Environmental Management Accounting and the REA business ontology – how to green REA

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1 Introduction

Accounting is used in management as a tool for gaining information, supporting control and decision making. New external and internal demands in addition to developments in information technology and controlling have advanced the role in the last decades. Environmental issues – along with the related costs, revenues and benefits – are of increasing concern in many countries around the world. But, according to Jasch and Savage (2008), there is growing consensus that many conventional accounting practices simply do not provide sufficient information for environmental management purposes. Environmental Management Accounting (EMA) tries to fill this gap; an important result has been the UN report of 2002. In response, the IFAC has come up with a guidance document on EMA (IFAC, 2005). According to this document, EMA is "the management of environmental and economic performance through the development and implementation of appropriate environment-related accounting systems and practices". More concretely, EMA is defined as the identification, collection, analysis and use of two types of information (for internal decision making): physical information on the use, flows and destination of energy, water and materials (including waste and pollution); and monetary information on environment-related costs, earnings and savings.

In this paper, we want to relate EMA and REA, by raising two questions: what is the role of the environmental aspect in REA (how green is REA?), and, second, can REA be a basis, or vehicle, for introducing EMA?

2 REA

In REA, a *resource* is any object that is under the control of an agent and regarded as valuable by some agent. Resources are modified or exchanged in processes. The constituents of processes are called *economic events*. REA recognizes two kinds of duality between events: conversion duality and exchange duality. A *conversion process* uses some input resources to produce new or modify existing resources, like in manufacturing. An *exchange process* occurs as two agents exchange (provide, receive) resources. To acquire a resource an agent has to give up some other resource. REA is a suitable value model as it abstracts from process details and implementation systems, and focuses on economic *value*. At the same time, it has been shown that REA structures also provide a solid basis for auditing (Weigand & Elsas, 2011). The dualities express fundamental integrity constraints that can be used for both the design of control mechanisms (preventive) and for the detection of deviating behavior (detective) that may indicate fraud.

3 REA conversion process.

A typical example of a REA conversion process is the following:

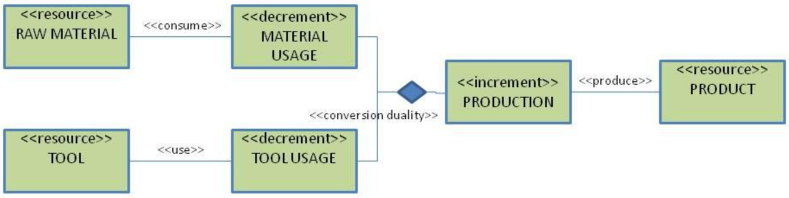

Fig. 1 Standard conversion process in REA

REA makes several useful distinctions, such as between consumption and use of resources at the expenditure side, but seems to have only one construct at the revenue side: “produce” product. From an EMA perspective, this picture must be incomplete: there is no production process that does not somehow produce waste in the form of material input remnants that cannot be used anymore, emissions, byproducts or packaging material to be disposed. So a first observation can be that the traditional REA work, like most traditional accounting approaches, pays little or no attention to the environmental aspect.

The question how to deal with this “waste” category in REA is not immediately clear. We see two approaches. One is to add the waste to what is *produced*, under a special “waste” stockflow stereotype, or by the same “produce” stockflow. This will be worked out below. A second approach, taken by Hruby (2006) is to account for it at the *expenditure* side: when a tool is used, its value decreases. At a certain moment, the value becomes negative. Then waste disposal becomes an economically viable event: by paying for the removal of the waste/tool some amount less than the absolute value of the waste, waste disposal. In the disposal, money is given (decrement). What is received? Not a material flow, evidently (the waste goes out), but the event adds value to the waste/tool, turning the value from negative to zero, so it is to be modeled as an <increment> event. For written-off machines, this seems a reasonable approach, but for waste that is output of the conversion processes, it is counter-intuitive, especially in EMA, where the physical flows are leading. We also think that the clever argument on the economic viability of the disposal is not valid. It suggests that if the disposal costs are higher than the absolute value of the waste, the company does not dispose. However, there is a very practical reason for disposing, independent of its costs: that the storage capacity of the company is limited. We suggest that the finiteness of living systems, including enterprises, should be incorporated into the axioms of REA.

The tracing of physical information on the flow of energy, water, materials and wastes is important under EMA because such information allows an organization to assess the important materials-related aspects of its environmental performance, and material purchase costs are key cost drivers in many organizations (50-60% on the average in the manufacturing industry, compared to less than 2% for waste disposal). Often, this information is not available in the company or it is only available in the production department and not cross-checked with the financial data of the accounting department. Moreover, experience shows (Jasch) that “often the data is only available by separate material numbers or in total aggregated format and only in monetary values”, so that the volumes consumed by material group cannot be calculated.

Under the physical accounting side of EMA, an organization should try to track all physical inputs and outputs and ensure that no significant amounts of energy, water or other materials are unaccounted for. The level of measurement precision can vary, but in principle the laws of preservation of mass and energy impose a strict duality on any conversion process: the sum of material input, in mass terms, is equal to the sum of material output, in mass terms (including air pollution and water pollution). Similar for energy.

4 MFCA

Material Flow Cost Accounting (MFCA) is a tool for measuring the flow and stock of materials for a production process in both physical and material units. It has been recorded that the use of MFCA makes companies more aware of the costs of waste and thus effectively helps to reduce the waste production and increase overall efficiency. First of all, it categorizes resources strictly in “positive products” and “negative products” or Non-Product Output (NPO), and accounts the production costs for both. In conventional cost accounting, the production costs of waste are not recorded separately but included in the cost of product output (together with disposal fees they are part of general overhead). However, in MFCA waste is treated as a separate negative product, and proper amounts of cost are allocated to it based on the weights of product and non-product output. E.g. in the case that material purchase cost is $1000 per 100 kg, and the positive products amount to 80 kg, then the material costs for these are not $1000, but $800; and the material costs of the negative product output (20 kg) is $200. Taking the processing costs into account as well, the negative value of the NPO produced is $210 (Fig.2). Once this is made visible, management can start to think of how to reduce this amount, or, alternatively, how to get most value from it – perhaps part of it can be recycled for other purposes.

5 Disposal

Fig. 2 also includes the disposal process, for the case that disposal is outsourced. Disposal is then an exchange where value is decremented (Money) and value is incremented, and to nullify the NPO, the value is $210. So there is a negative value jump for the company of $230, to be compensated by a positive value jump in the product sales value cycle.

In the figure, we have included physical and economic flow. Contrary to a conversion, in an exchange, there is no direct relationship between the resources exchanged. Still, the physical amounts play a role, e.g. the price of disposal is per kg. This allows an auditor to check the completeness of the disposal records (in combination with the other records in the cycle).

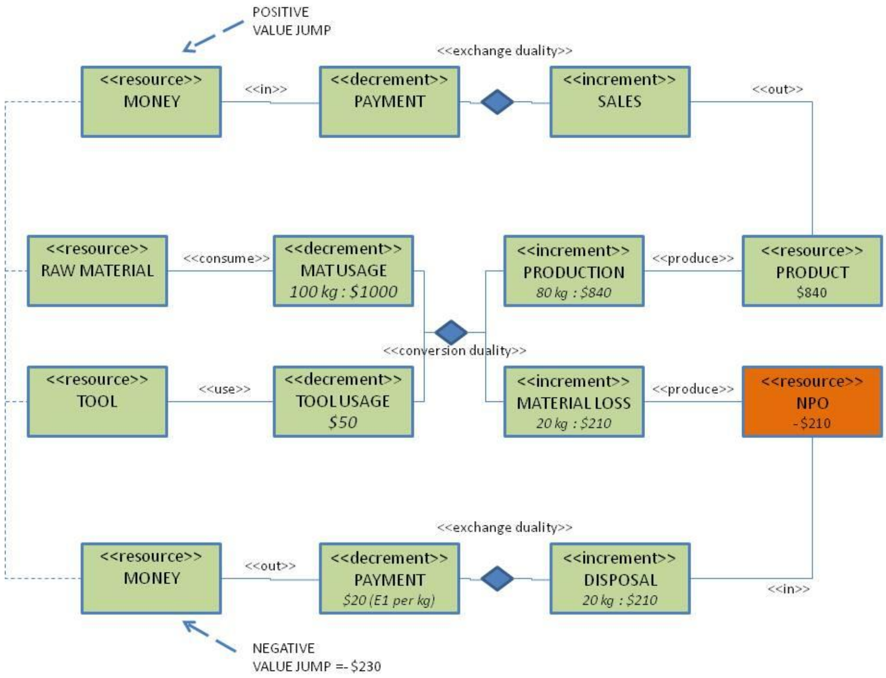

Fig 2 MFCA in REA – closing the negative value cycle

Introducing stores with a negative value raises some questions on the definition of the stockflow. In (Hruby, 2006), increment and decrement are defined in terms of economic value, not in terms of physical flow or ownership rights. Following this approach, we get to the following definitions:

Produce PO (production output)
{value (PO)=x, amount(PO)=a} produce(m,v) {value(PO)=x+v, amount(PO)=a+m}
Produce NPO (waste - NPO is seen as having negative value):
{-value (NPO)=x, amount(NPO)=a} produce(m,v) {-value(NPO)=x+v, amount(NPO)=a+m}
Out PO (product sales):
{value (PO)=x, amount(PO)=a} out(m,v) {value(PO)=x-v, amount(PO)=a-m}
In NPO (NPO removal)
{-value (NPO)=x, amount(NPO)=a} in(m,v) {-value(NPO)=x-v, amount(NPO)=a-m}

We omit here the other definitions, including that one of “out NPO”, which would be relevant for describing the business model of the cleaning firm.
In the above, we have claimed that the economic rationale for disposal is the finiteness of the enterprise system. However, it is also a bit like paying a debt. We suggest representing it as a new *restore duality*: “waste must be cleaned up”. The environmental management checks if at the end of a certain period, the duality, in terms of kg, between the waste produced and the waste disposed or recycled, has been reconciled (many-to-many relationship).

So far we have talked about waste as a stock item. There are more waste categories. Pollution, e.g. carbondioxide emission, is a slightly different story. In MFCA, this production is to be made explicit as well, although there is no cleaning firm to be paid for the removal. Under current legislation, companies have to pay for emission rights. These have to be recorded as quasi-goods. When the company (autonomously) disposes the NPO, during the actual emission, these rights are spent.

6 The Value Cycle Model contribution

From an auditing point of view, there may be an illegitimate interest of the management to *understate* the waste production and to *overstate* the waste disposal. In both cases, the management lets the waste disappear illegally. For the understatement case, the illegal waste or pollution dumping can only be found when the flow of products and profits is accounted for in comparison to its normative, rigorous relation between (taking industry-specific tolerance levels into account):

- on the one hand, realized profits and produced volumes of final products (PO per type of product), and
- on the other hand, generated volumes of production process specific 'side-effects', NPO like waste and pollution.

The overstatement case can, of course, also be addressed by the identical method of the understatement case. Since the overstatement case adds fake disposal invoices, or overstated disposal voices (possibly including the infamous kick-backs), common well-known audit methods are available. Nevertheless, without recognition of the full normative top-cycle relations one cannot have an accurate value for volumes of waste or pollution, thus neither for their under- or overstatement (NPO as related to profits and PO, both normatively and actually).

7 Conclusion

EMA/MFCA is getting more important, but the support in terms of models and tools, let alone principled ontologies, seems to be low. This is an opportunity for REA. MFCA puts on emphasis on physical flows, which poses a challenging question to REA: do REA events include physical flow (as the terminology stockflow suggests) or do they describe "only" monetary value flow? In the latter case, REA may still be useful, but then it will be necessary to seek alternative physical flow models and indicate how their underlying ontology can be linked to REA.

References

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