Risk Cost Accounting and Bottom Price Calculation – A Risk Management Information System

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Abstract. Due to legal regulations, most firms have installed risk management systems that monitor existence-threatening risks. Minor risks are usually not in their focus so that these systems are often not adequate for an effective operational risk management as they lack of a consistent quantification, valuation, and handling of risks. In particular for service providers who offer services at different levels, considering risks and their potential costs is crucial for the pricing scheme. Therefore, this paper presents a new kind of a risk management information system that extends the traditional cost accounting by introducing the concept of risk costs. This allows a consistent and uniform valuation and comparison of risks as well as an easy integration into existing enterprise IS. Besides the provision of detailed overviews of the risk situation of cost centers, cost units, business units, business areas etc., different levels of risk adjusted bottom prices for products and services can be calculated.

Keywords: Managerial accounting · Risk information system · Risk management · Risk cost accounting · Bottom price calculation

1 Introduction

For nearly two decades, governments oblige companies [3, 15] by law (e.g. US: Sarbanes-Oxley Act, Germany: KonTraG) to install a risk management system (RMS) that enables them to monitor their risk situation. The exact implementation itself is not regulated by law. Instead, firms can choose how to "live" their risk management (RM). Usually, strategically oriented RMS are used that monitor only such risks that threaten the very existence of a firm. As a matter of fact, minor risks are therefore neglected. Empirical studies underline that such risk information systems (RIS) commonly used in business are not adequate for an effective RM [21]. Although it should be possible to integrate a RIS into an existing enterprise information system [6] and although a RIS should be based on a single consistent measurement [8] both requirements are mostly not fulfilled [21].

In particular, when RM is done on an operational instead of the strategic level, using a consistent quantification of risks is crucial. Otherwise, risks can hardly be compared and therefore not controlled and handled adequately. Hence, this paper presents a new concept for a RIS that is based on a consistent quantification of risks.

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For this, it extends the classic managerial cost accounting (MCA) with a sample accounting that assigns risk costs to products or services, cost centers, business areas etc. Such a risk oriented sample accounting provides several advantages. First of all, it can easily be integrated into existing information systems (IS) without any changes in classic calculations. Secondly, decision makers get an IS that provides risk information about different business areas in several detail levels. Thirdly, the sample accounting allows for computing costs under risk so that it is possible to calculate more realistic (bottom) prices. This, in particular, is important for service providers as services costs depend on many different parameters like contracted volume, performance, failure rate, response time etc. that all are subject to risks and therefore to uncertainty [27].

The remainder of this paper is organized as follows. The next section gives a short overview about existing risk information concepts. Section 3 deals with the fundamental definitions and the concept of risk costs. In Sect. 4, the RIS itself is presented that consists of two parts: The risk cost center accounting and the product risk cost accounting. This concept is illustrated by an example in Sect. 5 before the paper closes with a summary and an outlook.

2 Research Background

As legislation does not define risk and especially RM [2] but the area of application [15], the RM literature provides numerous suggestions for the information supply of RM. Because of the complexity of risks, many authors recommend a so-called risk map [11] where important risks are put into a coordinate system according to their potential harm and incidence rate. Its advantage is the aggregate and therefore management appropriate visualization of a firm's risk situation. Additionally, risks do not need to be quantified exactly. A rough estimate is often sufficient because potential harm as well as the incidence rate are not measured exactly but in fuzzy categories. But because of the aggregate presentation, information about the risks, i.e. their exact harm and incidence rate, the relations between causes and effects are getting lost [11].

Many authors try to overcome this deficit by using the Balanced Scorecard (BSC) (e.g. [13]) that provides a holistic management view on different heterogeneous information. The BSC is usually used in strategic fields where its strength is to present complex situations clearly and in a concentrated form. Especially the usage of cause-effect chains is advantageous in comparison to simple approaches like the risk map. But as those interdependencies are quite difficult to identify and to quantify, authors usually resign to quantify them [19] with only a few exceptions (e.g. [19, 24, 28]). Siepermann [28] gives an extensive overview about different approaches. This overview shows that there is no silver bullet using the BSC. Instead, the BSC provides many degrees of freedom so that different approaches do not necessarily lead to the same results. In a strategic field of application, this is acceptable. But in an operational field, an exact and consistent quantification cannot be renounced. For this, several authors propose risk costs but resign to define them exactly [17]. In addition, they do not show how to continue processing the risk costs consistently. In this paper, such a consistent processing is shown.

The MCA already copes with risks and their costs in four different ways [18, 20]: First of all, during the planned cost accounting, planned prices are forecasted as precisely as possible. If necessary, different prices are used during one period. Secondly, quantities are planned according to the optimal consumption, but waste is constantly examined so that over-consumption finds its way into the planning. Thirdly, imputed risks are also considered within the cost accounting. And fourthly, for cost control purposes, post calculations regularly take place in order to discover the appearance and quantity of risks and imputed risks so that they can be considered in future calculations. But a comprehensive consideration of all enterprise risks does not take place within the MCA. Costs for RM are reported not specifically and scattered among the whole accounting. Costs for the risk analysis can be found within administration costs. Costs for risk reducing measures (except insurances) cannot be identified at all (e.g. costs for material of higher quality in order to improve the product quality and to reduce warranty claims). An explicit disclosure of such risk costs in cost centers is highly recommended for RM purposes because only in this case RM becomes visible concerning the cost aspect. This improves the whole view on a firm's risk situation.

3 Risk and Risk Costs

3.1 Risk

The usual meaning of risk represents a venture, a danger or the possibility of a loss, as well as the possibility that a negative occurrence of some sort will occur [12, 23]. The risk manifests itself – in the case of occurrence – as property loss, loss of profits, etc. [1]. The main characteristic of risk consists of the uncertainty which will occur in the future. For the quantitative determination, the possible developments are set in relation to a reference value. Since risks are of a forward-looking nature which is highly dependent on business decisions in firms, almost all recent scientific publications define risk as the possibility that, due to uncertainty about future events, the realized value and the plan size of a firm's economic key figure differ negatively [5, 25]. Thus, the value of a risk R_T in period T = [t,t'] concerning key figure K is the potential difference between the key figure's realized value $K_t^{I(t')}$ at the end of the period (t') and its planned target value $K_t^{P(t')}$:

$$R_T(K) = K_t^{I(t')} - K_t^{P(t')} \tag{1}$$

During planning, the value $K_t^{I(t')}$ is an anticipated value that has to be calculated with the help of the plan size and the risk value. For the determination of risk value several approaches exist like the maximum possible loss, the value at risk or the lower partial moments. Which of these metrics are used depends on the purpose. The banking sector usually uses the value at risk. In order to determine the maximum risk, the maximum possible loss is used. For an averaged view on the risk situation the lower partial moments of the first order should be used. This metric indicates the averaged risk if the plan size is missed [29].

3.2 Risk Costs

A closed and commonly accepted definition of risk costs does not exist in literature. The MCA uses imputed risks which are extraordinary expenses that are unusual for the business and occur suddenly, sporadically and unexpectedly, i.e. haphazardly [22]. But they do not cover all possible risks [9], are distributed among several periods, and are mostly summed up in one calculatory cost type so that they cannot distinguish unwanted over-consumption and price deviations [7]. For cost accounting matters this is reasonable, but for risk management, risk costs should be reported on an accrual basis [7]. Besides, not only (unexpected) deviations but also expenses for the risk management process itself should be considered as risk costs [16, 26].

As a result, *risk costs* comprise two kinds of costs: *Risk management costs* and *risk following costs*. *Risk management costs* encompass all costs that arise for the risk management process, i.e. for analysis, control, and monitoring of risks as well as counter measures in order to ensure a firm's continued existence [25]. These costs are already considered within the MCA but scattered among the whole accounting. *Risk following costs* are monetarily valuated negative deviations from a planned target value that occur because a potential risk strikes in reality. If these deviations result in out-payments, we are usually facing cost overruns. Otherwise, we talk about some kind of opportunity costs like lost profit [16]. If we understand the wasted time that was not used well as a good, we are facing costs in the common sense [4] even if these costs are not considered in the classic cost accounting.

Missing a target value can accrue due to three kinds of deviations: price, quantity, and quality. Any other deviation can be explained by one of these three deviations. Therefore, risk costs can be subdivided into price risk costs, quantity risk costs and quality risk costs. However, these factors are intertwined: The higher the quality of a good is, the higher is its price. The less (higher) the quality is, the more (less) of the good is needed. The lower the quality of the good is, the lower is the quality of the end product/service resulting in less output. Thus, when calculating the risk values and a good cannot be procured with the planned quality, the price respectively the risk value of the price must be lower. Therefore, before calculating the price risk value, the quantity and the quality risk value have to be calculated in advance. Not until then and under consideration of this quality risk value the price risk value can be calculated correctly. A suitable process is as follows: Price and quality are subject to a 3D density function. If the quality is determined, the 3D-density function is cut by a vertical plane onto which the 2D price density function is projected. With the help of this 2D density function, the price risk value can be determined. This process can also be applied for calculating services risks. Different service levels imply different cutting planes so that different risk values can be obtained.

4 Risk Information System

The MCA is the central IS for decision makers. There, all relevant data is collected and analyzed. It is the basis for planning, control and monitoring of all processes in a firm. It consists of the cost type accounting, cost center accounting and the cost-unit accounting

[7, 18]. In analogy to this, we introduce a RIS, i.e. the *risk cost accounting* with the same structure. As seen in Sect. 3, risk costs are of three types: price risk costs, quantity risk costs and quality risk costs. But although many risk classifications exist (e.g. [5, 9, 10, 12]), a universal risk categorization is said to be unobtainable so that each firm has to categorize its risks on its own [12, 14]. Even if this situation is not satisfactory, it is sufficient for our purpose. For this, we will focus on a risk cost center accounting and a risk cost-unit accounting in the following chapters.

4.1 Risk Cost Centre Accounting

While the classic cost center accounting records which costs occur in each area of a firm during a period [7, 18, 20], the risk cost center accounting records the risks and their risk costs that due to uncertainty can but do not necessarily have to occur. The formation of centers should be oriented to the classic MCA. Only if the allocation of risks and risk costs is not clearly possible, sub or aggregated centers should be built.

First of all, all risks (causes as well as effects) have to be determined and recorded in that risk cost center where they occur. That means if there is the risk of hard disc crash (effect) in the risk cost center Computing, then this risk should be recorded there even if the reason for the risk (cause) is a low quality of hard discs for which the risk cost center procurement is responsible. Risks that occur in several centers and cannot clearly be assigned to one center are recorded in an aggregated risk cost center. After the risks, the risk costs are determined and recorded. Risk management costs for administration and risk measures are already part of the classic MCA so that they just have to be clearly accentuated as risk costs. In contrast, risk following costs have to be calculated explicitly according to the risks and their risk values of a risk cost center: The recorded risks have an effect on the firm's key figures that are already part of the classic cost accounting, i.e. quantities and prices. Additionally, within a risk cost accounting the quality of goods may also matter. These effects are recorded in each risk cost center. Then, the risk costs can be calculated in a sample accounting in addition to the classic cost calculation. The allocation bases of the risk cost centers remain the same as in the classic accounting. Also for sub centers the allocation bases of the superior centers can be used. Only for additional aggregated centers, new suitable allocation bases have to be found.

Cost deviations result from deviations concerning price, quantity and quality where quality can mostly be transferred into quantity. Thus, for each cost position of the classic accounting we are facing two risk positions in the risk accounting: price risk costs and quantity risk costs where the latter one can be subdivided into quality risk costs. The distinction between variable and fixed costs remains even if variable risk costs usually will be higher than fixed risk costs. This is because fixed costs are less dependent on processes and decisions and therefore fluctuate less and can be predicted better. For each cost type, there are additional risk price costs and quantity price costs so that the variable costs per unit as well as the fixed costs increase. Figure 1 illustrates the increase in costs when risk costs are considered.

Akin to the cost deviations of second order in the classic cost accounting [18, 20], there are risk cost deviations that can be added to one single deviation cause (price risk or quantity risk) or recorded as cumulative deviations. Because these second order

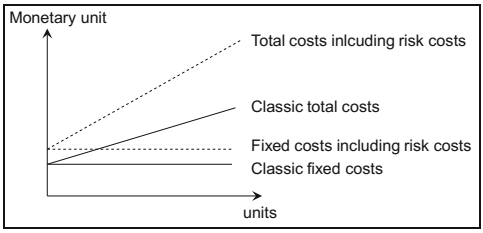

Fig. 1. Cost changes under consideration of risk costs.

deviations result from two different risks and therefore possibly two different parties are responsible for these costs, an explicit recording as cumulative deviation should be used. The classic planned costs $C^{P}_{T,s}$ in period T = [t,t'] of a risk cost center s is the sum of all single costs $c^{P}_{T,s,i}$ that can be divided into fixed and variable costs with $p^{P}_{T,i}$ being the planned price for good i and $m^{P}_{T,s,i}$ being the planned quantity. In the case of variable costs, the quantity $m^{P}_{T,s,i}$ as a rule is a linear function of the allocation base AB ($m^{P\,variable}_{T,S,i} = f\left(AB^{P}_{T,S}\right)$) [18, 20]:

$$C^{P}_{T,s} = \sum_{i=1}^{n} c^{P}_{T,s,i} = \sum_{i=1}^{n} \left(c^{P\,variable}_{T,s,i} + c^{P\,fixed}_{T,s,i}\right) = \sum_{i=1}^{n} p^{P}_{T,i} \cdot \left(m^{P\,variable}_{T,s,i} + m^{P\,fixed}_{T,s,i}\right) \quad (2)$$

Due to risks, prices and quantities can deviate from the planned size with a price risk value $R^{P}_{T}(p^{P}_{T,i})$ and a quantity risk value $R^{P}_{T}(m^{P}_{T,s,i})$ so that the realized costs $C^{I(t')}_{t,S}$ at t' (the end of period T) and predicted at t (the beginning of period T) will exceed the planned costs and risk cost will occur:

$$C^{I(t')}_{t,s} = \sum_{i=1}^{n} \left(\left(p^{P}_{T,i} + R^{P}_{T}(p^{P}_{T,i})\right) \cdot \left(m^{P\,variable}_{T,s,i} + R^{P}_{T}(m^{P\,variable}_{T,s,i}) + m^{P\,fixed}_{T,s,i} + R^{P}_{T}(m^{P\,fixed}_{T,s,i})\right)\right) \quad (3)$$

Then, the risk following costs $RC^{P}_{T,s} = RC^{P\,variable}_{T,s} + RC^{P\,fixed}_{T,s}$ of risk cost center s are composed of price risk costs, quantity risk costs and the combination of both:

$$\begin{aligned} RC^{P}_{T,s} = \sum_{i=1}^{n} \Bigg(& p^{P}_{T,i} \cdot \left(R^{P}_{T}(m^{P\,variable}_{T,S,i}) + R^{P}_{T}(m^{P\,fixed}_{T,S,i})\right) && \text{price risk costs} \\ & + R^{P}_{T}(p^{P}_{T,i}) \cdot \left(m^{P\,variable}_{T,S,i} + m^{P\,fixed}_{T,S,i}\right) && \text{quantity risk costs} \\ & + R^{P}_{T}(p^{P}_{T,i}) \cdot \left(R^{P}_{T}(m^{P\,variable}_{T,S,i}) + R^{P}_{T}(m^{P\,fixed}_{T,S,i})\right)\Bigg) && \text{price/quantity risk costs} \end{aligned} \quad (4)$$

Given the allocation base $AB^{P}_{T,s}$ we get a new risk adjusted calculation rate in addition to the classic calculation rate of cost center s:

$$RCR^{P}_{T,s} = RC^{P\,variable}_{T,s} / AB^{P}_{T,s} \tag{5}$$

4.2 Risk Cost-Unit Accounting

The classic cost-unit accounting consists of two parts: the product costing and the period costing. The latter one can be extended to a short-term profit and loss account. The purpose of the product costing is the calculation of cost prices in order to determine quotation prices, the bottom prices, the value of stock and prices for advertised bidding [7, 18, 20]. With the help of the cost center accounting, the overhead costs then are allocated source-related to the cost units.

Also for a risk cost accounting the risk costs should be allocated source-related to the cost units in order to see which products bear more what kind of risks. Additionally, quotation prices and bottom prices should be calculated according to a firm's risk situation. Prices lower than risk oriented bottom prices do not reflect the firm's risk situation because if risks occur the firm will probably not be able to cover these risks within the limits of the planned business concern. The basis for a risk oriented cost-unit accounting is the classic cost-unit accounting with the classic costs and their parameters. With the help of the risk values of the cost parameters, it is then again possible, like in the risk cost center accounting, to calculate the risk costs of a firm's cost units. The structure as well as the cost structure of the risk cost-unit accounting is similar to the classic accounting. There are direct risk costs that can directly be allocated to a cost unit. Variable overhead risk costs come from the risk cost center accounting and can be allocated easily to the cost units according to the stress of a cost center by cost units. Fixed overhead risk costs as well as risk costs that cannot be allocated directly to cost units because they belong to a set of similar units and it is not possible to distinguish which cost unit is the originator (e.g. law risks when rights are violated), have to be taken into account during contribution margin accounting.

Risk management costs as well as imputed risks are already part of the cost unit accounting and just have to be accentuated as risk costs. They must not be allocated to cost units twice. Thus, only the risk following costs need a special consideration. The total risk costs of a cost unit i $RCUC^{P}_{T,i}$ are composed of the clearly assignable direct risk costs $DRC^{P}_{T,i}$ and the overhead risk costs $ORC^{P}_{T,i}$ that are allocated to the cost units according to the stress of a cost center:

$$RCUC^{P}_{T,i} = DRC^{P}_{T,i} + ORC^{P}_{T,i} \tag{6}$$

Let x_i be the production quantity of cost unit i. Then, direct risk costs are composed of the nv variable direct risk costs multiplied with x_i and the nf fixed direct risk costs:

$$DRC^{P}_{T,i} = \sum_{j=1}^{nv} x^{P}_{T,i} \cdot vDRC^{P}_{T,ij} + \sum_{j=1}^{nf} fDRC^{P}_{T,ij} \tag{7}$$

Let S_P be the number of procurement, S_M the number of main (production or services), and S_A the number of administration and distribution cost centers, $mdc^P_{T,i}$ the direct material costs of cost unit i, $q^P_{T,S,i}$ the stress of cost center s by cost unit i, $h^P_{T,i}$ the direct costs of production and $rh^P_{T,i}$ the risk oriented direct costs of production. Then, the total overhead risk costs of a risk cost unit i are:

$$ORC^P_{T,i} = x^P_{T,i} \cdot \left(\sum_{s=1}^{S_P} mdc^P_{T,i} \cdot RCR^P_{T,s} + \sum_{s=1}^{S_M} q^P_{T,s,i} \cdot RCR^P_{T,s} + \sum_{s=1}^{S_A} (h^P_{T,i} + rh^P_{T,i}) \cdot RCR^P_{T,s} \right) \quad (8)$$

The risk oriented direct costs of production $rh^P_{T,i}$ are the sum of all variable direct and the overhead risk costs that are allocated according to the stress of the cost centers:

$$rh^P_{T,i} = \sum_{j=1}^{n} vDRC^P_{T,ij} + \sum_{s=1}^{S_P} mdc^P_{T,i} \cdot RCR^P_{T,s} + \sum_{s=1}^{S_M} q^P_{T,si} \cdot RCR^P_{T,s} \quad (9)$$

Then, the risk cost price $rs^P_{T,i}$ of a risk cost unit i is:

$$rs^P_{T,i} = \sum_{j=1}^{n} vERK^P_{T,ij} + \sum_{s=1}^{S_P} mdc^P_{T,i} \cdot RCR^P_{T,s} + \sum_{s=1}^{S_M} q^P_{T,si} \cdot RCR^P_{T,s} + \sum_{s=1}^{S_A} (h^P_{T,i} + rh^P_{T,i}) \cdot RCR^P_{T,s} \quad (10)$$

The total risk costs of a cost unit that reflect the complete risk potential of the cost unit are as follows:

$$RCUC^P_{T,i} = x^P_{T,i} \cdot rs^P_{T,i} + \sum_{j=1}^{m} fDRC^P_{T,ij} \quad (11)$$

Usually, costs will be higher when risks are considered because of the surplus of risk costs. That means that if prices remain the same, the profit margin is shrinking. For this, instead of the classic cost price $s^P_{T,i}$ the cost price under risk $s^P_{T,i} + rs^P_{T,i}$ should be used as bottom price because the risk cost price comprises the averaged cost deviations that result from risks. These cost deviations will quite likely occur in the planning period so that prices below $s^P_{T,i} + rs^P_{T,i}$ mean that the costs of the cost unit will not be covered at an averaged occurrence of risks.

Beside variable (risk) costs also fixed direct (risk) costs should be taken into account. While the (risk) cost price tells what price to claim for each additional unit, the (risk) cost price with fixed direct (risk) costs tells what price to claim when the product is produced for the first time in the planning period assuming that the fixed costs are periodically degradable. Thus, the fixed (risk) costs must be made proportional to the planned sales volume $sv^P_{T,i}$. Let F be the number of different fixed direct costs. Then, the classic proportionalized direct costs $pfDC^P_{T,i}$ are calculated as follows:

$$\mathrm{pfDC}^{\mathrm{P}}_{\mathrm{T,i}} = \sum_{\mathrm{j=1}}^{\mathrm{F}} \mathrm{DirectFixedCosts}^{\mathrm{P}}_{\mathrm{T,i,j}} / \mathrm{sv}^{\mathrm{P}}_{\mathrm{T,i}} \tag{12}$$

The fixed direct risk costs can be made proportional in the same way using the sales volume under risk. But note that the denominator is different then. In comparison to the proportionalized direct fixed risk costs, the classic one distributes the fixed costs among a bigger quantity. That means that the proportionalized direct fixed risk costs are not the risk value of the classic proportionalized direct fixed costs. Therefore, the risk costs that are allocated to the sales volume under risk have to be considered in the calculation:

$$\mathrm{pfDRC}^{\mathrm{P}}_{\mathrm{T,i}} = \left(\sum_{\mathrm{j=1}}^{\mathrm{F}} \mathrm{R}^{\mathrm{P}}_{\mathrm{T}}(\mathrm{DirectFixedCosts}^{\mathrm{P}}_{\mathrm{T,i,j}}) - \mathrm{R}^{\mathrm{P}}_{\mathrm{T}}(\mathrm{sv}^{\mathrm{P}}_{\mathrm{T,i}}) \cdot \mathrm{pfDC}^{\mathrm{P}}_{\mathrm{T,i}} \right) / \left(\mathrm{sv}^{\mathrm{P}}_{\mathrm{T,i}} + \mathrm{R}^{\mathrm{P}}_{\mathrm{T}}(\mathrm{sv}^{\mathrm{P}}_{\mathrm{T,i}}) \right) \tag{13}$$

Then, we get four kinds of bottom prices: The lowest one remains the cost price $\mathrm{s}^{\mathrm{P}}_{\mathrm{T,i}}$. Above this, the next bottom price is the cost price under risk $\mathrm{s}^{\mathrm{P}}_{\mathrm{T,i}} + \mathrm{rs}^{\mathrm{P}}_{\mathrm{T,i}}$. These are the costs that will quite likely be realized during the planning period so that this bottom price is much more realistic. In order to consider also the fixed direct costs, the proportionalized fixed direct costs $\mathrm{pfDC}^{\mathrm{P}}_{\mathrm{T,i}}$ are the next bottom price. The last bottom price are the proportionalized direct fixed risk costs $\mathrm{pfDRC}^{\mathrm{P}}_{\mathrm{T,i}}$ that takes all direct costs and direct risk costs into account. For sure, these bottom prices can be undercut in the case of price war or below capacity employment. But a permanent lower price than the cost price under risk is dangerous because then the variable costs that will be realized with quite high probability cannot be covered during the period.

5 Example

In this section, the risk cost accounting is illustrated by an example for each calculation. A Cloud Service Provider provides a computing service with the help of 100 computers running 24/7. Energy production is in-house as well as maintenance. The first calculation is the (risk) cost center accounting for the cost center "Maintenance & Repair". On the left side of Fig. 2 we can see the classic cost center accounting.

The right side depicts the risk cost center accounting. The column "Risk" contains the risk value of each parameter that can be found in the first column. The wages are subject to a price risk with a risk value of 2 monetary units (MU) but not to a quantity risk. Concerning the overtime, there is a risk of 90 additional hours. The operating/auxiliary material is subject to all types of risk: Price risk of 6 MU, quantity risk of 12 kg and quality risk of a 10% lower quality. The cost center uses electricity produced by cost center Power. This cost center has a risk adjusted calculation rate of 0.05 so that there is a price risk accordingly. Beyond that, there is a quantity risk of 500 kWh needed additionally. Summing all up, we get a classic calculation rate of 61.10 MU and a risk adjusted calculation rate of 2.69 MU in addition. This risk adjusted

Classic cost center accounting							Risk cost center accounting								
Maintenance & Repair							**Maintenance & Repair**			**Allocation base**		8760.00 h			
Allocation base		8760 h								**Risk type**	**Plan**	**Risk**	**Total**	**Variable**	**Fixed**
		Quantity	**Price**	**Total**	**Variable**	**Fixed**									
Employees							Employees								
Wages	h	8760	55.00	**481,800.00**	481,800.00	0.00	Wages	h	Price	55.00	2.00	**17,520.00**	17,520.00	0.00
	variable	8760							Quantity	8,760	0.00	**0.00**		
	fix	0.00							variable	8,760	0.00		0.00	
									fixed	0.00	0.00			0.00
									Price/Quantity			**0.00**	0.00	0.00
Overtime	h	920.00	55.00	**50,600.00**	50,600.00	0.00	Overtime	h	Price	55.00	0.00	**0.00**	0.00	0.00
	variable	920.00							Quantity	920.00	90.00	**4,950.00**		
	fix	0.00							variable	920.00	90.00		4,950.00	
									fixed	0.00	0.00			0.00
									Price/Quantity			**0.00**	0.00	0.00
Operating/Auxiliary material							Operating/Auxiliary material								
Lubricants	kg	100.00	35.00	**3,500.00**	2,625.00	875.00	Lubricants	kg	Price	35.00	6.00	**600.00**	450.00	150.00
	variable	75.00							Quantity	100.00	12.00	**420.00**		
	fix	25.00							variable	75.00	2.00		70.00	
									fixed	25.00	10.00			350.00
									Quality	1.00	0.10	**388.89**		
									variable		8.33		291.67	
									fixed		2.78			97.22
									Price/Quantity			**72.00**	12.00	60.00
									Price/Quality			**66.67**	50.00	16.67
Subtotal				**535,900.00**	535,025.00	875.00	Subtotal					**24,017.56**	23,343.67	673.89
Power							Power								
Electricity	kWh	4,000.00	0.2370	**948.00**	237.00	711.00	Electricity	kWh	Price	0.2370	0.0500	**200.00**	50.00	150.00
	variable	1,000.00							Quantity	4,000.00	500.00	**118.50**		
	fix	3,000.00							variable	1000.00	500.00		118.50	
									fixed	3000.00	0.00			0.00
									Price/Quantity			**25.00**	25.00	0.00
Total				**536,848.00**	**535,262.00**	**1,586.00**	**Total**					**24,361.06**	**23,537.17**	**823.89**
Calculation Rate					**61.10**		**Risk adjusted calculation rate**						**2.69**		

Fig. 2. Classic and risk cost center accounting for cost center maintenance and repair.

Classic cost-unit accounting							Risk cost-unit accounting								
Computing Service							**Computing Service**								
Planned output		876,000 h					**Planned output**		876,000 h						
ME		**Quantity**	**Price**	**Total**	**Variable**	**Fixed**			**Risk type**	**Plan**	**Risk**	**Total**	**Variable**	**Fixed**
Operating Material							Operating Material								
Prod. Coeff.		0.400					Prod. Coeff.		Quantity	0.400	0.075			
Energy	kWh	350,400	0.237	**83,044.80**	83,044.80	0.00	Energy	kWh						
									Price	0.237	0.050	**17,520.00**	17,520.00	0.00
									Quantity	350,400	65,700.00	**15,570.90**	15,570.90	0.00
									Price/Quantity			**3,285.00**	3,285.00	0.00
Cooling	kWh	321,408	0.24	**76,173.70**	0.00	76,173.70	Cooling	piece	Price	0.24	0.05	**16,070.40**	0.00	16,070.40
Total				**159,218.50**	**83,044.80**	**76,173.70**	**Total**					**52,446.30**	**36,375.90**	**16,070.40**
Direct costs					0.09480		Direct risk costs						0.04153	
Computing center overhead costs					0.05000		Computing center overhead costs						0.03000	
Costs of service provided					**0.14480**		**Costs of service provided**						**0.07153**	
Administration overhead costs				1.78%	0.00258		Administration overhead risk costs					0.20%		
							on costs of services provided					0.1448	0.00028	
							on risk costs of services provided					0.0715	0.00014	
Cost price					**0.14738**		**Cost price under risk**						**0.07195**	

Fig. 3. Classic and risk cost-unit accounting for the service computing.

calculation rate is then used as a price risk in other risk cost centers like Power or the Computing center that make use of cost center Maintenance & Repair.

The (risk) cost-unit accounting calculates the cost price of a service. The pricing of the computing service is based on hours. The calculation of the direct costs resembles the one of the (risk) cost center accounting (see Fig. 3). Overhead costs for the cost center that generates the service (here: computing center) are added to the direct costs. Administrative overhead costs calculated within the (risk) cost center accounting for the cost center Administration are added on a percental basis (1.78% and 0.20%).

Using the fixed direct (risk) costs in addition to cost prices and their risk values, four bottom prices can be calculated. The lowest bottom price is the classic cost price of 0.147 MU per h (see Fig. 4). If the selling price is lower, the firm incurs losses. But

	Computing Service		
	classic	Risk value	under risk
Planned volume	876,000.00	-52,560.00	823,440.00
Planned price	0.490	-0.050	0.440
Cost price	**0.147**	**0.072**	**0.219**
Profit margin I	0.343	0.122	0.221
Fixed Direct costs	76,173.70	16,070.40	92,244.10
Proportional	0.087	0.025	0.112
Bottom price	**0.234**	**0.097**	**0.331**
Profit margin II	0.256	0.147	0.109

Fig. 4. Classic and risk cost price and bottom prices for the service computing.

even if the selling price is below 0.219 MU (the second bottom price), the probability of losses is high because this bottom price comprises the quite probable risk that will occur in the planning period. The last two bottom prices of 0.234 MU and 0.331 MU under risk also consider the fixed costs. Usually, the selling prices should be greater than the last bottom price under risk because only then all probable risks are covered.

6 Conclusion

The MCA is the most important IS of an enterprise. It provides a detailed overview about the costly structure of all business areas. The only deficit is that it does not handle risks and risk costs in detail, only averaged costs of several periods are considered by imputed risks. Therefore, this paper extended the classic cost accounting with a risk cost accounting. This new accounting system provides a detailed view about a firm's risk situation. The risk situation of cost centers as well as the risk contribution of cost-units can be analyzed in detail. The integration into existing IS can easily be done because the risk cost accounting is designed as a sample accounting that can be done alongside. If the risk accounting is introduced in a firm, it is only necessary to determine the risk values of different cost parameters. The calculation itself can be done automatically.

Further research must be done concerning the risk values themselves. It is evident to calculate them. But the calculation is also difficult. Risks and risk measures are embedded in a highly complex risk cause and effect network that influences the risk values. One change in this network can affect several other risks and therefore different parameters. What is needed is an additional IS with which such a risk cause effect chain can be stored, analyzed and risk values calculated.

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