REA-based Cost & Financial Accounting Model: Integrated Resource-Based Cost and Financial Accounting

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Abstract

Cost accounting is not cost accounting. There are different conceptualizations of cost accounting. E.g., in traditional cost accounting direct cost are traced directly and indirect (overhead) costs are allocated indirectly via cost pools to the cost objects. In Activity-Based Cost (ABC) accounting the indirect costs are related to activities and from there they are allocated to the cost objects. Flexible standard-cost accounting traces direct costs and allocates indirect costs via input standards for the resources applied in the activities to the finished goods. The same holds true for the financial accounting domain as there also exist different conceptualizations. The traditional financial accounting is purely based upon monetary terms. In the Resource Event Agent (REA)-based accounting transactional information related to the exchange and conversion of resources is collected. In ERP systems and production control systems resource-based approaches already are – mostly proprietary – implemented. But still missing is an accounting model that aligns resource-based cost and financial accounting in a single comprehensive domain model. In this article this integration problem will be solved by establishing the 'REA-based cost & financial accounting model' that seamlessly incorporates the resource-based accounting approaches for the cost and financial accounting domains.

Keywords

ABC accounting, flexible standard-cost accounting, REA-based financial & cost accounting

1. Introduction

The primary research objective of this article is the establishment of a comprehensive accounting system that integrates the resource-based financial and cost accounting domains. For achieving this objective the 'REA-based financial accounting model' is specified first. This financial accounting model has its origin in McCarthy's seminal 'Resource Event Agent (REA) accounting model' [1] and its subsequent extension by McCarthy/Geerts [2] into the 'REA business ontology' to incorporate a policy infrastructure next to the accounting infrastructure. For assuring its financial accounting compliance and for having a compact representation, the modifications by Schwaiger [3] and the modeling of Fischer-Pauzenberger/Schwaiger [4] are applied for specifying the REA-based financial accounting model. By integrating the flexible standard-cost accounting conceptualization into it, the 'REA-based cost and financial accounting model' is derived. This conceptual model seamlessly integrates the resource-based financial and cost accounting domains and hence, it solves the integration problem. As conceptual model it contains the key concepts of the cost & financial accounting domain and as such it defines the language spoken in that domain in a formal modeling language. The benefits of the integrated domain model relate to a potential fostering of the understanding of the integration problem and its solution in existing ERP and Production Control systems. But beyond that, it might inspire new ventures or refacturing considerations for building ERP and Production Control systems that use from the very beginning the integrated resource-based approach.

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This article is structured as follows. The next section specifies the 'REA-based financial accounting model'. After that concepts of flexible standard-cost accounting and its relations to the different variants of the ABC accounting are investigated. Next the 'REA-based cost and financial accounting model' is derived by integrating the key concepts from flexible standard-cost accounting into the REA-based financial accounting model. In the final section the paper is concluded.

2. REA-based Financial Accounting Model: Specification

The 'REA accounting model' was developed McCarthy [1] as 'a generalized framework for accounting systems in a shared data environment'. It conceptualized the economic logic of double entry bookkeeping in the entity-relationship modeling language without having to refer to the accounting concepts like 'debit', 'credit' and 'account'. Instead, the REA accounting model focuses on the conceptual key concepts of 'economic resource', 'economic event' and 'economic agent' as well as their relationships that link the underlying 'stock flows' of resources among the agents according to the 'duality principle'. The REA accounting model was extended by McCarthy/Geerts [2] to include next to the REA-related 'accounting infrastructure' an additional 'policy infrastructure'. At the policy level additional key concepts for capturing future related 'business policies' are included like 'commitment', 'economic contract' and 'economic agreement' as well as their relationships among each other and to the elements in the accounting infrastructure.

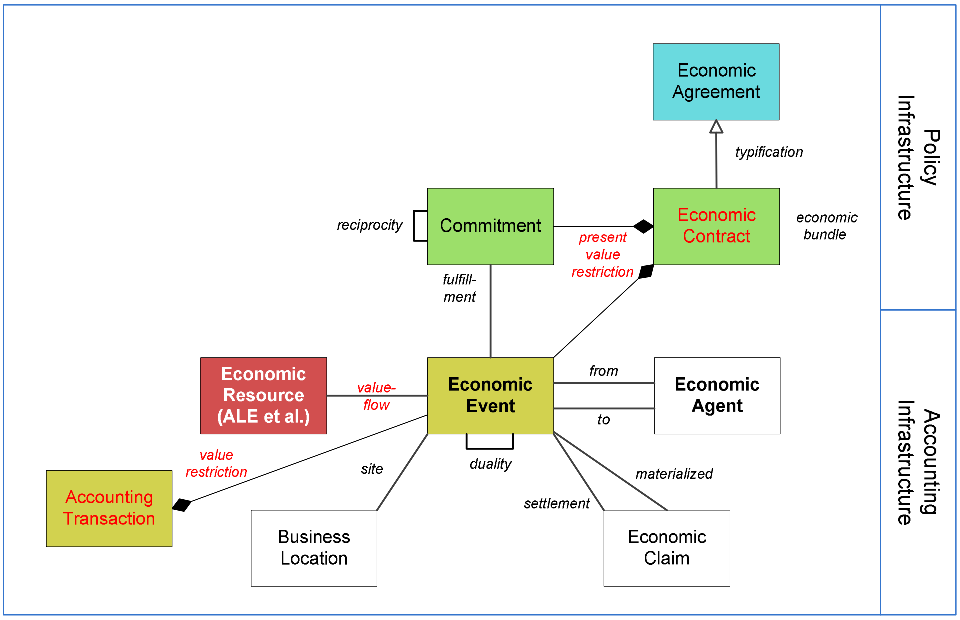

Figure 1: REA-based ALE Accounting Model – UML conceptualization [3, p. 571].

Figure 1 shows these key concepts in form of the 'REA-based Asset Liability Equity (ALE) accounting model' developed by Schwaiger [3] for making the REA modeling compatible with the requirements from the ALE accounting domain. For assuring the compatibility the stock flow relationship between the resources and events is substituted by the 'value flow' concept so that also changes in the values of the resources are captured in the 'accounting transactions'. The resource related changes can be caused by stock flows and/or by changing resource prices. Accordingly, the increment and decrement event types are replaced by the debit and credit event type categorization. Furthermore, the accounting transactions impose the 'value restriction' on its containing debit and credit events for ensuring that they are balancing in total.

Figure 2 shows the 'REA©-based ALE accounting model' [4] which is a condensed version of the REA-based ALE accounting model where the '©' sign stands for '(C)', i.e. commitment. Now the accounting transaction and its accompanying value restriction is incorporated in the 'balanced duality' relationship. The contractual foundation of all types of accounting transactions is captured in the 'balanced reciprocity' relationship among all debit and credit commitments contracted in each transaction.

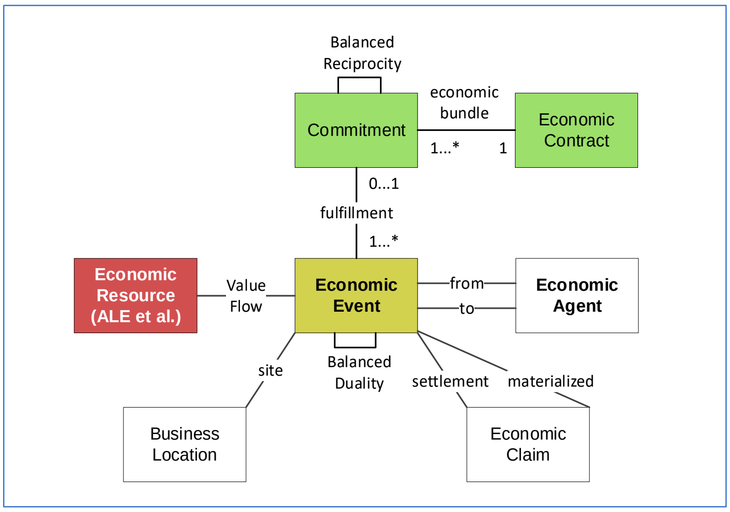

Figure 2: REA©-based ALE Accounting Model – UML conceptualization [4, p. 516].

Figure 3 shows the REA©-based ALE accounting model in its generic version which neglects the 'business location' concept as it is not important later of. The 'economic claim' is now explicitly shown as sub-type of the economic resource among the other ALE sub-types. The cardinalities are eliminated as they are not needed later on. The model provides the key structure of the 'REA-based financial accounting model' and accordingly it is called like this. Only one refinement is added that is discussed next.

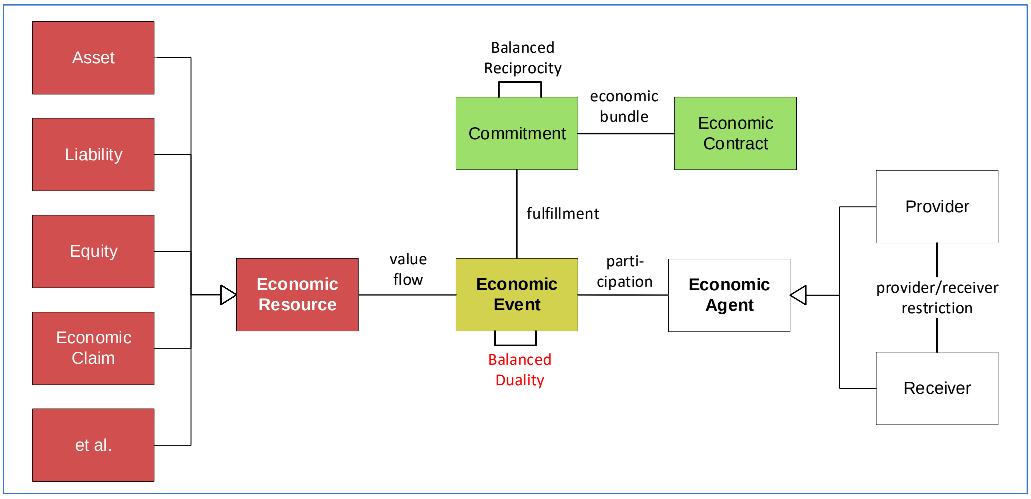

Figure 3: REA-based financial accounting model – UML conceptualization.

Concerning the concept balanced duality Guarino et al. make an important observation. "Besides the duality relation, a further ontological constraint that links an increment event and its dual decrement is the fact that they are both part of the same *economic exchange* event. This was indeed the choice made in a former paper by Schwaiger [...], which was unfortunately changed in the OntoREA version. We believe that putting explicitly this mereological constraint in the model is important to avoid undesired interpretations (note that in the original REA model no constraints are put on the duality relation)." [5, p. 96].

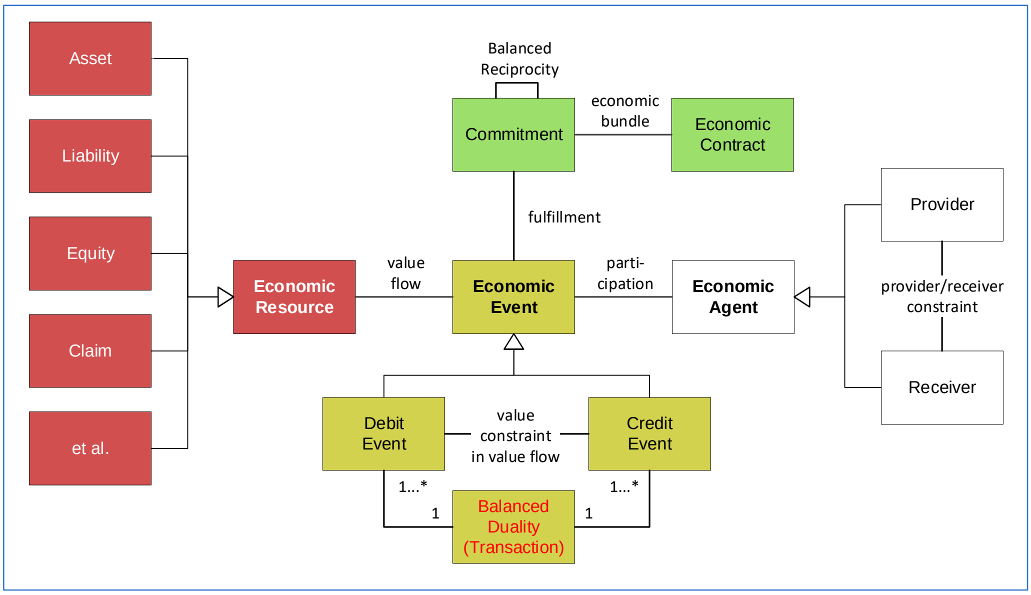

Figure 4: REA-based financial accounting model - 'Balanced Duality' (meronymic relationship).

The deficiency of not explicitly showing the mereological constraint is solved in Figure 4 by indicating the connection of the balanced duality to the accounting transaction and showing its parts in form of debit and credit events that are constraint by the value restriction so that they balance in total. In this representation the balanced duality is the 'holonym' of its 'meronyms' in form of debit and credit events. "Instances of *IsPartOf* are also called meronymic relationships (from the Greek word *méros*, which means 'part'). If *P* is part of *W*, then we say that *P* is a meronym of *W* and that *W* is a holonym of *P*. In conceptual modeling, these relationships are usually called aggregations or compositions, although these terms have unfortunately become overloaded with a diversity of meanings and we shall not use them here." [6, p. 142].

3. Conceptualizations of Cost Accounting: Flexible Standard-Cost Accounting

There are different conceptualizations of cost accounting [7] that can be considered for being integrated into the REA-based financial accounting model. The traditional cost accounting is a '2-stage allocation' system as the indirect (overhead) costs are allocated in the first step to cost pools and in the second step to the cost objects. Direct costs are traced directly to the cost objects. The traditional Activity-Based Cost (ABC) accounting [8] also is a 2-stage allocation system. In this system the indirect costs are allocated to activities in the first step and in the second step the activity costs are allocated to the cost objects. The ABC accounting has the advantage of allowing a more accurate cost allocation compared to the traditional volume-based approach, but this happens at the expense of a huged data requirement concerning the information needed for determining the activity costs [9, p. 16].

Kaplan/Anderson [10, 11] recognized and solved this shortcoming of the traditional ABC accounting by introducing the Time Driven (TD)-ABC accounting. "The basis for the new approach (TD-ABC) is highlighted in an early cost management article, where Robin Cooper articulated the difference between transactional and "effort" cost drivers. Transactional cost drivers count the number of times an activity is performed." [10, p. 6]. "An alternative approach for estimating an ABC model, which we call 'time-driven activity-based costing', addresses all the above limitations. It is simpler, less costly, and faster to implement, and allows cost driver rates to be based on the practical capacity of the resources supplied." [10, p. 5]. "The essence of activity-based costing and activity-based management is the measurement and management of the organization's capacity. For this purpose, ABC systems require two estimates:

1. The unit cost of supplying capacity, and
2. The consumption of capacity (unit times) by the activities the organization performs for products, services, and customers." [10, p. 6].

"In retrospect, we wish that the evolution of ABC in the 1980s had taken a different path so that this method could have been implemented at the outset. But the underlying theory for ABC had not been developed when it was first introduced in the mid-1980s so the elegance and conceptual clarity of this new approach were not obvious at the time." [10, p. 5].

Focusing upon the consumptions of capacity resources in the activities shows two important properties of TD-ABC accounting, firstly, it actually is a Resource Consumption Driven (RCD)-ABC and secondly, it can be extended to also include materials and other directly consumed resources. Seeing and extending TD-ABC in that way gives exactly the scope covered by the flexible standard-cost accounting. "One of the main features of 'flexible standard costing' [12, p. 306, fn 6] lies in its production theoretic foundation which reflects a company as a complex input-output system. This theory is based on Leontief's work and has been generalized for quite arbitrary production functions ... This foundation is widely used both for tracing direct costs to products and for allocating indirect costs." [12, p. 306]. "In Germany flexible standard costing finally found a better theoretical basis in the production theory ... The production theory ... was developed to study the input-output relations of a business enterprise in great detail ... The main characteristic of this theory is that there are two different input-output relations in a firm – direct relations between output and input of direct materials and direct labour, and indirect relations. In cases of indirect relations the input depends on the number of elementary work units of cost centres wanted, the intensity or speed of production and the technical features of the assets used. Thus flexible standard costing has a theoretical basis for direct and indirect costs which, by referring to work units, is similar to activity-based costing." [13, p. 265].

Accordingly, flexible standard-cost accounting is comprehensive system that firstly allocates indirect costs via unit-input standards for the resources 'applied' in the activities to cost objects in a 1-stage allocation system and secondly, it also traces direct costs to the cost objects. Concerning the applied resources it distinguishes between (direct) material resoureces that are 'consumed' in the activities and capacity resources like personnel and equipment that are 'used' in the activities. Hence, the flexible standard-cost accounting is based upon a Resource 'Consumption' Driven (RCD)-ABC accounting concept. Its RCD foundation extends the time-driven foundation of the TD-ABC accounting as not only unit-time is considered for resource inputs into the activity but also volume-based unit-inputs like e.g. for the unit-input of material resources in pieces, kilogram, liter etc. In Leontief's input-output economic analysis the unit-inputs are called 'production coefficients'. The production coefficients are standardized input-output ratios what is the reason for the naming of the flexible standard-cost accounting.

Using the production coefficients from the flexible standard-cost accounting the unit-costs, i.e. cost per unit of output of each resource applied in the activity can be calculated simply by multiplying the production coefficient, i.e. the RCD-quantity with the price of the input-resource, i.e. the RCD-price. This unit-cost measurement metric is formalized in equation (1) where production coefficient (a) specifies the unit-input of the resource and the RCD-price is the input-resource's cost rate (r). Due to its RCD home base it is called 'RCD-ABC metric' of the flexible standard-cost accounting.

$$(1) \qquad \underbrace{uCost_{acty,res,fG}}_{[kgCO_2e]} = \underbrace{a_{acty,res,fG}}_{[res.input/unit]} * \underbrace{r_{acty,res,fG}}_{[price/res.unit]}$$

As can be seen by the sub-indices, the unit-cost metric calculates the cost for the finished good (fG) with respect to the applied activity (acty) and the employed input resource (res) in form of materials as well as capacity resources. For calculating the finished goods's total cost (FG_cost) the costs of all its attributable activities and input-resources have to be summed up.

4. REA-Based Financial Accounting Model: Integrating Cost Accounting

Now, the RCD-ABC accounting concept and its associated unit-cost measurement metric are integrated into the REA-based financial accounting model. For doing this, the traditional distinction of an accounting transaction into its two sub-types, i.e. 'economic exchange' activity and 'conversion' activity is important. The RCD-ABC concept relates to a conversion activity where input-resources are converted into an output in form of finished goods. In the language of the REA-based accounting domain the task of modeling an activity "that creates new products or services or adds value to the existing ones as *conversion* of some economic resources to others" is formulated by Hruby [14] as follows. "During the conversion, the enterprise uses or consumes economic resources in order to produce the resource of the same or another kind.

- Each conversion consists of at least one *increment economic event* that increases the value of the resource by modifying its features, and at least of one *decrement economic event* that decreases the value of a resource by modifying its features. The *increments* and *decrements* in the conversion process typically occurs over a period of time.
- Each *increment event* is related to exactly one *economic resource* by a relationship called *produce*. The *produce* relationship means that the economic event creates a new *economic resource* or modifies some features of an existing *resource*. Each *decrement event* is related to exactly one *economic resource* either by a *use* or by a *consume* relationship. The *consume* relationship means that the economic resource does not exist after the decrement event (the resource is consumed). The *use* relationship means that the economic resource still exists after the decrement event, but some of its features have been modified.
- In order to keep track of which *resources* have been used or consumed in order to produce others, the *increment* and *decrement* economic events are related by the *conversion duality* relationship, or in short, *conversion*. The *conversion duality* is an n-ary relationship; in the application model there can be many increment and many decrement events related by a single conversion duality." [14, p. 41].

Hruby uses the increment/decrement notations from the REA accounting model and the REA business ontology model, what does not cause any problem as in the conversion activity no financial instruments are involved. The 'conversion duality' concept is defined as holonym with meronymic parts in form of increment and decrement events that are related to resources. Concerning the input-resources the distinction is made between 'consumed' resources that do not exist after the conversion, i.e. the material resources, and the 'used' resources that exist after the conversion, i.e. the capacity resources. Accordingly, the definition of the conversion duality reflects the production coefficient concept from the RCD-ABC concept in the flexible standard-cost accounting. By including the value contraint between the decrement and increment events into the duality conversion also the financial accounting requirement is fulfilled that the cost of the output, i.e. the finished good is equal to the cost of all its input-resourse needed for producing it.

Building on Hruby's argumentation, the RCD-ABC accounting concept and its associated unit-cost measurement metric can be integrated into the REA-based financial accounting model as shown in Figure 5. The integration starts with explicitly distinguishing the different types of input-resources. For ensuring practical relevancy the categorization ISO/IEC's 'Enterprise Control System Integration' (ECSI) standard [15] is taken for that purpose as this standard provides a precise definition of the language spoken in the 'Enterprise Resource Planning (ERP) and Production Control' (short: 'ERP-Control') domain.

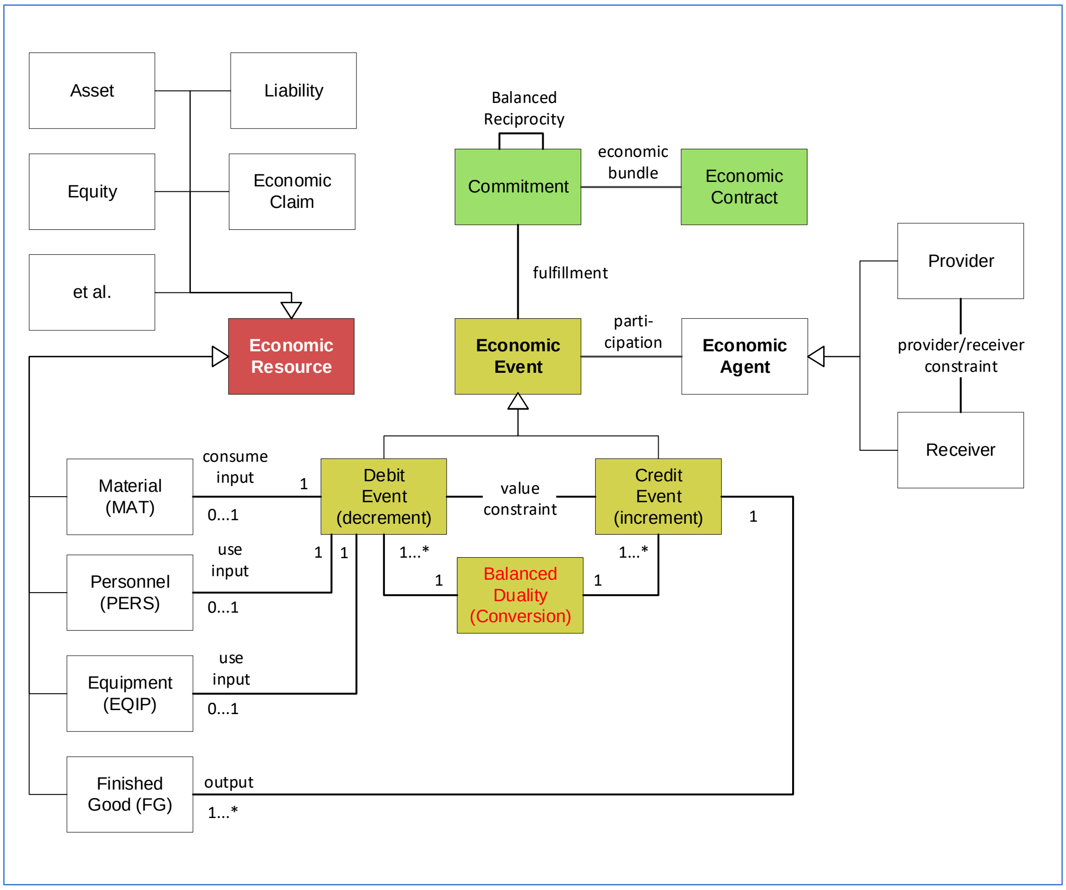

Figure 5: REA-based cost & financial accounting model - Input-resources (ECSI-categorization)

Figure 5 shows the explicit inclusion of the ECSI standardized types of input-resources in form of 'material' and the capacity resources in form of 'equipment' and 'personnel'. For addressing the conversion context, the balanced duality now relates to the conversion activity. In this activity materials are input-resources that are consumed whereas the capacity resources personnel and equipment are used. The output of the conversion activity is the finished good. For satisfying the value constraint, all involved debit (decrement) and credit (increment) events have to be balanced in monetary terms.

The required balancing of the conversion activity's debit and credit events relates to the unit-cost measurement metric, i.e. the RCD-ABC metric in equation (1). In this metric the unit-cost of the finished good is calculated by multiplying the production coefficients, i.e. the RCD-quantities with the corresponding prices of the input-resources, i.e. the RCD-prices and summing up all resulting terms over the activities and input-resources needed for the finished good.

Figure 6 shows the relevant excerpt from the REA-based financial accounting model where the production coefficients (ProCo) are exemplarily specified for the input-resources material, personnel and equipment. Aggregating over all attributable activities and input-resource the unit-cost of the finished good (FG_cost) is calculated by multiplying the corresponding production coefficients with the prices related to them.

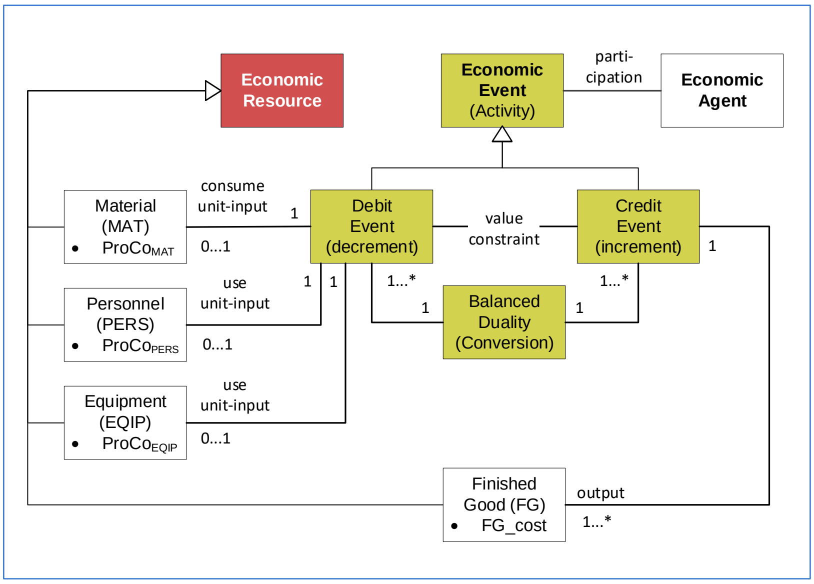

Figure 6: REA-based cost accounting model (incl. RCD drivers) – Excerpt from Figure 5.

5. Conclusion

The primary research objective of this article is the establishment of a comprehensive accounting system that seamlessly integrates resource-based financial and cost accounting domains. This integration problem was solved by starting with the specification of the REA-based financial accounting model. Next, the different cost accounting conceptualizations were investigated. There the flexible standard-cost accounting showed most beneficial and its key concepts in form of the production coefficients and their related RCD-ABC metrics paved the way for modeling conversion activities along Hruby's considerations.

The final result is the 'REA-based cost & GHG accounting model' – shown in Figure 6 – that specifies the conversion activity as an input-output system where input-resources are converted into the output in form the finished good. Important to note is that this input-output system is not restricted to the company's production domain but instead it can be applied to any activity in the company's direct or indirect domains. So, the production coefficient-based RCD-ABC metrics can also be applied for cost accounting in the logistics domain where time is not the most important cost driver, but weight of the transported goods and the transport distances are more relevant.

The integrated domain model should foster the understanding of the integration problem and its solution in existing ERP and Production Control systems. Beyond that, it might inspire new ventures or refacturing considerations for building ERP and Production Control systems that use from the very beginning the integrated resource-based approach. Furthermore, for the future the integration of the GHG emission accounting into the REA-based cost & financial accounting model should be possible anlong the lines of the work of Emblemsvåg/Bras [16, 17]. Such an expansion to a 'REA-bases cost & GHG & financial accounting model' not only gives a common understanding of the often very differently conceptualized domains of cost, GHG emission and financial accounting. But also current and potential future providers of ERP and Production Control systems should benefit from having a domain-driven [18] conceptual model specified in the formal UML language that they can use for designing and implementing such enhanced systems, e.g. by using the domain engineering methodloyg [19].

6. References

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