPI for each process

After all level processes are defined, key performance indicators for each process can be constructed. The KPIs can include not only financial measurements but also customer, internal process, as well as learning & growth perspectives [21].

3) Integration

The last step for the business reporting is to build a continuous monitoring dashboard to monitor all processes and KPIs. The KPIs need to be aggregated at a task, activity, process (group), and category levels to obtain a larger picture of performance at each level (Figure 3). These can also be aggregated in monetary or percentage score formats. The KPI monitoring system can also be combined with process mining, which analyses the compliance and variance of processes[28].

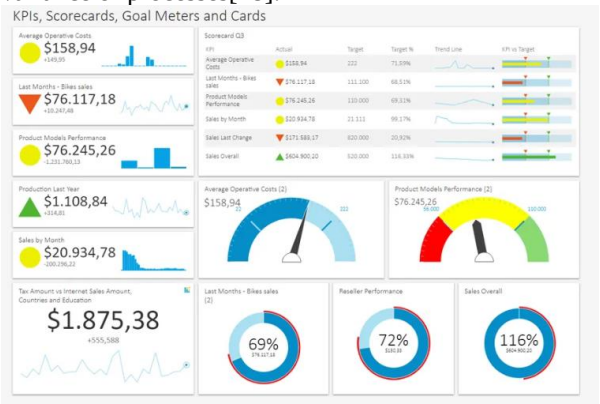

Figure 3: KPI Monitoring Example (Adopted from [23])

B. Continuous Measurement for sustainability reporting

Besides business reporting, sustainability reporting is nowadays also a major concern of information users. Some changes in environmental circumstances can be catastrophic to companies, consequently, the timely monitoring and measurement of the sustainability-related information is very important. There are multiple sources for sustainability or Environment, Social, and Governance (ESG) information, including company annual reports, company websites, regulatory filling, news, etc (Briscoe [15]). These different and highly unstructured data satisfy many requirements but are of very difficult obtention. Thus, a comprehensive measurement system can be very useful for both the usage by the company and its external stakeholders.

The European Union has been working on corporate sustainability for many years. In recent years, the European Financial Reporting Advisory Group (EFRAG) is moving full speed ahead in the development of sustainability reporting disclosure standards and has published many sustainability-related working papers. Companies can follow the proposed topic and subtopics proposed by EFRAG [12] (see Figure 4) to construct their own reporting range and measure related metrics dynamically.

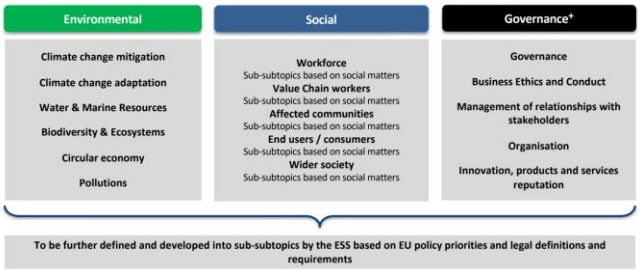

Figure 4: Proposal for a detailed structure for sustainability reporting topics and sub-topics (Adopted from [12])

C. Continuous Measurement for Cybersecurity

Cybersecurity needs had taken very central roles in modern business concerns. Firms that experience cyberattacks or incidents may suffer substantial costs and other negative impacts, such as remediation costs, increased defensive costs, lost business, litigation risks, increased insurance premiums, reputation damage, and so on [33]. According to the 2019 data breach report (IBM [16]), the average cost of a data breach is globally 3.92 million dollars and 8.19 million of dollars for the United States. A cyberattack on May 7, 2021, over a fuel pipeline company caused an emergency declaration in Washington D.C. and 17 states [29].

To respond to the increasing cyberattacks and potential side effects, the AICPA [3] issued cybersecurity risk management description criteria which can provide some guidance on how to measure the cybersecurity-related risks. This guidance consists of nine topic areas, including business operation, cybersecurity objective, governance structure, control process, and so on (see Table I). Companies can continuously measure the listing cybersecurity-related information, and thoroughly understand the organization's cybersecurity status.

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TABLE I. CRITERIA FOR CYBERSECUTIRY RISK MANAGEMEN

Nature of Business and Operation • The principal products or services and the methods by which they are distributed
Nature of Information at Risk • The principal types of sensitive information created, collected, transmitted, used, or stored
Cybersecurity Objective • Objectives related to availability, confidentiality, integrity of data, and integrity of processing
Inherent Cybersecurity Risks • characteristics of technologies, connection types, use of service providers, and delivery channels used by the entity • organizational and user characteristics • environmental, technological, organizational and other changes during the period covered by the description at the entity and in its environment.
Cybersecurity risk governance structure • The process for establishing, maintaining, and communicating integrity and ethical values to support the functioning of the cybersecurity risk management program
Cybersecurity Risk Assessment Process • Process for identify and access related risk
Cybersecurity Communications and Quality of Cybersecurity Information • The process for internally and externally communicating cybersecurity information
Monitoring of the Cybersecurity Risk Management Program • Conduct evaluation of the operating effectiveness of key control activities • Evaluate and communicate, in a timely manner, identified security threats, vulnerabilities, and control deficiencies to parties responsible for taking corrective actions, including management and the board of directors, as appropriate
Cybersecurity Control Processes • The process for developing a response to assessed risks, including the design and implementation of control processes

Source: Adopted from [3]

IV. CONCLUSION

The traditional periodic interval measurement is usually yearly or quarterly, and it is standardized, stable, and well regulated, since it has been used for several centuries. However, this measurement is not adequate for the real time economy[10]. Companies may lose great opportunities due to outdated information, and investors may incur in many extra costs to obtain more timely information. Thus, more frequent measurements can benefit both parties. Moreover, the continuous business activities and ERP data, the just-in-time production, and the available exogenous data provide the foundations for short interval or continuous measurement. TABLE II summarizes the advantages and disadvantages of long and short interval measurements. Initial measurement costs might be high but they will decrease over time while the company is getting more familiar with the measurement process. The same will occur for measurement accuracy, which can be low at the beginning, and then improve over time.

TABLE II. LONG INTERVAL AND SHORT INTERVAL MEASUREMENT COMPARSION

	Advantages	Disadvantages
Long interval Measurement	• Standardized • Well regulated • More stable • More familiar to users	• Outdated • Relies on a series of assumptions and rules (e.g., depreciation)
Short interval measurement	• Timely • High Transparency • Comprehensive	• Less regulated • Measurement cost might be high at the beginning

To summarize, continuous measurement can benefit both the company and investors in the long run, but there's still a long way to achieve its desired utility. These will have a profound effect on standards. Consequently, future research is needed to further explore questions like what proxies are appropriate for the continuous measurement, what techniques can be used, how the regulations, standards, and assurance professions will be affected, etc.

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