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The monetary value of knowledge assets: a micro approach

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Abstract

Measuring the value of knowledge is rapidly becoming a topic of interest in the wake of the increasing attention for knowledge management. Several approaches have been proposed in the past, most of them focused on measuring at a high level of abstraction the "intellectual capital" of a company. A low-level approach, meant to measure the value of separate knowledge assets is defined in a formal model. The model calculates the return on a knowledge asset (its value) as the difference between the cost incurred for using the knowledge asset in activities to produce products minus the revenues generated by these products. The activity side of this equation relies on Activity Based Costing. For the revenues side different procedures can be used for distributing product revenues over activities and knowledge assets. The approach is illustrated by a case study concerning loan revision performed in a large bank in Netherlands. It was shown that the method is applicable and led in the case study to the unexpected result that the return on most knowledge assets for loan revision was negative. The results of the method could also be used to calculate the financial prospects of re-engineering proposals. To conclude, several constraints and benefits of the method are discussed.

Keywords: Value of knowledge; Formal model; Process re-engineering; Knowledge management

1. Introduction

The upsurge of interest in knowledge management has also resulted in renewed attention for the question how to measure the value of knowledge. From a knowledge management perspective a satisfactory answer on this question is of paramount importance, because decisions concerning the knowledge resources of an organisation will be heavily influenced by their value to the organisation. Traditionally calculating the value of organisational assets has been the domain of the accounting profession, but already from an early stage problems were encountered in making visible the value of certain assets on the balance sheet. This held for human resource accounting (see, e.g. Sackmann, Flamholtz & Bullen, 1989) and more recently also for knowledge, because both resources cannot be proven to be *owned* by the company in the sense that it owns the physical assets. A recent report published in the Netherlands reaches the following conclusions concerning the presence of knowledge assets on the balance sheet

> Arguments pro and contra lead to a stalemate. Advocates and opponents have no way out in the framework of the annual statement of accounts. The knowledge balance, or better, activating knowledge and human resources on the balance sheet, does not fit in this framework. (Knowledge in balance, 1996, p. 17)

However, it can be said that knowledge management and accounting do not serve the same masters. The goal of the latter is to set defensible standards for organisational accounting that give outsiders a reliable picture of the financial state of the company. The former is concerned with optimising the use of knowledge resources in the company. The fact that the company does not own its knowledge assets is a challenge for the former, rather than an obstacle. Recent advances in this area increasingly meet this challenge.

Wilkins, van Wegen and de Hoog (1997) (see also Liebowitz & Wright, 1999; Skyrme, 1998) review several approaches to measuring the value of knowledge assets. They make a distinction between global approaches, trying to measure the *overall* value of the knowledge in an organisation, and local or micro approaches, which set out to measure the value of *separate* knowledge assets. The first approach is best represented by the work of Edvinsson and Malone (1997) and Sveiby (1997). Although their approach is quite useful, it is of less help when dealing with knowledge assets at a level lower than the organisation as a whole. For this, micro approaches are better suited. This paper describes such a micro approach and applies it to a real world example. It is an extension and enhancement of a model initially proposed by Wilkins et al. (1997).

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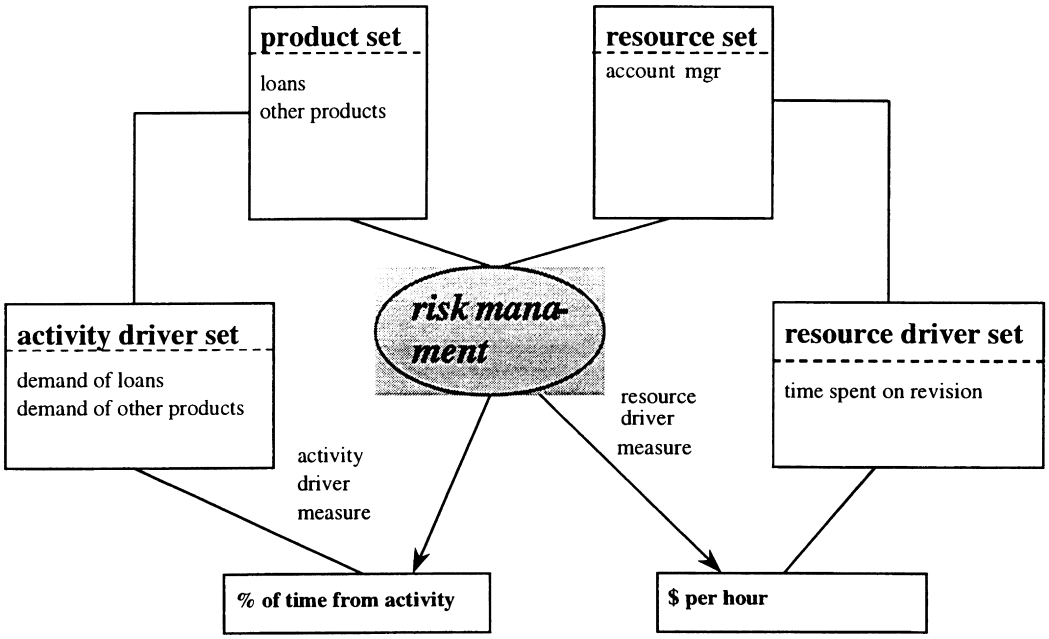

Fig. 1. Example of a costed activity.

Section 2 introduces the general theoretical model underlying the micro approach. The third is devoted to applying the model to a case: measuring the value of separate knowledge assets in a large Dutch bank. Section 4 shows how results of the measuring operation are used to devise and calculate process re-engineering proposals. Finally, some conclusions and limitations are discussed

2. The model

The approach starts from the assumption that the knowledge used in a company can be identified and described at the proper level of granularity. For this we use the notion of a *knowledge item* as defined by Wiig, de Hoog and van der Spek (1997). We will not discuss this notion more extensively in the context of this paper. Experience gained in several projects has shown that this is a usable way of characterising knowledge at the required level of detail.[1]

The model uses two definitions reflecting the value of a knowledge item:

- The *value* of a knowledge item is the revenues generated by a product, which can be ascribed to the knowledge item, summed over all products in the process using it as a resource.
- The *return* on a knowledge item is the value of a knowledge item as defined above, minus the costs incurred for using the knowledge item as a resource, summed over all products[2] using it.

In order to make these concepts more precise, which is a prerequisite for measurement, we introduce the more formal definitions below.

Let $v(kr_e) = \sum_{k=1}^{0} b(kr_e)_k$ be the value of knowledge item e, where $b(kr_e)_k$ stands for the revenues generated by product k which can be ascribed to knowledge item e. The return on a knowledge item e $r(kr_e)$ is now defined as

$$r(kr_e) = \sum_{k=1}^{0} b(kr_e)_k - \sum_{k=1}^{0} c(kr_e)_k \tag{1}$$

where $c(kr_e)_k$ stands for the costs for using knowledge item e in producing the product k.

Thus establishing the return on a knowledge item according to Eq. (1) requires the measurement of two quantities c and b (costs and revenues per product).

For calculating c we will use Activity Based Costing (see also; van Wegen & de Hoog, 1996; Wilkins et al., 1997). This involves the following concepts.

- *Activity:* a task that is part of a process.
- A *set of resources* consumed by the activity.
- A *set of products* that consume effort of the activity.
- *Resource drivers:* a variable that indicates how the volume of cost of resources must be assigned to the various activities that consume them.
- *Activity drivers:* a variable that indicates how the volume of cost of an activity must be assigned to the various products produced by the activity.
- *Resource driver measure:* a measure which permits

[1] Though the description format for a knowledge item is fairly stable over different domains, the granularity or level of detail can differ depending on the context (see also Section 3.1, step 3).

[2] The "detour" over products is necessary because only products generate revenues. If we would measure the value of knowledge by only taking into account the costs of using it in the process, we could skip the product set and subscript

quantification of the resource driver variable.
- *Activity driver measure:* a measure which permits quantification of the activity driver variable.

The general cost structure of an activity is shown in Fig. 1.

For calculating the cost of a knowledge item we have to carry out the following operations:

- for each product processed by the activity the multiplication of resource and activity driver values is calculated;
- these outcomes are summed over all products;
- if the resource drivers consist of knowledge intensive resources (humans, KBS's etc.) only, the costs involved for carrying out the activity is a measure of the value of the knowledge;
- otherwise we have to find a distribution schema.

This can also be made more formal. Let

$$R = \{r_1, \ldots, r_i, \ldots, r_n\}$$

$$A = \{a_1, \ldots, a_j, \ldots, a_m\}$$

$$P = \{p_1, \ldots, p_k, \ldots, p_o\}$$

$$KR = \{kr_1, \ldots, kr_e, \ldots, kr_z\}$$

respectively, be the set of resources R used in a production process, the set A of activities making up the production process, the set P of products produced, the set KR of knowledge items.

Now define:

$$\mathrm{RTV}_i = \sum_{j=1}^{m} \mathrm{RDM}_{i,j} \tag{2}$$

as the total use of r_i by all activities where RDM_{ij} is the resource driver measure for use of r_i by activity a_j.

$$\mathrm{RDC}_i = \frac{\mathrm{RTC}_i}{\mathrm{RTV}_i} \tag{3}$$

the cost of use of r_i per unit, where RTC_i are the total costs for r_i.

Let Fa_j be the percentage of the occurrence of activity a_j in the process under consideration. Then

$$\mathrm{TCA}_j = Fa_j * \sum_{i=1}^{n} (\mathrm{RDC}_j * \mathrm{RDM}_{i,j}) \tag{4}$$

the total cost for executing activity a_j in an average single loop of the process under consideration. However, we have to sum over products

$$\mathrm{ATV}_j = \sum_{k=1}^{0} \mathrm{ADM}_{j,k} \tag{5}$$

the total "demand" of the 0 products for a_j, where $\mathrm{ADM}_{j,k}$ is the activity driver measure representing the "demand" of product p_k for activity a_j

$$\mathrm{ADC}_j = \frac{\mathrm{TCA}_j}{\mathrm{ATV}_j} \tag{6}$$

the cost of a unit "demand" on a_j

$$\mathrm{ICP}_{j,k} = (\mathrm{ADC}_j * \mathrm{ADM}_{j,k}) \tag{7}$$

the cost for producing a unit of product p_k.

Let F be frequency of executing a loop of the process under consideration, then

$$\mathrm{TICP}_{j,k} = F * \mathrm{ICP}_{j,k} \tag{8}$$

total costs of executing a_j for p_k in a specific time interval.

Knowing which knowledge items are "embodied" in which resources and which activities are using these resources we can use $\mathrm{ICP}_{j,k}$ as an estimator of $c(kr_e)_k$. We have to deal with the following cases.

- $n = 1$ and r_i embodies only one kr_e carrying all the costs of r: $\mathrm{ICP}_{j,k}$ is a direct estimator of $c(kr_e)_k$.
- $n > 1$ and each r_i embodies only one kr_e carrying all costs of r_i: $\mathrm{ICP}_{j,k}$ has to be distributed over the r_i according to their relative contribution to $\mathrm{ICP}_{j,k}$ which is the estimator of $c(kr_e)_k$.
- $n = 1$ and each r_i embodies more than one kr_e carrying all costs of r: $\mathrm{ICP}_{j,k}$ has to be distributed over the kr_e according to the relative 0.72^{q}contribution of kr_e to product p_k which is the estimator for $c(kr_e)_k$.
- $n > 1$ and each r_i embodies more than one kr_e carrying all costs of r_i: the value found in the second case has to be distributed over the kr_e according to a schema, the resulting values are an estimator for $c(kr_e)_k$.

This completes the cost side of Eq. (1).

Next we turn to the revenues $r(kr_e)$. This is a top down process, in which the overall revenues must be distributed to the level of the knowledge items. Calculation for final results is of course bottom up. For this we need some definitions:

$$\mathrm{TR}_{\mathrm{process}} = \sum_{k=1}^{0} b(p_k) \tag{9}$$

total revenues of the process under consideration (distributing total revenues over products)

$$\mathrm{TR}_m = \sum_{j=1}^{m} \sum_{k=1}^{0} b\,(a_j, p_k) \tag{10}$$

total revenues of activities a related to products p (distribute individual product revenues over activities used in producing them)

$$\mathrm{TR}_n = \sum_{i=1}^{n} \sum_{j=1}^{m} b(r_i, a_j) \tag{11}$$

the total revenues of resources r "consumed" in executing

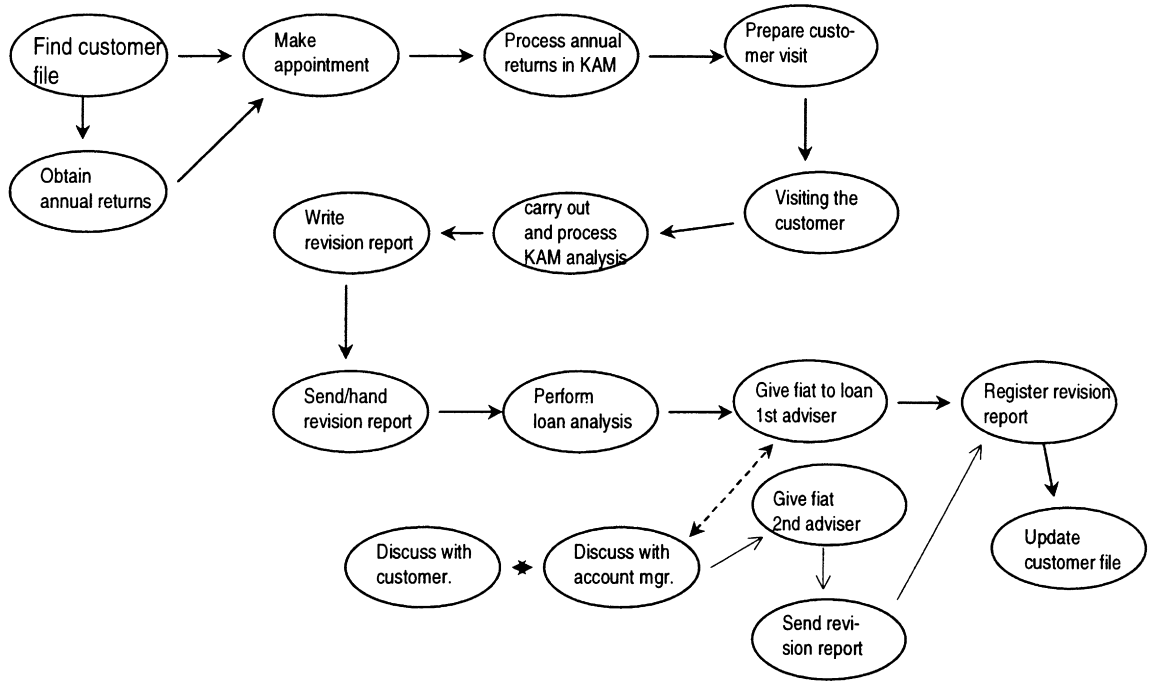

Fig. 2. The process and the activities in loans revision.

activities a (distribute activity revenues over resources used)

$$\mathrm{TR}_z = \sum_{e=1}^{z} \sum_{i=1}^{n} b(kr_e, r_i) \tag{12}$$

the total revenues of knowledge items kr embodied in resources r (distribute resource revenues over knowledge items they "possess").

We need $b(kr_e, r_i)$ as the estimator of $b(kr_e)_k$, the part of the revenues of product p_k which can be ascribed to knowledge item kr_e.

Table 1
Example of a standard activity description

Activity: processing annual returns in KAM[a]
Activity driver/measure $ADM_{j,k}$: % demand of products k on the activity
Resource driver/measure $RDM_{i,j}$: average time needed to enter annual returns and processing them
Resources: account manager, KAM[a]
Description: annual returns are entered in KAM, KAM derives indicative numbers and other info. relevant for estimating risks
Result: input for analysis

[a] KAM is a computer program used for analysing annual returns and other customer data.

In general we can have the following.

- $\mathrm{TR}_{\mathrm{process}} \geq \mathrm{TR}_m$, there can exist activities contributing to the products not belonging to the process under consideration.
- $\mathrm{TR}_n \geq \mathrm{TR}_z$, not all resources will be "used" for their knowledge item exclusively:
  - some revenues are generated by "knowledge poor" resources;
  - some smart resources are used for "stupid" activities.

However, this is theory. The actual distribution has to be found in practice, depending on the specific context.

3. Application of the model: a case study

The model presented in the previous section was applied in a case study in one of the largest banks in the Netherlands. This bank has a very strong position in commercial loans. Basically there are two processes involved in commercial lending:

- Loan requests processing, which amounts to assessing and awarding the loan.
- Loan revision, on a yearly basis assessing the current state of the loan, in particular the ability of the customer to fulfil the obligations attached to the loan.

The last process was chosen as the focus of the analysis.

Loan revision consists of two main activity types:

- Risk analysis/management activities: trying to (re)assess the risks associated with the loan.

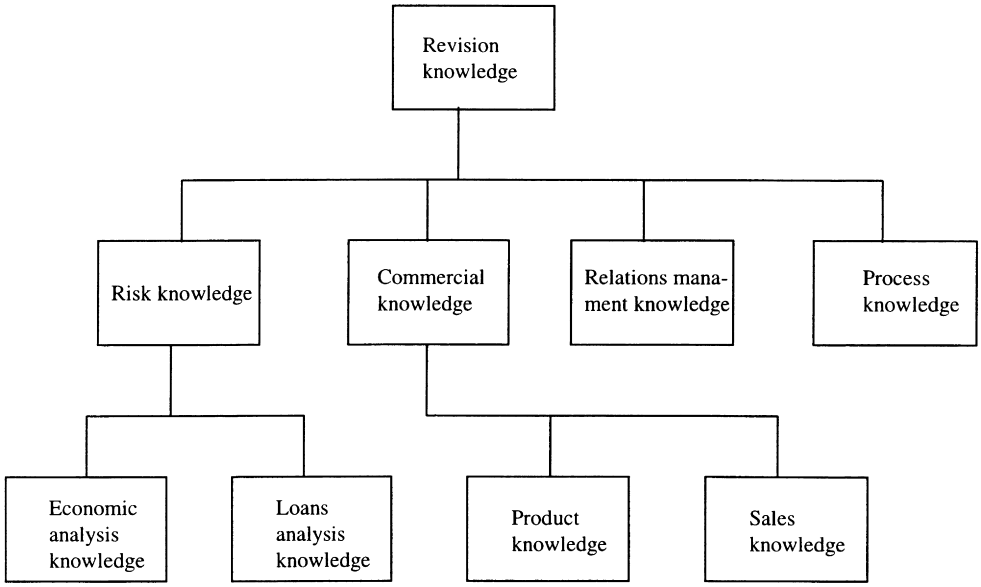

Fig. 3. Decomposition of the knowledge used in the loans revision process.

- Commercial activities: selling additional services to the customer when revising the loan.

In order to apply the model, the products should be identified first. During the loan revision process the following products are produced:

- loan products;
- payment products (electronic payment devices);
- services (general advice concerning the business, e.g. the introduction of the Euro);
- intelligence (an internal product which amounts to gathering information about the customer, the market etc.).

Next the process producing these products must be modelled. The process model is shown in Fig. 2.

3.1. The cost side: calculating $c(kr_e)_k$

For all activities in Fig. 2 we have to find the costs according to the ABC theory. This requires a standard activity description. For reasons of space we give an example of only one such a description (see Table 1).

For all activities in Fig. 2 descriptions like the one above were made. In addition to the activity descriptions, a list of knowledge items used in the process is needed. Fig. 3 gives the main decomposition of the knowledge used.

The knowledge areas from Fig. 3 were described in more detail by means of knowledge item description frames (see Wiig et al., 1997) in order to find out which agents are carriers of the knowledge. For reasons of space, we will omit these detailed descriptions

After this initial analysis the basic elements needed for applying the cost side of the model are available. From here, we can proceed in well-defined steps.

Step 1: determine resource used and their basic values. The process under consideration uses almost entirely human resources and the cost of non-human resources (e.g. the KAM system) is negligible. Thus to simplify the analysis

Table 2
Resources used and their costs

Resource	RTC_i (in US$)	RTV_i (in min)	RDC_i (in US$)
Senior account manager	112.000	101 040	1.11
Account manager	94.500	96 900	0.98
Commercial support	76.000	96 900	0.78

Table 3
Activity costs in the loans revision process

Activity	$RDM_{i,j}$	RDC_i	Fa_j	TCA_j
1. Find customer file	5	0.85	100	4.25
2. Obtain annual returns	15	1.00	50	7.50
3. Make appointment	15	1.00	100	15.00
4. Process annual returns in KAM	15	0.90	100	13.50
5. Prepare customer visit	30	0.98	100	29.50
6. Visiting the customer	60	0.98	100	58.50
7. Carry out and process KAM analysis	15	1.00	100	15.00
8. Write revision report	60	0.98	100	58.50
9. Send/handover revision report	2	0.90	100	1.80
10. Perform loan analysis	25	0.90	16	3.60
11. Analyse and give fiat to loan 1st adviser	25	1.20	100	30.00
12. Discuss with account manager	30	2.00	10	6.15
13. Discuss with customer	30	1.30	5	1.95
14. Send revision report	2	0.94	16	0.30
15. Give fiat to loan 2nd adviser	25	2.40	16	4.90
16. Register revision report	2	0.97	100	1.95
17. Update customer file	5	0.90	100	4.50
Total	361			257.00

Table 4
Distributing activity costs over products

Activities	ADC_j	$ADM_{j,loans}$	$ICP_{j,loans}$	$ADM_{j,other}$	$ICP_{j,other}$	$ADM_{j,r\&s}$	$ICP_{j,r\&s}$
Find customer file	4.25	100	4.25				
Obtain annual returns	7.50	100	7.50				
Make appointment	15.00	34	5.00	33	5.00	33	5.00
Process annual returns in KAM	13.50	100	13.50				
Prepare customer visit	29.50	60	18.00	20	6.00	20	6.00
Visiting the customer	58.50	40	23.50	30	17.50	30	17.50
Carry out and process KAM analysis	15.00	100	15.00				
Write revision report	58.50	100	58.50				
Send/handover revision report	1.80	100	1.80				
Perform loan analysis	3.60	100	3.60				
Analyse and give fiat to loan 1st adviser	30.00	100	30.00				
Discuss with account manager	6.15	100	6.15				
Discuss with customer	1.95	100	1.95				
Send revision report	0.30	100	0.30				
Give fiat to loan 2nd adviser	4.90	100	4.90				
Register revision report	1.95	100	1.95				
Update customer file	4.50	100	4.50				
Total	257		200		28.50		28.50

only the human resources are included. Three main types of human resources (as organisational roles) are involved:

- Senior account manager.
- Account manager.
- Commercial support.

For all these resources the resource driver measure RDM_{ij} is the average number of minutes needed to carry out an activity. Table 2 below shows the relevant values for the variables[3] introduced in Section 2.

Step 2: determine total costs for the one time execution of an activity. This step needs the actual values of the $RDM_{i,j}$ for all activities. In addition, the process under consideration consists of branches, meaning that not all activities are executed with the same frequency, depending on decisions made in the process. This requires also the Fa_j values. Both values were obtained by interviewing several (senior) account managers and people from the accounting department. Table 3 shows the complete calculation for all activities in the process.

As can be seen from Table 3 the longest instance of the process takes 361 min, which is about 6 h. The total cost of processing a single complete loan revision is US$ 257.

Step 3: distribute activity costs over products. As has been said above, there are four products produced in the revision process: loans, other products, relations and services, intelligence. After discussing these products with people from the bank, it turned out that it would be very difficult to reliably assign costs to intelligence because in general no specific time is spend on gathering intelligence. Thus, this product is left out of the list of products analysed. In this case the quantity ATV_j was 1 for all activities,[4] which lead to the result that $ADC_j = TCA_j$ which can be seen in Table 4. This table shows the distribution of the activity costs over the products.

As can be seen from Table 4 most costs are associated with the loans product, which is not surprising as this is the reason for the existence of the process in the first place. If we summarise Table 4 over products we find the following product costs:

- Loans US$ 199.50.
- Other products US$ 28.50.
- Relations and services US$ 28.50.

Step 4: establish costs of used knowledge. As has been shown in Fig. 3 the knowledge used can be divided into four major segments: risk knowledge, commercial knowledge, relations management knowledge and process knowledge. In the knowledge items identified (not shown here) the link between activity and knowledge items used was described. In order to keep the analysis tractable it was decided to continue the analysis at a somewhat higher level of abstraction by clustering the activities, which serve more or less the same goal and subsequently link the knowledge items to these clusters. Table 5 shows the results of this clustering.

From Table 4 the costs of activities can be directly attributed to the three areas in Table 5, given the activity cluster costs. Also from Table 4 the distribution over products can be derived. Allocating these costs to the knowledge used is simple for risk management and facilitating because they only use one knowledge item/area. For the customer cluster it is different, because there is not yet a link with the

[3] All monetary values in the subsequent tables and Figs. are in US$.

[4] This is equivalent to the statement that the products in the process "consume" the total effort of every activity in the process

Table 5
Linking activity clusters to knowledge items/areas

Cluster name	Activities in the cluster	Knowledge used
Risk management	● Process annual returns in KAM ● Carry out and process KAM analysis ● Analyse and give fiat 1st adviser ● Write revision report ● Perform loan analysis ● Discuss with account manager ● Discuss with customer ● Give fiat to loan 2nd adviser	● Risk oriented knowledge
Customer oriented	● Make appointment ● Prepare customer visit ● Visiting the customer	● Risk oriented knowledge ● Commercial knowledge ● Relations knowledge
Facilitating	● Find customer file ● Obtain annual returns ● Send/handover revision report ● Register revision report ● Update customer file	● Process knowledge

products. The costs of Commercial Knowledge are the sum of the costs associated with selling loans and selling other products, the costs of Risk oriented knowledge and Relations management are the remainder of column 4 and the whole of column 8 respectively in Table 4. This leads to Fig. 4, which summarises the cost side of the analysis.

As can be seen from Fig. 4 most costs are attributable to Risk related knowledge, which is not too surprising, as this is the main focus of the process under consideration. Note that in Fig. 4 there is no "Resource" layer between activities and knowledge domains because is this case all costs are labour costs.

3.2. The revenue side: calculating $b(kr_e)_k$

While calculating costs can be carried out in a generic way using Activity Based Costing, this does not hold for calculating and distributing revenues. Although expressions (9)–(12) form the basic procedure, already at the level of distributing total revenues of the process over the products it is bound to be domain specific. This also holds for the case study described: detailing this process would require quite some space, which has mainly to do with the intricacies of banking and is as such not very interesting from a more general point of view. Moreover, some of the information needed is confidential and cannot be reproduced in a public document. Thus in this section we will skip over some details.

Step 1: distribute revenues over products (Eq. (9)). As far as distributing revenues over products is concerned we will only show the end result of the calculation procedure in Table 6.[5]

Step 2: distribute product revenues over activities (Eq. (10)). Again there is no standard procedure for doing this. An obvious argument for doing it in a certain way could be that if an activity generates much revenue the organisation will pay much attention to it, which reversed leads to the statement that most revenues will have to go to activities which take much time. However, this line of reasoning is dangerous because it takes the current way of organising as the "correct" way. As the bank was not convinced that the current state was the benchmark state, they decided to let the distribution of product revenues over activities be guided by strategic considerations, more in particular the relative contribution of each activity to the strategic goals of the bank. For this a balanced score card (BSC) (Kaplan & Norton, 1996) approach was followed. This BSC was developed based on interviewing key persons, policy documents and an already existing BSC. This resulted in the following categories:

- *Financial perspective*

1. Minimise risk of defaulting clients.
2. Try to obtain as many securities from the client when the risk is high.
3. Figure out where other products can be sold to the client.

Table 6
Product revenues

Product	Average revenue for a revision
Loans: $b(p_{loans})$	159
Other product: $b(p_{other})$	42.50
Relations and services $b(p_{r\ \&\ s})$	17.50
Total ($TR_{process}$)	219

[5] Note that from Table 6 it can be immediately derived that the process will probably cost more than the revenues bring in. The question is of course why this is so, or in the framework of this paper which knowledge has positive returns and which has negative returns

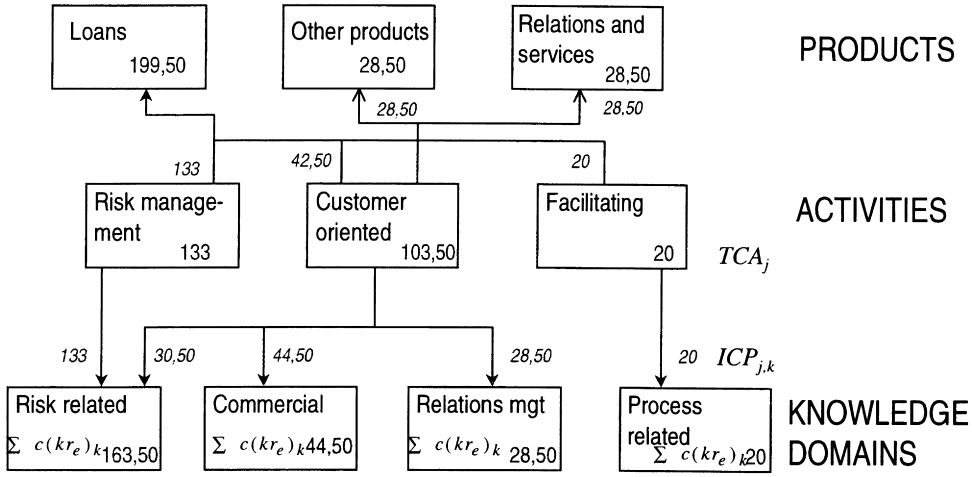

Fig. 4. The results of the cost calculation.

- *Internal perspective*

1. Differentiate work according to risk: more effort into high-risk cases.
2. Make process more efficient through computerised support.
3. Make process effective and uniform through computerised support.

- *Client perspective*

1. Support the client with information and advice.
2. Offer the client customised solutions instead of standard ones.

- *Innovation perspective*

1. Make procedures flexible in order to be able to produce customised solutions.
2. Improve learning by experience by analysing requests, revisions.

Next, the contribution of the activities to these goals must be established, to begin with linking activities to goals. This led to Table 7, which was obtained by analysing the activities[6].

After linking strategic goals and activities we have also to link strategic goals and products, expressing the contribution of the goal to either reduce the costs of producing the product or increasing the revenues. The distinction between cost reduction and revenue increase is relevant because it forces the analyst to be precise about the relation between strategic goals from the BSC and the products produced in the process. Based on analysis and expert advice, Table 8 was constructed showing the relations discussed above.

From Table 8 it can be seen that the goal "Differentiate work" will contribute to cost reduction for the loan product because not all loans have to be revised in the same way, reducing the workload. The goal "Minimize risk of defaulting customers" contributes to revenues for the loan product because in the long term this will increase the returns on the loans portfolio of the bank. Combining Tables 7 and 8 leads to a schema (see Table 9) for distributing product revenues over activities which does not rely on the "most effort, most revenue" approach. It should be noted again that this was a decision of the bank, which is not necessarily valid in other contexts.

To clarify how Table 9 can be derived from Tables 7 and 8: the activity "Visiting the customer" contributes to the

Table 7
Linking activities and strategic goals

Activity no.	Financial			Internal			Client		Innovation	
	1	2	3	1	2	3	1	2	1	2
3							X			
4	X			X	X	X				X
5	X	X	X	X			X	X		
6	X	X	X	X			X	X		
7	X			X	X	X				X
8				X						
10	X	X								
11	X	X		X						
12	X	X								
13	X	X								
15	X									

[6] From Table 7 those activities are missing not contributing to any of the perspectives according to the judgement of the bank. As a consequence they will not receive revenues from products (see also Table 9 and Fig. 5). This is a far-reaching statement by the bank, because it immediately follows that these activities (and its associated knowledge) will have a negative return. At first glance this seems unfair, because it neglects *synergies* between activities. It is hard to imagine that the process could be carried out without at least parts of these activities. However, after a second look it sounds less strange. The question is not whether the process can carried out, but what are the activities/knowledge with positive and negative returns from a strategic perspective. For the process as a whole it is acceptable to have activities/knowledge with negative returns as long as other activities/knowledge have sufficient positive returns to offset the negative ones.

Table 8
Linking strategic goals and products

Perspectives	Loans		Other products		Relations and Service	
	Cost reduction	Revenue increase	Cost reduction	Revenue increase	Cost reduction	Revenue increase
Financial						
Minimize risks		X				
Obtain securities		X				
Selling products				X		
Internal						
Differentiate work	X					
Efficient process	X					
Effectivity revision		X				
Customer						
Support customer		X		X		X
Customised solutions		X		X		X
Innovation						
Flexible procedures		X		X		X
Improve learning		X		X		

financial perspectives (all three, see Table 7), to the internal perspective 1 and customer perspectives 1 and 2 (see Table 7). From Table 8 we see that the first two financial perspectives contribute to the revenue side of the loans product ($=2$ points for loans revenues) and the revenue side of the other products ($=1$ point for revenues other products). The first internal perspective contributes to the cost reduction of the loans product ($=1$ point for cost reduction loans). Finally the two customer perspectives contribute to the revenue side of all products ($=2$ points for each). Thus, we have for the costs of loans 1 point, for the revenues of loans 4 points ($2+2$), for the revenues of other products 3 ($1+2$) and for relations and services 2 points (all from the customer perspectives).

Returning to the activity clusters as defined in Table 5 and used in Fig. 4, we can calculate the relative weight for each product of each cluster in terms of its contribution to organisational goals by simply adding their product scores from Table 9. This results in the following numbers.

- *Loans*: risk management 14.5 points, customer oriented 11 points, facilitating 0 points, thus 57% of the loans revenues go the risk management cluster and 43% to the customer oriented cluster.

Table 9
Relative distribution of product revenues over activities

Activity	Loans		Other products		Relation and services	
	Cost reduction	Revenue increase	Cost reduction	Revenue increase	Cost reduction	Revenue increase
1. Find customer file						
2. Obtain annual returns						
3. Make appointment		1		1		1
4. Process annual returns in KAM	2	2.5				
5. Prepare customer visit	1	4		3		2
6. Visiting the customer	1	4		3		2
7. Carry out and process KAM analysis	2	2.5				
8. Write revision report	1					
9. Send/handover revision report						
10. Perform loan analysis		0.5				
11. Analyse and give fiat to loan 1st adviser	1	2				
12. Discuss with account manager		0.5				
13. Discuss with customer		0.25				
14. Send revision report						
15. Give fiat to loan 2nd adviser		0.25				
16. Register revision report						
17. Update customer file						

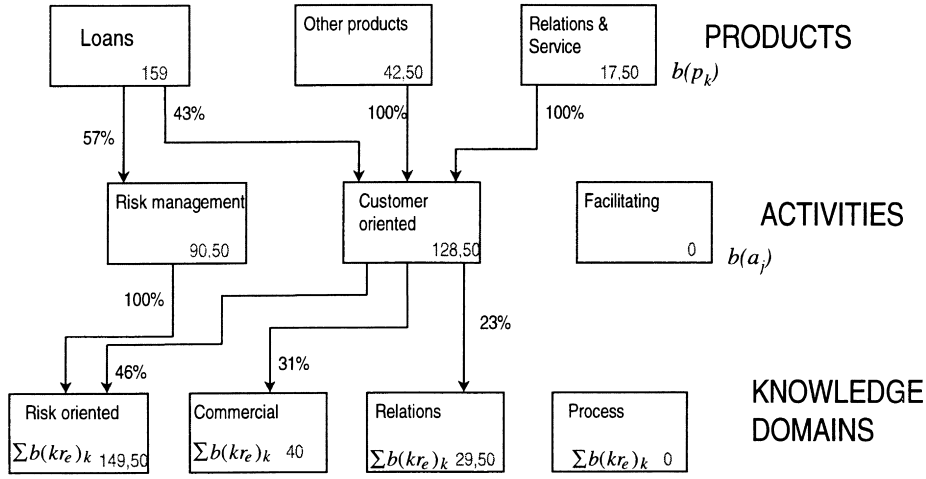

Fig. 5. The results of the distribution of the product revenues.

- *Other products*: contribution only from customer oriented cluster, 100% of the other product revenues go to that cluster.
- *Relations and services*: the same as above, 100% to the customer oriented cluster.

As the Facilitating cluster does not contribute to strategic goals, it will receive no revenues (see also footnote 7).

Step 3: distribute activity revenues over knowledge domains (Eq. (12)). As we do not have a resource layer in our case study (see also Section 3.1), we can skip Eq. (11) and use a simplified version of Eq. (12):

$$\mathrm{TR}_z = \sum_{e=1}^{z} b(kr_e)$$

As can be seen from Table 5 only the Customer oriented activities use more than one knowledge domain, the other two directly receive all the revenues of the activity in which they are used as a resource. The Customer oriented cluster consists of three activities which each contribute in a different way to the strategic goals. From Table 7 it can be derived that the activities "Preparing customer visit" and "Visiting the customer" contribute to six strategic goals. For each strategic goal it is fairly easy to determine which knowledge is needed for attaining this goal. For three goals "Risk oriented knowledge" is used, for two goals "Commercial knowledge" and for one goal "Relations knowledge". The "Make appointment" activity serves one goal for which "Relations knowledge" is needed. Thus the Risk oriented knowledge is used 6 times, Commercial knowledge 4 times and Relations knowledge 3 times. Thus, 46% of the Customer cluster revenues are allocated to Risk oriented knowledge, 31% to Commercial knowledge and 23% to Relations knowledge.

These results are summarised in Fig. 5 below where it is shown what the estimates for the different $b(kr_e)$ are.

3.3. Putting things together: calculating $r(kr_e)$

Given Figs. 4 and 5 the final step is straightforward: applying Eq. (1) to the bottom line boxes in both figures However, in the analysis process we have also calculated

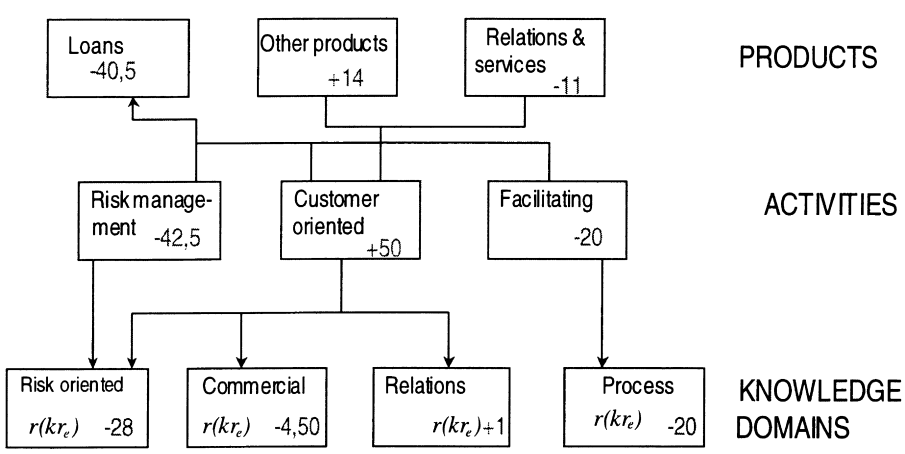

Fig. 6. The return on the knowledge used according to Eq. (1).

Table 10
The yearly costs, revenues and return on the knowledge domains

Knowledge domain	Total costs	Total revenues	Return
Risk oriented	9.8	8.9	−1
Commercial	2.6	2.4	−0.26
Relations	1.7	1.75	0.07
Process	1.2	0	−1.2

values for products and activities and the results of calculating the equivalent of Eq. (1) for those is also shown in Fig. 6.

Fig. 6 shows that, to the surprise of the bank, the return on the knowledge used is mainly *negative*. Only a small return is earned on Relations knowledge, in particular Risk oriented and process knowledge cause substantial losses. In general, the whole revision process will loose money to the bank. One should keep in mind that the numbers in Figs. 4–6 refer to a *single* loop of the revision process. In reality this process is executed many more times in a year, approximately 60,000 times. Table 10 takes this frequency into account and shows the total costs, revenues and return on the four knowledge domains in millions of US$.

Thus the bank is losing approximately US$ 2 million a year on the knowledge used in the loans revision process and as knowledge is the most important resource used, also on the entire process. How to deal with this fact is the topic of the next section. As the analysis contains many assumptions we decided to carry out a modest sensitivity analysis on the results, in order to find out what the plausible boundaries for the results in Fig. 6 and Table 10 were.

3.4. Sensitivity analysis

Sensitivity analysis can be performed on the two main components of the method: costs and revenues. First, we will review the assumptions from the cost side.

- Taking labour costs as the single indicator of the process cost: though this seems reasonable, there is still a chance that the real costs are higher.
- The average time to perform an activity: though this has been researched carefully, it seems possible that the sum of the time devoted to all activities is lower than the process time, in particular when the activities are spread over several days ("start up time"). Some account managers gave as their opinion that they are spending 15–20% of their time on revisions, while this is 12% in the study.
- We left out the costs of a resource: the investment in supporting systems like KAM.
- The sample of branch offices from which we collected our data was biased. This does not seem likely because the branch offices selected showed variety in size, which guarantees sufficient coverage of the entire loans portfolio.
- Our estimates of the frequency and volume of sales and risk management activities were wrong. As far as volumes are concerned, most account managers agree on the numbers, but for the frequency of activities, this is different due to substantial differences in individual process organization. However, in our calculations we chose the positive angle: the numbers were adjusted upwards.

Next the revenue side, where the possible sources of error are:

- The product revenues could be estimated either too high or too low. The product revenues are set at a higher value then indicated in some internal reports of the bank.
- The procedure for distributing revenues is has a positive or negative bias. As this is entirely judgmental it is "biased" by definition. However, this "bias" reflects the strategic orientation of the bank.

Taken together it seems that as far as revenues are concerned, our calculations will err rather on the positive than the negative side. In addition, one should keep in mind that this calculation is based on the current state of affairs. It is very well possible that changing the strict monitoring of loans will influence the behaviour of the customer, which in turn can influence the revenues. Based on the considerations outlined above we carried out a more formal sensitivity analysis by changing the variables influenced by the uncertainties in the method upward and downward. The upper boundary is the situation where we assume that on all these variables our numbers were too pessimistic, i.e. a positive change (costs down, revenues up). The lower boundary is the reverse, our numbers were too optimistic, i.e. a negative change (costs up, revenues down). As these calculations must be constrained we decided to the fix the

Table 11
Results of the sensitivity analysis

	Maximum positive deviation	Maximum negative deviation
Costs	25.50	76
Revenues	46.25	98.25
Total deviation	+ 71.75	−174.25
Total return on a single revision	+ 34	−212
Total yearly return on entire process	+ 2 million	−12.7 million

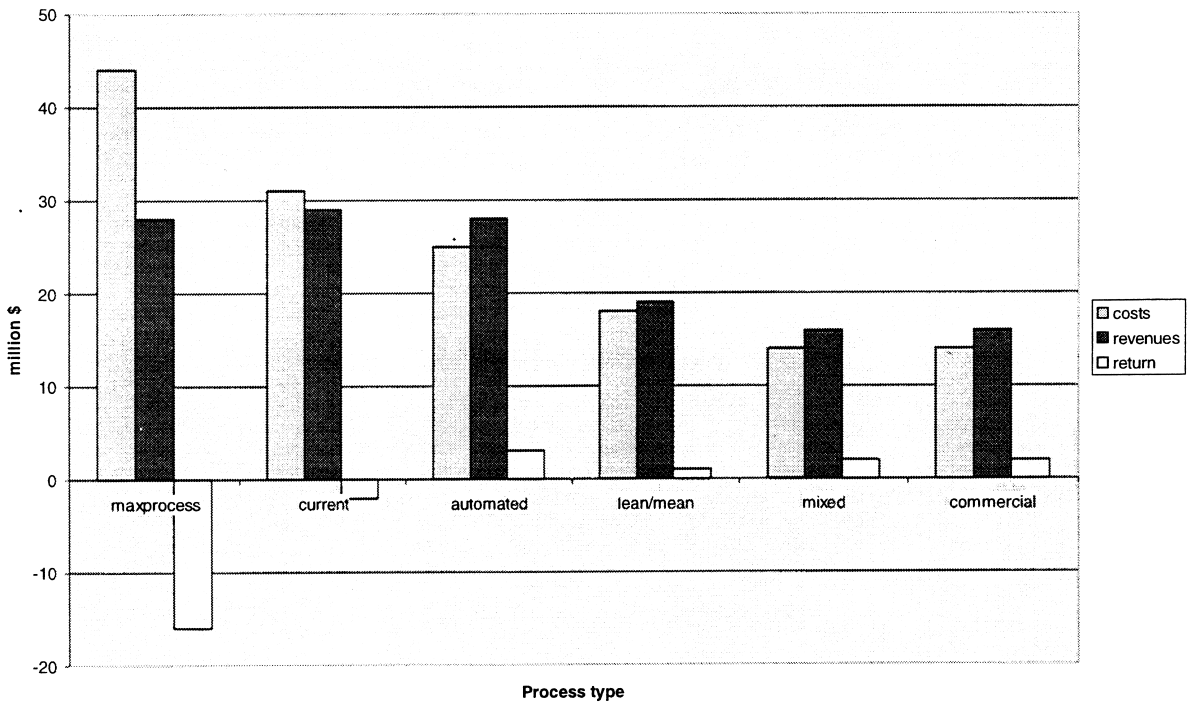

Fig. 7. The cost, revenues and returns of different re-engineering proposals.

plausible boundaries between 10–20% for each relevant variable. Table 11 below shows the results of this exercise.

As can be seen from Table 11, the upper positive boundary (+2 million) and lower negative boundary (−12.7 million) are far apart. The question is how to deal with these boundaries. Basically three different possibilities can be considered:

- The maximum negative deviation.
- The maximum positive deviation.
- No deviation of the original values.

The probabilities of these will decide on the conclusion. Let us assume that the prior probabilities for all three are equal. However, we can say that the probability of a negative correction of the return per revision is larger than the probability of a positive correction of the return per revision, because the maximum negative deviation is larger than the maximum positive deviation. This fits to another argument: needed to make the entire revision process profitable: all (18) variables involved should have their (almost) maximum positive deviation (costs down, revenues up). The probability of this seems close to zero. Taken together our sensitivity analysis showed that is seems quite unlikely that the revision process has positive returns. Consequently, the original conclusion concerning the negative return on most knowledge assets remains valid.

Summarising the results of the case study we can say that:

- The yearly loss on the revision process amounts to US$ 2 million, results of the sensitivity analysis indicate that the "real" loss is probably even higher.
- Most substantial losses are incurred on non-customer oriented risk management activities.
- The knowledge "possessed" by the bank used in the process has for the larger part a negative return in the framework of the process under consideration.

The most important causes for this state of affairs are:

- Too much time is spent on managing small loans, which are not very profitable.
- Differentiation to risk is almost non existent, and when applied scarcely reduces the total amount of time spent on risk management.
- Processing large amounts of information and knowledge during risk management is sometimes counter productive because the account managers lose overview, leading to much communication between other agents and an increase in time needed.

From the perspective of the value of knowledge assets the interesting conclusion is that this value is not *absolute*, but relative to the way the process is organized in which the knowledge is used. We will turn to this in the next section.

4. Re-engineering the process

The analysis described in the previous section alerted the bank on the negative returns of the loans revision process. It raised the question whether the process should not be re-engineered to make it more profitable. Though this is strictly speaking outside the scope of this paper, as it does not impinge on the *procedure* for calculating the value of

knowledge assets, we will briefly describe the alternatives considered and their effect on the value of the knowledge assets. After an in depth analysis, six new ways of organising the process were taken into consideration:

1. *Maximum process*: for all loans once a year a complete revision (including risk analysis) takes place, with each customer a talk is organised and each revision requires double fiats.
2. *No revisions*: drop all risk revision activities.
3. *Commercial revision*: drop all risk revision activities, but keep the commercial revisions.
4. *Lean and mean revision*: drop the internal control activities, but still keep the simple risk analysis with KAM and talk with the customer.
5. *Optimised automated revision*: develop and implement a computer based system that sorts revisions into different classes each asking for a particular way of processing (i.e. differentiate more and better to a priori risk assessments), keep the commercial revision activities.
6. *Mixed scenario*: a combination of the Lean and mean and Optimised variants, i.e. Lean and mean with risk differentiation.

The financial consequences[7] of these redesigns could be calculated using the original process data, because all redesigns effected changes in the process (activities dropped, frequencies changed). These are shown in Fig.7.

From Fig. 7 it can be seen, that overall the optimised automated revision process would give the best results in terms of financial results as well as qualitative improvement of the entire process. Whether this was also the most preferred option in the final decision making process, will not be described in this paper.

5. Conclusions

It has been shown that a *micro approach* to valuing knowledge assets can be defined, formalised and used in practice. The level of detail permitted that results of the analysis were used to investigate ways of improving the process in order to increase the return on knowledge assets. This clearly sets the method apart from more global approaches, which address the *overall value of intellectual capital* in an organisation. These approaches mostly don't make it possible to derive rather precise improvement plans from the numbers calculated. From an operational knowledge management point of view it is interesting to observe, that after a knowledge value analysis it is not always necessary to come up with purely knowledge-related actions like the ones proposed by Wiig et al. (1997). The process reengineering alternatives considered did not all fell into the basic categories of development, distribution, consolidation or combination of knowledge. None the less, the availability of the value analysis made it feasible to calculate the advantages and disadvantages of the alternatives, thus contributing significantly to the "Definition of required improvements" step in the overall cycle in Wiig et al. (1997).

Reflecting on the method and its use in the case study, several points come to the fore which are listed below:

- The organisation should operate (or can be described as operating) in a process oriented way. As this is very often the case, this requirement seems to be not too prohibiting.
- The method only supplies the value of the knowledge derived from the process under consideration. Additional value from other process can only be taken into account when these other processes are analysed along the same line. Thus, the value of the knowledge areas as shown in Fig. 6 is not the *total* value of a knowledge area. In the case study, risk oriented knowledge is also used in the *loans request processing* process and without a comparable analysis of this process a "final" word on the value of the knowledge area cannot be given. Thus it is possible that the total value is positive.
- The method assumes that the organisation has described its knowledge areas and gets a price for its products on a market. Both assumptions are rather strong and will limit its usability. However, one could argue that whenever an organisation wants to perform knowledge management it needs at least insight into the knowledge assets it possesses, making the first requirement probably less forbidding.
- The value of a knowledge area is entirely defined in terms of its *current* value. Nothing is said about its future value, which is quite often also important, especially in highly innovative organisations. For these organisations, the macro approach may be better suited.
- Activity Based Costing works fine when determining the costs of processes.
- Distributing product revenues over activities, resources and knowledge areas is probably the hardest part. In the context of the case study, a strategic approach was chosen, which fitted the organisation under consideration well. Nevertheless, this cannot be easily generalised to other organisations, requiring a careful analysis of the proper method to apply.
- From other case studies with the same method, not described in this paper, it seems that the more detailed the level of description of the knowledge items, the easier it is to derive knowledge improvement plans from the knowledge valuation results.

As any method, the approach defined and used in this paper relies on assumptions and definitions for which it is impossible to prove that they are right. In the absence of this, the second best way to proceed is to make them as

[7] We limit ourselves to the description of the financial consequences for reasons of space. Of course all of them will have many other effects on the organisation which will play a role when one has to decide between them. Several of these were identified in the project and ultimately taken into consideration.

explicit as possible, giving future users the opportunity to decide for themselves which ones are acceptable and which ones not, given their particular context. A prerequisite for this is to be as precise and formal as possible. We claim that the work presented here satisfies this important criterion.

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