MAIN ARTICLE

Uncovering dynamic complexity in annual reports: a methodological approach using resource mapping

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Abstract

This study explores the role of qualitative system dynamics (SD) models in representing and analyzing the information of corporate annual reports by uncovering their hidden "dynamic complexity." The study employs a specific qualitative SD technique, resource mapping, and outlines a methodology to apply it in practice. This study has several contributions. First, it provides methodological guidelines and practical insights on how to apply qualitative SD, using stock-and-flow diagrams, in the field of corporate reporting to represent visually and analyze the dynamic complexity implicit in businesses. Second, it underlines the performative role of accounting together with qualitative SD. Specifically, it provides useful insights into how to use qualitative SD in the accounting field to enhance both internal analysis and external communication, thereby supporting decision-making processes. Third, it shows how to integrate different discipline-related technical languages, thereby bridging differences in backgrounds, skills, and expertise that might characterize intended readers and users.

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Introduction

The use of qualitative system dynamics (SD) has been the subject of multiple discussions among scholars in the field. For example, Wolstenholme and Coyle (1983) suggested that qualitative SD could be a rigorous approach to system description as an antecedent to simulation, and Coyle (2000) provides a list of additional papers that support this point of view. These authors also propose that describing "a system is, in itself, a useful thing to do and may lead to better understanding of the problem in question" (Coyle, 2000, p. 226). Similarly, Homer and Oliva (2001, p. 347) suggest that "qualitative mapping is useful for describing a problem situation and its possible causes and solutions." Qualitative maps can also help to highlight issues in mental models and improve understanding of feedback processes (Senge, 1990). Additionally, qualitative mapping is part of the initial stages

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in SD modeling, e.g. Sterman (2000)'s five stages, as it helps to understand the structure of the problem situation.

Definitively, qualitative maps cannot help to infer the behavior of the variables since this would require the use of a quantitative model. However, there are cases where describing qualitatively the problem situation can generate useful insights for decision-makers, allowing them to analyze all the sources of data and information potentially at their disposal to portray key relationships in the structure of the systems under analysis. According to Sterman (2000), these relationships, relying on the interconnections among components and forming the feedback loops which drive their development, define the "dynamic complexity" of a system. In this context, qualitative SD can be effectively used jointly with traditional sources of information (Forrester, 1980) to visualize and provide additional elements to discuss and understand the complexity behind such information. In the SD literature, this property is associated with the concepts of "operational thinking" and "closed-loop thinking." In detail, the former implies the discovery of the primary material configurations of the modeled system, i.e. of "the core stock-and-flow infrastructure that lies at the heart of a system" (Richmond, 1994, p. 141), while the latter seeks to exploit the concept of feedback loop, thereby helping people "to see causality as an ongoing, interdependent process" (Richmond, 2000, p. 7).

In managerial contexts, a main source of information is certainly represented by accounting, which embodies the cornerstone of organizational reporting systems to the point it can be considered the official "language of business" (Carnegie *et al.*, 2021, p. 65). Particularly, by studying the usefulness of accounting information in the business field, several studies have highlighted that the primary source of this information is represented by corporate annual reports, whose drafting is mandatory and governed by shared regulations and principles (e.g. Epstein and Pava, 1993; Anderson and Epstein, 1995; Bence *et al.*, 1995; Naser and Nuseibeh, 2003; Alattar and Al-Khater, 2007; Roychowdhury *et al.*, 2019).

According to a conventional perspective, accounting has been traditionally and primarily (Chabrak *et al.*, 2019) viewed as a technical practice or a calculative process (Hopwood, 1992) useful to provide information for internal and external stakeholders (Carnegie *et al.*, 2021). However, how accounting acts in social sciences and in the definition of individual behaviors and strategies still represents a fertile field of study for managerial scholars, who have recently emphasized the potential of accounting in terms of being a "performative" agent for action in the business field (e.g. Lowe, 2004; Boedker, 2010; Vosselman, 2014; Revellino and Mouritsen, 2015). This potential refers to the active role that accounting can play "in enacting and (re)formulating strategies" (Skærbæk and Tryggestad, 2010, p. 108).

Since its development by defining calculative practices as engines that can evolve financial markets (Mackenzie, 2006), the performative approach to

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accounting has particularly guided the study and analysis of annual reports "as models that would influence the world because they would lure people into action" (Revellino and Mouritsen, 2015, p. 32). However, the adoption of this approach requires practitioners and researchers to use methodologies able of supporting people's actions through annual reports by overcoming the limits that are traditionally attributed to the information disclosed therein, such as its static nature (e.g. Healy and Palepu, 2001; Boedker, 2010), or its focus on financial transactions and the past (Merchant, 1997). Indeed, some recent models of corporate reporting, such as Integrated Reporting (IIRC, 2013, 2021), have tried to overcome these limits by increasing the information provided according to a multi-dimensional and dynamic perspective. Interestingly, such reports make also use of multiple means of communication—i.e. not only numerical data but also textual descriptions and a variety of visuals (Bell and Davison, 2013)—since they aim to better clarify and enrich the content of the disclosure provided to the intended readers, also by using different forms of language simultaneously (e.g. Busco *et al.*, 2023). Unfortunately, these newly developed reports are not always available for both internal analysis and external communication since their drafting is normally made on a voluntary basis, and their content is highly variable (Baret and Helfrich, 2019) as it is defined on guiding principles rather than on a standard model. In these terms, improving the informative effectiveness of annual reports would instead allow to define action according to accounting information that is always available and, being standardized, allows comparisons among organizations.

In this study, we argue that a methodology that can effectively overcome the limits of annual reports and sustain the performative role of accounting is the qualitative SD technique named resource mapping, which is based on stock-and-flow diagrams (Kunc and Morecroft, 2009). Specifically, this study suggests that accounting information is yet a fertile area of application for qualitative SD, particularly to enhance the potential use of accounting to understand the hidden dynamic complexity in business. In detail, by comparing the notion of "performativity" in the accounting literature with the concepts of operational thinking and closed-loop thinking in qualitative SD (Richmond, 1993; Richmond, 2000), this study advocates using resource mapping to enhance the performative role of accounting by uncovering the organization's dynamic complexity that is hidden in accounting information in terms of connections, accumulations, and feedback processes. The joint use of accounting information and resource mapping will subsequently show "how things really work" (Richmond, 1993, p. 127) in business and where relevant levers for value creation lie in real systems by using a unified representation. To this aim, the study outlines a six-stage process that allows the application of resource mapping methodology to the information contained in annual reports, also providing practical insights and useful exemplifications for each stage and for analyzing the map thereby developed.

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The use of resource mapping to analyze corporate reports has been already investigated in previous studies (e.g. Barnabè *et al.*, 2019; Giorgino *et al.*, 2020), which essentially employed a recent model of corporate report, i.e. integrated reports, which is more transparent in terms of stocks and flows. However, in comparison to them, this study has several different contributions. First, it provides methodological guidelines and practical insights into how to apply resource mapping and qualitative SD in general in the field of accounting and corporate reporting to represent visually and comprehensively the dynamic complexity implicit in any business environment. Second, it provides useful insights on how qualitative SD can be used to support the performative role of accounting, therefore enhancing both the internal analysis and external communication of organizations, by dealing with a source of accounting information (i.e. annual report) that, differently from integrated reports, is available for any kind of organization and is highly standardized. Third, it shows how to integrate different technical languages, thereby bridging differences in backgrounds, skills, and expertise that might characterize the intended readers and users. Last, this study starts a series of research on how to embed SD methods into the accounting discipline, which we hope can inspire more research into how to embed stock-and-flow thinking into other disciplines.

The remainder of the article is structured as follows. The second section positions resource mapping within the context of SD methods. The third section provides a brief literature review on accounting and SD. The fourth section describes thoroughly our approach while also providing examples and insights from a descriptive case study. Section five contains the discussion. Finally, the conclusion is the last section of the study.

Resource mapping in brief

Research in the field of SD has been traditionally devoted to building diagrams and models able to tackle the issue of dynamic complexity existing in many of our daily domains. In this context, the focus has been constantly directed towards the identification and analysis of the relationship between structure, which are stocks, flows, causal linkages, and feedback loops, and behavior, which comprehends the dynamic performance of the system over time. The identification of the causal mechanisms at the basis of a specific system is, therefore, a fundamental step of the overall approach (Forrester, 1961; Forrester, 1968) and is the key to inferring the reference mode of behavior over time—that is, for the articulation of a "dynamic hypothesis" (Randers, 1973; Randers, 1980). The dynamic hypothesis is a cornerstone of good SD modeling practice since it "explains the dynamics as endogenous consequences of the feedback structure" (Sterman, 2000) and

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explicitly states how structure and decision policies originate the behavior observed (Richardson and Pugh, 1981).

Within this stream of research, a lively debate has stimulated researchers and practitioners to focus more on the qualitative side of the analysis, i.e. to rely on qualitative SD tools, principles, and research methods to inspect social systems and their structures. Many studies have presented tools and insights associated with the use of qualitative SD, such as causal loop diagramming (e.g. Senge, 1990; Wolstenholme, 1999), cognitive mapping (e.g. Eden, 1992; Rees *et al.*, 2018), critical thinking (Cavana and Mares, 2004), mental model elicitation tools (e.g. Ulysse—an approach explained in Desthieux *et al.*, 2010), systems archetypes (Senge, 1990), resource mapping (e.g. Kunc and Morecroft, 2009), and qualitative social science techniques (e.g. Luna-Reyes and Andersen, 2003).

More specifically, the SD literature has shown plenty of applications of qualitative SD to analyze managerial problems (e.g. Wolstenholme and Coyle, 1983; Coyle and Alexander, 1997; Pala *et al.*, 2003; Pala and Vennix, 2005; Snabe and Größler, 2006; Kopainsky and Luna-Reyes, 2008; Lane, 2008; Dhawan *et al.*, 2011; Gary and Wood, 2011; Sherwood, 2022). In some cases, the SD literature has also provided examples of combining qualitative SD with corporate reporting tools to analyze business issues and support decision-making (e.g. Giorgino *et al.*, 2020; Kunc *et al.*, 2021, focused on the analysis of sustainability; Duran-Encalada and Paucar-Caceres, 2012, discussed the information reported by companies on the Global Initiative Reporting website; Saryazdi *et al.*, 2020, employed the Document Model Building technique to generate a qualitative SD model).

One of the methods employed in corporate analysis is resource mapping (Kunc and Morecroft, 2009). A *resource map* is a graphical tool that assists organizations in visualizing the key strategic resources at their disposal, their connections, and the overall pattern of value creation (Kunc and Morecroft, 2009; Kunc and O'Brien, 2017; Barnabè *et al.*, 2019). From a graphical point of view, resource maps can be viewed as a typology of stock-and-flow diagrams, whereby the selection of the stocks and flows included in the map (and the causal relationships connecting such variables) is informed by the financial and nonfinancial information available. Resource maps can be related to influence diagrams (e.g. Figure 3, p. 234, in Coyle, 2000) since they describe stocks and flows but do not have the details of auxiliary variables and functions of quantitative SD models (Coyle, 1996). A resource map is a specific typology of qualitative SD-based diagrams.

The related modeling technique, i.e. resource mapping, uses the concepts of the stream of research named *Dynamic Resource-Based View* (DRBV) (Morecroft, 1997), which combines the key elements of the Resource-Based View of the Firm (RBV – Barney, 1991) and SD (Forrester, 1961; Forrester, 1968). While RBV strongly emphasizes that an organization's

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performance is determined by the set of "resources" and "capabilities" developed or acquired over time, SD offers a set of techniques and tools able to operationalize RBV concepts such as asset stock accumulation and feedback processes, thereby building qualitative maps (and, subsequently and if needed, also quantitative simulation models) that are useful in business, social, and sustainability-related systems because the structure reflects concepts accepted in business domains (e.g. Kunc, 2008; Kunc, 2012).

Previous literature has already underlined the various strengths of resource mapping. For example, in the business domain, resource maps may effectively assist organizations to visualize their strategy (Kunc and Morecroft, 2009; Kunc and Morecroft, 2010) and the fundamental architecture according to which the specific business system operates (Warren, 2008). In doing so, resource mapping allows us to demonstrate graphically the complexity existing in business models and analytically its impact on value creation through the analysis and evaluation of the feedback processes represented in a resource map (Kazakov and Kunc, 2016). Interestingly, resource mapping has been also viewed as a potentially unifying language, able to bring together views, terms, and concepts that could be expressed differently before the mapping exercise (e.g. Kunc and Morecroft, 2009; Kunc and O'Brien, 2017). Resource mapping also overcomes some of the weaknesses of other SD-based tools, such as causal loop diagrams, especially in terms of understanding the dynamic complexity of organizational systems (Schaffernicht, 2010; Giorgino *et al.*, 2020). Additionally, resource maps can support operational thinking and closed-loop thinking (Richmond, 1993; Richmond, 2000) since a resource map describes critical arrangements of the system, such as the stock-and-flow infrastructure and the pattern of feedback loops underpinning the financial performance of a business, and it is based on visualizing and understanding an organization's data rather than performing data analysis.

Qualitative SD and accounting information

A brief literature review

Even though the role assigned to pure accounting principles, tools, and numbers in the SD field has been often a marginal one, some studies have witnessed how relevant it is to calculating correctly the impacts generated by business policies in financial terms (e.g. Bianchi, 2016). However, it is notable that accounting, as well as annual reports, has often played just an ancillary role to the activity of modeling centered on the core business operations, with "numbers" (i.e. calculations in terms of costs, revenues, profit and loss, etc.) seen as just a consequence of the business policies centered on such activities. Less frequent is the situation in which accounting

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principles and annual reports have provided the focal point for the modeling activity or the subsequent analysis.

In particular, we found that just a few papers have been explicitly devoted to analyzing and explaining SD-based modeling activities applied to corporate annual reports. For example, Yamaguchi (2003) described how to represent accounting-based documents and accounting-related principles using stock-and-flow diagrams and SD concepts; Melse (2006) studied how to create a dynamic system of accounts, and Pierson (2020) discussed how to develop a comprehensive accounting model starting from the data contained in traditional accounting reports. Additionally, some studies have investigated how to evaluate specific sections or items from corporate financial statements—such as in the study by Yamaguchi and Yamaguchi (2021) that focused on the representation and analysis of money stock (i.e. the sum of coins, notes, and demand and time deposits)—or to represent an organization's business model and its main operations using SD maps and diagrams (e.g. Duran-Encalada and Paucar-Caceres, 2012, focused on GRI and Barnabè *et al.*, 2019, analyzed integrated reporting practices).

Other studies have explored how to use SD jointly with accounting data and documents to support strategic management control; for example, Bianchi (2002) described how to use SD models for planning and management control purposes; Khan *et al.* (2020, 2021) employed SD to investigate the effects of an organization's investment and financing policies on firm value; Bianchi and Rivenbark (2014) discussed how to use SD in order to promote performance management in local government settings; Akkermans and van Oorschot (2002, 2005) as well as Kunc (2008), Bianchi and Montemaggiore (2008), Capelo and Dias (2009), and Barnabè (2011) investigated how to design dynamic balanced scorecards and strategy maps.

Finally, some studies have looked at the use of accounting-related concepts (such as those of costs, revenues, profits, marginality, unit price, etc.) to inform and support policy- and strategy-making decisions. For example, the concept of *operating costs* is key for designing a strategy in the well-known Beer Game (Sterman, 1992) as well as in the Fish Bank model (Meadows *et al.*, 2001).

Enhancing the joint use of qualitative SD and accounting information

Overall, the SD literature offers many examples of how it is possible to combine—to some extent and for specific purposes—SD tools and principles with accounting concepts and performance measurement systems (also see Cosenz and Noto, 2016; Oladimeji *et al.*, 2020, for systematic literature reviews about this). For example, Giorgino *et al.* (2023) and Baptista *et al.* (2023) discussed how to combine accounting concepts with stock-and-flow representations in educational settings.

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However, from a methodological standpoint, a detailed analysis of how annual reports and accounting-based information can be represented and analyzed using SD-related tools, and communicated to relevant stakeholders, is as yet missing to the authors' knowledge.

The representation and analysis of annual reports entail going beyond the "mere" calculative role assigned to accounting information and records, to move towards a more compelling and active—or "performative"—use of them (Mackenzie, 2006). Indeed, since several agents, both internal and external, as well as both human and nonhuman, participate in the decision-making processes and strategies involving organizations, their action can be hardly characterized by linear pathways (Boedker, 2010). Instead, the actions are defined by the linkages or ties of a network of relationships involving these agents as the "actants" (i.e. a dynamic entity with the power of molding) of strategies as social products (Latour, 2005). In the resulting actor-network, accounting represents a nonhuman (or material) actant, which can have the power to mold and create a strategy while representing it. This power of accounting summarizes the main contents of its performative role, as well as the same concept of performativity as stated by "the dynamics through which actants become defined through the performance of network relations" (Lowe, 2004, p. 614).

The performative approach to accounting has been particularly helpful in guiding the study and analysis of annual reports because it defines calculative practices as engines that can evolve financial markets (Mackenzie, 2006). According to this approach, for example, accounting-based information and reports are routinely used by investors to decide if and where to invest. Furthermore, accounting information is used for a number of purposes by various external stakeholders, such as regulators to evaluate business performance and also detect fraud. Accounting may also be oriented internally to a specific organization, to help managers understand the strategic resources at their disposal, and visualize the paths of value creation (Aaltola, 2019).

However, this use requires overcoming the limitations that are typically ascribed to accounting information. For instance, previous studies have highlighted that annual financial reports do not entirely reduce the information asymmetry between internal decision-makers and external stakeholders (Healy and Palepu, 2001), tend to reduce strategic thinking to only costs and revenues, are unable to quantify the future, and may even provide misleading numbers (Aaltola, 2019). Furthermore, annual reports are often said to be too static, focused on the past, and not able to show clearly, holistically, and comprehensively an organization's value creation process because they are "transactions oriented" and fail to recognize changes in value that do not result from transactions (Merchant, 1997, pp. 458–459). These limitations entail the need for several complementary sources of information—often provided textually through different forms of corporate reports, such as

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integrated reports—or based on decision-makers' and stakeholders' mental models (Forrester, 1980), which can have their own limitations. However, these complementary sources are not always available since they are generally produced on a voluntary basis and do not favor comparison between different organizations due to their heterogeneity in both form and content.

In this study, we argue that activating the performative role of accounting requires the adoption of methodologies capable of overcoming the limitations of accounting information by transforming its role from being an output to being an input of decisions (Boedker, 2010; Skaerbaek and Tryggestad, 2010). Particularly, this study suggests that qualitative SD, and above all a qualitative SD technique named resource mapping (Kunc and Morecroft, 2009), may represent an effective methodology to support the performative role of accounting from the perspective of both internal decision-makers and other stakeholders. Moreover, by relying on previous studies that have emphasized the usefulness of maps and diagrams as teaching aids (e.g. Leauby and Brazina, 1998; Leauby *et al.*, 2010; Phillips *et al.*, 2012; Somers *et al.*, 2014), this study suggests that the same SD methodology of resource mapping can have additional potential also to enhance the learning processes about accounting, as better discussed below.

Method to develop a resource map starting from accounting information

This study introduces a methodology to develop a resource map starting from the accounting-based information and the related descriptions provided by an organization's annual report (i.e. mostly balance sheet, income statement, and notes to the financial statements). The International Financial Reporting Standards (IFRS) framework—considered as the reference in this work—however associates annual reports with an additional document named *Management Commentary*, which provides the management comments related to financial statements prepared in accordance with IFRS guidelines. This document has the function of integrating the accounting data of annual reports with additional information on the organization's resources and particularly with management's view about the overall performance, position, and future development of the organization, and also on the basis of claims against its activities. Due to the relevance of this information for the aim of this study and considering its presence in any annual report, the management commentary can be considered an additional section of the annual report under analysis.

Before starting the mapping process, the annual reports are investigated considering the fundamental accounting principles and the information that those reports include, subsequently identifying relationships among the accounting data (Kim and Andersen, 2012). This information is used as

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input to resource mapping that, briefly, includes the following six main methodological steps (Kunc and Morecroft, 2009; Barnabè *et al.*, 2019), as explained in greater depth in Table 1:

1. Lay out the resources (stocks);
2. Identify the processes (flows) responsible for building or eroding resources;
3. Identify capabilities;
4. Portray relationships and polarities (positive and negative);
5. Identify feedback loops (reinforcing and balancing);
6. Analyze the map to uncover leverage points and key processes for value creation.

Various SD-related software can be used to develop graphically the resource map. This study develops resource mapping examples in a Vensim environment. Additionally, for the sixth step of the approach outlined above, this study suggests the use of specific tools—such as the SDM-Doc software (Martinez-Moyano, 2012)—in order to generate additional information for decision-makers and relevant stakeholders.

Examples and insights from a descriptive case study are used to exemplify how the methodology is applied in practical terms. Descriptive case studies describe "systems, techniques and procedure used in practice" and are useful "in providing information concerning the nature and form of current accounting practices" (Ryan *et al.*, 2002, p. 143), thereby enabling the analysis of events in their "real-life context" (Adams *et al.*, 2006, p. 364). In this study, this typology of case study is used to describe the resource mapping process in an organization to reply to questions such as the following: How is a resource map developed? Which are the contents of annual reports that can be used to develop a resource map? To what extent can a resource map be used to represent the dynamic complexity underlying an organization's value creation? How can a resource map be used to uncover the leverage points and key processes of an organization's value creation?

The organization chosen for the analysis is a typical manufacturing organization whose name has been anonymized.

The method outlined in Table 1 is described in the sections below.

Stage 1. Layout the resources

Traditional financial-based reports contain two main documents: a balance sheet (including assets, liabilities and equity) and an income statement.

The first step of the resource mapping process outlined in this study starts by considering the information displayed by an organization's balance sheet which is to be regarded as a collection of stocks at a specific point in time (i.e. usually the 31st of December of a given financial year). A balance sheet

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Table 1. Steps to create a resource map from annual reports

Resource mapping stages	Description and sources of information within annual reports
1. Lay out the resources (stocks)	A balance sheet specifies the name of the assets owned by an organization, which helps in the identification of the resources. The balance sheet also reports the list of liabilities and equity for the organization. Additional information about the resources at the organization's disposal can be drawn from the income statement (costs and revenues generated by the use of resources) and the notes to the financial statements. To identify and describe resources in the annual reports, there is a set of questions: What are the resources identified in the report? How is this resource built? Does the resource have a long-term life in the organization? Is this the basic unit of analysis or can we identify another accumulation process defining the resource?
2. Identify the processes (flows) responsible for building or eroding resources	The information in the report has to be analyzed to recognize and represent the processes causing the resource increase or decrease, i.e. inflows and outflows. Assets, liabilities, and equity are increased by inflows and decreased by outflows. The income statement and the notes to the financial statements provide relevant information in this regard.
3. Identify capabilities	Capabilities originate from either a single resource or from a set of related resources. Capabilities can build other resources, generate value by attracting customers, or generate activities influencing external stakeholders. These questions are used to identify capabilities: What processes originate from resources? and Where this activity comes from? The capabilities discovered in the annual reports are presented in the resource maps using auxiliary variables and not stocks. A combined analysis of the balance sheet and the income statement is useful for this purpose.
4. Portray relationships (direct and indirect) and polarities (positive and negative)	To design the resource map for an organization it is necessary to identify and represent the causal links active in its domain, i.e. within and between the items reported in its financial statements. Such links are depicted using connectors (lines) which contain the direction of the linkage and the type of linkage. The type of linkage indicates a positive impact (an increase in A increases B) or a negative impact (an increase in A decreases B). The signs of polarities ("+" and "−") are used for this purpose.
5. Identify feedback loops (reinforcing and balancing)	The resource map is finished with the identification of the feedback processes between resources and flows. Feedback loops are either positive (or reinforcing—denoted by the letter "R") or negative (or balancing—denoted by the letter "B" in the resource map).
6. Analyze the map to uncover leverage points and key processes for value creation	The resource map is analyzed to uncover its "dynamic complexity." Data about the causal structure of the resource map are subsequently generated, and information about value creation processes is obtained. In detail, this stage of the methodology provides information about leverage points (e.g. Key Value Creation Spots) and processes (e.g. Key Value Creation Loops) affecting value creation for the organization. This step is also fundamental to explaining trade-offs among resources and matching data portrayed by the resource map with traditional accounting-based key performance indicators.

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reports the aggregate effects of the transactions implemented by the organization during the financial year just ended, by arranging these effects in terms of assets, liabilities, and shareholder's equity, and according to the following equation:

$$\text{Assets} = \text{Liabilities} + \text{Equity}.$$

The IFRS framework provides a definition for each one of the three categories of items that are represented in a balance sheet. Particularly, an asset is defined as "a resource controlled by the enterprise as a result of past events and from which future economic benefits are expected to flow to the enterprise"; a liability represents "a present obligation of the entity arising from past events, the settlement of which is expected to result in an outflow from the entity of resources embodying economic benefits"; last, equity "is the residual interest in the assets of the entity after deducting all its liabilities" (IASB, 2018).

A generic representation of an organization's balance sheet is portrayed in Table 2.

The analysis of this report allows for immediately identifying the resources owned and used by the organization (assets) as well as its different

Table 2. A generic example of a balance sheet

Assets	€	Equity and liabilities	€
Non-current assets		**Equity**	
Land		Share capital	
Buildings		Retained earnings	
Machinery		Other components of equity	
Equipment			
Patents			
Trademarks			
Current assets		**Non-current liabilities**	
Cash		Bonds payable	
Cash equivalents		Notes payable	
Short-term deposits		Deferred tax payable	
Account receivables		Long-term debt	
Inventory		Capital lease	
Marketable securities			
		Current liabilities	
		Accounts payable	
		Interest payable	
		Income taxes payable	
		Bank account overdrafts.	
		Accrued expenses	
		Short-term loans	
Total assets		Total equity and liabilities	

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sources of financing (liabilities and equity). Thus, the first step of the resource mapping process entails including the organization's resources in the map—using the icons of "stocks," thereby taking a first step in combining accounting concepts with SD language. The following example (Figure 1) includes some resources that are particularly relevant for the operations carried out by any organization—such as the one selected for our descriptive case study—i.e. "Machinery," "Cash," and "Patents."

All these resources represent assets for the organization, with two of them belonging to noncurrent assets (Machinery and Patents) and cash being part of the current assets.

Unfortunately, assets in balance sheets usually do not contain all the resources necessary for business operations, since they include only the resources being legally owned by or available for the organization. For example, even though human resources are critical for business operations and represent a strategic resource, they are not measured as assets in financial terms like a factory or a building and are not included in balance sheets. The existence of such resources is therefore made evident by a combined analysis of balance sheets with the other main documents which compose the basic accounting reporting systems, i.e. income statement and the notes to the financial statements containing additional explanatory information

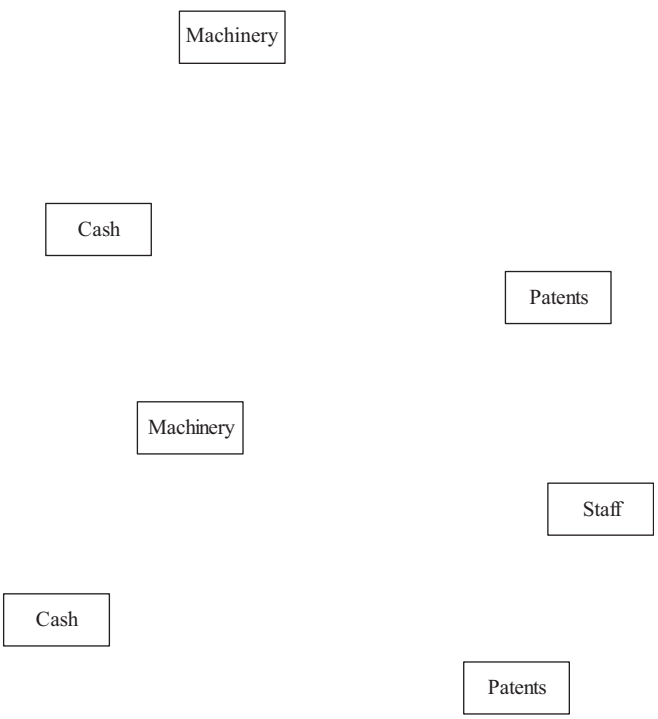

Fig. 1. Example of resources included in the organization's balance sheet (Stage 1)

Fig. 2. Resources at the organization's disposal (Stage 1—extended)

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about the items in the balance sheet and income statement. For example, salaries recorded as costs in the income statement would reflect the amount of personnel employed by the organization. This information is used to further expand the resource map developed in its initial stage, thereby including additional resources (as said, not owned by the organization, however at its disposal), as portrayed in Figure 2 with the addition of "Staff." Further information about this stock, which usually represents a relevant resource for the organization even if it cannot be included in the balance sheet since it is not "owned," can however also be provided by the management commentary.

Notably, the notes to the financial statements and the management commentary can also provide information about soft factors that might be relevant to an organization's overall strategy and its operations but that can be neither included in the balance sheet nor represented by using variables and values from the income statements, such as corporate reputation, brand strength, and product quality. These elements would be then included in the map, expanding the organization's representation.

Stage 2. Identify the processes (flows) responsible for building or eroding resources

This stage identifies and represents the processes causing the resource increase or decrease, i.e. the inflows to and outflows out of them. This happens according to the general rule governing processes of accumulation in stocks, i.e. Eq. (1):

$$\text{Stock}_t = \text{Stock}_{t0} + \int_{t0}^{t} flow * dt \tag{1}$$

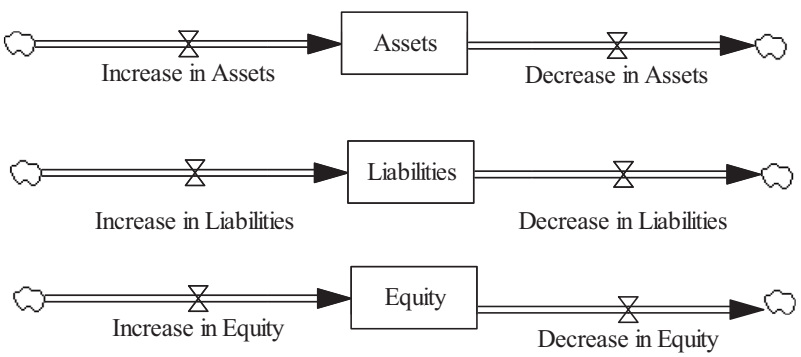

Fig. 3. A generic representation of assets, liabilities, equity, and their flows

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Assets, liabilities, and equity are increased by inflows and decreased by outflows, as represented below (Figure 3).

Investigating an organization's annual report to identify such inflows and outflows involves looking both at the balance sheet and the income statement, since the former lists the resources, and the latter collects all the inflows and outflows that have impacted the stocks during the period being considered. Specifically, an organization's income statement reports expenses and incomes such as revenues, selling and administrative expenses, operative costs, taxes, etc., as well as intermediate and final results such as gross profit and net profit, in a comprehensive, coherent, and logical manner.

A generic example of an income statement is reported in Table 3.

For example, the resource Machinery (included in the balance sheet) would be increased by new items that have been purchased in the time under analysis (e.g. a new piece of machinery for production) and would be decreased by outflows related to sales of old assets or by the depreciation of

Table 3. A generic example of an income statement

Income statement	€
Revenues	
Cost of goods sold	
Gross profit	
Salaries	
Other operative costs	
Marketing, advertising, and promotion	
General and administrative costs	
EBITDA (earnings before interest, taxes, depreciation and amortization)	
Depreciation and amortization	
EBIT (earnings before interest and taxes)	
Interests	
Profit before taxes	
Taxes	
Net profit	

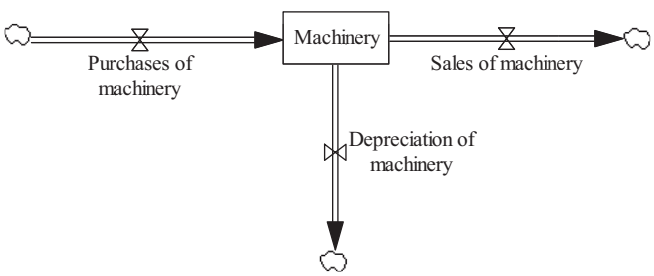

Fig. 4. An example centered on the asset "Machinery" (stage 2)

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them (see Figure 4). Please note that assets are expressed in the balance sheet through their book value.

The same logic would apply to the other stocks included in the balance sheet, however, taking into consideration the peculiarities of each of them and based on the specific transactions that occurred during the period under consideration. Stated differently, whereas a traditional income statement appears as a top-down document that, in what seems a straightforward and simple way, allows moving from the revenues to the net profit simply accounting for the different typologies of revenues and costs generated by the organization (as shown in Table 3), a more in-depth analysis would reveal that different much-needed pieces of information are dispersed over several documents. The example of machinery that we already provided can be considered in this context since the stock would be included in the balance sheet, its depreciation is shown in the income statement, and the information about the depreciation period and rate of the machinery would be reported in additional documents kept by the organization.

Additionally, and as we already mentioned, an income statement would also reveal which resources have been used by the organization during the period under analysis and for its business activities. For example, the costs related to the item "Salaries" would be related to the resource Staff and so on. Subsequently, these additional resources would be added to the resource map during this stage.

Stage 3. Identify capabilities

Capabilities originate from either a single resource or from a set of related resources and refer to qualitative aspects of resources, productivity, or processes that can provide a competitive advantage for the organization and can be exploited to create distinctive value. The capabilities discovered in the

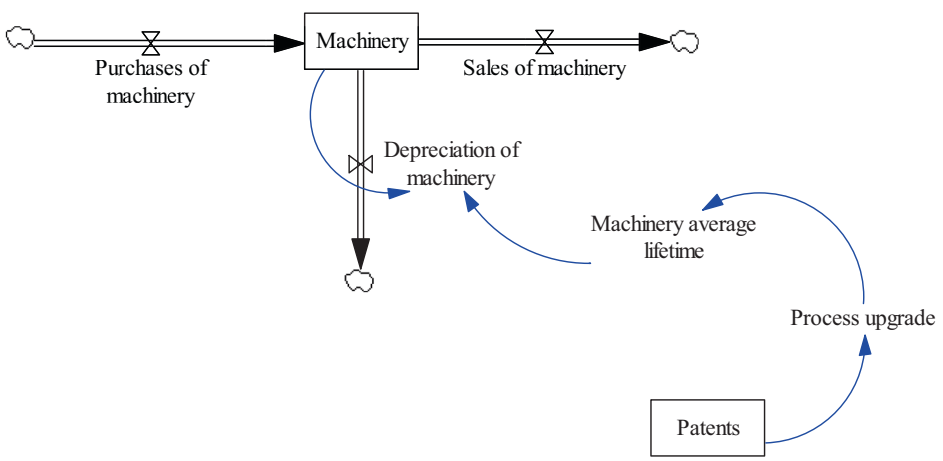

Fig. 5. An example centered on the asset "Machinery" (Stage 3) [Color figure can be viewed at wileyonlinelibrary.com]

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annual reports are mainly presented in the resource maps by using auxiliary variables. For example (see Figure 5), "Patents" (resource) boost "Process upgrade" (process capability), which in turn impacts "Machinery average lifetime" (qualitative capability), thereby influencing "Machinery" (resource) via its outflow "Depreciation of machinery" (flow). It is noteworthy that the identification of capabilities also builds on the information traced by the notes to the financial statements, which provide some additional details and explanations of the items reported in both the balance sheet and income statement. In the example below, for instance, the notes would allow deducing the Machinery average lifetime through the details provided on the depreciation plan of Machinery (as for the other noncurrent assets which are subject to the depreciation process). In this case, the accounting information reflects the capabilities of the machinery measured in lifetime.

The same logic would apply to identify and portray additional information (mostly in the form of auxiliaries) in the resource map, such as information about the interest rate on bank loans and the average time to pay debts and/or collect credits. This information, originally dispersed across several documents, would be now condensed into a single representation.

Step 4. Portray relationships (direct and indirect) and polarities (positive and negative)

Causal links among the resources and the variables included in the resource map are added now. Causal links are depicted using connectors (direct lines) which contain the direction of the linkage. "Polarities" are specified for each link (see the example in Figure 6) thereby indicating if there is a positive impact (the icon "+" for a polarity denotes that an increase in A increases B)

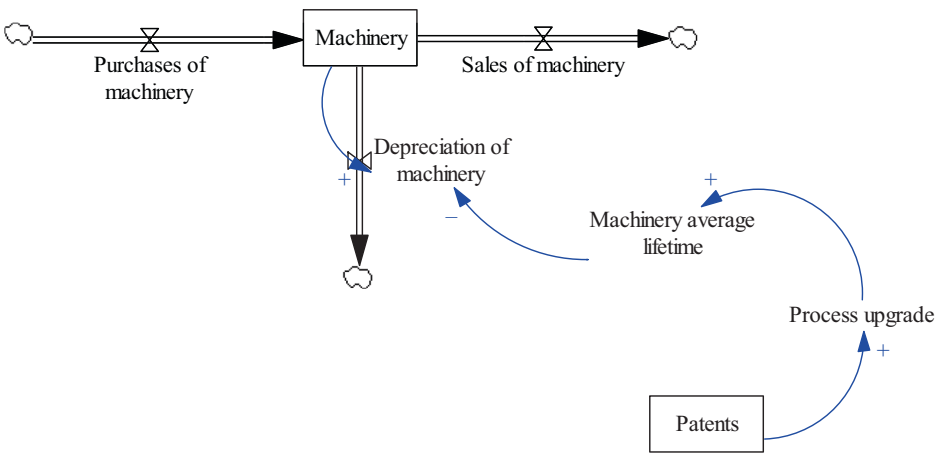

Fig. 6. An example centered on the asset "Machinery" (Stage 4) [Color figure can be viewed at wileyonlinelibrary.com]

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or a negative one (the icon "−" for a polarity denotes that an increase in A decreases B).

When this stage is completed, the map not only connects the balance sheet and the income statement of the organization but also displays the typologies of effects (through polarities) existing between them, thereby providing additional and explicit information content for the readers and users of the resource map.

Stage 5. Identify feedback loops (reinforcing and balancing)

The fifth stage of the resource mapping approach requires the identification of the feedback processes between resources and flows. In the simple example developed so far, one negative loop (i.e. B1 in Figure 7) is generated by the effect of "depreciation" on the resource "Machinery."

Figure 7 shows that the stock "Machinery" is decreased over time because of depreciation. In detail, the outflow "Machinery depreciation" (given by Machinery divided by the "Average machinery lifetime") clarifies that this resource will progressively decrease until it will reach the value of zero, thereby becoming an asset no longer of value for the organization and to be replaced. Overall, the content of information presented in Figure 7 would be fragmented in traditional financial-based documents (i.e. Machinery is included in the balance sheet, Machinery depreciation is displayed by the income statement, and the Average machinery lifetime is calculated using information included in additional supplementary documents) and is now visualized in a condensed manner thanks to the resource map. Additionally, SD-based software also provides a number of technical solutions able to assist users in discovering more easily and with additional jargon the information available about the loop(s) under analysis (see Table 4, developed by using the software Vensim).

Additional loops can be subsequently identified within the resource map, either manually or using specific software to automatically detect the presence of feedback loops and their characteristics, as we mentioned above for the information displayed in Table 4.

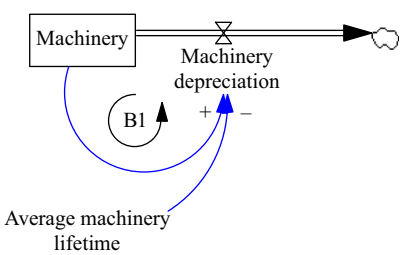

Fig. 7. A negative feedback loop identified in the resource map [Color figure can be viewed at wileyonlinelibrary.com]

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Table 4. Identifying and describing feedback loops

Identification of loops and their structure	Machinery depreciation : Loops Loop Number 1 of length 1 Machinery depreciation Machinery
Causes tree	Machinery depreciation: Causes Tree Average machinery lifetime (Machinery depreciation) — Machinery Machinery depreciation
User uses tree	Machinery depreciation: Uses Tree Machinery depreciation — Machinery — (Machinery depreciation)

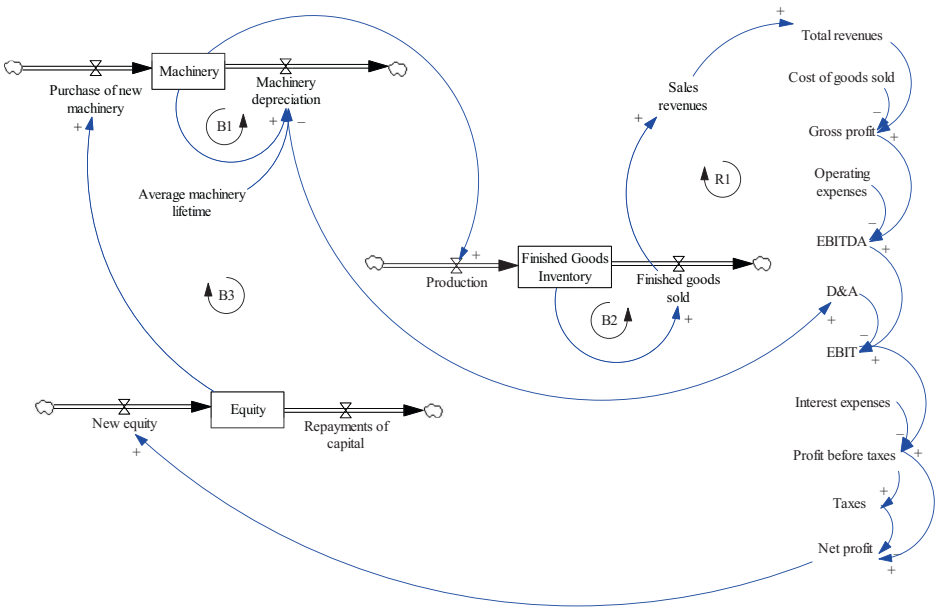

Fig. 8. Partial resource map with the identification of positive and negative feedback loops [Color figure can be viewed at wileyonlinelibrary.com]

In this regard, Figure 8 displays an expanded portion of the resource map developed for this study.

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Figure 8 portrays in a simplified way the core operations and processes for this organization: it implements a simple production process, based on the use of one type of noncurrent asset ("Machinery") to transform the raw materials purchased (recorded in the "Raw Materials Inventory") into the organization's final goods or products for sale (affecting the "Finished Goods Inventory"). Therefore, the map visualizes and makes clear all the connections among the organizations' resources, operations, and performances. From an accounting perspective, the map also presents both the financial and the economic dimensions of its activities. The former finds its synthesis in the dynamics involving the resource "Cash" as caused by the credit and debt policy adopted by the organization in its sales and purchases activities. The latter, which is mainly represented on the right side of the map, explains the gradual determination of the net profit deriving from the activities implemented by the organization in the period under investigation, as well as its subsequent destination to dividend payments and/or equity increase.

Through these expansions, the resource map progressively reveals the existence of multiple feedback loops (both negative and positive) characterizing the organization's value creation process. Specifically, the partial resource map in Figure 8 portrays four feedback loops, with one of them being a positive one (R1), and the other three (i.e. B1, B2, and B3) being negative ones. In this way, the resource map presents the main resources at the organization's disposal and their inflows and outflows, thereby connecting explicitly all the information that was originally contained, but also, dispersed across the annual report.

Further expansions will progressively lead to the development of a more comprehensive resource map for the organization under analysis (see Figure 9 for an expanded version of the resource map). Such expansions allow not only linking together all the pieces of information originally dispersed in different financial statements and documents, thereby visualizing their linkages and interplays, but also discovering systemic structures (i.e. feedback loops) that might have been difficult to see previously or that were hindered using technical language (e.g. of accounting) different from what instead happens with resource mapping.

As an example, the feedback loop R1, of length 13, is a reinforcing one, operating by connecting circularly the following variables:

- "Purchase of new machinery";
- "Machinery";
- "Production";
- "Finished Goods Inventory";
- "Finished goods sold";
- "Sales revenues";
- "Total revenues";

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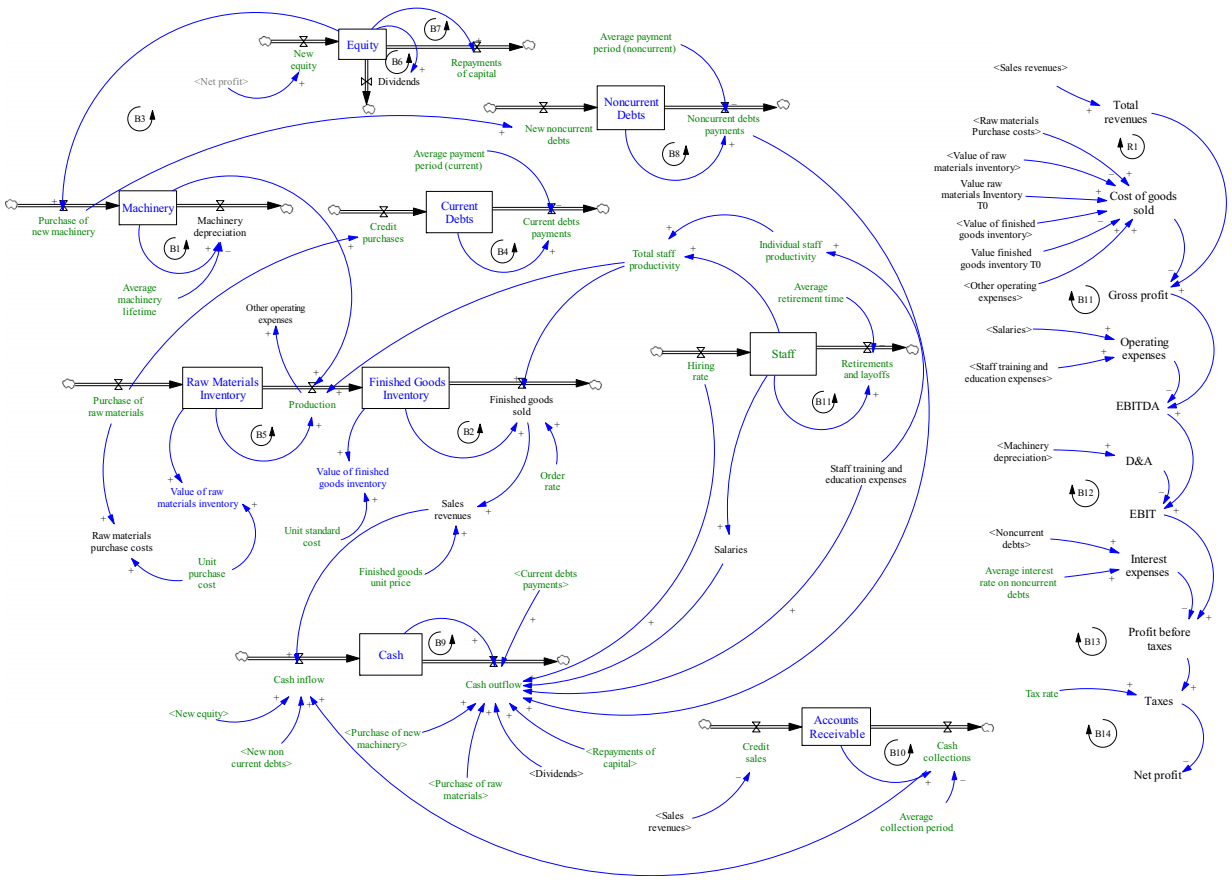

Fig. 9. The resource map created from the organization's annual report [Color figure can be viewed at wileyonlinelibrary.com]

- "Gross profit";
- "EBITDA";
- "EBIT";
- "Profit before taxes";
- "Net profit";
- "New equity";
- "Equity";
- "Purchase of new machinery", thereby closing the loop.

In Figure 9 colors were added in order to convey where information about specific variables can be found: blue for items included in the balance sheet; black for the items from the income statement, and green for information

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that is to be retrieved from other accounting documents (e.g. from the notes to the financial statements or the management commentary).

Stage 6. Analyze the map to uncover leverage points and key processes for value creation

Figure 9 and the previous stages demonstrate how the accounting information of annual reports may be analyzed to generate a resource map for the organization and the business domain under analysis. Notably, the resource map—as developed at this stage—already considers the main building blocks generating dynamic complexity in a given system, such as accumulation processes, feedback loops, and delays (Sterman, 2000; Yasarcan, 2023). Building on that, the sixth stage investigates the resource map to generate further information and knowledge about the dynamic complexity of the business and to uncover leverage points and processes.

When dealing with annual reports, typical methods of analysis involve both relying directly on the information provided by such reports (e.g. the values of the net profit and the equity are relevant for investors) or the calculation and interpretation of indexes based on this information (e.g. the use of return on equity, as the net profit divided by the equity, is a relevant indicator for shareholders and investors) (Merchant, 1997).

Within the methodological lines proposed in this study, we advocate that such analysis can be enriched by relying on a thorough examination of the resource map.

In broad terms, a qualitative SD diagram and, particularly, a resource map can be evaluated by relying on various metrics, such as (e.g. Schaffernicht, 2017; Kunc *et al.*, 2020):

- The number of its components that are stocks (i.e. the resources), inflows and outflows (i.e. change processes), and auxiliaries (i.e. capabilities originated from resources);
- The type and the number of relationships connecting the components;
- The number of connectors affecting specific components;
- The number of feedback loops including specific components;
- The length of the loops identified in the map;
- The number of delays affecting each loop;
- The percentage of loops involving specific components compared to the whole hierarchy of loops included in the map.

Generating this information requires relying on available software tools such as the SDM-Doc software (Martinez-Moyano, 2012) that is used in this study, as shown below.

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First, the analysis involves the main components and characteristics of the resource map, as portrayed in Table 5.

This first step of the analysis provides a rather aggregated view of the structure represented in the map and conveys general information about its overall level of complexity such as the number of stocks, causal links, and link polarities (positive and negative).

The resource map can be subsequently further evaluated considering additional data provided by the software. For example, the data included in Table 6 reflect additional information about the characteristics of each variable included in the model. Notably, for illustrative purposes, Table 6 presents a selection from the total number of resources included in our map.

The data shown above may be subsequently used to identify Key Value Creation Spots (KVCS) and Key Value Creation Loops (KVCL), i.e. resources, outputs, and processes that are particularly "dense" and relevant for the organization's value creation.

KVCS (Barnabè *et al.*, 2019) are resources or value outputs that are affected by dense feedback processes under the control of the organization's managers or relevant stakeholders. In this context, the density of a resource or output is, therefore, not only a property useful for investigating the structure of the resource map (e.g. Groesser and Schaffernicht, 2012) but also a proxy or the relevance of such variables for the overall organization's value creation (e.g. Kunc and Morecroft, 2009).

Even considering a descriptive case study and a simple example like those presented in this study, the analysis returns results that show the complexity

Table 5. Structural analysis of the resource maps presented in Figure 9 (overview)

	Total number of variables	Number of stocks/ resources	Number of exogenous variables	Number of endogenous variables	Number of causal links	Number links with positive polarity	Number links with negative polarity
Resource Map	64 (100%)	9 (14.06%)	23 (35.9%)	41 (64.1%)	92 (100%)	71 (77.17%)	21 (22.83%)

Table 6. Quantitative analysis of the resource map presented in Figure 9

Variable	In/out counts	In/out ratio	In links by polarity (positive/negative)	Out links by polarity (positive/negative)
Equity	3/3	1.00	2/1	3/0
Production	3/3	1.00	3/0	2/1
Raw materials	2/2	1.00	1/1	2/0
Inventory				
Staff	2/3	0.67	1/1	3/0
Net profit	2/1	2.00	1/1	1/0

[Correction added on 18 September 2023, after first online publication: Table 6 legend has been corrected in this version.]

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Table 7. Examples of feedback loop characteristics and Key Value Creation Loops from the resource map

Feedback loop no.	Typology and length of feedback loop	Number and names of stocks included in the loop	Description of the feedback loop	Description of the loop in terms of value creation	Source of information for the stocks, flows, and auxiliaries
B1	Negative (Balancing) 1	1 Machinery	An increase in machinery depreciation decreases the stock of machinery.	The value of this asset will be eroded over time because of wear and tear, thereby indicating that his contribution to value creation will be progressively decreasing.	Machinery: balance sheet Machinery depreciation: income statement To calculate machinery depreciation, it would be necessary to know the average machinery lifetime, information that might be found in additional documents such as in the notes to the financial statements or in an asset management plan.
B2	Negative (Balancing) 4	1 Finished Goods Inventory	An increase in finished goods sold decreases the stock of finished goods Inventory	The sales of finished goods will decrease the inventory at disposal. Thus, production processes will be necessary to sustain the organization's commercial activity.	Finished goods inventory: balance sheet. Finished goods sold: income statement.
B3	Negative (Balancing) 8	3 Machinery Finished Goods Inventory Equity	An increase in the purchase of new machinery increases the stock of machinery, increases machinery depreciation, increasing depreciation and amortization (D&A), decreasing earnings before interests and taxes (EBIT), thereby affecting profit before taxes, net profit, new equity, equity and the purchase of new machinery, thereby closing the loop.	The value of depreciation will eventually decrease the net profit and the equity of the organization, thereby constraining the opportunity of investing in new fixed assets.	Purchase of new machinery: purchase invoice. Machinery: balance sheet. Machinery depreciation: income statement. D&A: income statement. EBIT: income statement. Profit before taxes: income statement. Net profit: income statement and balance sheet. New equity: notes to the financial statements. Equity: balance sheet.

(Continues)

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Table 7. Continued

Feedback loop no.	Typology and length of feedback loop	Number and names of stocks included in the loop	Description of the feedback loop	Description of the loop in terms of value creation	Source of information for the stocks, flows, and auxiliaries
R1	Positive (Reinforcing) 13	3 Machinery Finished Goods Inventory Equity	An increase in purchase of new machinery increases the stock of machinery, increases production, increases finished goods inventory, increases finished goods sold thereby generating more sales revenues and total revenues, which increase gross profit, EBITDA, EBIT, profit before taxes, and net profit, that increases new equity and equity, thereby allowing an increased purchase of new machinery that closes the loop.	The loop identifies one relevant opportunity of growth over time for this organization, granted by investing in new fixed assets (i.e. machinery), thereby boosting the capacity of the organization in terms of production processes and subsequent sales on the market, and generating increased net profits and equity that could be reinvested.	Purchase of new machinery: purchase invoice. Machinery: balance sheet. Production: production plan and production report. Finished goods Inventory: balance sheet. Finished goods sold: income statement. Sales revenues: income statement. Total revenues: income statement. Gross profit: income statement. EBITDA: income statement. EBIT: income statement. Profit before taxes: income statement. Net profit: income statement and balance sheet. New equity: notes to the financial statements. Equity: balance sheet.

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embedded in the resource map. For example, data like those shown in Table 6 allow immediately identifying the number and typology of connections affecting specific resources, thereby hinting at their position and relevance in the complex hierarchy of causal connections forming the map and providing details about how endogenous and exogenous variables are connected throughout the map.

Subsequently, the next stage discovers KVCL. Kim (1997, 2001) advocated a shift from the concept of Key Success Factors to that of Key Success Loops, i.e. from single components of the business to processes—embedded in and governed by feedback loops—that are relevant for value creation (see Table 7).

Specifically, Table 7 considers some of the feedback loops already presented in Figure 9, providing for each of them the main properties and characteristics that can make them fundamental processes for the organization's value creation. In this regard, Table 7 also describes how each loop is structured and ought to be analyzed in terms of value creation.

This information can help internal as well as external stakeholders to identify relevant business processes originated by the system of resources at the organization's disposal, understand where feedback loops are active (thereby relying on the concept of closed-loop thinking) and create better operational thinking about the business behind the accounting-based results.

Discussion

Our study contributes to the methodological challenges related to embedding SD into other disciplines using qualitative SD, which can help in facilitating the initial steps of non-modelers into SD and in engaging with stakeholders. Building up from, and expanding, our previous experience (e.g. Barnabè *et al.*, 2019; Giorgino *et al.*, 2020), we present a generic methodology (see Table 1) to use stock-and-flow diagrams as a qualitative approach to modeling.

Within the stream of the qualitative SD literature, this study contributes to the application of qualitative SD principles and tools in the business domain by relying on accounting information (e.g. Bianchi, 2002; Yamaguchi, 2003; Melse, 2006; Giorgino *et al.*, 2020; Pierson, 2020; Yamaguchi and Yamaguchi, 2021). However, the main contribution, which hopefully can be employed in other areas of application, is the use of stock-and-flow diagrams in qualitative SD modeling, a novel contribution to qualitative SD that facilitates the understanding of dynamic complexity compared with causal loop diagrams.

Specifically, in this study, we investigated the application of a qualitative SD methodology named "resource mapping" to the core set of annual reports that organizations are called upon to draw annually to provide relevant,

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updated, and timely information to both their internal and external stakeholders.

The methodology depicts how a resource map may translate the accounting information of annual reports into a representation of the organization with a focus on its dynamic complexity, thereby also making clear how the organization actually works. As stated by the concept of operational thinking (Richmond, 2000, p. 16) this allows answering questions such as "What causes this outcome?" or "How does this activity really work?" In this regard, this study specifically creates a bridge between traditional accounting-based reports and qualitative SD in the form of resource maps and provides a core set of methodological stages to be applied to support the performative role of accounting (e.g. Boedker, 2010; Vosselman, 2014; Revellino and Mouritsen, 2015).

The analysis of our resource map by using the SDM-Doc software (Martinez-Moyano, 2012) allows tracing the information about the organization's dynamic complexity (Sterman, 2000; Yasarcan, 2023) embedded in its annual report (see Tables 5 and 6) that is described not only in terms of stocks and flows (i.e. accumulation processes) and referring to their connections and typologies but also in terms of feedback loops. In this regard, our analysis highlights the characteristics as well as the density (i.e. a proxy or its relevance) of each resource and output in the organization's value creation process (specifically allowing clear identification of the KVCSs; Barnabè *et al.*, 2019). Subsequently, the analysis reveals which feedback loops are included in the map and are actionable to create value for this organization and its stakeholders, also representing particularly relevant processes (thereby embedding and activating the concept of KVCLs as proposed by Kim, 1997, 2001). This information, which ultimately is embodied by the concept of closed-loop thinking (Richmond, 2000), may support all the relevant stakeholders in understanding the successive and key steps of value creation within an organization, therefore also creating better operational thinking about the business behind the financial results. Additionally, this information may be easily and purposely combined with traditional accounting-based measures (such as the ones mentioned in our study—e.g. Net Profit and ROE) for a more comprehensive analysis and communication about the organization's value creation.

At the same time, this allows overcoming limitations of annual reports, i.e. being past-oriented (e.g. Merchant, 1997), to move towards a forward-looking oriented view of the organization's processes. In this context, besides straightening the performative role of accounting in reference to the external actants of the organization's strategy (Latour, 2005), the use of qualitative SD methodologies and tools also contributes to solving the static issue that is traditionally attributed to annual reports.

Furthermore, this study exemplifies how to jointly use qualitative SD and accounting reports for both internal and external purposes. In detail, our methodology shows that starting from annual reports, resource mapping

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Table 8. Comparison between concepts in accounting and resource mapping practice

Concept	Accounting practice	Resource mapping practice
Stocks	They include all of the elements of the balance sheet (assets, liabilities, and equity) but they are not limited to these (e.g. corporate reputation). Traditional approaches to analyzing them are based on ratios, showing relationships between balance sheet items, or between these items and income measures (e.g. when calculating return on equity—net profit divided by equity). These analyses may be static (if developed for 1 year) or dynamic (if carried out over medium- and long-term periods—e.g. a 3-year period).	They correspond to the resources at an organization's disposal to be included in the resource map, They include all of the stocks from the balance sheet and also a number of stocks that are captured by this document.
Flows	Economic and financial flows are traced from the income statement and the notes to the financial statements. However, there is no comprehensive capture of flows, especially the reasons for the flows.	Some information is provided by accounting reports, but resource mapping offers a systematic approach to identifying all the flows affecting the resources. Therefore, resource mapping is more comprehensive than accounting practices.
Capabilities	There is neither regulated information about this concept in financial statements nor a standardized method to search for it. If it is mentioned, it could be located as part of the letter to shareholders or the management commentary, being capabilities-specific and distinctive for the organization.	This is a new perspective with respect to traditional accounting practice. This perspective provides an operational view of the organization in terms of abilities to generate value and the place where such value-creation processes start or happen (i.e. considering KVCS and KVCL). In this case, resource mapping would also bring a framework used in strategic management to complement traditional accounting practice.
Relationships between concepts and feedback processes	They are not explicitly and comprehensively mentioned anywhere in an annual report. Some of them may be emphasized in the letter to shareholders or in the management commentary, usually in a textual way. Traditional analysis may try to infer relationships between concepts through regression without feedback processes.	Discovering relationships between concepts is a key part of resource mapping. Resource mapping can complement annual reports to highlight relationships and feedback processes.
Leverage points and key processes for value creation	Traditional financial statements do not have information about them and the development of key performance indicators is usually suggested to highlight the "areas" contributing the most to profitability or value creation. The management commentary or other accounting-based report may contain some information about them. However, there is no analytical method that allows combining all the information above systemically.	The analysis of the resource map with additional tools, e.g. SDM-doc, provides a unique analysis that uncovers the leverage points and the key processes for value creation, by highlighting critical factors (i.e. KVCS) and feedback processes (i.e. KVCL).

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allows converting the accounting-based information of these reports (mainly, quantitative data and textual explanations, provided in the form of tables of top-down reports) not only by using a different communication language but also reorganizing existing knowledge into a different state, therefore facilitating internal analysis and external communication. This would entail assigning resource mapping much more than the mere role of a visualizing tool for the information originally included in financial statements, to embody that of a means of communication able to condense meanings originally expressed with different jargon and dispersed in various reports and documents (see again Figure 9 and Table 7). Overall, this also allows continuous shifting back and forth between the two concepts of operational thinking and closed-loop thinking used in this work.

Table 8 showcases the benefits of using this approach compared with traditional analytical approaches, such as financial statement analysis. As can be appreciated from the table, resource mapping can play a key role in complementing traditional accounting practice, which is a largely unexplored area for SD practice.

Conclusion

This study has several contributions.

First, it provides the methodological guidelines and a core set of practical insights to effectively use stock-and-flow diagrams (in this case, in the form of resource maps) as qualitative SD. Subsequently, there are some lessons on how to use stocks and flows as qualitative SD that can be shared with the broader community:

- Stocks and flows need to have a clear association with widely used concepts, which reflect accumulation processes, in the area of application. This is critical to facilitate one-to-one association between accumulation processes and stocks and flows. Moreover, this can facilitate embedding "accumulation reasoning" (Cronin *et al.*, 2009). In our study, this is primarily clarified by the interplays between the balance sheet (stocks) and the income statement (flows).
- Causal links and polarities can mostly be observed from detailed reports that have to be widely available. While mental models are critical for defining them, the existence of public reports can provide a trusted source and increase the acceptability of the model.
- The analysis of the structure of the stock and flow diagram can provide insights about the dynamic complexity of the system and, more specifically, about value-creation processes. In this regard, the map shows the fundamental factors at the core of the concept of dynamic complexity (e.g. stocks and flows, accumulation processes, delays, feedback loops).

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Subsequently, both KVCS and KVCL can be identified and communicated internally and externally in order to inform further decisions and action.

A second important contribution of the article is in terms of potential approaches to embedding SD in other disciplines gradually. Focusing on the interactions between accounting and SD, this study hints at the opportunities that exist both in theoretical and practical terms in the following areas:

- Looking for disciplines where accumulation processes are important. In our case, assets, as stock accumulation processes, investment decisions, as operating policies driving the inflows and outflows of assets, and profitability outputs, as a potential result thereby depicting potential future value creation processes, are critical concepts in the accounting discipline.
- Creating stock-and-flow mapping processes able to align the concepts of the discipline to the components of the stock-and-flow diagram (e.g. when portraying the interrelationships between balance sheet and income statement).
- Finding documents, reports, statements, and/or theories (in this case, accounting-based reports and the bookkeeping method) that offer sources and examples to use for stock-and-flow mapping processes.
- Bringing together experts from different fields and communicating the findings in discipline-related journals.

This is a gradual approach to make qualitative SD more visible to other disciplines where we start by embedding stock-and-flow and feedback thinking to understand the problem situation and system's characteristics. Over time, the use of quantitative SD can become more prominent and support ambitious research related to testing theories and evaluating specific problems.

Third, this study expands the role traditionally assigned to accounting information in SD-related research which quite often looks at accounting-based documents as mere communication and reporting tools and not as the focal point of the analysis. The combined use of these documents with qualitative SD methodologies is instead capable of emphasizing the performative role of accounting, thereby supporting internal analysis and enhancing external communication, with the ultimate goal of informing relevant decision-makers and stakeholders when defining their strategies referred to an organization. In this context, this approach also shows how to integrate different discipline-related technical languages, thereby bridging differences in backgrounds, skills, and expertise that might characterize intended readers and users.

Last, this study is not limited to the bridge that can be built between accounting and SD; rather, it might start a series of research efforts on how

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to embed SD methods into other disciplines, something that could open up further research avenues.

This study is not without limitations. First, this study presents a descriptive case study about a simplified production process by relying on a selection of information taken from the organization's annual report. Further information may be existing within the organization that is therefore not considered. However, the process outlined in this study can be applied in a similar way to map any other business or value creation process and has the strength of being based on an organization's annual report. As we mentioned in the article, accounting information can be considered a primary source of information since annual reports are mandatory and governed by shared regulations and principles (e.g. Epstein and Pava, 1993; Anderson and Epstein, 1995; Bence *et al.*, 1995; Naser and Nuseibeh, 2003; Alattar and Al-Khater, 2007; Roychowdhury *et al.*, 2019); therefore, their information can be easily accessed and used by modelers.

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