Model-based Auditing Using REA

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Abstract. The recent financial crisis has underlined the urgency to improve the added value of the auditing profession. One of the ingredients for innovation is a model-based auditing approach in which control requirements are derived in a principled way. In this paper, we relate REA, a well-established business ontology, to the owner-ordered auditing tradition. It is shown that REA provides a solid basis for model-based auditing. The analysis also suggests some directions in which the REA auditing approach can be further worked out.

Keywords: REA, owner-ordered auditing, internal control

1 Introduction

The financial crisis has thrown doubts on the relevancy of the auditing profession. As articulated recently by auditors who took a national lead in a steadily growing and progressing international audit reform: “What if the mandatory, statutory audit is halted today: will our clients still call us for our added value tomorrow?” (Pieter de Kok, with endorsement by the Dutch Association of Chartered Accountants, NBA/Royal NIVRA, on accountant.nl, November 2010). And less direct, but nevertheless to-the-point: identifying direction to strengthen the profession’s contribution to long-term ownership and society interests (Financial Reporting Supply Chain initiative of the International Federation of Accountants, IFAC, 2010).

To clearly understand the pull in the audit market it is helpful to mentally reconstruct the original market mechanisms, thus before regulation made audit mandatory. These authentic market mechanisms are actually the raison d’être for the audit profession, since regulation by law followed later. Recall that these original market mechanisms actually never disappeared; they were just less visible due to regulation. To avoid confusion: it is not the statutory status of the audit, but instead what it is that has been made statutory, that is up for renewal.

There is increasing recognition of the market mechanisms that originated the auditing discipline: especially the long-term oriented owner-ordered auditing as opposed to the any-term management-ordered auditing. Leading to increasing interest on how to capture and internationalize key concepts and methods from the locally (Netherlands) integrated owner-ordered and management-ordered audit traditions to modernize today’s global management-ordered-only modus operandi. And there is increasing visible susceptibility on how the profession may extend its mandate to
contribute to systemic risk anticipation: by aggregating and channeling key information from the micro-economic level to the macro-economic level.

Concerns about the relevancy of auditing were already pronounced before the financial crisis. We refer e.g. to Vaserhelyi and Alles (2006) quoting Rebecca McEnally, project director of the Comprehensive Business Reporting Model and director of the Capital Markets Policy Group for the CFA Centre who stated: “Investors worldwide are too often in the dark about the true value of companies because accounting practices fail to reflect the economics of today’s business operations.” Vaserhelyi goes on arguing that users of financial information should not only have access to this information continuously online (cf. Kogan et al., 1999; Murthy & Groomer, 2003), but also have the possibility to drill down. We fully support this argument, and like to add that for the goal of better serving the needs of shareholders it is of paramount importance that external auditing includes a checking of management from the perspective of owner interests: by applying proven methods from the owner-ordered audit tradition. That is, instead of only focusing on addressing management’s illegitimate interest to overstate profits (i.e. focus of management-ordered auditing is to increase credibility to attract capital; relevant for growing companies), also explicitly focus on management’s illegitimate interest to understate profits (i.e. audit assertion: completeness of revenues; relevant for established, or over-established, shrinking companies). This is based on the insight that management should be held accountable for its use of resources entrusted to them by resource owners (shareholders). However, the same kind of accountability also extends to society at large.

To understand the function of the audit profession in the relation ‘company – society’ it is best to turn to Limperg’s theory of rational confidence from the 1930s, also known as Limperg’s theory of rational expectations, and also known as the theory of inspired confidence. Especially of importance are the interpretations of (Blokdijk, 1975) and (Carmichael, 2004). The latter served as first and founding Chief Auditor of the Public Company Accounting Oversight Board (PCAOB, the board that oversees auditors of companies to protect investors). The essence of Limperg’s theory is concisely stated in (Carmichael, 2004): “Thus, the most important factor is society’s needs, and the related factor that interacts with it is the ability of auditing methods to meet society’s needs. However, society’s needs are not fixed and change over time. Also, auditing methods can change and improve over time.” As witnessed by recent events, society has a need to counteract moral hazard for tax-payer bailouts (potential shareholders, who may become shareholder, voluntarily or forced).

It is exactly the change for improvement, and thus innovation of auditing methods that we as authors, and not only we, are pursuing. In line with the owner-ordered auditing tradition, we advocate a model-based approach that derives control requirements systematically from an economic model of the enterprise. Such an approach fundamentally blends rule-based and principle-based approaches. Business process modeling plays an important role nowadays in the design of automated information systems, so it is an interesting question whether model-based auditing can be grounded in one these modeling methods. In the overview provided by (Carnaghan, 2006) it is suggested that the REA method (McCarthy, 1982) is promising in this respect. It differs from most business process modeling notations by
its economic abstraction. The objective of this paper is to assess and, if necessary, extend the auditing support potential of REA by relating it to the owner-ordered auditing tradition. The presentation of this auditing tradition, as it was cultivated in the Netherlands, and integrated with the management-ordered tradition over the period 1920s-1990s, is contained in section 2 and based on (Blokdijk, 1995) and (Elsas, 1996). This section ends with a listing of requirements for a model-based auditing approach. Section 3 continues with a systematic analysis of REA along the main auditing components, in order to check how far REA meets the listed requirements. In section 4, a case based on (Carnaghan, 2006) is used to show how a REA model-based audit approach can actually identify risks and internal control mechanisms. Section 5 is an explorative discussion on the possible application of the model-based approach to financial institutions. In the conclusion, we summarize the results and indicate directions for future research.

2 Auditing theory - background

The primary objective of an audit of an organization’s financial statements is to form an opinion on the trustworthiness of the included information and to make this opinion public to an interested audience. The financial statements include information on the financially relevant aspects of (the results of) an organization’s performance in a prior year or period.

Trustworthy information is to be understood as information which is in accordance with the notions reflected, and represented in a way suitable for correct interpretation by an (intended) audience. There are well-established criteria for both (i) the classification (also: arrangement) and (ii) the audit of (the items in) the financial statements. In the United States of America, for example, these criteria are set out as mandatory in the Generally Accepted Accounting Principles (GAAP) and the combination of Generally Accepted Auditing Standards (GAAS) and International Standards on Auditing (ISAs), respectively. The audit criteria impose, in some sense, a minimum on scope and depth of the audit to be performed.

Since the financial statements of an organization are prepared by that organization itself, it is—from the principle of segregation of interests—necessary that the opinion on the trustworthiness of the information included therein is given by a party which is independent from that organization. Only by so doing, the audience can rely upon such an opinion. The independent party competent to form such an opinion and to perform the audit necessary therefore, is referred to as the external auditor. The organization subject to the audit is referred to as the auditee.

2.1 Owner-ordered auditing vs. management ordered auditing

Whenever a separation between ownership and management takes place, that is, whenever capital is attracted from investors who buy shares in the organization, (from the principle of segregation of interests) the necessity arises, for these investors, to let the account rendered by management as to their usage of the invested capital be verified by an independent party. As a matter of fact, it was this very separation which
originated the auditing discipline, more precisely: the *attest* function of the external auditor, in the middle of the nineteenth century in both the Netherlands and the United Kingdom. However, not in the United States of America, where it arose as a consequence of seeking foreign capital, thus the audit was ordered by the management, instead of the stockholders.

It is to be understood that a potential conflict of interest exists between the management of an entity and its owners (stockholders). A management-ordered audit is meant to attract new investment capital by providing external assurance that net profits are *correct*, aren’t *overstated*. Correctness refers collectively to the audit assertions: existence / occurrence, rights and obligations, valuation & allocation / accuracy, cutoff and classification (SAS 107). This is to be opposed to an owner-ordered audit focusing on providing external assurance that net profits are *complete*, aren’t *understated*, since net profits are the basis for owner’s dividends and the value of their stock (Whittington et al., 1983), (Cockburn, 1987). In an integrated owner-ordered and management-ordered audit approach it’s the auditor’s task to determine whether management’s illegitimate interest is to either overstate or understate net profits, while consistently prevailing owner’s and potential owner’s interests over management’s interests.

During the twentieth century the classification and valuation of financial statements’ items have been codified, which is relevant to the *assess* function of the auditor, and the attest function of the auditor has been institutionalized.

The audience of an auditor is formed by members of the public who have an interest in the auditor’s opinion, for instance: shareholders of auditee’s shares, potential shareholders, banks, auditee’s suppliers, auditee’s clients, tax authorities, trade unions and government agencies. The independent audit in the Netherlands originated from the need to verify the accounting of the funds entrusted to the management of an enterprise on behalf of those who had a direct financial interest in the results of that enterprise. It should be emphasized that these included not only the stockholders but also other stakeholders and potential stockholders (society at large). The current economic crisis highlights societal interests (systemic risk, forced bailouts and increased moral hazard). The financial sustainability of numerous auditees, either on their own (‘too big to fail’) or as an accumulated group of institutions (financial institutions, pension funds, automobile industry, etc), is a society concern.

2.2 Main components of owner-ordered auditing

The main components of the owner-ordered auditing framework are:

- Audit object
- The Value Cycle Model and related continuity equations
- Typology of organizations
- Internal control measures, in particular segregation of duties

We will briefly discuss each component in turn.
Audit object. We must distinguish two related audit objects of a different modality, being:

(i) The object which is subject to the audit, called the Ist, ‘As Is’ audit object, and,
(ii) The object which is used as a norm in the audit of the Ist object, called the Soll, ‘To Be’ audit object.

The Ist audit object incorporates potential errors, while the Soll audit object is free of potential errors. The check whether (i) meets (ii), while taking some tolerance into account, produces the audit opinion, thus forming the conceptual core of auditing. As a prerequisite for performing such a check, the auditor has to identify both Soll and Ist audit objects, on three levels, namely: primary, secondary and tertiary:

Primary: The financial statements with associated assertions (cf. Leslie et al., 1986);
Secondary: The information system providing the financial statements;
Tertiary: The core business, represented as a Value Cycle Model (VCM).

The core business embedding the information system is represented by a system structure of alternately connected discrete business actions and discrete business buffers, as illustrated in Fig. 1.

Fig. 1. Example Value Cycle Model, after (Veenstra, 1972)

The transactions in a Value Cycle Model are to be understood to have the potential of occurring independently of one another, and even concurrently. As an effect of a transaction’s occurrence all connected states are changed (instantaneously). The
change of a connected state is in the direction indicated adjacent to the connecting arc. That is, the direction of change is either an increase, symbolized as a “+” symbol, or a decrease, symbolized as a “−” symbol. For example, in case of a Collect occurrence, Debtors is decreased and Cash is increased; and, in case of a Pay occurrence, both Creditors and Cash are decreased. The direction of the connecting arcs symbolizes the direction of the flow of value.

In the example Value Cycle Model (VCM) of Fig. 1, a Collect (on Debtors) causes a direct inflow of Cash, and a Pay (of Creditors) causes a direct outflow of Cash, thereby establishing the so-called Money Stream. Indirectly, the inflow and outflow of Cash is caused by the Sales and Purchase transactions, respectively. Furthermore, a Purchase causes a direct inflow of Means of Production, and a Sales causes a direct outflow of produced Articles, thereby establishing the so-called Goods Stream. Clearly, the Purchase and Sales transactions link the Money Stream and the Goods Stream to one another.

The general rule for the VCM is that the difference between the final state of a buffer, denoted “E” (in Dutch: “einhoeveelheid”) and the initial state of that buffer, denoted “B” (from the Dutch term: “beginhoeveelheid”), equals the difference between all the additions made to that buffer, from the beginning until the end, denoted “T” (from the Dutch: “toevoegingen”) and all the subtractions made from it, from the beginning until the end, denoted “A” (from the Dutch: “afgiften”), i.e. $E - B = T - A$. This latter rule is known in the Dutch accounting and auditing doctrine under the name BETA-equation, since $B - E + T - A = 0$, and is applicable to every individual buffer. (Starreveld et al., 1988), “The law of the coherence between state and event” (in Dutch, “De wet van de samenhang tussen toestand en gebeuren”).

By definition, a company is only economically viable when it is making profit. This means that in the VCM there is a structurally incorporated positive difference in money value between the revenues and the overall expenses. This difference is called the Structural Value Jump or Structural Gross Margin, and is incorporated in a set of BETA-equations by parameter coefficients. This is the other basic law, “The law of the rational relation between matters consumed and produced” (in Dutch, “De wet van het rationeel verband tussen opgeofferde en verkregen zaken”), the rational correlation between revenues and expenses.

Deriving from a Value Cycle Structure its specific set of BETA-equations, leads to a Value Cycle Equation System, also known as a set of Continuity Equations. The identification of these Value Cycle System equations, possibly including some tolerance, results from auditor’s business economical analysis. An equation which is part of a Value Cycle Equation System is called a spanning equation (in Dutch: “omspannend verband”). The spanning equations form the basis for the so-called spanning reconciliation checks, i.e. the backbone of the quantitative audit.

Typology. A Value Cycle System is specific for an enterprise type. In the Dutch auditing tradition, a typology of organization types has been developed, such that for each type a specific Value Cycle Equation System is identified. The typology is typically based on the rigidity of the auditee’s Value Cycle Structure. From an audit point of view, this rigidity is to be interpreted as a gauging-rod for the potential
applicability of the Value Cycle Structure as a (normative) basis for the quantitative audit, especially for showing completeness of revenues.

Internal control measures: When an agent (in casu, a manager) gives other agents (employees) the responsibility over some of the resources entrusted to him, this delegation does not dismiss him from his own responsibilities. That is why checking and evaluating the reliable use of delegated authorizations is not only his right but also his obligation (towards his own principal, in this case, the owner). He can do that himself or delegate this task to a third agent (internal auditor), under certain conditions. The most important condition is the independence of the auditor. The auditor requires certain internal control measures to be in place and checks that they are implemented correctly. A distinction can be made between assertion level, basic control measures that have a preventive or detective character and entity-level, organizational control measures (sometimes referred to as “disciplines over basic controls”).

Organizational measures are necessary; they can sometimes be replaced by ex post checks (from an internal or external auditor), but most of the time they cannot without jeopardizing the reliability of the accounting system. This latter category of irreplaceable internal control has been extensively studied in the owner-ordered audit tradition (Blokdijk, 2004). A prominent example of an irreplaceable internal control is segregation of duties. Within a company, work can be divided for several reasons. Control-fortifying segregation of duties is intended to reduce the opportunities to allow any person to be in a position to both perpetrate and conceal errors or fraud in the normal course of the person’s duties (IFAC). The most common types are disciplining rules of restriction on an organization’s authorization, access control and incentive structure, e.g.

- Separation of decision making and custody.
- Separation of resource use and resource custody.
- 4-eyes principle that requires 2 persons for certain critical actions.

In the owner-ordered audit tradition, there are three categories of design principles for segregation of duties that lead to a stronger substantiation than possible in the management-ordered audit tradition, allowing for a computationally formal approach (Elsas, 1998) and (Elsas, 2008):

- Compartimentalization of the VCM. An agent should not be responsible for multiple steps in the VCM, which would allow him to circumvent the system. Limit every agent’s access control to only one compartment in the VCM.
- Organizing opposing interests. This means that an agent is viewed not just as a mechanical executor but as a rational economic agent that aims to optimize its own profit, if necessary by collusion with other agents (“shop-in-shop”). Arrange authorizations in such a way that traceless value concealments are only possible by collusion, and maximize required collusion sizes (collusion of six agents is harder than collusion of only two).
Typification of duties based on potential conflict of interests. The ownership-oriented tradition recognizes and refines types of duties based on their interrelational potential conflict of interests, and applies this potential conflict as a design principle for typification and segregation. Leading to five fundamental types of duties that are to be segregated: decision making, execution, custody, registration and checking. Allowing further refinement, especially focusing on refining the managerial, decision making duty from the point of view of potential conflict of interest. This to prevent, detect or correct (incentives for) certain types of management overriding or to recognize and address client-imposed audit scope limitations (Blokdijk, 1995, paragraph 5.6).

2.3 Model-based auditing

On the basis of this short overview of the owner-based auditing tradition, we are now in a position to define more precisely what we mean by “model-based auditing”. The key idea is that the auditing process and the internal control measures are not just added to independently developed business processes, to mitigate any risks these processes may contain, but that these processes are made correct (fraud-resistant etc) by design. The above-mentioned notion of “core business system” becomes essential then, as an identification of the value transformation to be protected. Because of its central importance, the “core business system” must be developed in a principled way so that no value and no value transformation will be overlooked. Then the next step is to make sure that the business processes manipulating the value objects indeed protect against abuse or illicit extraction. The best way to do that is to derive these processes and the accompanying information systems from the core business system on the basis of explicit control principles. So the basic requirements for a model-based auditing approach are:

R1 – It should include an enterprise-wide normative, Soll model and a representative, Ist model of value objects and their transformations (“core business system”)
R2 – It should allow for a principled way of developing this core business system model (of identifying the value objects and their transformations) in both Soll and Ist modalities
R3 – It should support explicit control principles
R4 – It should be possible to derive preventive control mechanisms from this core business system model, in particular, irreplaceable internal controls like segregation of duties on access controls
R5 – It should be possible to derive enterprise-wide comprehensive, encompassing detective controls, in particular, continuity equations from the Soll model
R6 – There should be a systematic relationship between the core business system and the information system
R7 – It should be possible to identify relevant financial statements from the core model

These requirements will be used in the next section to assess a REA model-based auditing approach.
3 REA and Model-based Auditing

3.1 Introduction to REA

The Resource-Event-Agent (REA) method is based on the REA ontology as formulated originally in (McCarthy, 2002) and developed further at several places, e.g. in (Geerts & McCarthy, 2006). Its conceptual origins can be traced back to traditional business accounting. REA was originally intended as a basis for accounting information systems and focused on representing increases and decreases of value in an organization. REA has been extended to form a foundation for enterprise information systems architectures (Hruby, 2006), and it has also been applied to e-commerce frameworks (UMM, 2003). The following is a short overview of the core concepts of the REA ontology.

An economic resource is any value object that is under control of the company and can be exchanged, including goods, services and money. Resources are modified or exchanged in processes. A conversion process uses some input resources to produce new or modify existing resources. For example, water and flour can be used as input economic resources in a baking conversion process to produce the output economic resource bread. An exchange process occurs as two agents exchange resources. To acquire a resource an agent has to give up some other resource. For example, in a goods purchase a buying agent has to give up money in order to receive some goods. The amount of money available to the agent is decreased, while the amount of goods is increased.

The constituents of processes are called economic events. An economic event is carried out by an agent and affects a resource. In REA, the notion of stockflow is used to specify in what way an economic event affects a resource. REA identifies five stockflows: produce, use, consume, take and give, where the first three occur in conversion processes and the latter two in exchange processes. The stockflows produce and take are positive stockflows in the sense that they increase the value of some resource for an agent – an economic event with a produce stockflow creates or improves some resource in a conversion process while an economic event with a take stockflow transfers a resource to the agent in an exchange process. Similarly, the stockflows use, consume and give are negative stockflows in the sense that they decrease the value of some resource for an agent – an economic event with a use or consume stockflow uses or consumes some resource in a conversion process while an economic event with a give stockflow transfers a resource from the agent in an exchange process. An agent is an individual or organizational unit capable of having control over economic resources, and transferring or receiving the control to or from other agents (Gaily & Poels, 2007). Between agents, there is a responsibility relationship.

What we have described so far is the operational level. In addition, REA distinguishes a policy level that is concerned not with what has happened but with what should happen. It includes commitments and policies. Commitments, called “claims” in the original article (McCarthy, 1982) are fulfilled by events. In analogy to the duality between events, there is a reciprocity between commitments, combined in
a contract. In the following, we take the commitment not only as a promise to perform an economic event, but also including the decision to do so.

3.2 Formalization of REA

Formalizations of REA have been developed by (Geerts & McCarthy, 2002) and (Gaily & Poels, 2007), among others. In the following definitions, we have tried to be as concise as possible. To that purpose, we use the notion of model to describe what REA uses to call the type level. The other components of the REA policy level – commitments and policies – can be viewed as a special kind of resources, intentional resources (Weigand et al, 2011). We do not include them in this basic formalization, but have more say about them in §3.8

Definitions

A REA business model is defined as a tuple \((OT, Stockflow, Control, LT)\) where OT is a set of Object Types. \(OT = RT \cup ET \cup AT\) (resource types, event types, agent types). Stockflow is a function \(ET \rightarrow RT\) that specifies for each event type the resource type that it manipulates. Events are categorized according to \(StockflowCat = \{\text{produce, use, consume, take, give}\}\). Control is a function \(ET \rightarrow AT \times AT\) that specifies for each event type two controlling agents, providing and receiving, respectively. LT is a set of links, defined as a relational subset of \(OT \times OT\). The links can be labeled using a function \(LT \rightarrow LL\), where \(LL\) is a finite set of labels.

An operational REA business system for a given REA business model is defined as a tuple \((O, Type, S, C, L, Date)\) where \(O = R \cup E \cup A\) (Resources, Events, Agents); Type is a function \(O \rightarrow OT\) that maps resources to resource types, etc.; \(S\) and \(C\) are functions between events and resources, respectively agents, corresponding to Stockflow and Control, i.e., for each \(e \in E\), \(Type(S(e))\) \(\in\) Stockflow\((Type(e))\), similar for \(C\); \(L\) is a set of links, defined as relational subset of \(O \times O\), such that for each link \(<o_1, o_2> \in L\), it holds that \((\text{type}(o_1), \text{type}(o_2)) \in LT\). Date is a function \(E \rightarrow Time\)

Within R, we distinguish a subset called commitments. CT (commitment types) is a subset of RT. Each commitment type has a “fulfill” link (in LT) to one event type. Furthermore, in LT we distinguish a class of responsibility links between agent types.

Axioms

Axiom I - Every event type that involves production of a resource type has a duality link (via L) to at least one event type that involves acquiring a resource (use, consume), and vice versa, that is, every acquisition is linked to a production (conversion duality)
Axiom II - Every event type that involves giving of a resource type has a duality link (via L) to at least one event type that involves taking a resource type, and vice versa (exchange duality)
Axiom III - For every resource type there is at least one inflow event type (produce, take) and one outflow (give, consume, use) (stockflow duality)
For the operational REA business system, this implies the following rules. We state them as axioms, but it should be kept in mind that they have a deontic character and represent norms for the auditor’s normative, Soll model as used in confrontation to client’s actual, Ist business system. For that reason, we use the modality “must”. The two main reasons why the Ist business system may violate the rule are (a) the limited time frame – the violation may disappear with more time; (b) human error or fraud.

**Axiom 1** -- At least one inflow event must exist for each economic resource (stockflow axiom)

**Axiom 2** -- All events affecting an outflow must be eventually paired in duality relationships with events affecting an inflow and vice-versa (duality axiom)

**Axiom 3** -- Each exchange needs an instance of both the inside and outside subsets (participation axiom)

**Axiom 4** -- Eventually, all commitments must be paired in fulfillment relationships with operational events and vice-versa (fulfillment axiom)

In this definition, we have included the responsibility relationship, although in a minimal manner. We will come back to this point in section 3.8 when discussing the Information System. We have also not included semantic integrity rules (akin to business rules in Entity Relationship modeling). From a technical point of view we suggest to separate the business model from domain semantics, by positioning a domain ontology in which these semantic relations and rules are formally described. The domain ontology itself may integrate several aspectual ontologies. The REA business model is required to be aligned with the domain ontology on its object types.

The axioms stated here – including the deontic ones – have a descriptive character – they describe economic reality. The same axioms can be used in a normative way for a business model designer – to check whether his crafted model obeys economic reality. The axioms also have a normative character when applied by the auditor – to check the consistency and completeness of the information system contents.

### 3.3 REA and the Value Cycle Model

Evidently, by focusing on resources and the economic events that affect them (rather than how the processes are implemented), REA fulfills the first requirement (R1) of supporting a description of value objects and value transformations. However, the question is whether this model can be derived in a principled way (R2). The Value Cycle Model is based on the principle of a closed cycle. We claim that there is a direct equivalence between this principle and the (duality) axioms of REA. Let us look at the way the value cycle of Fig. 1 would be represented in REA (Fig. 2).
The production step in the VCM produces articles and uses production means, and hence consists of two or more dual business events when mapping the VCM to REA. The exchange duality says supply events of goods or services are complemented by receive events of money or debits. This corresponds on the sell side to the delivery of goods and/or services and cash collect steps in the VCM, and on the buy side to the receipt and acceptance of goods and/or services and payment steps, respectively. As we see, application of the REA axioms automatically leads to a closed cycle model (in the case of a company transforming goods and/or services in a value-adding way – refinements and other types are considered in §3.5).

Still, there are a few subtle differences. The VCM distinguishes Debtors and Articles as intermediate “buffers”, whereas in REA the Delivery of articles and Cash collect of debtors have a direct duality link. Comparing Fig. 1 and 2, we conclude that at this point, REA is a bit more precise, as it distinguishes the Delivery event from the Sales order commitment that it fulfills on the sell side (similar for Accept and Purchase order on the buy side). Also, REA distinguishes between Sales as a symmetric contract and a Sales order as an asymmetric commitment. A Sales event (at contract time) does not create one kind of commitment, as the basic VCM may suggest, but two explicitly reciprocal ones:

1. one for the Sales order (Seller commits to deliver, and Customer commits to receive and inspect for acceptance, i.e. corresponding to Customer’s recorded Purchase order), and
2. one for Debtors (Customer commits to pay after receipt and acceptance, i.e. Customer’s recorded Creditors entry, and Seller commits to this price - and not, later on, a higher one).
Furthermore, it can be noted that the REA models contain more semantics, e.g. by distinguishing between an exchange event, a conversion event and the fulfillment of a commitment.

Because of its extended semantics, the REA model explicates the *multivalency* of the business events, in particular the exchange events. A payment to creditors is not only a decrement of cash resource: it is *also* a fulfillment of the purchase contract commitment. Furthermore, it is *also* a reconciliation of the exchange duality, which means that it can only be performed when the materials have been received (physically) and accepted (legally, based on the acceptance criteria in the contract terms).

On the other hand, the VCM brings in some aspects that are a bit implicit in REA. The VCM approach is top-down. It starts from an enterprise-wide, global picture of the business, recognizing its type of business. In contrast, REA modeling is usually done “middle-out”, that is, it allows the modeler to start anywhere. We return to this issue when talking about the typology.

Qualitatively, the axiomatic connections in the VCM correspond to the duality-based axioms of REA. From an auditing perspective, the *quantitative* aspect is also of fundamental importance. The VCM promotes a “buffer” interpretation of both resources and commitments that has a direct relation to the company’s balance sheet (R7). This buffer interpretation is not common in REA, but given the equivalence of modeling primitives between the Value Cycle Model and the REA business model, it is clear that this buffer interpretation can be assigned to the resource types as well, as a typified, classified container. Since it is said in axiom 2 that events are *eventually* paired, and since resource types have incoming and outgoing flows, while these flows are not synchronized, it can be derived that resources do not only flow but can also stand still for some time.

Having concluded that the REA model can be used very well as “core business system”, we still have to answer the question whether it distinguishes Soll and Ist modality (R1). In order to audit the core enterprise, the auditor must identify the Soll and Ist modality (cf. §2.2). Buffer contents, either values or their recordings, and event recordings are susceptible to illicit decreases or increases. Such errors have consequences for other audit objects. For instance, an elementary illicit decrease of some type of business value leads to an overstatement of its recording, when this recording is not decreased too, and hence, by aggregation, of a financial statements item. More interesting are constellations of illicit decrements of recordings of business events (sell, buy) and their related, generated profits and recordings (e.g. “shop-in-shop” traceless parasite constructs, that should require at least collusion of two agents). From a REA perspective, such illicit events correspond to events that violate the REA axioms (Soll modality). In other words, the Soll and the Ist models correspond to the operational REA business system and its axioms (Soll), with potential and encountered violations (Ist).
3.4 REA and continuity equations

In auditing, the spanning continuity equations as induced by the core enterprise are an important instrument. Since there is a direct equivalence between the VCM and REA business models, the same equations can be derived from REA, based on the duality axioms and the general law of conservation, thus fulfilling requirement R5 above. We write the equations as 1st statements. If we want to check the outflow statement (“afgifte”), A is put on the right side.

\[ B + T - E = A + \delta \]

Here \( \delta \) stands for the deviation error. In the Soll modality, \( \delta = 0 \), which is the conjunction of (i) correctness - isn’t A overstated? - and thus \( \delta \geq 0 \), and (ii) completeness - isn’t A understated? - and thus \( \delta \leq 0 \). For the general direction in the owner-ordered audit it is sufficient to check the completeness of the revenues and the correctness of the expenses. Checking the completeness of revenues is done by checking the completeness of the recorded outflow of debtors, accounts receivables, as resulting from cash receipts, collected cash from debtors. So in this case A is the outflow of debtors, or account receivables, that is to be checked on completeness, on understatement, so the auditor checks whether \( \delta \leq 0 \) holds. This implies checking the completeness of B and the completeness of T, from Sales, and the correctness of E.

The variables in the continuity equations correspond to aggregation queries on the REA business system. For instance, applying the BETA formula to the outflow of articles, we can define A to be sum of articles that have been delivered (deliver event) in a certain time window \( <t_1, t_2> \) of the REA business system (event time \( t_1 \) and event time \( t_2 \)). By multiplying this number with the product’s cost price (Griffioen et al., 2000), A can also be expressed as a value.

3.5 REA and the VCM typology of organizations

In the Dutch owner-based auditing tradition, the typology of organizations is considered important as it allows designing the normative, Soll VCM in a principled way (R2). As far as we know, such a typology has not been developed in the REA community. However, this does not mean that it is impossible. We claim that starting with the duality axioms and systematically exploring the cases how these could be realized, a typology can be developed in a principled way. The preliminary results is projected in Fig. 3.

We start the typology by distinguishing organizational systems that exchange resources on the market (with the aim of making profit to be viable), from the ones that don’t (membership organizations, government). The organizational systems that exchange on the market have at least one economic interface to the market. Starting from this sales side interface we can reason for the cases that the goods sold are either in possession or not at the time of the sales.
When the goods are possessed when sold, the question can be asked where the resource transferred to the market stems from, and what kind of resource it is. A first distinction can be made based on the three main REA resource classes: physical resources (goods), non-physical resources (services) and financial resources (money). Physical resources are either purchased or produced; in the latter case, raw goods are needed. Fig. 1 (and Fig. 2) depicts the basic VCM for this type of organization, while the more elementary latter type (trading company) has a very similar VCM but without technical transformation and production events. A special type can be distinguished when the product is produced without resource consumption. However, from REA it follows that at least some other resource is used. This case corresponds to the agrarian and extractive organization type, the primary sector, e.g. agriculture, animal husbandry, horticulture, forestry, mining industry, fishing industry, or solar, hydro and wind energy production. It can be reasoned, in this way, that in all these cases the primary market interface is complemented by a secondary market interface via which production means or access rights to raw goods, “use resources” are acquired. This acquisition is linked to a payment event, or giving owner, stockholder rights to the equity provider, thus closing the cycle.

If the resource is a service, another category is identified. A service involves the use of certain resources in order to increase the value of a customer resource. The resource used is either provided to the customer (e.g. restaurant) or remains in the possession of the company. In the former case, again a value cycle can be distinguished for these resources. In the latter case, there is still the customer resource and there are used resources. So also in this case a flow of goods can be distinguished. To identify service instances, it may be necessary to introduce quasi-goods (individualized paper documents that typically provide access to some space, being the “used” resource; e.g. a cinema ticket- Wouters, 1992). These quasi-goods are produced and exchanged like normal resources, but they have the property that there
is a 1-1 correspondence between the quasi-good and the service instance. The flow of customer resources contains conversion events of, for example, a technical transformational type (e.g. car repair) or transportational type (e.g. taxi), that according to REA are governed by conversion duality axioms. As far as the used resources are concerned (e.g. hotel rooms as part of a lodgings service), the use events are also in the REA business model (so that they are susceptible to correctness and completeness checks). A special service category does neither include a flow of goods nor access to a spatial resource, but “only” a flow of money, e.g. financial institutions, like banks, hedge funds or insurance companies. We will come back briefly on this special case in section 5.

To purchase goods or “use technology”, investments must be made. Even when the goods or services are not possessed when sold, there has been some investment in human labour to make sure that the business is able to deliver in time what is sold. So it can be concluded that besides the primary market interface there must be also a secondary, investment interface with, an investment capital provider, the business owner or stockholder. The owner may be an agent in the company (owner-manager), or completely external. The owner provides certain resources (financial or license rights, e.g. franchisor, or exploitation access rights, e.g. mining), expecting other resources in return (dividends and/or increasing stock prices, related to realized net profits). The VCM describing the flow of goods and operational finances is connected to its owners via business equity capital. The investment interface that we derive here corresponds to the “structural value jump” in the VCM (section 2.3).

3.6 REA and basic internal controls

Basic internal controls must be designed and analyzed on their effectiveness in either preventing illicit events (preventive internal control) or in being able to notice them when they occur (detective internal control), including ability to notice violations of the internal controls themselves (compliance procedures). For detective controls, the continuity equations (§3.4) play a central role; we already showed how they can be derived from the core business model. Now we focus on preventive internal control.

We claim that preventive internal controls can be derived in a principled way from the REA business model, in particular from the links. This means that REA also satisfies requirement R4. The duality axioms can be seen as the fundamental control principles (requirement R3).

Let Pay and Accept Goods be two dual exchange events. In order to prevent a violation of the duality axiom caused by non-delivery, it is safe to wait with the payment till the goods have been delivered and accepted. In other words, the duality defines a specific precondition on Pay. Since Pay is controlled (provided) by the company, it means that if this rule is implemented, the company is always in control of preserving the duality. However, this is not the only possible preventive control. It may be that the supplier requires prepayment. An alternative preventive control is then to require a strong commitment of delivery, either by the supplier himself or by a third party. In addition, or alternatively, it is possible to include a preventive check that asserts the likelihood of the delivery to take place, e.g. by a reliability check.
Let Pay be the fulfillment of CreditCommitment. In order to prevent a violation of the fulfillment linking, it is safe to wait with the payment till the payment has been authorized by CreditCommitment. This implies another precondition on Pay. If this is not possible, for some business reason, then rely on a strong commitment of CreditCommitment, that is, the clerk performing the payment has a commitment from the A/P (Accounts Payable, or creditors) manager that authorization will follow. This commitment can take the form of a payment policy that says e.g. that the clerk is allowed to perform payments lower than $1000 without pre-authorization.

In both cases, preventive internal controls are derived from the REA axioms. More internal controls follow from the semantic integrity of the REA model. For instance, the Payment event has a providing and receiving agent of money. The agent receiving the money is, according to the model, a “Supplier”. This implies another precondition to Pay: that the money-receiving agent is an existing supplier. A third class of internal control sources is formed by the independently stated policies (REA policies). In a model-based approach, these policies are not just imposed from somewhere, but related to the core model in a principled way; still, it is positive that REA accommodates the expression of these policies.

Note that each of these preventive controls could also be replaced by a detective control, being simply a check of the duality axioms (modulo some reconciliation effort) on the data afterwards.

So we can see that although various control strategies are possible, control requirements follow directly from the REA business model. The auditor meta-checks whether these requirements are sufficient, adequate for the auditee at hand, while not being over-sufficient (that would be inefficient), and actually checks whether these requirements are fulfilled. If an automated business policy management system is in place, along the lines of (Weigand et al, 2011), using a set of validated control patterns (cf. the examples above), then the auditor can be involved in checking whether the business policy specification (as a set of rules) is logically in line with the control requirements. Different control strategies can be evaluated and compared on the basis of effectiveness and efficiency (costs).

The executable business process structure is a combination (“weaving”) of a mapping of the economic events on process activities (core process) with built-in controls (Gal & McCarthy, 1985; Lee et al, 2001). Preconditional checks are typically implemented by means of decision services working on declarative business rules. In this way, the process specification itself does not need to be adapted when the business checking rules change (or only minimally).

3.7 REA and segregation of duties

In (McCarthy, 1982), agents are defined as persons or agencies participating in an event. Agents have a control relationship to events, where (in the case of an exchange) one is an inside agent and the other an outside agent. For internal agents, a responsibility relationship is defined as well, reflecting the management hierarchy.
In a recent paper of Gal, Geerts and McCarthy (2010), it is asserted that the authorization structure can be derived partially from the duality relationships:

“Separation of duties requires incompatible functions to be excluded from different levels of the employee type hierarchy. The REA model allows for certain types of separation of duties to be expressed directly as opposed to on an ad hoc basis. The duality relationship connects events that from a separation of duties perspective should be carried out by distinct employee types within certain business processes. In each business process the events that are paired in the duality relationship are increment and decrement events. Within the Revenue business process this duality relationship connects the Sale (decrement resources) with the Cash Receipt (increment resources – cash). To enforce separation of duties the same employee type should not be connected to both of these events”.

In §3.2, we identified, among others, a fulfillment and exchange relationship, both governed by a duality. In order to use these relationships as semi-independent evidence (not completely independent, as top-management may overrule the independence), it is indeed necessary that they are controlled by different agents. So the application of this REA principle leads to the separation of decision and custody on the one hand, and the compartmentalization of the VCM (section 2) on the other. Conversion events also stand in a duality relationship. Separation of duties on the basis of this duality implies a separation between custody and execution. So, considering the five fundamental duties to be separated – decision, execution, custody, registration and checking – then apparently at least the first three can be traced back to the dualities. In other words, REA provides substantial support to requirement R4.

To formalize the segregation principle, we add the following axioms:

**Axiom**

Axiom IV - For each event type, the providing agent type is different from the receiving agent type (control axiom)

Axiom 5 -- For each event, the providing agent must be different from the receiving agent.

The second part is needed because it is not excluded, a priori, that an agent takes on more than one role (agent type).

### 3.8 REA and the Information System

According to McCarthy (1982), the agent-event control relationship also expresses accountability, since “the power to control resources is often provided by someone else, who in return demands that the entity accounts for the resources under its control”. This applies both to the internal organization of the company (authorization and incentives structure) and in its relationship to the external organization (authorization delegator), that is, the relationship with the owner. In the above, we
already concluded that an organization that produces for the market by necessity has an ownership interface. For the owner it is important to receive a complete and correct account of the profits made, that is, of the realized “value jumps”, or gross margins, in the VCM interrelated flow of goods and money.

So the need for an Information System mediating between the core business model and the financial statements follows from the REA principles. The REA business ontology also provides the right concepts for this system, which is not surprising. After all, REA has been designed originally as a framework for accounting (McCarthy, 1982). However, information objects, such as accounts, are not made explicit: the Information System is supposed to be based on the REA model, but the REA model does not include the Information System.

In our formal definition of REA, we have defined responsibility as a link type between agents. This is in accordance with what has been written so far on this topic in the REA literature, but from an accountability point of view, it is rather minimal. A more substantial treatment is possible along the following lines. First of all, it is important to explicate the reciprocity between “power to control” resources of the owner (source of authorization) and accounting for the execution of this control. This disallows situations in which agents receive authorizations without there being any appropriate account, as well as situations in which agents have to account for situations beyond their control (or beyond their scope of access controls: designed or implemented authorizations). When authorizations and accountings are included in REA, then requirement R6 is met as well. Accountings should be read here as registrations that are critical with respect to the performance of the event (not self-registrations).

![Fig. 4. Accounting duality](image)

**Definitions**

We distinguish a new subclass of resources called *intentional resources* that correspond to (are represented by) information objects. The subclass can be seen as generalization of the class of REA commitments. They are under control of the company and can be valued but in contrast to normal resources, they cannot be traded. Within the subclass of intentional resources, we distinguish *Authorizations* and *Accountings* (on the model level and system level). Via the event that creates them, they are related to agents. We can use the term *Delegrator* for the agent creating the authorization, and *Delegatee* for the agent receiving the authorization. An authorization type is related via a “permit” link to some event type, such that the receiver of the authorization (Delegatee) equals the provider of the operational event.
Axioms

Axiom V - All authorizations (types) permitting an event are paired in “duality” relationships with accountings for that event, and vice versa (accountability duality)

Axiom 6 -- Eventually, all operational events must be paired in “account” relationships with accountings and vice versa (accountability axiom)

Axiom 7 -- Eventually, all operational events must be paired in “permit” relationships with authorizations, and vice versa (authorization axiom)

Axiom 8 -- Eventually, all accountings (instances) must be paired in “duality” relationships with authorizations (instances), and vice versa

![Diagram](image)

**Fig. 5. Control or delegation cycle**

To further strengthen the model, the dynamics of the intentional resources have to be formalized. In addition to the VCM modeling the flow of goods and money (extensional resources), it is useful to structure the events in question into another cycle. Fig. 5 is a first attempt to model this control cycle for delegation in REA. The events in the center layer should be read as a combination of use and produce events. The intentional resources at the bottom represent different information types, corresponding to different phases of the event $e$ in question: authorized, executed, recorded (accounting), and checked (evidence). Being intangible by nature, these intentional resources have to be represented in physical form, such as an authorization table or account bookings (for the “execution” as intentional resource, we should think of traces of the execution, for instance, a receipt of the “receiving” agent). Interestingly, when we accept this control cycle, the preferred segregation of duties between execution, registration and checking follows from the general control axiom (axiom IV, 5).
The formalization provided here is not intended to be complete. For both Accountings and Authorizations at instance level, we should allow for individual event references as well as aggregations. It is also necessary to ground authorization rights in ownership rights. Here is a need for more research.

4 Example: process returned goods

To illustrate how the REA model-based approach can be used to derive control requirements, we use the case of Carnaghan (2006), which is about the processing of returned goods. The objective of this process is to process returns in a timely manner and ensure that the amount of refunds is appropriate. Risks recognized in this case are:

1. Goods were not purchased from company
2. Return for credit is not authorized, or authorized after the fact
3. Goods were not returned, but credit was still provided
4. Credit note issued to wrong customer
5. Amount of credit was incorrect
6. Processing and credit payment not being handled in a timely manner.

Fig. 6. Example Return Sales process in REA (core business model, UML style)

Several business process models are being compared, including REA. The core business model in REA terms as developed by Carnaghan consists of two economic event types “sales return” and “cash disbursement” that stand in an exchange duality. The latter decreases the Cash resource, the former increases the Articles resource. Carnaghan distinguishes three agent/event relationships per event: provide/authorize
process for the former, and receive, approve, prepare for the latter. However, this is not standard REA. In order to normalize, we replace “process” by “receive” and “prepare” by provide, so that we have the two standard roles provide/receive with each agent. The “authorize” and “approve” roles can be represented as REA authorizations. The sales manager indicates that the sales return may be executed; this is realized when the inventory clerk “receives” (processes) the sales return event. It applies similarly for approving the cash disbursement. (We note in passing that in this case, some commitment will be involved as well, in the form of a contract term that promises the customer the possibility of sales return under certain conditions. However, as this commitment plays no role in the risks identified above, we omitted it). Carnaghan also distinguishes a reverse duality between “sales return” and “sales”. However, such a duality does not exist in REA. What the REA model will contain, instead, is a semantic integrity rule that identifies sales returned to sales sold (by definition of “returned sale”). For the sake of this example, we interpret the reverse duality as a reference to this semantic integrity rule and apply it to the “cash disbursement” and “cash collection” as well. The resulting REA model is depicted in Fig. 6.

Now it can be shown that the model and the duality axioms allow for deriving internal control requirements that address the respective identified risks (1 to 6):
P1: All the goods coming in by the return sales event have been gone out (earlier) by a sales event (follows from reverse duality)
P2: All executed sales return events are “permitted” by an authorization (follows from mandatory constraint on permit link, that is, the authorization axiom)
P3: All cash disbursement events are complemented by a sales return event (follows from exchange duality between sales return and cash disbursement)
P4: Cash is received by the provider of returned goods, which is the customer of some preceding sales event (follows from combination of exchange duality and reverse duality)
P5: The amount of cash returned equals the amount of cash paid earlier by the customer in the sales event (follows from combination of exchange duality and reverse duality, to be implemented as a preventive control)
P6: All sales return events are (eventually) complemented by a cash disbursement event (follows from same exchange duality as in P3, but now in the other direction). This constraint excludes the situation that the customer returns a sale but is not credited for it (or, still has to wait for a credit). This is the bottom line of risk 6 above, but the timeliness is not explicit. We could argue that timeliness must be included in the exchange duality axiom (two dual events must happen, not just “eventually”, but in the same period). Additionally, a specific business policy can be formulated for this case, with a specific target, e.g. 15 days. Such a policy should also specify then how this target is to be reached, in the form of processing constraints and resource investments. If the target is not reached, these processing constraints and resource investments must be reconsidered.

All these constraints can be checked at the instance level as well as at type level using a Continuous Monitoring service. It should be remarked that the risks in this example can all be prevented by checking available information (recorded event logs) as part of the event’s precondition. This is not always the case. Well-known counter examples are the risks in the order processing related to the creditworthiness of the
customer and the availability of the goods. As we have shown in §3.6, these risks are derivable from the dualities: accepted orders are linked to reciprocal commitments of the customer to pay. This is a future event and so it cannot be checked as such at order time, but proactively, the organization can make an estimation of its success. In other words, it should collect evidence on the basis of which this success can be derived with reasonable assurance. Some evidence is stronger than others: a bank guarantee is stronger than a judgment based on past performance of the customer. The content of the risk mitigation constraint is a choice that cannot be derived from the duality axioms, but the constraint itself can.

5 Financial institutions

In this section, we briefly explore the possible application of the model-based auditing approach to financial institutions. Since a strongly interconnected flow of services and money is lacking in the value cycle of financial institutions, the owner-ordered audit tradition has been geared to compensate this absence by extra irreplaceable and indispensable internal control. Please recall that the owner-ordered audit tradition substantiates the concept of internal control from the perspective of the owners’ original and authentic long-term interests. Leading in particular to ownership-oriented segregation of duties and long-term incentives, thus including managerial duties and incentives from a critical point of view of opposite interests (profit sharing), therefore key in the irreplaceable and indispensable internal control. The owner-ordered tradition introduces the concept of a flow of quasi-goods for claims on bonus rights (Starreveld et al., 1988), integrated within the regular flow of goods and services, allowing for an integral assessment of the authorizations and incentives structure, as key component in the irreplaceable and indispensable internal control.

In this context, we also would like to refer to the recently expressed opinion of Jules Muis on the underlying causes of the financial crisis (IFAC, Financial Reporting Supply Chain, 2010). “We grossly underestimated the fact that the term ‘checks and balances’ is a painful misnomer. We have too many checks and too few balances in our international financial infrastructure, as well as within our organizations. Just look at the corrosive effect of turning the risk and control guidance of the Committee of Sponsoring Organizations or the Sarbanes-Oxley Act into a box ticking procedural marathon that somehow missed the key question of who calls the shots, and to what end. Or turning the CFO into an all-powerful money manager, with the privilege of also controlling the controller”. According to Muis the challenge is how “balances” can be restored. Obviously, segregation of duties, exploiting conflicting interests, plays a central role here. In the REA model-based auditing approach, such balances are first of all to be found and grounded in the fundamental economic dualities: conversion and exchange duality. In other words, in synchronizing the expenses and revenues side. As we have seen, exploring these basic balances for the purpose of accountability requires a segregation of duties (§3.7, 3.8). It is worthwhile to quote Muis again about the role of the CFO:

“Over the last 10 years, many CFOs have carved out such a broad function for themselves that, in my view, they are combining responsibilities that are incompatible with the fundamentals of checks and balances. Many CFOs nowadays are not only responsible for the proper functioning of the controls and for the integrity of the numbers, but they are also major game-makers in their financial management function. They are the ones who make money out of money, particularly in organizations, such as banks, where money management is the core business. You run into a conflict of interest if you combine an obvious management function with the controlling and accounting for it, in particular when the job is strongly bonus-driven.” (..)

“Therefore, I would strongly favor splitting the CFO role into an officer in charge of ‘bean-making’ and an officer in charge of ‘bean-counting,’ in particular for organizations that have financial management as a stand-alone profit center, such as banks and insurance companies, but also others.”

Another important question is whether a model-based auditing approach could and should be applied beyond the level of the enterprise. Individual financial institutions may each be free of an internal systemic risk (not “too big to fail”), while as a collective these institutions may induce an external systemic risk. This occurs when a lot of institutions take a similar position, while the other side is not sufficiently covered. Loosely speaking: too many are on the same side of the ship, without them being able to see one another. The external auditor is a pre-eminent party to make such an accumulated systemic risk visible. It is a party that is able to aggregate micro-economic information into macro-economic systemic risk indicators – or to certify the therefore required reporting channel – while taking professional care of confidentiality issues (nexus micro-macro) (Elsas, 2009).

6 Conclusion

Some of the problems currently faced by the auditing profession can be traced back to limitations of the management-ordered auditing tradition. The owner-ordered tradition suggests another approach that includes, among others, a core enterprise model as starting point for control design. That is why this paper has suggested innovating the auditing by a model-based approach that we have defined in a number of requirements. In the rest of the paper, we have checked how far REA meets these requirements (R1-R7). We have shown that the underlying ontology, in particular its duality principles, fully aligns with the fundamental auditing principles such as they have been developed in the owner-ordered auditing tradition. We therefore reject Carnaghan (2006)’s claim that REA does not provide constructs for describing risks and controls. At the same time, we have indicated several directions in which the REA business ontology needs to be extended, in particular with respect to the Information System and the characterization of the economic agent.

The owner-ordered auditing tradition distinguishes itself by including the management into the equation. Unfortunately, in the current paper, we have not been able to go into the question of auditing the management more specifically, but the current model provides already several vantage points: the commitments,
authorizations, accountings, and the duality between the latter two, as well as the control and accountability axiom that do apply to the enterprise-wide business system, including management events. An interesting application of audit of management is the franchising situation in which the franchisor owns resources that are managed by the franchisee. A management-ordered audit only approach is recognized as not being sufficient for this situation, as it does not check the completeness of the revenues.

One strong feature of REA has not been spelled out so far. Although it is formulated in business economics terms, it is also a good basis for database implementation (Gal & McCarthy, 1985). According to (Li et al., 2007), the current development of audit software suffers from a semantic gap between the business (audit) level and the IT system level. In our view, this gap is there to stay, as these levels are different indeed, but using a well-founded business model like REA can certainly help to bridge it. In future research, we aim to integrate the REA model-based auditing, together with several smart auditing techniques, into a Service-Oriented Auditing (SOAu) framework.

Other topics for future research include the formalization of REA the way in which the internal control components are derived from the REA business model. To support the principled development of REA business models, we think that besides the typology as developed in §3.5 it also useful to use decomposition, that is, a principled way of dividing the operational system into subsystems, or to aggregate business units, or product categories, into one conglomerate. Furthermore, we have on our research agenda the nexus micro-macro, not only for financial risk indicators, as mentioned in section 5, but also for sustainability indicators such as the statements on waste and pollution.

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