A Model for Quantifying Impacts of Supply Chain Cost and Working Capital on the Company Value

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Abstract. Supply Chain Management (SCM) is identified and accepted as a competitive advantage. Nevertheless holistic approaches for value-based SCM to leverage this advantage in a value adding way are missing so far. Efficient approaches to quantify and compare value contributions from Supply Chain (SC) value drivers are needed. This paper contributes to this need by proposing a model to efficiently quantify and compare value contributions from SC cost and working capital, that affect the profitability and asset performance. Properties and characteristics of the model, which is based on the Discounted Cash Flow concept, are illustrated by an industrial example of a single company. In this example, the relevance of timing and continuity of developments of SC cost and working capital for value creation is pointed out.

Keywords: supply chain management, supply chain cost, working capital, value-based management, discounted cash flow.

1 Introduction

Supply Chain Management (SCM) has become a competitive advantage for companies from various industries (Mentzer et al. [20], Christopher [2]), and competitive advantage is even considered as a defining characteristic of SCM (Handfield and Nichols [10]). Supply Chain (SC) performance improvements (Shepherd and Günter [28]) are initiated to increase this advantage. Improvements focusing on financial SC value drivers most often show conflicting effects on cost and capital respectively: methods to improve working capital components (inventory, trade payables, trade receivables) for instance often result in cost increases (e.g. negative effects on cash discount or production cost) and hence reduce the profitability, measured by e.g. earnings before interest and taxes (EBIT). One key question is how value contributions from SC value drivers can be quantified efficiently and how financial comparability of EBIT relevant changes of SC cost and asset relevant changes of working capital can be ensured.

To answer this question, a model based on a Discounted Cash Flow (DCF) approach is suggested to quantify value contributions generated by reductions

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of those two SC value drivers by one aggregated figure. The conceptual elements are described in section 2. Section 3 introduces the quantification model, which is illustrated and discussed based on an industrial example given in section 4. The paper concludes with summarized findings and future prospects for research in section 5.

2 Conceptual Elements

Value-Based Supply Chain Management. The idea of value-based management (VBM) is strongly linked to the term shareholder value, which stipulates all parts of a company to be managed in such a way that the equity value is sustainably increased (Rappaport [23]). Different valuation approaches, such as Economic Value Added (EVA) (Stewart [30]), Cash Flow Return on Investment (CFROI) (Madden [18]), Cash Value Added (CVA) (Ottosson and Weissenrieder [21]), Earned Economic Income (Grinyer [9]), have been developed and increased the popularity of VBM in academic science and managerial practice (Damodaran [7], Copeland et al. [6], Malmi and Ikäheimo [19], de Wet [31]). One well known valuation approach is the Discounted Cash Flow (DCF) model, which is broadly accepted in academic research (Hawawini and Viallet [11], Ross et al. [25], Weber et al. [33]) and often applied industrial practice (Geginat et al. [8]).

Existing literature emphasizes that the question of value-based SCM is of considerable interest for academic research for the last ten years. A thorough literature review would exceed the extent of this paper. Hence, a survey on selective literature indicating the heterogeneity of approaches and concepts for value-based SCM is depicted in Table 1. Value-based SCM concepts vary from functional or company specific perspective to network considerations. Core concepts and identified drivers for value-based SCM, which is most often linked to shareholder value and EVA, range from single functions, operational SC activities and processes to SC strategy. Empirical aspects are reflected differently - some rather theoretical papers give few references to industrial examples, some papers comprise case studies from one or few companies, some papers extensively evaluate several hundreds of observations.

Although it is taken for granted that SCM influences the cash flow and hence the shareholder value of a company (Christopher and Ryals [3], p. 5-7; Hendricks and Singhal [12], p. 503), value-based SCM approaches based on DCF models are found rather seldom. Furthermore little evidence exists that effective SCM is linked to shareholder value creation (Hendricks and Singhal [12], p. 502). Besides, future prospects in research address the need of cost effective ways to measure shareholder value impacts (Lambert and Burduroglu [15]) and the improvements regarding data used for evaluation (Hofmann and Locker [14]).

This paper contributes to these gaps and future prospects in academic research on value-based SCM. An approach is proposed which links SC cost and working capital to the company value. A simple quantification model based on DCF allows for measuring shareholder value impacts of those two SC value drivers in a simple and efficient way by using published data. The approach is illustrated by a company example from Fast Moving Consumer Goods (FMCG) industry.

Table 1. Value based SCM in selected research papers

Paper	SCM approach	VBM approach	Concept, value driver	Empirical aspects
Christopher and Ryals [3] (1999)	network of linked companies with internal processes and interfaces to suppliers and customers	shareholder value, mainly EVA	SCM affects four drivers of shareholder value (revenue, cost, fixed capital, working capital)	12 observations from industrial or consulting practice
Lambert and Burduroglu [15] (2000)	functional (logistics)	different approaches, shareholder value as most comprehensive	logistics influence on revenue, cost, fixed capital, working capital	none
Lambert and Pohlen [16] (2001)	integration of 8 key processes across companies to add value for customers and stakeholders	shareholder value, EVA	map 8 key processes to shareholder value	none
Hendricks and Singhal [12] (2003)	company-internal supply chain	market value of a firm (stock price)	examine impacts of production or shipment delays on stock price; SC strategy is linked to cash flow, earnings and assets	519 observations from industrial practice
Sridharan et al. [29] (2005)	functional (IT for SCM)	market value of a firm (stock price)	examine effects from implementation of IT for SCM on the market value of a firm	three company case studies
Hofmann and Locker [14] (2009)	inter-organizational management of flows of goods and information to ensure performance and customer achievements	shareholder value, EVA	SCM processes linked to EVA categories via KPI	case study from packaging industry

SC Cost. Research in SC cost management ranges from concepts, instruments and models (see e.g. Seuring and Goldbach [27]) to the link to other conceptual approaches, e.g. value based pricing (Christopher and Gattorna [4]) or logistics cost management (Suang and Wang [32]). SC cost comprise cost of goods sold (COGS), which reflect the direct cost and overhead associated with the physical production of products for sale (Poston and Grabinski [22]), and logistics cost for transportation, distribution logistics, inventory carrying and administration (Cohen and Roussel [5]):

$$SC\ cost = COGS + Logistics\ cost\ . \tag{1}$$

Furthermore, SC risks have a considerable influence on SC cost and SC performance (Winkler and Kaluza [34], Ritchie and Brindley [24], Lee [17]).

Working Capital. SC strategy and logistics management are linked to requirements of working capital (Christopher [2]), which has a strong influence on the liquidity position and the economic value of a company (Schilling [26]). In some definitions working capital comprises other components such as cash, prepaid expenses, accrued expenses (see e.g. Ross et al. [25] p. 176 or Hawawini and Viallet [11] p. 73). For simplicity reasons, these components are neglected in the working capital definition applied this paper. Working capital is defined as the sum of inventories and trade receivables reduced by trade payables (Brealey et al. [1] p. 145):

$$Working\ capital = Inventory + Trade\ receivables - Trade\ payables\ . \tag{2}$$

3 The Quantification Model

The DCF method, which is introduced thoroughly by e.g. Hawawini and Viallet [11] or Ross et al. [25], is the basis for the proposed quantification model. DCF determines the company value V, which is generated during time periods $p = 1, \ldots, P$, by the sum of the discounted free cash flows FCF_p:

$$V = \sum_{p=0}^{p} \frac{FCF_p}{(1 + WACC)^p}\ . \tag{3}$$

The free cash flow FCF is defined as difference between EBIT and expenses for tax, depreciation and net capital adjusted for working capital changes (Hawawini and Viallet [11] p. 399):

$$\begin{aligned} FCF = {} & EBIT - Tax\ expenses + Depreciation\ expenses \\ & - Net\ capital\ expenditures - \Delta\ Working\ capital\ . \end{aligned} \tag{4}$$

The free cash flow of each period is discounted by the weighted average cost of capital ($WACC$), which represents the minimum rate of return that must be generated in order to meet the return expectations of shareholders (Hawawini and Viallet [11] p. 329).

The key question is how to quantify value contributions that arise from changes of working capital or SC cost over a defined period of time periods $p = 1, \ldots, P$. As we see from formula 4, changes of working capital as well as EBIT relevant changes of supply chain cost affect the FCF and thus contribute to the company value. Therefore the value contribution VA^{WC} or VA^{SCC} generated by the respective value drivers over a time horizon of periods $p = 1, \ldots, P$ is the sum of the value contributions, or precisely value contributing FCF effects, VA_p^{WC} or VA_p^{SCC} of each period discounted by $WACC$:

$$VA^{WC} = \sum_{p=0}^{p} \frac{VA_p^{WC}}{(1 + WACC)^p} \ . \tag{5}$$

$$VA^{SCC} = \sum_{p=0}^{p} \frac{VA_p^{SCC}}{(1 + WACC)^p} \ . \tag{6}$$

To quantify those value contributions of each period, the respective FCF effects are calculated under consideration of three propositions:

1. In case that the development of a SC value driver (working capital or SC cost) is proportionate to sales development, the resulting value contribution is credited against sales development. Only in case that a SC value driver develops disproportionate to sales, the resulting value contribution is credited against the respective SC value driver.
2. Changes in working capital are one-time effects and thus result in a value contribution in only one period.
3. Changes of SC cost are recurring effects and thus result in value contributions in all subsequent period.

The first proposition is illustrated in Fig. 1 based on the example of working capital development.

To realize the second proposition, the value contribution VA_p^{WC} arising from working capital development in a time period p is defined by the difference of working capital WC_p at the end of period p and working capital WC_{p-1} at the beginning of period p adjusted for sales development $\frac{S_{p-1}}{S_p}$ in period p:

$$VA_p^{WC} = WC_{p-1} - \frac{S_{p-1}}{S_p} \cdot WC_p \ . \tag{7}$$

Similar approaches apply to quantify effects from supply chain cost under consideration of the third proposition. The value contribution arising from changes of SC cost SCC_p in a period p is defined by the difference of SC cost SCC_0 of period 0 and SC cost SCC_p of period p adjusted for sales development $\frac{S_0}{S_p}$ and tax rate T:

$$VA_p^{SCC} = (SCC_0 - \frac{S_0}{S_p} \cdot SCC_p) \cdot (1 - T) \ . \tag{8}$$

Illustrative example[1]:

[1] Note: In this paper, all figures are rounded to maximum one decimal digit.

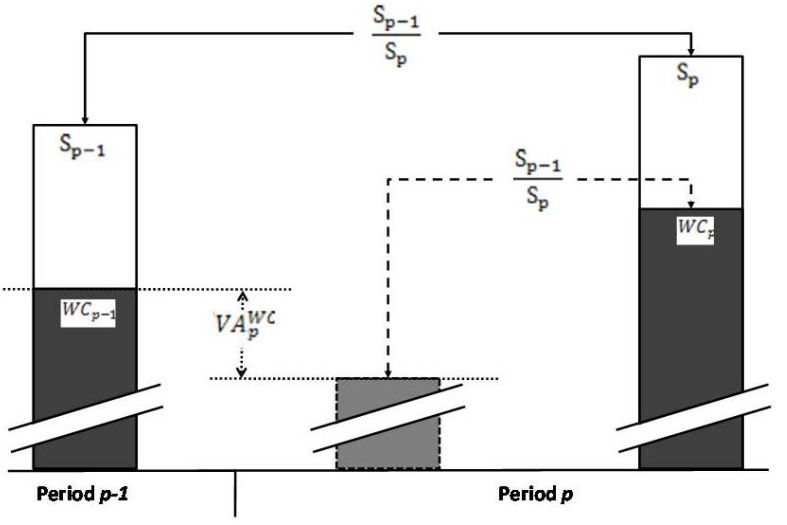

Fig. 1. Value contribution from a disproportionate working capital development

Let a fictitious company of 10,000 m EUR sales have a working capital of 1,600 m EUR and SC cost of 7,000 m EUR at a WACC of 10.0% and tax rate of 35.0%. Two example cases A and B are considered for developments of working capital and SC cost, each case split in two scenarios for sales development (with constant sales and with growing sales).

Case A: The developments of the two SC value drivers, working capital and SC cost, are proportionate to the sales development. Therefore they do not result in value contribution which is credited against those value drivers, although in scenario 2 the absolute figures for both SC value drivers grow (as required by proposition 1).

Case B: A value adding disproportionate working capital development in period p=1 is saved in period p=2 without additional value contribution (as required by proposition 2). The disproportionate development of SC cost in period p=1 results in value contributions in both periods p=1 and p=2 (as required by proposition 3).

Table 2 depicts the results of the model for this example.

4 Illustration Example from Industry

To illustrate and discuss the proposed quantification model, its properties and functionality are shown based on an example of a single company. Henkel KGaA from FMCG industry is selected as example case, because all required data is published in the annual reports [13] of this company: Working capital figures were

Table 2. Example for quantification of value contribution

			Constant sales			Growing sales		
	p		0	1	2	0	1	2
	S_p	m EUR	10,000	10,000	10,000	10,000	20,000	30,000
Case A	WC_p	m EUR	1,600	1,600	1,600	1,600	3,200	4,800
	VA_p^{WC}	m EUR	-	0	0	-	0	0
	VA^{WC}	m EUR	-	0	0	-	0	0
	SCC_p	m EUR	7,000	7,000	7,000	7,000	14,000	21,000
	VA_p^{SCC}	m EUR	-	0	0	-	0	0
	VA^{SCC}	m EUR	-	0	0	-	0	0
Case B	WC_p	m EUR	1,600	1,500	1,500	1,600	3,000	4,500
	VA_p^{WC}	m EUR	-	+100.0	0	-	+100.0	0
	VA^{WC}	m EUR	-	+90.9	+90.9	-	+90.9	+90.9
	SCC_p	m EUR	7,000	6,900	6,900	7,000	13,800	20,700
	VA_p^{SCC}	m EUR	-	+65.0	+65.0	-	+65.0	+65.0
	VA^{SCC}	m EUR	-	+59.1	+112.8	-	+59.1	+112.8

Table 3. Industrial example from Henkel KGaA

p	UOM	2003	2004	2005	2006	2007	2008
S_p*	m EUR	9,436	10,592	11,974	12,740	13,074	14,131
SCC_p*	m EUR	4,965	5,615	6,533	6,963	7,013	8,190
WC_p*	m EUR	1,845	1,840	1,693	1,699	1,500	1,651
Inventory*	m EUR	1,053	1,196	1,232	1,325	1,283	1,482
Receivables*	m EUR	1,581	1,743	1,794	1,868	1,694	1,847
Payables*	m EUR	789	1,099	1,333	1,494	1,477	1,678
$WACC$*	%	8.0	7.0	7.0	7.0	7.0	7.5
T*	%	35.0	35.0	35.0	30.0	30.0	30.0
VA_p^{SCC}**	m EUR	-	-24	-119	-135	-68	-353
VA^{SCC}**	m EUR	-	-23	-127	-236	-288	-534
VA_p^{WC}**	m EUR	-	206	342	96	237	-28
VA^{WC}**	m EUR	-	192	491	570	751	732
VA^{Total}	m EUR	-	170	365	333	463	198

* source: annual report of respective period

** calculated with described formulas

calculated from balance sheet data, for simplicity reasons SC cost are limited to cost of goods sold (COGS) figures taken from P&L statements, figures for tax rate and $WACC$ are published in the respective annual reports, too. The input data and results of the quantification model are depicted in Table 3.

The total value contribution VA^{Total}, i.e. the sum of value contributions VA^{WC} and VA^{SCC} from each SC value driver, is positive. Hence, SCM at Henkel KGaA added value to the company. Two other observations of this case can easily be made and examined further by a root cause analysis and a simulation scenario:

Table 4. SC cost and working capital ratios at Henkel KGaA

p	UOM	2003	2004	2005	2006	2007	2008
SC cost ratio	%	52.6	53.0	54.6	54.7	53.6	58.0
Working capital ratio	%	19.6	17.4	14.1	13.3	11.5	11.7

1. In no period of time, any value was generated by SC cost.
2. Value was generated by working capital in each period of time except in 2008.

Analyzing the developments of SC cost ratio, i.e. SC cost in % of sales, and working capital ratio, i.e. working capital in % of sales, helps explaining why value was added or lost by the developments of those value drivers (Table 4).

The SC cost ratio shows a continuous and deteriorating trend, the level of 52.6% in 2003 was never achieved in the subsequent periods 2004-2008. Hence no value was added from SC cost. The working capital ratio on the contrary develops continuously and significantly improving between 2003 and 2007, this achieved decline significantly adds value. A comparably small increase of working capital ratio in 2008 does not substantially influence the value contribution achieved so far.

A simulation scenario derived from this example case helps illustrating and discussing value adding developments of SC value drivers. This simulation scenario answers the question how SC cost should have developed in 2007 and 2008 to avoid the value loss of -534 m EUR. Similar approaches are possible for working capital. Based on defined target value contributions va_p^{SCC} for 2007 and 2008, the figures of target SC cost scc_p which are needed to achieve those value contributions can be calculated by rearranging formula 8:

$$scc_p = \frac{S_p}{S_0} \cdot (SCC_0 - va_p^{SCC} \cdot (1 - T)^{-1}) \ . \tag{9}$$

By 2006 a value contribution of -236 m EUR from SC cost was achieved, hence this value loss would be compensated by achieving +118 m EUR value contribution from SC cost in each of the last two periods. Applying formula 9, the required target SC cost scc_p can be calculated to obtain the simulation scenario depicted in Table 5 (figures obtained from simulation depicted in *italics*).

The example case and the derived simulation scenario illustrate important characteristics of value-adding SC value driver developments:

1. Continuous improvements and sustainable developments of SC value drivers foster value creation: Alternating improvements and deteriorations in SC value driver developments cannot guarantee overall value achievements.
   Proof from example case: Although in 2007 the SC cost improved slightly compared to 2006, this improvement was not sufficient to compensate losses from earlier periods. Furthermore the improvement was not strong enough to achieve the SC cost ratio from 2003 and hence did not add any value.
2. Timing aspects have to be considered: Improvements of SC value drivers achieved in later phases cannot guarantee to fully compensate deteriorations from earlier phases.

Table 5. Results of the simulation scenario for SC cost

p	UOM	2003	2004	2005	2006	2007	2008
S_p	m EUR	9,436	10,592	11,974	12,740	13,074	14,131
SCC_p	m EUR	4,965	5,615	6,533	6,963	*6,572*	*7,072*
VA_p^{SCC}	m EUR	-	-24	-119	-135	*155*	*170*
VA^{SCC}	m EUR	-	-23	-127	-236	*-118*	-
SC cost ratio	%	52.6	53.0	54.6	54.7	*50.3*	*50.0*

Proof from simulation scenario: The deterioration of SC cost in early periods 2003-2006 (SC cost ratio in 2006 deteriorated vs. 2003 by 2.1pp) can only be compensated by an disproportionately high reduction in the late periods 2007 and 2008 (SC cost ratio improvement vs. 2003 by 2.6pp in 2008 needed to compensate value losses from earlier periods).

5 Conclusion

This paper contributes to the development of frameworks and approaches to value-based SCM. A model is proposed to quantify impacts of SC cost and working capital on shareholder value. This model is mathematically derived from the DCF model and hence proofs the link between SC value drivers and shareholder value. The financial comparability of EBIT relevant changes of SC cost and asset relevant changes of working capital by one aggregated figure is ensured. An example of a company from FMCG industry illustrates how to use published data to efficiently measure shareholder value impacts of SC value drivers.

Further research opportunities are offered by the possibility to extend the empirical evaluations to other companies or industries. Furthermore the model can be applied or extended to evaluate specific SC value driver components. The performance of the working capital components inventory, trade receivables and trade payables as well as the value contributions of function-specific cost, e.g. for material acquisition or production, can be analyzed. Besides, the model can be extended to other financial SC value drivers, such as fixed asset performance. The context of SC risk management and value creation allows further research, especially regarding influences of SC risks on SC cost or WACC. Beyond this, a holistic value-based SCM concept must consider non-financial value drivers, such as SC risk, intangibles or intellectual capital, and inter-company aspects to reflect the network approach of SCM.

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