

## 2 Working capital management: a review of performance measurement and its drivers

### 2.1 Introduction

Researchers in the field of corporate finance have traditionally focused on long-term financial decisions. Pioneering and widely accepted research has been conducted in areas such as investment decisions<sup>7</sup>, firms' capital structure and business valuations.<sup>8</sup> At the same time, however, academic literature has neglected the management of current assets and liabilities, a concept subsumed under the term working capital management (WCM). There are various reasons why WCM attracts only peripheral interest. First, working capital decisions occur frequently in the course of the daily business routine. Second, despite the fact that 37% of all funds invested by manufacturing corporations in the U.S. were tied up in short-term assets, the individual impact of working capital decisions is only marginal.<sup>9</sup> Third, short-term financial decisions are typically reversible over time.<sup>10</sup> Notwithstanding, the number of publications and new concepts in this area has lately increased as many managers focus on working capital as a way to access liquidity.

The purpose of this literature review is to describe working capital concepts, to outline existing WCM performance measurement concepts and to identify value drivers that have been identified, analyzed, and tested. One fundamental change has taken place with regard to performance measurement: WCM is no longer seen as a discipline whose principal aim is to maintain sufficient liquidity in the event of liquidation. Rather, its purpose is now to underpin a company's operating cycle.<sup>11</sup> Both views and the corresponding measurements are elaborated herein. The shift toward a focus on the operating cycle has highlighted WCM as a key success factor for a firm's profitability. This thesis has been substantiated in numerous empirical studies. Since the positive impact of WCM on firm profitability has been substantiated in various empirical studies, several researchers have recently investigated potential drivers of WCM performance that potentially boost firm performance. Based on data available in the public sectors, a large quantity of drivers, including operational cash flow, firm size and sales growth, have been identified and tested. Up to now, however, three related

---

<sup>7</sup> Trossmann/Werkmeister (2001), p. 1-235.

<sup>8</sup> Nazir/Afza (2009), p. 19.

<sup>9</sup> Hill/Sartoris (1988), p. 9.

<sup>10</sup> Gentry/Mehta/Bhattacharyya/Cobbaut/Scaringella (1979), p. 28,

Richards/Laughlin (1980), p. 32.

<sup>11</sup> Fess (1966), p. 266.

operational research areas – manufacturing performance, supply chain performance and supply chain risk – have, to the knowledge of the author, not yet been included in these considerations. Nor were these research areas ever integrated to form additional value drivers, despite the fact that researchers in these areas confirmed a genuine link to WCM. Schonberger states that one fundamental objective of world class manufacturing performance is to "cut flow time, flow distance, inventory, and space along the chain of customers".<sup>12</sup> However, research in the field of manufacturing performance and financial performance is almost solely limited to product cost modeling.<sup>13</sup> Regarding supply chain risk, Jüttner notes that "[...] supply chain control mechanisms like decision rules and policies regarding order quantities, batch sizes and safety stocks can either amplify or absorb risk effects".<sup>14</sup> Scherr (1989) adds that "one of the major features of this world is uncertainty (risk), and it is this feature that gives rise to many of the strategies involving working capital accounts".<sup>15</sup> These remarks give clear indication that a genuine link of the research areas manufacturing performance, supply chain performance, supply chain risk and working capital management prevails – Providing strong support to further investigate in their correlation.

First, the concept of working capital is being introduced in chapter 2.2. The theoretical basis selected for further modeling is the Configurational Theory, which is presented and linked to WCM in section 2.3. Section 2.4 explains how the sample literature was determined and what eligibility criteria were applied. In section 2.5. the literature on WCM, manufacturing performance, and supply chain risk is reviewed to provide a comprehensive summary of the existing literature. Existing literature on the correlation between WCM and both profitability and the underlying value drivers is shown in sections 2.5.1 to 2.5.2. A review of the related research areas supply chain risk, manufacturing performance and supply chain performance is provided in section 2.5.3. A summary and discussion of the results follows. The review ends with a discussion of the limitations of the methodologies applied and suggestions for potential future research directions.

---

<sup>12</sup> Schonberger (1990), p. 296.

<sup>13</sup> Malik/Sullivan (1995), p. 171.

<sup>14</sup> Jüttner (2005), p. 123.

<sup>15</sup> Scherr (1989), p. 3.

## **2.2 Introduction to the concept of working capital**

### **2.2.1 Evaluation of the working capital concept over time**

The concept of working capital was originally to ensure that obligations could be met in case the firm went into liquidation. Holding sufficient short-term assets guaranteed that the firm would be able to satisfy short-term creditors in the event of liquidation. Thus, the main objective was to control business in a way that short-term assets matched short-term liabilities.<sup>16</sup> In practice, a one-year period was used to distinguish between the short and long terms.

In the mid-20<sup>th</sup> century, the focus shifted towards a going-concern view of the firm. By consequence, the immediate liquidation of the firm was no longer of concern. This strategic shift in the basic view of the firm had material consequences for the concept of working capital. Since then, the new paradigm of working capital management has been to maintain the firm's operating cycle while seeking to maximize its profitability. The operating cycle consists of the whole sequence of cash flows generated by the physical activities of the firm's operations.<sup>17</sup> To illustrate a metaphorical expression might be helpful: Working capital management has to keep a certain level of water in the bathtub bearing in mind current and future water inflows and outflows. The purpose of keeping water in the bathtub is to serve as a buffer. Since the market is exposed to inefficiencies such as transaction costs, information costs, scheduling costs, production limitations, etc., firms must maintain a short-term asset buffer to accommodate existing uncertainties. In a perfect world, operations would be accurately predictable. Inflows and outflows of raw materials, goods or cash could thus be anticipated with such precision that buffers in terms of inventory or cash holdings would be superfluous. However, in a world of machine outages, late payments and order changes, inventories, cash holdings and receivables are indispensable.<sup>18</sup> Given these imponderables, a firm that is shy of sufficient liquid reserves may need to delay payments, obtain temporary financing on potentially unfavorable terms or even sell assets.<sup>19</sup> To avoid such costly actions that, if the worst comes to the worst, can have serious repercussions, reserves are maintained that can be liquidated at sight. As a consequence, the main reasons for maintaining positive working capital are unexpected events that could affect inflows or outflows of cash, raw

---

<sup>16</sup> Fess (1966), p. 266.

<sup>17</sup> Hill/Sartoris (1988), p. 7.

<sup>18</sup> Scherr (1989), p. 2-3.

<sup>19</sup> Emery (1984), p. 25.

materials, or goods.<sup>20</sup> Maintaining a buffer of short-term assets to safeguard the operating cycle is only one side of the coin, however. Since short-term assets are usually the firm's least profitable assets, the goal is to keep them as low as possible. Low net working capital serves in this context to boost firm performance and, ultimately, increases shareholder value.<sup>21</sup> As such, working capital management is expected to resolve the trade-off between maintaining the operating cycle and keeping the firm profitable. The key to successfully mastering this trade-off is to use advanced planning systems both to predict inflows and outflows and to assess the quality and robustness of these results. The design of financial and non-financial supply chains, however, also has a significant impact on the way in which disruptions affect the operating cycle.

Osisioma (1997) defines proper working capital management as "the regulation, adjustment, and control of the balance of current assets and current liabilities of a firm such that maturing obligations are met, and the fixed assets are properly serviced".<sup>22</sup> In line with this definition, desirable quantities of each component of working capital must be maintained for management purposes. Identifying the best possible capital structure is clearly a challenging task that is discussed in several academic papers.<sup>23</sup> An overview of different state-of-the-art approaches in working capital management is presented by Smith.<sup>24</sup> An empirical study by Sarantis demonstrates that a significant negative financial risk effect on borrowing and fixed investment has been shown by modeling of inter-related demand equations in the UK demand sector.<sup>25</sup> Contrary to the theorem introduced by Modigliani and Miller (1958), this provides evidence that an optimal capital structure does in fact exist.<sup>26</sup> In all neoclassical studies of investment behavior, the influence of financial policy on the investment is ignored.<sup>27</sup> However, it is obvious that the assumptions drawn in neoclassical theory do not hold under any reasonable assumptions about the market.<sup>28</sup> It therefore seems perfectly reasonable to discuss strategies to optimize working capital. Excess working capital does not earn the cost of capital. As a consequence, determining the optimal amount of WC maximizes shareholder value.

---

<sup>20</sup> Gentry/Mehta/Bhattacharyya/Cobbaut/Scaringella (1979), p. 29.

<sup>21</sup> Scherr (1989), p. 4 f.; Hachmeister (1997b), p. 826-827.

<sup>22</sup> cit. op. Appuhami (2008), p. 10.

<sup>23</sup> Ball/Brown (1969), p. 300.

<sup>24</sup> Smith (1973), p. 50-55.

<sup>25</sup> Sarantis (1980), p. 393.

<sup>26</sup> Modigliani/Miller (1958), p. 261-297; Myers (1984), p. 575.

<sup>27</sup> Sarantis (1980), p. 393.

<sup>28</sup> Borch (1969), p. 1.

One mature area of research is the financial planning and the evaluation of the optimal cash level.<sup>29</sup> Insights into the dynamic optimization of cash balances are provided by Eppen and Fama (1968, 1969).<sup>30</sup> Their optimization model focuses on the opportunity cost of cash balances, penalty costs for negative cash balances and transaction costs. Optimal cash management policies are likewise analyzed by Kallberg et al. (1982) and Kim et al. (1998), who focus on uncertainty.<sup>31</sup> Emery et al. (1982) model a firm's liquidity as a Wiener process to determine the likelihood of insolvency and provide a relative measure of liquidity. In their model, they used the mean and variance of net cash flow per unit of time, the initial liquid reserve, and the length of the period in units of time.<sup>32</sup> A study of the link between the capital structure of the firm and ruin is provided by Borch (1969).<sup>33</sup> In their deliberations, Bierman et al. (1975) include the contingency of ruin, but enlarge the model by defining earnings as a function of the level of working capital.<sup>34</sup> In the Bierman et al. (1975) model the level of inventories and credit policies has an effect on sales figures. Contrary to these optimization models, Knight (1972) advocates applying a simulation approach to summarize major policy alternatives. In his view, a traditional optimization model is not appropriate, since one basic assumption of the optimization model does not hold in this case. In practice, working capital decisions involve multiple objectives with numerous interdependencies, all of which are subject to uncertainties. However, optimization requires a single objective equation and an algorithm or systematic mathematical procedure to find a unique solution. Knight (1972) therefore proposes the simulation approach as a way to determine a satisfactory solution by running sensitivity and variance analyses.<sup>35</sup>

Evaluating the above models on how to define an adequate short-term capital structure raises the question whether certain other major factors of influence must also be taken into account. Besides factors such as ruin, uncertainty and the cost of holding cash, which we have already seen, it seems to be obvious that other internal and external key drivers of an optimal working capital structure also exist. With regard to internal factors, one would assume that a general correlation between short-term assets and fixed investments exists. The condition of fixed assets such as production equipment certainly has an impact on required working capital

---

<sup>29</sup> Trossmann (1990), p. 27-36.

<sup>30</sup> Eppen/Fama (1968), p. 94; Eppen/Fama (1969), p. 119.

<sup>31</sup> Kallberg/White/Ziemba (1982), p. 670-682; Kim/Mauer/Sherman (1998), p. 335.

<sup>32</sup> Emery/Cogger (1982), p. 290-303.

<sup>33</sup> Borch (1969), p. 1-13.

<sup>34</sup> Bierman/Chopra/Thomas (1975), p. 199-200.

<sup>35</sup> Knight (1972), p. 33.

levels. Firm characteristics such as size, growth rates, the products offered, or industry-specific criteria are likewise postulated to affect requirements for short-term assets.<sup>36</sup> In addition, external factors such as upstream and downstream supply chain characteristics and the habits of suppliers and customers can also drive working capital requirements. All in all, the assumption is that numerous factors actually influence working capital requirements.

Recently, a small number of empirical studies have investigated the potential drivers of working capital requirements. Literature also provides comprehensive studies of manufacturing performance, supply chain risk and supply chain performance as separate research areas. These papers on the drivers of working capital nevertheless fail to link working capital management to corporate performance. Instead, they focus on identifying significant drivers of reduced or increased working capital requirements. Given that working capital management should not only safeguard the operating cycle but also focus on profitability, this link is worthy of further investigation. Supporting this proposition is that the dependency between working capital levels and corporate performance has indeed been tested in numerous papers on the cash conversion cycle – albeit without addressing the issue of performance drivers.<sup>37</sup>

An exhaustive review of existing papers that establish a link between working capital levels and corporate performance, that test working capital drivers in and that explore the related research areas manufacturing performance, supply chain risk, and supply chain performance is provided in section 2.5, including a summary of the methodologies applied and the results achieved. The section that follows begins by outlining existing measures of working capital management.

---

<sup>36</sup> Horrigan (1965), p. 564-565.

<sup>37</sup> Kamath (1989), p. 27; Soenen (1993), p. 55-57; Jose/Lancaster/Stevens (1996), p. 33; Shin/Soenen (1998), p. 39-43; Wang (2002), p. 168; Deloof (2003), p. 585; Eljelly (2004), p. 59; Lazaridis/Tryfonidis (2006), p. 34.

### 2.2.2 Static and dynamic measurements

At the end of the nineteenth century, financial ratios with which to analyze financial statements were developed in the United States.<sup>38</sup> The main purpose was to devise tools that would enable short-term borrowing capacity to be judged. By the end of the 1920s, financial ratios had already become a common analytical device for many institutions and analysts.<sup>39</sup>

Traditional liquidity ratios of relevance to the financial position of the firm include the current ratio, the quick ratio and net working capital.<sup>40</sup> One modified version is the ratio of net working capital to current liabilities or total assets.<sup>41</sup> The current ratio is calculated by dividing current assets by current liabilities. Subtracting inventory from current assets and dividing the result by current liabilities defines the quick ratio.<sup>42</sup> Net working capital is defined as the net current assets position or the excess of current assets over current liabilities.<sup>43</sup> The ratio can be calculated by adding marketable securities, accounts receivable, and inventories and subtracting short-term borrowings, accounts payable, and short-term net accruals.<sup>44</sup> The traditional aim of these ratios is to serve as a liquidity indicator by matching short-term assets to short-term liabilities. One major deficiency of these traditional liquidity ratios, however, is "that they incorporate assets that are not readily convertible into cash and exclude the liquidity provided by potential sources of financing".<sup>45</sup> This deficiency is conditional on whether one is seeking to cover the possibility of liquidation or is focused on the going-concern value of the firm. It may indeed be impossible for a firm to quickly convert inventory or receivables to cash at the reported book values. From the going-concern perspective, a further shortcoming is apparent: Besides wanting to evaluate whether liquid assets cover short-term liabilities, an external observer also wants to distinguish between changes in the operating cycle and changes due to the financial strategy of the firm.<sup>46</sup> However, ratios such as net working capital do not allow for this distinction, since balance sheet items are mainly affected by the operating cycle and those affected by financial triggers are typically reported as aggregates. According to Shulman et al. (1965), these ratios "[...] disregard the effect of operating cycle changes on corporate liquidity and the impact of capital

---

<sup>38</sup> Horrigan (1965), p. 558.

<sup>39</sup> Horrigan (1965), p. 558.

<sup>40</sup> Bernstein (1993), p. 491.

<sup>41</sup> Emery (1984), p. 26.

<sup>42</sup> Kamath (1989), p. 28.

<sup>43</sup> Sagan (1955), p. 121.

<sup>44</sup> Hawawini/Viallet/Vora (1986), p. 15.

<sup>45</sup> Emery (1984), p. 26.

<sup>46</sup> Kaiser/Young (2009), p. 70.

changes on the operating cycle".<sup>47</sup> A company could thus decide to increase cash reserves based on planned investments and, in so doing, significantly change its reported liquidity ratios. Yet external observers would not be able to judge whether the increase results from changes in the operating cycle or from an adjusted financial strategy. Neither can analysts be sure whether the increase has affected liquid items on the balance sheet, as it could just as well be attributable to relatively illiquid positions such as receivables or inventory. It follows that inter-firm or inter-period comparisons are of limited value to the stakeholder, since the restructuring of asset categories is not transparent.<sup>48</sup>

To be able to distinguish between the operating cycle and changes in liquid assets Shulman et al. (1985) refined the net working capital (NWC) ratio by repackaging and redefining the elements into two separate components, working capital requirements (WCR) and the net liquid balance (NLB).<sup>49</sup> Subject to this alteration, WCR represents the operating cycle accounts and NWC the liquidity accounts.

---

<sup>47</sup> Shulman/Cox (1985), p. 64.

<sup>48</sup> Richards/Laughlin (1980), p. 33.

<sup>49</sup> Shulman/Cox (1985), p. 64.



The total of WCR plus NLB equals NWC:

$$NWC = WCR + NLB$$

where WCR is defined as:  $WCR = (AR + INV) - (AP + NA)$

With:

<i>AR</i>	Accounts receivable
<i>INV</i>	Inventories
<i>AP</i>	Accounts payable
<i>NA</i>	Net accruals

and NLB is defined as:

$$NLB = (C - STB)$$

With:

<i>C</i>	Cash
<i>STB</i>	Short-term borrowings

The reclassification of NWC as WCR and the NLB ensures a strict distinction between assets that are genuinely attributable to the operating cycle and decision variables that must be assigned to treasury management and strategy. The components of WCR represent all aspects of the operating cycle: procurement, production, and sales. In other words, WCR is the amount of money that is tied up in the operating cycle of a company. Most companies have positive WCR, indicating a conservative approach to working capital management. If WCR is positive, the excess amount must be funded by either free cash flow or debt. Aggressive working capital management may lead to negative WCR. In such cases, the operating cycle serves as a source of funding for other assets. Cash and short-term borrowings as components of the NLB are seen as financial decision variables with no strict correlation to operations. Cash levels and liquid securities can be adjusted with no direct impact on the operations of the firm.<sup>50</sup> Since the NLB comprises only of highly liquid assets, it serves as a measure of the

---

<sup>50</sup> Hawawini/Viallet/Vora (1986), p. 15.

firm's liquidity. If operational requirements change, the NLB is usually affected. An increase in accounts receivable or inventory is then accompanied by a decrease in the NLB to bridge the gap.<sup>51</sup> A decrease in the NLB can, however, be avoided if the company is able to successfully boost accounts payable at the same time. The concepts of WCR and the NLB have consequently been picked up by numerous authors. Especially in empirical studies, researchers such as Hill et al. (2010), Appuhami (2008), and Chiou et al. (2006) have used the classification introduced by Shulman et al. (1985) to measure working capital.<sup>52</sup>

The concept introduced by Shulman et al. (1985) may remedy the disadvantage of obscuring operational and financial views of net working capital as KPI. One fundamental drawback nevertheless remains: WCR and the NLB are static measurements that do not permit estimates of the future pattern or size of working capital. The power of a liquidity indicator to anticipate future prospects is key, if one views a firm under the premise of going concern.<sup>53</sup> Accordingly, many authors have questioned whether these ratios are indeed suitable tools with which to evaluate working capital management.<sup>54</sup> Emery (1984) gets to the heart of this criticism, noting that "[...] when these ratios are calculated from standard accounting statements, they may simply indicate the adequacy of the firm's liquidity reserves for the immediate past period rather than for some relevant future period".<sup>55</sup> As a consequence, "an examination of conventional, static balance sheet liquidity ratios indicates the inherent potential for misinterpreting a firm's relative liquidity position."<sup>56</sup> Based on these findings, the flow concept of liquidity began to edge out static concepts. In a seminal paper, Gitman (1974) presents a concept for calculating the minimum cash balance required by a firm by looking at the total cash cycle.<sup>57</sup> Gitman (1974) defines the total cash cycle as the number of days from the time the firm pays for its purchases of raw materials to the time the firm collects revenues from the sale of its finished products. Although Gitman (1974) himself later revised his initial approach, it was taken up, annotated and used for empirical studies by numerous other researchers.

---

<sup>51</sup> Shulman/Cox (1985), p. 65.

<sup>52</sup> Hill/Kelly/Highfield (2010), p. 784; Appuhami (2008), p. 8; Chiou/Cheng/Wu (2006), p. 149.

<sup>53</sup> Jose/Lancaster/Stevens (1996), p. 34; Bernstein (1993), p. 492.

<sup>54</sup> Hager (1976), p. 20-21.

<sup>55</sup> Emery (1984), p. 27.

<sup>56</sup> Richards/Laughlin (1980), p. 36.

<sup>57</sup> Gitman (1974), p. 82.

The concept of static ratios can be converted into a dynamic flow concept by setting the relevant balance sheet positions in relation to the corresponding income statement items.<sup>58</sup> By definition, the new measure takes into account that the appraisal of working capital accounts depends on operational performance in the form of procurement, production, and sales. Calculating turnover instead of using static ratios empowers analysts to evaluate the working capital account in relation to the underlying activity. The proportionality of resources used to performance achieved can thus be analyzed. The turnover in accounts receivable is the ratio of accounts receivable to sales. This measure indicates how fast a company's receivables are converted into cash on average. A company that generates high sales and has comparatively low accounts receivable is no doubt in a better position than a company that runs up relatively high accounts receivable. Changes in a company's operating policy are reflected in this measure, as looser credit policy or less effort to collect receivables will raise the accounts receivable turnover ratio.<sup>59</sup> If a company increases sales and at the same time keeps its accounts receivable constant, the improved situation can be evaluated by calculating the turnover ratio. However, relying on accounts receivable as a static ratio in the same situation would leave the improvement in performance invisible. Inventory turnover indicates the frequency with which companies turn over their raw materials inventory, work in progress, and finished goods. The ratio is calculated by dividing the total average amount of inventory by the cost of goods sold. Unlike to the accounts receivable turnover, the cost of goods sold is the denominator in this case. The reasoning is that profit margins, the cost of sales and financing costs would falsify the interpretation of inventory turnover. If sales were taken as the denominator, a company with above-average profit margins or non-representative financing costs could reduce turnover without improving actual inventory performance. The most appropriate basis is therefore the costs of goods sold, as this reflects the production value of semi-finished and finished goods as they enter the warehouse. However, one should not forget that a main driver of inventories is sales, which reflects the level of demand and thus implies a positive relation to the required inventory.<sup>60</sup> High inventory turnover implies that a company can get by with little inventory as it maintains production and sales. The fact that the company's inventory turns over rapidly implies that on average each item in the warehouse stays in stock only for a short time on average. High turnover ratios keep

---

<sup>58</sup> Jose/Lancaster/Stevens (1996), p. 34.

<sup>59</sup> Bernstein (1993), p. 493.

<sup>60</sup> Bernstein (1993), p. 493.

warehouse efficiency high, as costs per item turned over are relatively low. Changes in operations, such as an increase in the quantity of defective goods or a reduction in sales figures, will naturally impact the measure. Likewise, the quality of the turnover ratio outperforms the static one. If a company manages to increase production leading to an increase in the cost of goods sold while keeping inventory at the same level, efficiency would increase. However, this improvement would again not be shown in a static ratio, as the total inventory volume would remain unchanged. To complete the operating cycle, a firm's liabilities must be considered when evaluating its liquidity position. Here the relevant turnover ratio is the ratio of accounts payable to purchases. This ratio depicts the average rate at which the company pays for purchased services or goods. Longer payment terms improve a company's liquidity position, as delayed payment effectively translates into financing by the supplier. The resultant improvement in the financial position can then be used to finance assets.

The cash conversion cycle (CCC)<sup>61</sup> represents in this context an approach that combines the individual turnover ratios discussed above to form a single measure representing the entire operating cycle. The CCC reflects "the net time interval between actual cash expenditures on a firm's purchase of productive resources and the ultimate recovery of cash receipts from product sales, establishes the period of time required to convert a dollar of cash disbursement back into a dollar of cash inflow from a firm's regular course of operations".<sup>62</sup> Studies on the subject utilize numerous definitions of the CCC, ranging from general statements to detailed specifications.<sup>63</sup>

Notwithstanding, the detailed definition of the CCC is commonly accepted as:<sup>64</sup>

$$CCC = \frac{\text{Net accounts receivable} \times 365}{\text{Net sales}} + \frac{\text{Inventory} \times 365}{\text{Cost of goods sold}} - \frac{\text{Accounts payable} \times 365}{\text{Cost of goods sold}}$$

---

<sup>61</sup> Other authors used the term "cash-to-cash", "C2C", "cash gap" or "operating cash cycle" as synonyms. Please see Farris II/Hutchison (2002), Farris II/Hutchison (2003), Farris II/Hutchinson/Hasty (2005), Boer (1999), Churchill/Mullins (2001). For a detailed list of commonly used terms, see Uyar (2009), p. 187.

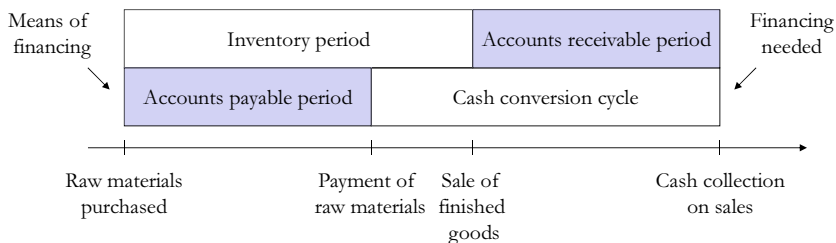
<sup>62</sup> Richards/Laughlin (1980), p. 34.

<sup>63</sup> Farris II/Hutchison (2002), p. 289.

<sup>64</sup> Keown/Martin/Petty (2011), p. 418.

The CCC depicts the average net time interval in days between the moment a firm has to pay for its purchases and the time the cash receipts are collected (figure 1).<sup>65</sup>

**Figure 1: Illustration of the cash conversion cycle<sup>66</sup>**



The figure for the CCC can be interpreted as the average number of days for which a company has to finance operating cycle requirements either through debt or equity.<sup>67</sup> Most companies have a positive CCC, indicating the need for financing for the operating cycle. The CCC may turn negative, however. In this case, accounts receivable are received prior to cash outflows to settle accounts payable.<sup>68</sup> In such a favorable situation, the company relies heavily on the financing by the supplier.<sup>69</sup> A low CCC indicates that a company manages its cash flows efficiently, as it generates more sales per unit of invested capital.<sup>70</sup> As the signs themselves indicate, an increase in net accounts receivable or the inventory ratio leads to a longer CCC. This is then accompanied by a higher financial requirement for the operating cycle, as assets must be financed over a longer period. Conversely, higher accounts payables turnover indicates greater financial leeway due to the spontaneous granting of credit by creditors, as long as no penalty is charged for late payment. If an increase in net accounts receivable or inventory cannot be offset by accounts payable, the firm will require additional liquidity to finance the increased capital that is now tied up in the operating cycle. Firms that manage to boost sales figures usually face increased financing requirements, as fixed assets

<sup>65</sup> Wang (2002), p. 160.

<sup>66</sup> Richards/Laughlin (1980), p. 35.

<sup>67</sup> Moss/Stine (1993), p. 25; Churchill/Mullins (2001), p. 137.

<sup>68</sup> Hutchison/Farris II/Fleischman (2009), p. 43.

<sup>69</sup> Farris II/Hutchison (2003), p. 83.

<sup>70</sup> Hutchison/Farris II/Anders (2007), p. 42.

tend to increase during the operating cycle.<sup>71</sup> Attempts to optimize the bottom line of the CCC must always give due consideration to all relevant aspects. Turning one "wheel" will always affect all the other components of the cycle.<sup>72</sup> Efforts to improve CCC efficiency ultimately lead to reduced costs and, by consequence, to higher profitability.<sup>73</sup> Thus, the CCC is a powerful tool to manage operations.<sup>74</sup> A longer CCC requires not only more capital but also entails the risk that a company may not be as agile in volatile economic times. Necessary shifts in production, sales, etc. take more time, which can be a serious competitive disadvantage. As a consequence, the CCC also serves as an indicator for the valuation of a company: a shorter CCC results in a higher net present value of operating cash flows.<sup>75</sup>

Ensuring the availability of sufficient capital is a stiff challenge for treasury managers. It is not only that the overall level of capital requirements must be maintained throughout the entire operating cycle. In addition, working capital investment flows are, by their very nature, asynchronous.<sup>76</sup> Permanent liquidity management is imperative if a company is to be able to handle volatile operating cash flows. Indeed, several studies indicate that the day-to-day management of working capital takes up most of financial managers' time.<sup>77</sup>

Gentry et al. (1990) further developed the CCC concept.<sup>78</sup> Their starting point was that the initial concept neglects the fact that the amount of funds tied up in each component of the CCC is not reflected in the calculation. By calculating weights for each component according to their relative share, a weighted cash conversion cycle (WCCC) can be determined. The result reflects both the number of days for which capital is tied up in each component of the cycle and the amount of funds thus tied. Although the concept is more advanced than its predecessor, in practice imponderables exist as external analysts struggle to determine the required data for calculating the proper weights.<sup>79</sup>

As a consequence, Bernstein (1993) modeled a measure on the CCC termed the net trade cycle (NTC).<sup>80</sup> The difference to the CCC is that sales is used as the denominator for all terms. Bernstein (1993) argues that his concept improves the uniformity and simplicity of the

---

<sup>71</sup> Soenen (1993), p. 54.

<sup>72</sup> Hager (1976), p. 19.

<sup>73</sup> Hutchison/Farris II/Fleischman (2009), p. 42.

<sup>74</sup> Farris II/Hutchison (2002), p. 297.

<sup>75</sup> Farris II/Hutchinson/Hasty (2005), p. 114.

<sup>76</sup> Richards/Laughlin (1980), p. 34.

<sup>77</sup> Hill/Sartoris (1988), p. 1.

<sup>78</sup> Gentry/Vaidyanathan/Lee Hei Wai (1990), p. 90-99.

<sup>79</sup> Shin/Soenen (1998), p. 38.

<sup>80</sup> Bernstein (1993), p. 510.

calculation at the cost of an acceptable lack of stringency. Indeed, some of the financial data that is needed to calculate the CCC may not be available, in which case the NTC might be a practical alternative.<sup>81</sup> Empirical studies confirm that the CCC and the NTC provide similar information.<sup>82</sup>

All in all, CCC provides a valid alternative to earlier static measures of corporate liquidity management. Many authors emphasize the benefits of this dynamic flow concept, arguing that it is more practical and can be used to replace or supplement liquidity ratios.<sup>83</sup>

### **2.3 Theoretical basis: Configurational Theory**

The theoretical basis for this dissertation is the Configurational Theory. Integrated, discussed and scrutinized by numerous scholars, the Configurational Theory is an offshoot of the Contingency Theory that dominated research until the 1970s.<sup>84</sup> In both theories, the concept of "fit" in strategic management is the underlying assumption.<sup>85</sup> The concept postulates that the performance of an organization depends on the fit of environment and organizational design.<sup>86</sup> Environment, as one of these two dimensions, has been subdivided into external, internal and integrated environments in the relevant literature. In line with this classification, researchers to date have focused on one of these clusters.<sup>87</sup> While the concept of fit is the cornerstone of both the Contingency Theory and the Configurational Theory, each theory emphasizes different aspects.<sup>88</sup> The Contingency Theory demonstrates that "attributes of environments, technologies, and structures interact to restrict the range of viable organizational forms".<sup>89</sup> Configurational theorists go a step further: Not only should a limited set of structural concepts such as centralization be considered, but provision should also be made for abstract situational concepts such as size and technological uncertainty. There is no question that the two concepts are linked: The Configurational Theory builds on the Contingency Theory. For this reason, the two concepts are discussed below in the context of Configurational Theory and working capital management.

---

<sup>81</sup> Shin/Soenen (1998), p. 38.

<sup>82</sup> Kamath (1989), p. 26.

<sup>83</sup> Kamath (1989), p. 28; Eljelly (2004), p. 50; Hutchison/Farris II/Anders (2007), p. 42.

<sup>84</sup> Smith/Shortell/Saxberg (1979), p. 669.

<sup>85</sup> Venkatraman/Camillus (1984), p. 513.

<sup>86</sup> Shortell (1977), p. 275.

<sup>87</sup> Venkatraman/Camillus (1984), p. 516.

<sup>88</sup> Vorhies/Morgan (2003), p. 111; Drazin/van de Ven (1985), p. 521.

<sup>89</sup> Meyer/Tsui/Hinings (1993), p. 1177.

The basic assumption behind contingency models is that the best performance can be achieved when organizational structures match external contingency factors. In other words, "contingency models posit that effectiveness is highest where the structure fits the contingencies. Match causes effectiveness, mismatch causes ineffectiveness."<sup>90</sup> Only those organizations that align their organization with the current environment achieve maximum output. Strategically significant external variables to be considered include economic conditions, demographic trends, sociocultural trends political/legal factors and industry structure variables.<sup>91</sup> Given that external factors may change rapidly, managers must constantly adopt their organizations to the new situation to ensure effectiveness. To guide practitioners and test the theory empirically, scholars have developed hypothetical best-fit organizational patterns for different environmental forms.<sup>92</sup> However, the use of patterns that assume linear relationships has also been criticized by researchers.<sup>93</sup> In terms of empirical testing, authors have found evidence that the contingency theory is a powerful approach to explaining structural change.<sup>94</sup>

The Contingency Theory "implicitly treats organizations as loosely coupled aggregates whose separate components may be adjusted or fine-tuned [...]".<sup>95</sup> Conversely, "configurational inquiry represents a holistic stance, an assertion that the parts of a social entity take their meaning from the whole and cannot be understood in isolation".<sup>96</sup> Configurational theorists thus emphasize the alignment of different design parameters in the organization and its environmental context. As with previous Contingency Theory assumptions, the hypothesis is that the match between organizational design parameters and context variables will posit greater effectiveness and efficiency for organizations.<sup>97</sup> At the same time, internal organizational design parameters such as work specifications, reward/incentive systems and coordination systems must likewise be brought into line. The Configurational Theory was initially developed by Shortell (1977), who introduced an approach that lists different context variables and internal design forms. Based on the variables defined, he named four model relationships and predicted either high or low efficiency and effectiveness.<sup>98</sup> However, this

---

<sup>90</sup> Donaldson (1982), p. 67.

<sup>91</sup> Hofer (1975), p. 798.

<sup>92</sup> Drazin/van de Ven (1985), p. 524-525.

<sup>93</sup> Schoonhoven (1981), p. 370.

<sup>94</sup> Donaldson (1987), p. 22.

<sup>95</sup> Meyer/Tsui/Hinings (1993), p. 1177.

<sup>96</sup> Meyer/Tsui/Hinings (1993), p. 1178.

<sup>97</sup> Doty/Glick/Huber (1993), p. 1196.

<sup>98</sup> Shortell (1977), p. 288.



general hypothesis is not applicable to all situations. For this reason, scholars went on to identify clusters of organization types that perform best in certain business situations in order to prepare recommended courses of action.<sup>99</sup> As a result, certain characteristics of organizational parameters can be recommended for specific business situations. The empirical relevance of the theory has been tested by a variety of scholars. The majority of researchers have found evidence for at least the partial validity of this hypothesis in practice.<sup>100</sup>

With regard to working capital management, the Configurational Theory claims that available parameters have to be set according to the contextual variables of the firm, such as the economic situation, industry structure, supplier variables, and demand behavior. However, it is not enough merely to align the contextual variables with working capital parameters. To maximize overall organizational efficiency and effectiveness, working capital parameters themselves must be aligned with the other relevant organization parameters. Given that, in accordance with the Configurational Theory, organizational performance depends primarily on the interplay between the different parameters. This being the case, relevant internal drivers of working capital performance must be identified and optimized with an integrated approach to match the requirements of the contextual variables. Only if these conditions are fulfilled overall firm performance will reach its maximum, as postulated by the Configurational Theory. In the underlying case correlations for the identified drivers, manufacturing, and supply chain performance must therefore be tested for correlation. Based on a firm's contextual variables, such as supply chain risk, an integrated optimization model must simultaneously be tested in light of identified correlations and the firm's environment. This implies that a firms' strategy in terms of e.g. business model, global footprint, and product portfolio must consider intra firm correlations and contextual variables such as supply chain set up. Based on the Configurational theory there exist only one distinctive configuration of manufacturing performance, supply chain performance, working capital levels, and the firms supply chain risk level that maximizes a firms performance. As such the basic question emerge how do the different drivers correlate with each other and finally what is the configuration that maximizes a firms performance. Nonetheless the existing literature

---

<sup>99</sup> Ketchen Jr./Combs/Russell/Shook/Dean/Runge/Lohrke/Naumann/Haptonstahl/Baker/Beckstein/Handler/Honig/Lamoureux (1997), p. 225; Smith/Shortell/Saxberg (1979), p. 682; Doty/Glick/Huber (1993), p. 1196.

<sup>100</sup> Vorhies/Morgan (2003), p. 111.

has to the knowledge of the author so far not tested for a model that simultaneously considers correlations of described variables and their impact on firm performance. There is high relevance to close this existing gap in the literature via an empirical study which allows for an evaluation of existing correlations and their individual strengths. Based on the empirically validated relations a model is developed to provide practical guidelines on how to align business processes to achieve maximum firm performance.

## **2.4 Data and methodology**

The main purpose of the eligibility criteria applied to the literature review – to ensure substantive and empirical relevance – was achieved by doing three things.<sup>101</sup> First, appropriate word stems were defined to enable a comprehensive literature search to be conducted. The word stems defined can be grouped into four categories: working capital management, manufacturing performance research, supply chain risk studies and supply chain performance scholars. Defined search criteria for the first category were "working capital", "cash conversion cycle", and "cash-to-cash" in order to cover static and dynamic concepts. The word stem "manufacturing performance" was selected for the second research field. "Supply chain risk" and "supply chain vulnerability" were intended to identify existing research in category three. Following the same logic, the word stem "supply chain performance" was selected to cover category four. The electronic library EBSCO (Business Source Premier) was selected as the database, as it covers more than 1,800 peer-reviewed journals in the field of economics and is constantly updated. Broad coverage and proven usefulness in other studies were the main reasons for this selection.<sup>102</sup> The time frame chosen for the search was 1970 to 2010. To limit the results, only scholarly peer-reviewed journals were included. When the searches were launched, Boolean operators were used to search for the word stems in both titles and abstracts. The exact word stem phrase was searched for using quotation marks. All in all, the search returned 1,167 hits. The keyword "working capital" yielded most of these hits (697). "Manufacturing performance" delivered 293 hits, "supply chain risk" 77, "supply chain performance" 70, "cash conversion cycle" 14, "supply chain vulnerability" 12 and "cash-to-cash" 4 hits. While these results were spread across a total of 344 journals, the top 30 journals accounted for approximately 50% of all hits. The top five journals were the

---

<sup>101</sup> Ennen/Richter (2010), p. 211-212; Meyer/Dalal/Hermida (2010), p. 131-132;  
Randolph (2009), p. 4; Newbert (2007), p. 124-126.

<sup>102</sup> Ennen/Richter (2010), p. 211.

Accounting Review (75 hits), the International Journal of Operations & Production Management (45 hits), the Journal of Accountancy (44 hits), the International Journal of Production Research (43 hits) and the International Journal of Production Economics (38). An analysis of the publications over time suggests that interest has steadily increased since the beginning of the nineteenth century. The amount of published articles has indeed increased in every decade since 1900 (see table 1).

From the 1990s to the first decade of this century, the number of publications actually more than doubled from 220 to 494. As shown in table 2, analysis of the number of publications in the top journals over time indicates that research into financial management peaked between the 1960s and the 1970s. Conversely, research into production and manufacturing was only just beginning in the 1990s and has not yet peaked. Reference lists of the main papers identified for the various research dimensions formed the second pillar of the literature research. This approach prevented the author from overlooking crucial publications due to the fact that certain keywords were not mentioned in the title or abstract. Reviewing the reference lists of main papers helped to identify 22 additional papers of relevance to the object of this research. Third, members of the academic network in related fields were contacted and asked for publications that had recently been submitted or were in the process of being published in non-mainstream journals. Discussions with these contacts revealed a further 4 relevant articles that had not yet been included in the sample. In total, the search for relevant publications produced a long list of 1,193 papers for review. The word stems defined for the database search covered a large quantity of papers. This ensured that all potentially relevant papers appeared on a long list and could be reviewed for genuine relevance. To focus the literature review more sharply, three steps were taken to narrow down the volume of papers in scope. The first step was to consolidate the results based on the different sources used and the elimination of duplicates.

**Table 1: Number of publications over time**

<b>Year</b>	<b>Number of publications</b>	<b>Percentage of total</b>
1910	1	0
1920	4	0
1930	13	1
1940	15	1
1950	24	2
1960	59	5
1970	103	9
1980	149	13
1990	220	19
2000	494	42
2010	85	7
Total	1.167	100

Second, all papers in the academic research areas working capital management, manufacturing performance and supply chain performance were screened and those that did not contain empirical studies were deselected. A search was made for papers that empirically tested indicators of working capital performance, or that linked working capital performance to firm performance. Papers that contained the word stem "manufacturing performance" were screened for empirical studies that tested indicators for manufacturing performance. The same procedure was repeated for the category supply chain performance. In addition, papers based on small-scale samples or case studies were excluded. As the number of papers covering supply chain risk research is rather limited, all papers that specifically defined either risk drivers or risk source items were selected irrespective of whether or not they conducted empirical tests.

**Table 2: Publications in top journals over time**

	<b>Year</b>	<b>Number of publications</b>	<b>Percentage of total</b>
Accounting Review	1920	2	1
	1930	5	2
	1940	8	3
	1950	15	6
	1960	25	10
	1970	3	1
	1980	7	3
	1990	4	2
	2000	6	2
International Journal of Operations & Production Management	1980	4	2
	1990	15	6
	2000	23	9
	2010	2	1
Journal of Accountancy	1960	5	2
	1970	14	6
	1980	11	5
	1990	9	4
	2000	3	1
	2010	2	1
International Journal of Production Research	1990	18	7
	2000	22	9
	2010	3	1
International Journal of Production Economics	1990	12	5
	2000	17	7
	2010	9	4
Total		244	100

Third, only those papers that contained research into the manufacturing industry were taken into account. Papers focusing on services such as banking were excluded. Deselection was conducted as follows: First, substantive but irrelevant papers were excluded based on a reading of the title and selective reading of the article. Second, all remaining papers were screened based on a full reading of all abstracts. Third, all papers that passed the first two steps were read in their entirety to further validate their relevance.

As a result, 92 papers met all the defined criteria (table 3). The section that follows analyzes, evaluates and cross-references all papers that matched the defined search parameter. In the

interests of clarity, the review of the selected papers was structured in line with the object of investigation. In the initial scope of investigation, all papers were collected that seek to analyze correlations between working capital management and firm performance. The independent variable in the correlation analysis can be either static or dynamic. In the second category, all papers were summarized that investigate drivers of working capital performance. As in the previous category, the dependent variable too can be static or dynamic. In the third to fifth categories, all papers were clustered that contain research into either manufacturing performance, supply chain risk or supply chain performance.

**Table 3: Number of publications per word stem**

<b>Search word stem</b>	<b>Number of publications</b>	<b>Percentage of total</b>
Manufacturing performance	35	38
Working capital	15	17
Supply chain risk	15	17
Cash conversion cycle	13	14
Supply chain performance	13	13
Supply chain vulnerability	1	1
Total	92	100

Accordingly, section 2.4 is structured as follows: Existing research into the correlation between working capital performance and firm performance is presented first (section 2.4.1). All studies covering indicators for the performance of working capital are outlined next (section 2.4.2). Lastly, the related research fields manufacturing performance, supply chain risk and supply chain performance are processed in the third section (section 2.4.3).

## **2.5 Review of the literature**

### **2.5.1 Working capital management and firm performance**

To the author's knowledge, a total of thirteen papers investigated the relation between working capital management and firm performance (table 4).

The first paper was published in 1989 and written by Ravindra Kamath (1989).<sup>103</sup> However, most of the papers were published in the first decade of this century, with the two most recent ones appearing in 2009. Although these papers all adopt a fairly uniform approach, their geographical focus varies significantly. Japan, Taiwan, Belgium, Saudi Arabia, Greece, Mauritius, Pakistan and Turkey were all selected as sample countries, alongside the U.S. The sample size differs as a result: The lowest sample size covered 29 companies in Saudi Arabia, the highest 2,718 in the United States. The average sample size was 825 companies. The database was chosen as a function of the focus country in each case. Investigations in the United States used the Compustat database. Other investigations used local databases, such as the PACAP database for the financial data of Japanese companies. It is worth noting that all the authors based their investigations on data available in the public domain, since the purpose of all papers was to examine correlations between working capital measures and firm performance KPIs. None of the authors used empirical surveys to collect the requisite data. However, both the independent and dependent variables used and the statistical approaches adopted to establish the described correlation are not uniform. The same holds for the results, for which neither the methodologies used to establish positive or negative relationships nor the quality of the models applied were as rigorous as they could have been. On the whole, the papers nevertheless conclude that successful working capital management has a positive impact on firm performance – a correlation that has been established in numerous papers by statistical methods.

The first paper in this research area was published by Ravindra Kamath (1989).<sup>104</sup> The objective of Kamath's academic work was to compare and contrast traditional static liquidity ratios with dynamic concepts such as the CCC. Moreover, she also investigated the relationship between these liquidity measures and firm profitability.

---

<sup>103</sup> Kamath (1989), p. 24-28.

<sup>104</sup> Kamath (1989), p. 24-28.

**Table 4: Working capital performance and firm performance <sup>a</sup>**

**Literature Review: Working capital performance and firm performance**

#	Year	Author	Area	Sample size	Source	Endogenous variable(s)	Exogenous variable(s)	Correlation	R <sup>2</sup>
1	1989	Kamath, Ravindra	United States	99	Compustat	• CCC • NTC • Current ratio • Quick ratio	• Operating profits/ total assets	• - • - • + • +	n.a.
2	1993	Soenen, Luc A.	United States	2,000	Compustat	• NTC	• Net income + interest expenses / total assets	• -	n.a.
3	1996	Jose, Manuel L. et al	United States	2,718	Compustat	• CCC	• ROA • ROE	• - • -	.0808
4	1998	Shin, Soenen	USA	n.a.	Compustat	• NTC • Current ratio	• Operating income/Total assets • Operating income/Sales • Operating income/Total assets • Operating income/Sales	• - • ? • - • -	n.a. n.a.
5	2002	Wang, Yung-Jang	Japan, Taiwan	1,934	PACAP-Database, TEJ-Database	• CCC	• ROA	• -	.0353
6	2003	Deloof, Marc	Belgium	1,009	n.a.	• CCC	• (Sales-COGS)/total assets-financial assets	• -	.0068
7	2004	Eljelly, Abuzar M. A.	Saudi Arabia	29	n.a.	• Current ratio • Cash Gap	• Net operating income - depreciations / net sales	• - • ?	.163
8	2006	Lazaridis, Ioannis; Tryfonidis, Dimitrios	Greek	131	ICAP SA database	• CCC	• (Sales-COGS)/total assets-financial assets	• -	.238
9	2006	Padachi, Kasseeen	Mauritian	58	SMIDO	• CCC	• Profit before interest and taxes / total assets	• +	.36
10	2007	Raheman, Abdul; Nasr, Mohamed	Pakistan	94	Karachi stock exchange	• CCC	• Net operating income + depreciations / (total assets - financial assets)	• -	.30
11	2007	Filbeck, Krueger, Preece	USA	1,000	Research Insider®	• Cash conversion efficiency rank • Days working capital rank	• Annual stock market closing price returns and dividends	• + • ?	.0139
12	2008	Uyar, Ali	Turkey	166	ISE (Istanbul Stock Exchange)	• CCC	• ROA • ROE • Sales	• - • ? • -	n.a.
13	2008	Nazir, Afza	Pakistan	204	Karachi Stock Exchange	• Current assets/Total assets • Current liabilities/Total assets • Size • Growth of Sales • GDP growth rate • Financial leverage	• ROA	• + • - • + • + • + • -	n.a.

<sup>a</sup> - significant negative correlation; + significant positive correlation; ? no significant correlation persistent



For her statistical analysis, Kamath used a sample of 99 firms over a time frame from 1970 to 1984. Regarding the assumed superiority of dynamic measures over static ones, she argues that the current ratio, quick ratio and CCC should be used concurrently, because considering only one measure could lead to misleading clues. Comparing the CCC and NTC on the basis of her data suggests that these KPIs provide the same information. The traditional liquidity measures current ratio and quick ratio were not found to exhibit the assumed negative correlation with firm performance, which is calculated as  $\frac{\text{Operating profits}}{\text{Total assets}}$ . However, dynamic ratios such as CCC and NTC did reveal the expected positive correlation in most cases. Over the 15 sample years, CCC and firm performance exhibited a significant negative correlation in five years, while NTC and firm performance did so in nine years, with 95 and 99 percent significance levels respectively. For his investigation four years later, Luc A. Soenen (1993) used the net trade cycle as the endogenous variable and the total return on assets, measured as  $\frac{\text{Net income} + \text{Interest expenses}}{\text{Total assets}}$ , as the exogenous variable.<sup>105</sup> For the purposes of his analysis, he classified all companies in the timeframe from 1970 to 1989 into four quadrants, depending on whether the observed net trade cycle and total return on assets was above or below the median value for that industry. In line with his hypothesis – the shorter the cash cycle, the higher the profitability – Soenen anticipated a high concentration in the quadrants that indicated a short cash cycle and a high total return on assets, and vice versa. Considering all 20 industries simultaneously (as only 55.4% of all observations matched up with his hypothesis), he concluded that, although the cash cycle does have some influence on the total return on assets, the correlation is not very strong. However, when analyzing the postulated correlation by industry, he found significant evidence for the negative correlation in 18 out of the 20 industries. In summary, Soenen concluded that a strong negative relationship exists between the cash cycle and the total return on assets depending on the type of industry. Following the same basic approach, Soenen (1993) published a further paper in collaboration with Hyun-Han Shin five years later.<sup>106</sup> Their database contained 58,985 firm years in the period from 1975 to 1994. The results confirmed the authors' previous conclusions: The statistics show a significant negative relationship between NTC and firm performance,

---

<sup>105</sup> Soenen (1993), p. 53-58.

<sup>106</sup> Shin/Soenen (1998), p. 37-45.

represented as  $\frac{\text{Operating income}}{\text{Total assets}}$ . Similarly, the correlation between the current ratio and firm performance is significantly negative. The authors therefore conclude that reducing the net trade cycle to a reasonable minimum increases shareholder value – a sound reason for financial executives to focus on this topic.

Departing from NTC as the measure of working capital used by Soenen and Shin, a large number of researchers in subsequent years investigated the relationship between CCC and firm performance. To the author's knowledge, a total of seven papers have been published on this subject. Manuel L. Jose, Carol Lancaster and Jerry L. Stevens (1996) started the ball rolling by publishing their article "Corporate Returns and Cash Conversion Cycles".<sup>107</sup> Their main focus was to support the hypothesis that successful management of a firm's operating cycle triggers superior firm performance. Arguing that in the past management focused mainly on investment and financing decisions, the authors wanted to draw attention to the day-to-day management of short-term assets and liabilities. In line with other empirical research in the US, they used the Compustat database with a sample size of 2,718 companies. The exogenous variables used in the model were the return on assets and the return on equity. For both relationships – between CCC and ROA and between CCC and ROE – the statistics show a significant negative correlation for all industries except financial services.  $R^2$  is .0808 for the first regression and 0.1155 for the second. Introducing a control for size difference increased the quality of the model: The negative relation is significant for all industries and the  $R^2$  measure rises to .3044 and .3145 respectively. These statistical findings are consistent with previous publications. After this investigation in the US, other researchers applied this approach to other countries too. The first person to do so was Yung-Jang Wang (2002), who, in line with the approach adopted by Jose et al. (1996), investigated whether the latter's conclusion could also be applied to the Taiwanese and Japanese markets.<sup>108</sup> Based on their sample of 1,934 companies, the statistical results again indicate a negative correlation between both ROA and ROE and firm performance in the overall sample. However, the expected relationship is not significant in all cases on an industry level. In the Japan sample, the correlation is not significant for both firm performance measures in the petrochemicals, electronics and transportation industries. For the Taiwan sample, the correlation is not significant at the .90 level in the electronics, transportation and services industries. Furthermore,  $R^2$  in their regression model is significantly lower, at .0353 for Taiwan and

---

<sup>107</sup> Jose/Lancaster/Stevens (1996), p. 33-46.

<sup>108</sup> Wang (2002), p.159-169.

.0068 for Japan. In particular, the very low  $R^2$  value for analysis on the Japanese market is regarded very critically, suggesting that the explanatory power of the model is rather limited. The first investigation in the European market was conducted by Marc Deloof (2003).<sup>109</sup> He analyzed a sample of 1,637 Belgian firms using almost the same variables. With regard to firm profitability, he slightly modified the ROA and ROS ratios used hitherto, instead using the KPI  $\frac{(Sales-COGS)}{(Total\ assets-financial\ assets)}$ . Similarly, he investigated a negative correlation with the CCC. Like previous papers, he investigated not only the correlation between the aggregate CCC and firm performance, but also each component in isolation. According to his calculations, the number of accounts receivable, inventory and accounts payable days correlate negatively to firm performance too. It is interesting that accounts payable correlate negatively despite the fact that payables are presumed to reduce the cash gap. Deloof (2003) argues that this finding, which appears contradictory at first glance, is the result of a shortcoming in Pearson correlations, which do not allow causes to be distinguished from consequences. A negative correlation is thus consistent with the view that highly profitable firms usually afford their suppliers shorter payment periods, as they have the financial resources to do so. According to Deloof (2003), profitability affects accounts payable days, not vice versa.

In 2006, Lazaridis et al. (2006) investigated the postulated correlation for companies listed on the Athens Stock Exchange.<sup>110</sup> Here again, a negative correlation was established. The model resulted in an adjusted  $R^2$  of .238. The comparably high value of  $R^2$  can be explained by the fact that Lazaridis et al. (2006) included in their regression model additional variables such as a fixed financial assets ratio, a financial debt ratio and a natural logarithm of sales indicating the size of the firm. These additional variables boost  $R^2$ , whose value is higher than in previous studies. Deloof and Lazaridis et al. (2006) both observed a negative correlation between accounts payable and firm profitability, arguing in the same direction. In conclusion, Lazaridis et al. (2006) advocate greater attention to working capital management and the optimized handling of the various components of the CCC.

Contrary to the research conclusions presented above, Padachi et al. (2006) published a positive correlation between CCC and ROA using a fixed asset model.<sup>111</sup> Several specifics of this case must nevertheless be considered when analyzing this result. First, a very small

---

<sup>109</sup> Deloof (2003), p. 573-587.

<sup>110</sup> Lazaridis/Tryfonidis (2006), p. 26-35.

<sup>111</sup> Padachi (2006), p. 45-58.

sample of only 58 companies serves as basis for the statistics used. Second, a market with unique conditions was chosen: Mauritius. Accordingly, Padachi et al. (2006) explain the contradictory results mainly due to the small firm sizes. They assume that smaller firms maintain a lower fixed asset base and rely mostly on current assets to increase profits. Also, when a pooled OLS regression was used, the correlation turned negative. Notwithstanding, the authors emphasize that there is a pressing need for further investigation, especially among SMEs.

Similar correlations between CCC and firm profitability have been analyzed for Pakistan and Turkey as well. Raheman et al. (2007) and Uyar (2009) respectively based their statistical analysis on data for companies listed on the Karachi and Istanbul Stock Exchanges.<sup>112</sup> The results confirmed the negative correlation.

A different measure to analyze working capital performance was used by Eljelly (2004).<sup>113</sup> He focused on the links between both the current ratio and the cash gap and firm performance. Firm performance is defined in his study as  $\frac{(\text{Net operating income} - \text{depreciations})}{\text{net sales}}$ . Based on his analysis of 29 Saudi Arabian companies, Eljelly was able to verify the negative correlation between the current ratio and firm performance. However, the correlation between the cash gap and firm performance was not significant. The explanatory power of the model has an R<sup>2</sup> value of 0.163.

A unique approach has taken by Filbeck et al. (2007).<sup>114</sup> Their research focused on whether efficient working capital management has a positive impact on annual stock market closing price returns and dividends. A database covering approximately 1,000 companies served as the basis for their statistical analysis. According to these authors' results, a positive correlation exists between efficient working capital management and the return to shareholders in terms of annual stock market closing prices and dividends.

The most recent paper to focus on the effect of working capital management on firm performance was published in 2009.<sup>115</sup> Nazir et al. (2009) investigated the effect of variables such as the asset structure or size of a company on firm performance, measured as the ROA. In particular, the authors reviewed a data set containing 204 companies listed on the Karachi Stock Exchange for six variables: current assets as a share of total assets, current liabilities as

---

<sup>112</sup> Raheman/Nasr (2007), p. 279-300; Uyar (2009), p. 186-193.

<sup>113</sup> Eljelly (2004), p. 48-61.

<sup>114</sup> Filbeck/Krueger/Preece (2007), p. 18.

<sup>115</sup> Nazir/Afza (2009), p. 19-30.

a share of total assets, size of firms, sales growth, the GDP growth rate and financial leverage. They conclude that the variables current assets as a share of total assets, firm size and the GDP growth rate correlate positively with the ROA. All the other variables correlate negatively. Nazir et al. (2009) see evidence that the degree of aggressiveness of an investment is negatively correlated to firm performance. Profitability increases as the ratio of current assets to total assets increases. The same applies for the liabilities ratio: The higher the ratio of current liabilities to total assets, the more aggressive the financing policy. According to the results of the study, then, an aggressive financing policy yields a negative return on assets. To summarize: Academic research confirms the initial hypothesis that successful working capital management leads to increased profitability. Especially with regard to the correlations based on the dynamic measures CCC and ROA, numerous papers statistically verify a negative correlation. This finding gains even greater importance from the fact that the investigations cover a large variety of industries and marketplaces. Given that the positive impact of successful working capital management on firm performance thus appears to be validated, the question of what specific factors affect working capital performance must now be addressed. If firm performance is to be boosted by improving working capital management, it is imperative to identify the precise drivers of working capital. The section that follows presents a comprehensive overview of existing literature on this topic.

## 2.5.2 Identified drivers of working capital performance

### 2.5.2.1 Production-related variables

A summary of all papers that investigate drivers of working capital performance is presented in table 5. Surprisingly, only one paper that matched the defined search criteria investigated production-related drivers of working capital performance. The paper by Kenneth P. Nunn Jr. (1981)<sup>116</sup> – the first to analyze drivers of working capital performance in general – tested several production characteristics for their significance. Based on a sample of 1,700 companies derived from a special database called the "PIMS database", Nunn published his key findings in 1981, proving seven production-related drivers to have a significant influence on working capital, which he defined as  $\frac{(\text{Accounts receivables} + \text{Inventory})}{\text{Sales}}$ . Nunn was able to

---

<sup>116</sup> Nunn (1981), p. 207-219.

substantiate a positive correlation for the factors "% of small batch size production", "% order backlog", "capital intensity" and "relative product line breadth".

The main explanation for these observations is to be found in the interplay of inventory and production. Small batches, substantial order backlogs, capital intensity and product line breadth all tend to increase inventory levels, which in turn increases working capital levels. Small batches require a relatively longer work-in-process cycle that drives inventory requirements. The same applies for order backlogs: Production at the limit of capacity leads to increased work-in-process cycles as lead times grow longer. This also determines raw material levels. Companies with capital-intensive production sites tend to maintain production levels even during slack periods in order to cover the cost of capital. The effects of relative product line breadth are obvious: The more product variants exist, the more raw materials and finished goods inventory has to be maintained. Four drivers that negatively impact working capital levels were identified: "% continuous process production", "% capacity utilization" and "make-to-order products". Here again, the main explanations are to be found in the relation to inventory. As a continuous process, production requires a short work-in-process cycle that lowers inventory needs.

**Table 5: Indicators of working capital performance <sup>a</sup>**

#	Year	Author	Area	Sample s	Source	Endogenous variable(s)	Exogenous variable(s)	Correlation	R <sup>2</sup>
1	1981	Nunn	USA	1,700	PIMS data base	<ul style="list-style-type: none"> <li>• % Small batch production</li> <li>• % Continuous process production</li> <li>• % Capacity utilization</li> <li>• % Order backlog</li> <li>• Capital intensity</li> <li>• Make-to-order products</li> <li>• Relative product line breath</li> <li>• Media Advertising/Sales</li> <li>• Sales Force Expense/Sales</li> <li>• % Gross Margin - Channels</li> <li>• % Sales to Components</li> <li>• Accounting Method</li> <li>• Relative market share</li> <li>• Market share instability</li> <li>• Relative image</li> <li>• Relative price</li> <li>• Industry exports</li> <li>• Industry imports</li> <li>• Industry concentration</li> </ul>	WC (accounts receivables + Inventory) / Sales	<ul style="list-style-type: none"> <li>• +</li> <li>• -</li> <li>• -</li> <li>• +</li> <li>• +</li> <li>• -</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• -</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> </ul>	.447
2	1986	Hawawini	USA	1,181	Compustat	<ul style="list-style-type: none"> <li>• Industry</li> </ul>	WCR / Sales	<ul style="list-style-type: none"> <li>• Significant effect persistent</li> </ul>	n.a.
3	1993	Fazzari, Petersen	USA	382	n.a.	<ul style="list-style-type: none"> <li>• Cash Flow/Fixed Capital</li> </ul>	• $\Delta$ Working Capital/Fixed Capital	<ul style="list-style-type: none"> <li>• +</li> </ul>	.280
4	1993	Moss	USA	n.a.	Compustat	<ul style="list-style-type: none"> <li>• Total net Sales</li> <li>• Total assets</li> <li>• Cash Flow</li> </ul>	• CCC	<ul style="list-style-type: none"> <li>• -</li> <li>• -</li> <li>• -</li> </ul>	n.a.
5	1998	Kim, Mauer, Sherman	USA	915	Compustat	<ul style="list-style-type: none"> <li>• Size</li> <li>• Market value to book value</li> <li>• Variance of Cash Flow</li> <li>• Difference ROA to short term treasury bills</li> <li>• Cash Cycle</li> <li>• Variance of cash cycle</li> <li>• Leverage</li> <li>• Return on Sales</li> </ul>	• Cash Holding (Cash + marketable securities to total assets)	<ul style="list-style-type: none"> <li>• ?</li> <li>• +</li> <li>• ?</li> <li>• -</li> <li>• -</li> <li>• ?</li> <li>• -</li> <li>• -</li> </ul>	.580
6	1999	Ricci	USA	89	Mail survey	<ul style="list-style-type: none"> <li>• Granting credit</li> <li>• Obtaining Information</li> <li>• Setting Credit Limits</li> <li>• Monitoring Receivables</li> <li>• Reporting to Management</li> </ul>	• Existence of Past Due Accounts	<ul style="list-style-type: none"> <li>• ?</li> <li>• ?</li> <li>• -</li> <li>• -</li> <li>• -</li> </ul>	n.a.
7	1999	Opler	USA	n.a.	Compustat	<ul style="list-style-type: none"> <li>• Market-to-book ratio</li> <li>• Real size</li> <li>• Cash flow/assets</li> <li>• Net working capital/assets</li> <li>• Capital expenditures/assets</li> <li>• Total leverage</li> <li>• Industry sigma</li> <li>• R&amp;D/sales</li> </ul>		<ul style="list-style-type: none"> <li>• +</li> <li>• -</li> <li>• +</li> <li>• -</li> <li>• +</li> <li>• -</li> <li>• +</li> <li>• +</li> </ul>	.223
8	1999	Lancaster, Stevens	USA	417	Compustat	<ul style="list-style-type: none"> <li>• Income before Extraordinary Items/Working capital from Operations</li> </ul>	<ul style="list-style-type: none"> <li>• Current Ratio</li> <li>• Quick Ratio</li> <li>• CCC</li> </ul>	<ul style="list-style-type: none"> <li>• effect exists</li> <li>• effect exists</li> <li>• No effect</li> </ul>	n.a.
9	2005	Filbeck, Krueger	USA	1,000	Research Inside®	<ul style="list-style-type: none"> <li>• Industry influence</li> <li>• Time influence</li> </ul>	<ul style="list-style-type: none"> <li>• Cash Conversion Consistency</li> <li>• Days of Working Capital</li> <li>• Days Sales Outstanding</li> <li>• Inventory Turnover</li> <li>• Days Payables Outstanding</li> <li>• Cash Conversion Consistency</li> <li>• Days of Working Capital</li> <li>• Days Sales Outstanding</li> <li>• Inventory Turnover</li> <li>• Days Payables Outstanding</li> </ul>	<ul style="list-style-type: none"> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> <li>• +</li> </ul>	n.a.

**Table 5: Indicators of working capital performance (continued)**

#	Year	Author	Area	Sample size	Source	Endogenous variable(s)	Exogenous variable(s)	Correlation	R <sup>2</sup>
10	2006	Chiou, Cheng	Taiwan	533	TEJ database	<ul style="list-style-type: none"> <li>• <math>\Delta</math> Business Cycle</li> <li>• <math>\Delta</math> Dept ratio</li> <li>• <math>\Delta</math> Operational Cash Flow/total assets</li> <li>• <math>\Delta</math> Sales growth</li> <li>• Age</li> <li>• <math>\Delta</math> Return on assets</li> <li>• <math>\Delta</math> Firm size</li> <li>• <math>\Delta</math> Business Cycle</li> <li>• <math>\Delta</math> Dept ratio</li> <li>• <math>\Delta</math> Operational Cash Flow</li> <li>• <math>\Delta</math> Sales growth</li> <li>• Age</li> <li>• <math>\Delta</math> Return on assets</li> <li>• <math>\Delta</math> Firm size</li> </ul>	<ul style="list-style-type: none"> <li>• <math>\Delta</math> WCR/Total assets</li> <li>• <math>\Delta</math> NLB/Total assets</li> </ul>	<ul style="list-style-type: none"> <li>• -</li> <li>• -</li> <li>• -</li> <li>• ?</li> <li>• +</li> <li>• -</li> <li>• +</li> <li>• -</li> <li>• -</li> <li>• +</li> <li>• -</li> <li>• -</li> <li>• -</li> <li>• -</li> </ul>	<ul style="list-style-type: none"> <li>.050</li> <li>.054</li> </ul>
11	2007	Garcia-Teruel, Martinez-Solano	Spain	11,533	n.a.	<ul style="list-style-type: none"> <li>• Financial solvency</li> <li>• Average maturity of assets</li> <li>• <math>\Delta</math> one year and six to ten year bonds</li> <li>• Depreciation/Total assets</li> <li>• log firms asset value</li> <li>• Total debt/shareholder equity</li> </ul>	• Short term debt	<ul style="list-style-type: none"> <li>• +</li> <li>• +</li> <li>• -</li> <li>• -</li> <li>• -</li> </ul>	.069
12	2008	Appuhami	Thailand	416	Financial statements	<ul style="list-style-type: none"> <li>• CAPEX</li> <li>• OPEX</li> <li>• Investment Expenditure</li> <li>• Operating cash flow</li> <li>• Dept ratio</li> <li>• Market to book ratio</li> <li>• Sales growth</li> <li>• CAPEX</li> <li>• OPEX</li> <li>• Investment Expenditure</li> <li>• Operating cash flow</li> <li>• Dept ratio</li> <li>• Market to book ratio</li> <li>• Sales growth</li> </ul>	<ul style="list-style-type: none"> <li>• NLB</li> <li>• WCR</li> </ul>	<ul style="list-style-type: none"> <li>• +</li> <li>• +</li> <li>• -</li> <li>• -</li> <li>• -</li> <li>• ?</li> <li>• ?</li> <li>• -</li> <li>• +</li> <li>• -</li> <li>• -</li> <li>• +</li> <li>• ?</li> <li>• ?</li> </ul>	<ul style="list-style-type: none"> <li>.404</li> <li>.304</li> </ul>
13	2008	Garcia-Teruel, Martinez-Solano	Spain	860	SABE-database	<ul style="list-style-type: none"> <li>• Growth</li> <li>• Size</li> <li>• Short term bank debt</li> <li>• Probability of financial distress</li> <li>• Leverage</li> <li>• Debt Maturity</li> <li>• Cash Flow</li> <li>• Investment in liquid assets</li> <li>• Opportunity cost of cash holdings</li> </ul>	• Cash Holding (Cash + marketable securities to total assets)	<ul style="list-style-type: none"> <li>• +</li> <li>• +</li> <li>• -</li> <li>• ?</li> <li>• +</li> <li>• -</li> <li>• +</li> <li>• -</li> <li>• ?</li> </ul>	n.a.
14	2010	Hill, Kelly, Highfield	USA	3,343	Compustat	<ul style="list-style-type: none"> <li>• <math>\Delta</math> sales growth</li> <li>• Gross profit margin</li> <li>• Sales volatility</li> <li>• Operating Cash Flow</li> <li>• Market-to-book ratio</li> <li>• Firm size</li> <li>• Market power</li> <li>• Financial distress</li> </ul>	• WCR/Sales	<ul style="list-style-type: none"> <li>• -</li> <li>• ?</li> <li>• -</li> <li>• -</li> <li>• +</li> <li>• -</li> <li>• +</li> <li>• ?</li> <li>• -</li> </ul>	.140
15	2010	Banos-Caballero, Garcia-Teruel, Martinez-Solano	Spain	4,076	SABE-database	<ul style="list-style-type: none"> <li>• Cash Flow</li> <li>• Debt/total assets</li> <li>• (Sales1-Sales0)/Sales0</li> <li>• log assets</li> <li>• Age</li> <li>• Tangible fixed assets/total assets</li> <li>• ROA</li> </ul>	• CCC	<ul style="list-style-type: none"> <li>• -</li> <li>• -</li> <li>• ?</li> <li>• +</li> <li>• +</li> <li>• -</li> <li>• -</li> <li>• +</li> </ul>	n.a.

<sup>a</sup> - significant negative correlation; + significant positive correlation; ? no significant correlation persistent

Companies facing high capacity utilization are able to realize economies of scale: While work-in-process inventory can be kept fairly constant, sales increases in proportion to capacity. A large proportion of make-to-order products ensures that the finished goods inventory remains within reasonable limits, as such products can normally be shipped to



customers immediately after completion. Although many of the drivers presented correlate with working capital levels as anticipated, Nunn (1981) was able to substantiate these correlations with statistical data. To the amazement of the present author, literature in this research area is rather scarce. In their investigations to date, almost all academics have leaned toward firm characteristics based on external KPIs as drivers of working capital requirements. It is assumed that this is not due to the belief that research into production-related drivers is irrelevant. The reason is rather to be found in the fact that little data on production-related variables is readily available. Such data usually has to be collected in time-consuming empirical surveys. On the other hand, firm characteristics such as the capital structure can easily be retrieved from public databases.

#### 2.5.2.2 Company characteristics

The different drivers with regard to company characteristics are separated into three groups: performance indicators, capital structure-related drivers and others. An examination of the relevant studies clearly shows that a multiplicity of endogenous and exogenous variables is used. Some drivers of working capital management recur in different published papers. Over time, however, new indicators have steadily been introduced. The same applies for measures of working capital management: Not all studies use standard measures such as CCC, WCR or the NLB. Such variations hamper the strict interpretation of published results. Published articles cover every decade from the 1980s to the present. In terms of frequency, it is conspicuous that most papers were published over the past decade, suggesting that the topic has lately gained in significance. The geographic coverage of the studies is rather limited. By far the majority of studies use data gleaned from U.S. companies. More recently, studies of Spain, Thailand and the Taiwanese market have rounded off the existing picture. In-depth studies of SMEs have been conducted for the Spanish market in particular. The goodness achieved by the models applied varies as a function of the exogenous variables they use. Given that values for  $R^2$  range from .050 to .580, it would seem to be difficult to derive a clear line from the figures presented.

Numerous authors have investigated correlations between two different performance measures – profitability and of the ability to generate cash flow – and working capital management. With regard to profitability, existing literature tends to confirm the finding of the previous chapter: that successful working capital management drives performance and

vice versa. This finding is a consequence of the fact that regressions do not allow us to distinguish between cause and effect. Switching dependent and independent variables leads to the same result. A negative correlation between ROS and cash holdings is, for example, presented in Kim et al. (1998)<sup>117</sup>, while negative correlations between ROA and WCR as well as NLB are outlined by Chiou et al. (2006).<sup>118</sup> For the correlation between performance and working capital KPIs, see also Lancaster et al. (1998).<sup>119</sup>

The relationship of cash flow to working capital management has been investigated in many studies. Different KPIs have been used: cash flow, operational cash flow, changes and variances in cash flow and cash flow in relation to assets.<sup>120</sup> Regarding the relationship between operating cash flow and WCR, both Chiou et al. (2006) and Appuhami (2008) confirm a significant negative correlation, indicating that a company's working capital management becomes more efficient as cash flow rises:<sup>121</sup> "Greater cash flow spawned by operations activity implies better working capital management".<sup>122</sup> This finding is in line with the results of Moss (1993) and Baños-Caballero (2010), who identify a negative correlation between cash flow and CCC.<sup>123</sup> The conclusions are the same: Superior working capital management results in higher cash flow, and vice versa. For the sake of completeness, it is important to mention that Hill et al. (2010) and Fazzari et al. (1993) arrive at different conclusions.<sup>124</sup> According to their research, positive operating cash flow enables companies to adopt a more conservative working capital strategy with a positive correlation. Statistical analysis of the data for 3,343 companies in the US confirms their hypothesis. Existing literature adopts a strict stance with regard to the correlation between cash flow and cash holdings. Among others, Opler et al. (1999) and García-Teruel (2008) determine a positive correlation in line with the initial hypothesis that financially strong companies hold relatively more cash reserves.

---

<sup>117</sup> Kim/Mauer/Sherman (1998), p. 354.

<sup>118</sup> Chiou/Cheng/Wu (2006), p. 154.

<sup>119</sup> Lancaster/Stevens/Jennings (1998), p. 37-46.

<sup>120</sup> Fazzari/Petersen (1993), p. 335; Moss/Stine (1993), p. 27; Kim/Mauer/Sherman (1998), p. 354; Opler/Pinkowitz/Stulz/Williamson (1999), p. 19; Chiou/Cheng/Wu (2006), p. 151; Appuhami (2008), p. 13; García-Teruel/Martínez-Solano (2008); p. 132; Hill/Kelly/Highfield (2010), p. 786; Baños-Caballero/García-Teruel/Martínez Solano (2010), p. 514.

<sup>121</sup> Chiou/Cheng/Wu (2006), p. 154, Appuhami (2008), p. 16.

<sup>122</sup> Appuhami (2008), p. 150.

<sup>123</sup> Moss/Stine (1993), p. 33; Baños-Caballero/García-Teruel/Martínez Solano (2010), p. 523.

<sup>124</sup> Hill/Kelly/Highfield (2010), p. 786; Fazzari/Petersen (1993), p. 336.

The second group of indicators for working capital management focuses on the capital structure of the company. Again, numerous authors have contributed to this research field. One frequently used indicator is the amount of total assets as a proxy of firm size.<sup>125</sup> The relationship between firm size and WCR has been investigated by Chiou et al. (2006) and Hill et al. (2010), leading to the same conclusion.<sup>126</sup> According to their findings, the more assets a company has, the higher the WCR. This is because size is seen as a proxy for capital market access. Smaller firms face greater challenges in seeking to finance a positive WCR. For this reason, they more closely monitor operating working capital strategies. Following the arguments for WCR, larger firms do not need to hold as much cash, as they have better access to the capital market. Accordingly, larger firms are able to use the short-term debt market according as and when the need arises. The relationship between size and cash holdings follows this line of argumentation. Larger firms are not forced to hold significant liquidity, as they have much greater flexibility in responding to demand for short-term liquidity.<sup>127</sup> Smaller firms may experience severe difficulties if cash buffers are unable to satisfy unexpected demand. Correlating total assets to CCC, Moss (1993) observes evidence that larger firms are able to achieve lower CCC.<sup>128</sup> Especially with regard to inventory and accounts receivable, the study suggests that smaller firms have room to improve. In the study conducted by Baños-Caballero et al. (2010), this variable reveals no significance – one possible explanation being the study's focus on SMEs. Besides using total assets themselves as a variable, several authors also use total asset ratios. Opler et al. (1999) analyze the correlation between capital expenditure and total assets including cash holdings, revealing a positive correlation.<sup>129</sup> Their reasoning is that firms that are able to invest relatively more usually also enjoy greater liquidity. Another study reveals that the ratio of depreciation to total assets correlates negatively to short-term debt.<sup>130</sup> Firms with less depreciation expenses usually have fewer tangible assets but greater growth options. It is therefore expected that these firms will use more short-term debt. Correlating the ratio of tangible fixed assets to total assets with CCC produces a negative sign. The authors develop the hypothesis that fixed

---

<sup>125</sup> Moss/Stine (1993), p. 29; Kim/Mauer/Sherman (1998), p. 354; Opler/Pinkowitz/Stulz/Williamson (1999), p. 25; Chiou/Cheng/Wu (2006), p. 154; García-Teruel/Martínez-Solano (2008), p. 134; Hill/Kelly/Highfield (2010), p. 795.

<sup>126</sup> Hill/Kelly/Highfield (2010), p. 795, Chiou/Cheng/Wu (2006), p. 154.

<sup>127</sup> Opler/Pinkowitz/Stulz/Williamson (1999), p. 25; García-Teruel/Martínez-Solano (2008), p. 134.

<sup>128</sup> Moss/Stine (1993), p. 30.

<sup>129</sup> Opler/Pinkowitz/Stulz/Williamson (1999), p. 25.

<sup>130</sup> García-Teruel/Martínez-Solano (2007), p. 592.

assets compete for funds with levels of working capital when a company is operating under financial constraints.<sup>131</sup> García-Teruel et al. (2007) include an additional question in their considerations. According to their findings, the average use of short-term debt is greater when the average maturity of assets is shorter.<sup>132</sup> The authors argue that this is consistent with the usual practice of adapting asset liquidity to the time it takes to settle liabilities.

Another widely covered field is way in which leverage and working capital management interact. Given that working capital positions are relatively liquid, they are a major focus when financial distress situations occur. The existence of a correlation in the way financially distressed companies tend to squeeze out working capital positions has been postulated, whereas – according to the same hypothesis – other firms can afford to finance sufficient levels. This initial hypothesis has been confirmed by many studies.<sup>133</sup> The main line of argumentation is that companies short of funds tend to raise capital internally before issuing new stocks or borrowing money from outside, as this path is usually barred.<sup>134</sup> It follows that a rising debt ratio forces companies to pay more attention to working capital management. Another explanation heading in the same direction is that indebted firms, whose financial risks are greatest, try to control risk by lengthening the average maturity of their debt.<sup>135</sup> For this reason, highly leveraged firms try to increase maturity in order to avoid liquidation. Interestingly, the study conducted by García-Teruel et al. (2007) comes to different results. While their data shows a positive correlation, they themselves qualify their statement. On the one hand, it is argued that, in light of their limited access to the capital markets, small firms might prefer to maintain high cash levels rather than using cash to reduce their debt. On the other hand, the significance of both this variable and the coefficients is low. The authors therefore opt to give limited support to these findings.

Besides performance and capital structure indicators, scholars have also tested the empirical relevance of several other items that reflect company characteristics with regard to working capital performance. Nunn (1981), for instance, focuses on sales-related variables.<sup>136</sup> Specifically, he investigates whether the ratios media advertising to sales, sales force

---

<sup>131</sup> Baños-Caballero/García-Teruel/Martínez Solano (2010), p. 524.

<sup>132</sup> García-Teruel/Martínez-Solano (2007), p. 592.

<sup>133</sup> Kim/Mauer/Sherman (1998), p. 354; Opler/Pinkowitz/Stulz/Williamson (1999), p. 25; Chiou/Cheng/Wu (2006), p. 154; García-Teruel/Martínez-Solano (2007), p. 591; Appuhami (2008), p. 16; Hill/Kelly/Highfield (2010), p. 795; Baños-Caballero/García-Teruel/Martínez Solano (2010), p. 523.

<sup>134</sup> Chiou/Cheng/Wu (2006), p. 150.

<sup>135</sup> García-Teruel/Martínez-Solano (2007), p. 593.

<sup>136</sup> Nunn (1981), p. 211.

expenses to sales, the gross profit margin as a percentage and sales as a percentage of components have a significant impact on working capital measures. The exogenous measure used in his model is the ratio working capital divided by sales. According to Nunn's calculation, the first and last variables presented have a significant negative impact and the other two are revealed to have a significantly positive correlation. The significance level for all variables is .999. According to Nunn (1981), media advertisement leads to a competitive advantage in the market concerned, resulting in working capital-related economies. In particular, it is expected that the use of credit and fast delivery as selling tools can be reduced. The positive correlation between sales force expenses and working capital levels can be explained as follows: The more powerful the sales force is, the more pressure will be exerted on the finance and production functions to provide more generous credit terms and faster shipment. The same applies for the third variable. A larger gross profit margin creates an incentive to ship quickly and lowers barriers to the granting of credit. The variable percentage of sales to subsidiaries correlates negatively to working capital, as finished products are usually shipped on completion and accounts receivable are paid on time in line with company guidelines. To the knowledge of the author, no empirical research other than that of Nunn has yet investigated similar sales-related variables. Given that significant correlations in line with initial hypotheses have been identified, this is astonishing. Another interesting variable used to explain working capital success is the ratio R&D spend divided by sales. Opler et al. (1999) analyze this effect and discover that the relative R&D spend has a significant positive impact on cash holdings.<sup>137</sup> They argue that this effect results from existing information asymmetries that are expected to be higher at firms whose R&D spend is higher. According to the authors, R&D expenses are a form of investment in which information asymmetries are of importance. Another unique research question is tackled by Filbeck et al. (2005),<sup>138</sup> who investigate whether key working capital performance indicators change over time. According to their sample of 1,000 companies from 1996 to 2000, the standard deviation of key performance measures is comparatively low. For instance, average days working capital for the whole timeframe were 51.8, with a standard deviation of 4.7 days. However, the authors do find significant changes in working capital measures over time. These changes are explained mainly by macroeconomic factors such as interest rates, the rate of innovation and competition. As a factor of influence on working capital, age is analyzed in studies by Chiou

---

<sup>137</sup> Opler/Pinkowitz/Stulz/Williamson (1999), p. 11.

<sup>138</sup> Filbeck/Krueger (2005), p. 13

et al. (2006) and Baños-Caballero et al. (2010).<sup>139</sup> It is argued that companies tend to achieve higher growth rates in their early years. As management loosens the reins over time, working capital management becomes less efficient. Another explanation is that older firms have better access to external capital sources. Since they are able to obtain liquidity from the market, these companies maintain CCC for longer because of the lower cost of financing.

A study conducted by Appuhami (2008) traces the impact of capital expenditure (CAPEX) and operating expenditure (OPEX) on the net liquid balance and the working capital requirement.<sup>140</sup> Based on the results, CAPEX has a significant positive impact on NLB with a coefficient of .531. The same applies for OPEX: The data shows a significant positive impact. These findings are in line with the assumption, formulated earlier, that future growth opportunities require a higher current cash balance and more short-term investment. Working capital requirements exhibit a significant negative correlation to CAPEX, indicating that companies tend to manage working capital more efficiently when investment is high. Conversely, working capital requirements correlate positively to OPEX, indicating that companies seem to hold more current assets when they have commitments to pay interest.

One final company characteristic that has attracted considerable attention from researchers, as has its impact on working capital, is sales and sales growth. The first study that included sales as a variable was conducted by Moss (1993).<sup>141</sup> Like other scholars, Moss (1993) used sales as an indicator of firm size. According to his results, there is a significant impact in that firms with higher sales – i.e. larger firms – have shorter CCC cycles. Based on this outcome, Moss concluded that smaller firms probably have the potential to shorten the CCC by applying strategies to reduce inventories or receivables or both. Several subsequent studies also investigated sales as a driver of working capital, but found no significant correlation.<sup>142</sup> More interestingly, García-Teruel et al. (2008) described a significant positive correlation between sales growth and cash holdings in companies. According to their line of argument, firms with growth opportunities should retain higher liquid reserves in order to be able to exploit these opportunities.<sup>143</sup> Another study by Hill et al. (2010) analyzed the correlation between sales

---

<sup>139</sup> Chiou/Cheng/Wu (2006), p. 154;  
Baños-Caballero/García-Teruel/Martínez Solano (2010), p. 522

<sup>140</sup> Appuhami (2008), p. 13

<sup>141</sup> Moss/Stine (1993), p. 33

<sup>142</sup> E.g. Chiou/Cheng/Wu (2006), p. 154; Appuhami (2008), p. 16-18; Baños-Caballero/García-Teruel/Martínez Solano (2010), p. 523.

<sup>143</sup> García-Teruel/Martínez-Solano (2008), p. 141.

growth and WCR.<sup>144</sup> Based on the data used, a significant negative correlation exists. The main reason cited by Hill et al. (2010) is that companies tighten their credit policy as they achieve planned levels of sales growth. In addition, the authors argue that prior sales growth provides net financing. The same study also examined an additional correlation: the question whether sales volatility has an impact on working capital management. A significant negative correlation between sales volatility and working capital requirements was identified, suggesting that managers tend to manage working capital more aggressively when their sales figures become more volatile. According to these findings, companies with highly volatile sales usually reduce working capital to the minimum needed to ensure liquidity.

### 2.5.2.3 Competitive position

Besides company-specific variables, many researchers have drawn attention to external variables as well. The aim is to analyze whether external factors that companies are scarcely able to influence might also impact working capital decisions. The most obvious variable is the question of whether the economy's business cycle has an impact on working capital levels. According to academic research conducted by Chiou et al. (2006), companies tend to increase NLB and WCR when the business cycle is in recession.<sup>145</sup> The reason for the positive correlation to NLB is that, during periods of economic recession, cash supply is comparatively tight. Companies therefore have to keep more current assets available in order to maintain the operating cycle. The same applies for the correlation to WCR: In a recession, companies face higher levels of WCR. When a company faces difficult economic conditions, growth often falls short of planned targets. Collecting accounts receivable tends to take longer, while inventory levels rise due to reduced sales figures. All in all, these assumed consequences result in higher levels of NLB and WCR.

A further competitive variable in respect to working capital management is the company's market share. The underlying question is whether companies that enjoy a relatively powerful market position in respect of their competitors, suppliers and customers pursue different working capital policies to companies that face stiff competition. Nunn came to the conclusion that a strong competitive position in its market enables companies to reduce working capital levels.<sup>146</sup> Basically, powerful companies manage to maintain lower levels of working capital due to advantages in buying and selling. On the upstream side, dominant

---

<sup>144</sup> Hill/Kelly/Highfield (2010), p. 794-796.

<sup>145</sup> Chiou/Cheng/Wu (2006), p. 152f.

<sup>146</sup> Nunn (1981), p. 212.

companies can leverage their larger scale of purchases to drive down procurement costs. In addition, these companies are most likely to be able to dictate suppliers' delivery schedules, due dates, credit terms, etc. to their own advantage. On the downstream side, a powerful market position reduces the need for marketing tools such as credit and fast delivery, as competitors are hardly in a position to jeopardize their sales. This argumentation is in line with the results arrived at by Hill et al. (2010),<sup>147</sup> though it should be noted that the tested correlation is not statistically significant. The authors nevertheless stated that, in line with their initial hypotheses, a negative correlation is indeed expected. Nunn then expanded on his deliberations by investigating the effects of unstable market shares.<sup>148</sup> His results were in line with the correlations identified in the first run. The more instable a company's market position, the more working capital it requires. In situations where customer loyalty is uncertain, managers may therefore step up the use of sales tools such as credit and fast delivery.

Another widespread variable used in studies is the market-to-book ratio. The results for this variable are not clear-cut, as some indicate positive correlation while others find no indication of any significant correlations. The first researchers to explore this issue were Kim et al. (1998), who investigated putative correlations between market-to-book values and cash holdings. According to their study, a significant positive correlation exists, indicating that the higher the ratio, the higher the cash levels maintained.<sup>149</sup> It is argued that a higher market-to-book value is determined by growth opportunities. However, companies whose value is determined to a large extent by growth opportunities usually face more serious information asymmetries. Such information asymmetries ultimately lead to information-induced financing constraints that force these companies to hold more liquid reserves. The results documented by Kim et al. (1998) are in line with research published by Opler (1999).<sup>150</sup> Appuhami (2008) was unable to establish a significant correlation, even though correlations to NLB were, as in the two previous studies, positive.<sup>151</sup> Hill et al. (2010) investigated the correlation between the market-to-book ratio and WCR/sales. The authors identified a significant positive correlation, presenting a correlation coefficient of -.128.<sup>152</sup> In line with the arguments put forward by Kim et al. (1998), the higher market-to-book ratio in their results seems to indicate the existence of

---

<sup>147</sup> Hill/Kelly/Highfield (2010), p. 797.

<sup>148</sup> Nunn (1981), p. 212f.

<sup>149</sup> Kim/Mauer/Sherman (1998), p. 352-355.

<sup>150</sup> Opler/Pinkowitz/Stulz/Williamson (1999), p. 25.

<sup>151</sup> Appuhami (2008), p. 16.

<sup>152</sup> Hill/Kelly/Highfield (2010), p. 797.



increased information asymmetries. The degree of information asymmetries can be taken as a proxy for the cost of external financing. Based on this line of argument, firms with higher market-to-book ratios face higher financing costs and will seek to reduce WCR. Another of the arguments provided points in the same direction: Companies with substantial growth opportunities aim to reduce WCR to free up the liquidity needed to fund future growth. It follows that both the negative correlation between the market-to-book ratio and cash holdings described by Kim et al. (1998) and Opler (1999) and the positive correlation between the market-to-book ratio and WCR described by Hill et al. (2010) are consistent and support each other.

By analogy to the variables outlined above, researchers have also tested the impact of external assessments of companies' financial strength on working capital. Kim et al. (1998) studied potential effects of the interest spread between the return on assets and the return on short-term treasury bills.<sup>153</sup> The spread can be interpreted as the opportunity cost of cash holdings: The higher the return on physical assets, the lower the opportunity cost for cash holdings. The results of Kim et al.'s indicate a significant negative correlation. This outcome is consistent with the prediction that the higher the return on physical assets compared to liquid assets, the lower will be the investment in liquid assets. García-Teruel et al. (2008) likewise tested whether there is a correlation between the interest spread and working capital decisions.<sup>154</sup> They were unable to establish any significant results.

With regard to external views of companies and their products, moreover, Nunn (1981) also tested the impact of the customers' perception of a company's image and the image of its products on working capital levels. Nunn anticipated a negative correlation between a company's relative image and working capital levels. According to his assumption, the better the brand image of a company, the greater the degree of loyalty and the more favorably products would be perceived relative to those of rivals. These attributes would guarantee sales while reducing the need for extensive accounts receivable and inventories. In the course of his study, Nunn (1981) was able to confirm his assumption, presenting a correlation coefficient of -.114 at the .999 significance level. Along the same lines, he analyzed the impact of relative price levels compared to a company's competitors. Nunn (1981) predicted a positive impact, postulating that the higher the selling price compared to a company's competitors, the greater its relative sales profitability would be. Consequently, higher relative profitability

---

<sup>153</sup> Kim/Mauer/Sherman (1998), p. 352-355.

<sup>154</sup> García-Teruel/Martínez-Solano (2008), p. 145-146.

would increase the incentive to use marketing tools such as credit granting to attract new customers or retain the loyalty of existing customers. Nunn (1981) backed up the hypotheses in his study by showing a positive correlation of .079 at the .995 significance level.

#### 2.5.2.4 Industry factors

Not surprisingly, many academic researchers expected industry affiliations to have a significant effect on working capital management. Since different industries require different levels of capital intensity depending on their business models, one would logically expect to find different working capital requirements. The first scholar who investigated these relationships was Nunn (1981),<sup>155</sup> who argued that companies that export a large proportion of their products have to maintain longer pipelines for raw materials and work-in-progress inventories. In addition, these companies may also need to operate part of their production in the foreign countries they serve. Besides pressure on inventory levels, it is expected that the collection period too may be longer as both distance and payment procedures in the host country can drive complexity. Regarding the share of imports, he argues along similar lines: The more a company is dependent on foreign raw materials and primary products, the longer the supply pipelines and therefore the greater the transit inventories. Given that a large share of imports implies exposure to the risk of supply chain interruptions, companies are expected to increase buffer inventories too. The data used in Nunn's study supported his assumptions: Both exports and the share of imports correlate positively to working capital/sales.

Another aspect is industry concentration. Nunn (1981) argues that heavy industry concentration supports a greater spread of price to marginal costs than under normal market conditions.<sup>156</sup> A relatively higher spread of price to marginal cost, however, makes companies more sensitive to disruptions and dissatisfied customers. In other words, the higher the spread, the more beneficial it is to a company to carry higher inventory levels. The same applies to the granting of credit: The higher the spread, the more beneficial it is to a company to satisfy customers by using this kind of marketing tool, for example. By consequence, Nunn (1981) was able to confirm his assumptions by presenting statistics that affirm a significant positive correlation.

---

<sup>155</sup> Nunn (1981), p. 212-213.

<sup>156</sup> Nunn (1981), p. 213.

Hawawini et al. (1986) adopted a more generous approach in investigating industry effects on working capital.<sup>157</sup> Based on Compustat data for 1,181 companies in the period from 1960 to 1979, they analyzed whether the variability of WCR-to-sales ratios is different within industries to the variability across industries. According to their results, a significant industry effect was persistently visible in all of the nineteen years examined. They then extended their research by identifying industries that have more similar working capital requirements and others that differ very considerably. These findings were confirmed in a study conducted by Filbeck et al. (2005).<sup>158</sup> Analyzing the data for approximately 1,000 companies in the period from 1996 to 2000 confirmed that working capital measures such as cash conversion consistency, days working capital and days sales outstanding vary significantly between industries. By way of example, the petroleum industry managed average days working capital of 6 days throughout the entire period, whereas the scientific equipment industry averaged 25 days.

## 2.5.3 Related research topics interfacing with working capital management

### 2.5.3.1 A literature review of supply chain risk

#### 2.5.3.1.1 Supply chain risk drivers versus risk sources

On a very general level, risk can be defined as "the probability of variance in an expected outcome" or "the variance of the future return around its expected value".<sup>159</sup> In other words, risk is the product of the two separate but interrelated elements uncertainty and impact.<sup>160</sup> Alongside copious research derived from risk and risk management, one emerging discipline has been to analyze the aspects of risk associated with supply chains.<sup>161</sup> In line with these general definitions of risk, Jüttner et al. (2003) defined supply chain risk as "variation in the distribution of possible outcomes, their likelihoods, and their subjective value".<sup>162</sup> According to this definition, there is an "upside" and a "downside" risk as the *ex-post* situation could be above or below the expected value *ex ante*. This definition is not uncontroversial: Wagner et al. (2006) argue that, for the purposes of supply chain management research, a notion of risk

---

<sup>157</sup> Hawawini/Viallet/Vora (1986), p. 18-23.

<sup>158</sup> Filbeck/Krueger (2005), p. 14.

<sup>159</sup> Spekman/Davis (2004), p. 416; Ball/Brown (1969), p. 301.

<sup>160</sup> Zsidisin/Ragatz/Melnyk (2005), p. 48.

<sup>161</sup> E.g. March/Zur Shapira (1987), p. 1404-1418; Lhabitant/Tinguely (2001), p. 343-363.

<sup>162</sup> Jüttner/Peck/Christopher (2003), p. 200.

as being purely negative corresponds best to supply chain reality. To this end, they define supply chain risk as "the combination of (1) an unintended, anomalous triggering event that materializes somewhere in the supply chain or its environment, and (2) as a consequential situation which significantly threatens normal business operations of the firm in the supply chain". Following, supply chain risk is the exposure to a breakdown of flows between the different components of the supply chain.<sup>163</sup> This position has been supported by several studies confirming that, in human perception, the downside potential of risk is overrated.<sup>164</sup> For this reason, it seems appropriate not to consider "happy disasters": situations in which managers intentionally "gamble" on risk in a supply chain context, as outlined by Wagner et al. (2006).<sup>165</sup>

Supply chain risk research has spawned different nomenclatures. For this reason, it is appropriate first to specify, structure, and link existing terms relating to supply chain risk management. The first terms that form a pair are supply risk drivers and supply chain vulnerability. These terms describe the degree to which a supply chain is exposed to disruptions. Supply chain vulnerability is the total exposure of the company's supply chain to undesirable conditions. If this total exposure is broken down into its components, one speaks of supply chain risk drivers. Svensson (2002) defined supply chain vulnerability as "a condition that affects a firm's goal accomplishment dependent upon the occurrence of negative consequences of disturbance [...]".<sup>166</sup> From a supply chain perspective, these negative consequences potentially prevent effective supplies to the end customer market.<sup>167</sup> One important factor regarding to supply chain vulnerability seems to be the company's perceived trust and reliability. According to Svensson (2002), trust is important in lean business relationships, as lean models tend to increase supply chain vulnerability.<sup>168</sup> Existing literature determines supply risk drivers to be variables such as global sourcing, supplier concentration, and increased outsourcing.<sup>169</sup> Supply chain risk drivers as such, and supply chain vulnerability as a whole, do not lead to negative consequences. Rather, negative consequences require variables "that cannot be predicted with certainty and from which

---

<sup>163</sup> Lavastre/Gunasekaran/Spalanzani (2011), p. 829.

<sup>164</sup> March/Zur Shapira (1987), p. 1407.

<sup>165</sup> Wagner/Bode (2006), p. 303.

<sup>166</sup> Svensson (2002), p. 112.

<sup>167</sup> Jüttner/Peck/Christopher (2003), p. 200-201.

<sup>168</sup> Svensson (2004), p. 469.

<sup>169</sup> Chopra/Sodhi (2004), p. 54.

disruptions might emerge."<sup>170</sup> In other words, supply chain exposure leads only to a negative impact once a trigger or risk source is apparent. In existing literature, these triggers of negative consequences have been called supply risk sources or supply disruptions. According to the definition proposed by Jüttner et al. (2003), supply risk sources are environmental, organizational or supply chain-related variables whose characteristics cannot be predicted with certainty in advance.<sup>171</sup> These variables nevertheless impact supply chain outcome variables. Norrman et al. (2004) define supply chain risk sources as the "devastating ripple effects that disasters or even minor business disruptions can have in a supply chain", in line with the classification formulated by Jüttner et al. (2003).<sup>172</sup> Studies list potential supply risk sources such as environmental risk sources (e.g. sociopolitical actions and *force majeure*) and organizational risk sources (e.g. strikes and machine failures).<sup>173</sup> As is obvious from the list, the nature and impact of supply risk sources varies significantly. The impact and probability of an earthquake will most likely differ greatly from the characteristics of a supplier default. A further consideration is that supply chain risk sources can be endogenous (such as machine downtime) or exogenous (such as a political instability). As a consequence, various taxonomies have been established though they generally contain many inconsistencies. The demarcation of different categories likewise varies, as does the assignment of single risk sources to super ordinate classes.<sup>174</sup> One of the first researchers to investigate and classify potential supply chain sources was Miller (1992). Miller (1992) defined "input supply uncertainties" and "production uncertainties" as one aspect of integrated risk management.<sup>175</sup> Based on a perspective current at that time, however, his understanding reflected only a small subset of potential supply chain disruptions. Miller focused on raw material shortages, quality changes, spare parts restrictions, machine failures and other random production factors. According to his risk definition, "input supply uncertainties" and "production uncertainties" belong to "operative uncertainties" that are part of overall "firm uncertainties". Besides "firm uncertainties", he also identified "general environmental uncertainties", "industry uncertainties" and "financial risk uncertainties" as risk drivers to the company. This taxonomy was later broadened by Jüttner et al. (2003), who defined three main pillars: "environmental

---

<sup>170</sup> Jüttner (2005), p. 122.

<sup>171</sup> Jüttner/Peck/Christopher (2003), p. 200.

<sup>172</sup> Norrman/Jansson (2004), p. 435.

<sup>173</sup> Jüttner/Peck/Christopher (2003), p. 201; Norrman/Jansson (2004), p. 435;

Wagner/Bode (2006), p. 304-305.

<sup>174</sup> E.g. Jüttner/Peck/Christopher (2003), p. 201; Wagner/Bode (2006), p. 304-305;

Chopra/Sodhi (2004), p. 54.

<sup>175</sup> Miller (1992), p. 18.

risk sources", "organizational risk sources" and "network related risk sources".<sup>176</sup> For other taxonomies, please see Wagner et al. (2006), Manuj et al. (2008) and Svensson (2000).<sup>177</sup> Some papers, however, preferred to analyze potential risks to supply chains in general rather than discussing these different constructs in particular.<sup>178</sup> One special focus of supply chain risk research was initiated by Zsidisin et al. (2000), who published a paper about purchasing risk assessment and management-named supply risk.<sup>179</sup> These authors were the first to define supply risk as "the transpiration of significant and/or disappointing failures with in-bound goods and services".<sup>180</sup> As outlined in the definition, Zsidisin et al. (2000) focused their work on one part of the value chain: the inbound supply chain. This focus reflects the fact that sourcing is becoming a competitive advantage, as the scope of outsourcing is on the rise in many companies, such that product supply lines span the entire global marketplace.<sup>181</sup> The foundation for research into supply risk was laid even earlier, however. In 1983, Kraljic (1983) published a highly regarded paper on the need to integrate purchasing in supply management.<sup>182</sup> These papers moved numerous authors to conduct further investigation into potential disruptions along the whole value chain from suppliers, through the internal transformation process to final distribution to customers. Others, such as Giunipero et al. (2004) and Zidisin et al. (2003), followed Zsidisin et al. (2000) in studying the specialized field of supply risk.<sup>183</sup>

The negative impact of the occurrence of a supply risk is called risk consequence.<sup>184</sup> The consequences of a supply risk focus on the supply chain outcome in terms of cost, quality, quantity and time, for example.<sup>185</sup> Christopher et al. (2004) named several potential supply risk consequences, such as inventory costs due to obsolescence, markdowns, stock-outs and retail markdowns.<sup>186</sup> To avoid these negative impacts of supply risks, companies need to develop mitigation strategies. The underlying supply chain risk drivers serve as the levers that can be used to steer supply chain risk. Mitigating strategies are those actions that organizations deliberately undertake to mitigate the uncertainties identified from potential

---

<sup>176</sup> Jüttner/Peck/Christopher (2003), p. 201-202.

<sup>177</sup> Wagner/Bode (2006), p. 304-305; Manuj/Mentzer (2008), p. 201; Svensson (2000), p. 739.

<sup>178</sup> Spekman/Davis (2004), p. 419-420.

<sup>179</sup> Zsidisin/Panelli/Upton (2000), p. 187-197.

<sup>180</sup> Zsidisin/Panelli/Upton (2000), p. 187.

<sup>181</sup> Christopher/Mena/Khan/Yurt (2011), p. 67.

<sup>182</sup> Kraljic (1983), p. 109-117.

<sup>183</sup> Giunipero/Eltantawy (2004), p. 698-713; Zsidisin/Ellram (2003), p. 15-27.

<sup>184</sup> Jüttner/Peck/Christopher (2003), p. 200.

<sup>185</sup> Bogataj/Bogataj (2007), p. 291.

<sup>186</sup> Christopher/Lee (2004), p. 388.

supply disruptions.<sup>187</sup> Potential mitigating strategies have been outlined by Chopra et al., Christopher et al. (2004) and Jüttner et al. (2003).<sup>188</sup> Companies must adopt a holistic approach to managing supply chain risk. They must cover the identification of supply chain risk sources, their consequences and the underlying supply risk drivers in order to develop mitigation strategies – supply chain risk management, in other words.<sup>189</sup> Jüttner et al. (2003) defined supply chain risk management as follows: "The identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole".<sup>190</sup>

Most authors in the field of supply chain risk management claim that today's business conditions and requirements necessitate a larger number of supply chain risk sources and drivers, as well as interrelations and correlations. Christopher et al. (2004), for example, list greater uncertainties in supply and demand, the globalization of the market, ever shorter product and technology lifecycles and the increased use of manufacturing, distribution and logistics partners as trends that are driving greater risk exposure in today's supply chains.<sup>191</sup> Others, such as Svensson (2001) and Lee (2004, 2010), also emphasize the trend toward ever leaner supply chains based on practices such as just-in-time delivery.<sup>192</sup> Indeed, there is hardly a company nowadays that does not supply its wares to Far Eastern or triad markets, sell to global customers or make use of integrated value chains. Besides these business trends, another trend too is apparent: The number of natural disasters, terrorist attacks, instances of political instability and man-made disasters has likewise increased perceptibly of late.<sup>193</sup> The growing frequency of such incidents has also driven monetary losses as a consequence of these disasters.<sup>194</sup> Recent reports indicate that total monetary losses in 2011 reached the second highest total of USD 108 billion.<sup>195</sup> One major cause of greater storm damage and flooding, as in the wake of Hurricane Katrina, for example, is undoubtedly the process known as global warming. Accordingly, experts predict increasing threats to global supply chains going forward. Following on from 9/11, the Madrid bombings and the attacks in London,

---

<sup>187</sup> Miller (1992), p. 322.

<sup>188</sup> Chopra/Sodhi (2004), p. 55; Christopher/Lee (2004), p. 10; Jüttner/Peck/Christopher (2003), p. 19.

<sup>189</sup> Berg/Knudsen/Norrmann (2008), p. 288-310, Ritchie/Brindley (2007), p.1398-1410.

<sup>190</sup> Jüttner/Peck/Christopher (2003), p. 201.

<sup>191</sup> Christopher/Lee (2004), p. 388.

<sup>192</sup> Svensson (2001); p. 208; Lee (2004), p. 102; Lee (2010), p.64.

<sup>193</sup> Kleindorfer/Saad (2005), p. 53.

<sup>194</sup> Stecke/Kumar (2009), p. 1.

<sup>195</sup> Handelsblatt, 15<sup>th</sup> December 2011.

terrorist activities too have attracted greater attention in recent years.<sup>196</sup> Decision makers have recognized that such disruptions have the potential to severely harm profits or even threaten the existence of entire companies.<sup>197</sup> One recent example was the Japanese earthquake, which caused many supply chains in the automotive and electronic industries to collapse. All in all, it is assumed that these trends will add to the vulnerability of today's supply chains.<sup>198</sup> Strategic maneuvers by decision makers are required to develop mitigation strategies and properly manage supply chain risk levels. In light of the above, companies have no choice but to adapt and "weatherproof" their supply chains in the future.<sup>199</sup>

Literature on supply chain risk has been attracting considerable attention since the early years of this century.<sup>200</sup> However, there is still a lack of work in this research field.<sup>201</sup> In particular, empirical surveys that test supply risk constructs and correlations between constructs are conspicuous by their absence.<sup>202</sup> A few case studies covering the topic have been conducted, such as those by Norrman (2004) and Peck (2005).<sup>203</sup> The number of large-scale studies is very limited, however. To the knowledge of the author, only a handful of studies make use of large-scale surveys. One of the first was Zsidisin et al. (2003), who gathered data from a mail survey addressed to 1,000 randomly selected purchasing professionals. In total, 261 usable mailings were returned, equivalent to a response rate of 28 percent.<sup>204</sup> In 2005, Jüttner (2005) conducted an empirical survey in cooperation with the Chartered Institute for Logistics and Transport and was supplied with the views of 137 logistic managers.<sup>205</sup> The latest large empirical study was conducted by Wagner et al. (2006). All in all, 760 usable responses were generated by top executives in logistics and supply chain management positions.<sup>206</sup> All authors who have worked empirically on this topic have bemoaned the lack of a substantiated empirical database on supply chain risk and encouraged for further contributions by the scientific community.<sup>207</sup>

---

<sup>196</sup> Martha/Subbakrishna (2002), p. 19.

<sup>197</sup> Hendricks/Singhal (2005), p. 35.

<sup>198</sup> Thun/Hoenig (2011), p. 247.

<sup>199</sup> Martha/Subbakrishna (2002), p. 19.

<sup>200</sup> Zsidisin/Panelli/Upton (2000), p. 187; Jüttner/Peck/Christopher (2003), p. 197; Chopra/Sodhi (2004), p. 53.

<sup>201</sup> Thun/Hoenig (2011), p. 243.

<sup>202</sup> Tang/Nurmaya Musa (2011), p. 25.

<sup>203</sup> Norrman/Jansson (2004), p. 440; Peck (2005), p. 211.

<sup>204</sup> Zsidisin/Ellram (2003), p. 20.

<sup>205</sup> Jüttner (2005), p. 124.

<sup>206</sup> Wagner/Bode (2006), p. 306.

<sup>207</sup> Jüttner (2005), p. 139; Tang/Nurmaya Musa (2011), p. 31-33.



#### 2.5.3.1.2 Risk drivers and risk source items

Besides large-scale empirical studies, numerous researchers have also listed and classified supply chain risk drivers and supply chain risk sources (see table 6). This section therefore documents and clusters the identified supply chain risk drivers and supply chain risk source items. All in all, 16 papers more or less cover research into supply chain risk management in terms of the way they list the sources and drivers of supply chain risk. Research into these issues peaked from 2003-2005, the period in which most of the papers were published. As we saw in the previous section, the first paper published dates back to 1992 and was published by Kent D. Miller (1992). This section first outlines all the supply chain risk drivers identified in existing literature, followed by a review of literature on supply chain risk sources.

The first scientific work that listed supply chain risk drivers in the context of supply chain risk management was conducted by Jüttner et al. (2003). All in all, these authors list five supply chain risk drivers, claiming that these drivers had emerged over the past decade and therefore had thus increased companies' supply chain risk levels. The risk drivers named were "a focus on efficiency rather than effectiveness", "the globalization of supply chains", "focused factories and centralized distribution", "the trend to outsourcing" and "reduction of the supplier base".<sup>208</sup> These risk drivers affect the complexity of network structures (in the context of globalization, for example) or lead to more integrated supply chains. Most of the identified supply chain risk drivers have been confirmed by other researchers. Norrman et al. (2004) identified "globalization of supply chains" as a risk driver, for example, as did Jüttner (2005), Peck (2005), Wagner et al. (2006).<sup>209</sup> Similarly, lean supply chains, centralized distribution, outsourcing and the reduced supplier base have all been acknowledged as risk drivers by at least one of the authors named above, which also confirms the initial hypothesis of Jüttner et al. (2003). Still more authors have extended the list of supply chain risk drivers with regard to a more integrated supply chain. Norrman et al. (2004) identified "more intertwined and integrated processes" as a risk driver in today's supply chains.<sup>210</sup> Additionally, Norrman et al. (2004) identified "reduced buffers, e.g. inventory and lead time" as a risk driver, a finding that was confirmed by Jüttner (2005) in a paper published later.<sup>211</sup> In terms of network-related risk drivers, the initial list put forward by Jüttner et al. (2003) has been

---

<sup>208</sup> Jüttner/Peck/Christopher (2003), p. 205.

<sup>209</sup> Norrman/Jansson (2004), p. 434; Jüttner (2005), p. 134; Peck (2005), p. 214-216; Wagner/Bode (2006), p. 305-306.

<sup>210</sup> Norrman/Jansson (2004), p. 434.

<sup>211</sup> Norrman/Jansson (2004), p. 434; Jüttner (2005), p. 134.

expanded as follows: Peck (2005) cited "IT upgrades" and "internal network redesigns" as additional drivers, both of which have since been confirmed by others such as Chopra et al. (2004).<sup>212</sup> Other drivers in this category named by at least one author are: centralized production, industry consolidation, ongoing regulatory changes, single sourcing, the financial strength of customers, high capacity utilization of the supply source, inflexibility of the supply source, system integration or extensive systems networking, e-commerce and vertical integration of the supply chain.<sup>213</sup> In addition to these network-related drivers and drivers toward an integrated supply chain, however, researchers have also come up with further drivers to complete the picture. In recent literature, another aspect has received growing attention: the importance of demand-related risk drivers.

---

<sup>212</sup> Peck (2005), p. 215; Chopra/Sodhi (2004), p. 54.

<sup>213</sup> Jüttner (2005), p. 134; Peck (2005), p. 215; Wagner/Bode (2006), p. 305; Chopra/Sodhi (2004), p. 54

**Table 6: Literature review of supply chain risk management**

#	Year	Author	Object of investigation	Drivers level 1	Drivers level 2
1	1992	Miller	Risk sources	<ul style="list-style-type: none"> <li>• Labor uncertainties</li> <li>• Input supply uncertainties</li> <li>• Production uncertainties</li> <li>• Product liability</li> <li>• Emission of pollutants</li> <li>• Problems with collectibles</li> </ul>	<ul style="list-style-type: none"> <li>• Labor unrest</li> <li>• Employee safety</li> <li>• Raw materials shortages</li> <li>• Quality changes</li> <li>• Spare parts restrictions</li> <li>• Machine failure</li> <li>• Other random production factors</li> </ul>
2	2000	Zsidisin, Panelli, Upton	Risk sources	<ul style="list-style-type: none"> <li>• Business risk</li> <li>• Supplier capacity risk</li> <li>• Quality</li> <li>• Production technological changes</li> <li>• Disasters</li> </ul>	
3	2003	Jüttner, Peck, Christopher	Risk drivers	<ul style="list-style-type: none"> <li>• Focus on efficiency rather than effectiveness</li> <li>• Globalisation of Supply Chains</li> <li>• Focused factories and centralized distribution</li> <li>• Trend to outsourcing</li> <li>• Reduction of supplier base</li> </ul>	
			Risk sources	<ul style="list-style-type: none"> <li>• Environmental risk sources</li> <li>• Organizational risk sources</li> <li>• Network-related risk sources</li> </ul>	<ul style="list-style-type: none"> <li>• Result of accidents (e.g. fire)</li> <li>• Socio-political actions (e.g. fuel protests or terrorist attacks)</li> <li>• Acts of God (e.g. extreme weather or earthquakes)</li> <li>• Labour (e.g. strikes)</li> <li>• Production uncertainties (e.g. machine failure)</li> <li>• IT-system uncertainties</li> <li>• Lack of ownership</li> <li>• Chaos</li> <li>• Inertia</li> </ul>
4	2003	Zsidisin	Risk sources	<ul style="list-style-type: none"> <li>• Individual supplier failures</li> <li>• Market characteristics</li> </ul>	<ul style="list-style-type: none"> <li>• New product development problems</li> <li>• Delivery failures</li> <li>• Relationship issues</li> <li>• Supplier obligations to other customers</li> <li>• Quality problems</li> <li>• Price/cost increases</li> <li>• Inability to meet quantity demand</li> <li>• Technologically behind</li> <li>• Discontinuity of supply</li> <li>• Sole source/limited qualified sources</li> <li>• Market shortages</li> <li>• Commodity price increases</li> <li>• Geographic concentration of suppliers</li> <li>• Supplier patents</li> </ul>
5	2003	Zsidisin, Ellram	Risk sources	<ul style="list-style-type: none"> <li>• Inability to handle volume demand changes</li> <li>• Failures to make delivery requirements</li> <li>• Cannot provide competitive pricing</li> <li>• Technologically behind competitors</li> <li>• Inability to meet quality requirements</li> </ul>	

**Table 6: Literature review of supply chain risk management (continued)**

#	Year	Author	Object of investigation	Drivers level 1	Drivers level 2
6	2004	Chopra, Sodhi	Risk drivers	<ul style="list-style-type: none"> <li>Disruptions</li> <li>Delays</li> <li>Systems</li> <li>Forecast</li> <li>Intellectual property</li> <li>Procurement</li> <li>Receivables</li> <li>Inventory</li> <li>Capacity</li> </ul>	<ul style="list-style-type: none"> <li>Natural disaster</li> <li>Labor dispute</li> <li>Supplier bankruptcy</li> <li>War and terrorism</li> <li>Dependency on a single source of supply</li> <li>High capacity utilization at supply source</li> <li>Inflexibility of supply source</li> <li>Poor quality or yield at supply source</li> <li>Excessive handlings due to border crossings etc.</li> <li>Information infrastructure breakdown</li> <li>System integration or extensive systems networking</li> <li>E-commerce</li> <li>Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycles, small customer base</li> <li>"Bullwhip effect" or information distortion due to sales promotions, incentives, lack of supply-chain visibility and exaggeration of demand in times of product shortage</li> <li>Vertical integration of supply chain</li> <li>Global outsourcing and markets</li> <li>Exchange rate risk</li> <li>Percentage of a key component or raw material produced from a single source</li> <li>Industrywide capacity utilization</li> <li>Long-term versus short-term contracts</li> <li>Number of customers</li> <li>Financial strength of customers</li> <li>Rate of product obsolescence</li> <li>Inventory holding cost</li> <li>Product value</li> <li>Demand and Supply uncertainty</li> <li>Cost of capacity</li> <li>Capacity flexibility</li> </ul>
7	2004	Christopher, Lee	Supply Chain Confidence	<ul style="list-style-type: none"> <li>Demand volatility</li> <li>Product and technology life-cycles</li> <li>Outsourcing</li> <li>Reduce supplier base</li> <li>Globalisation of the markets</li> <li>Increased use of manufacturing, distribution and logistics partners</li> </ul>	
8	2004	Giunipero, Eitan	Risk creators	<ul style="list-style-type: none"> <li>Material availability</li> <li>Long distances</li> <li>Insufficient capacity</li> <li>Demand fluctuations</li> <li>Technological changes</li> <li>Financial instability</li> <li>Labor instability</li> <li>Management turnover</li> </ul>	
9	2004	Norrmann, Jansson	Risk drivers	<ul style="list-style-type: none"> <li>Increased use of outsourcing of manufacturing/R&amp;D</li> <li>Globalization of supply chains</li> <li>Reduction of supplier base</li> <li>More intertwined and integrated processes</li> <li>Reduced buffers, e.g. inventory and lead time</li> <li>Increased demand for on-time deliveries</li> <li>Shorter lead times</li> <li>Shorter product life cycles</li> </ul>	
			Risk sources	<ul style="list-style-type: none"> <li>Hurricanes</li> <li>Diseases</li> <li>Fires</li> <li>Rapidly weakening demand</li> <li>Inaccurate supply planning</li> <li>Supply chain capacity risks</li> </ul>	
10	2004	Spekman, Davis	Risk sources	<ul style="list-style-type: none"> <li>Supplier capacity risk</li> <li>Quality</li> <li>Changes in product design and production processes</li> <li>An inability to reduce costs</li> <li>Unanticipated delays and supply disruptions</li> </ul>	
11	2005	Jüttner	Risk drivers	<ul style="list-style-type: none"> <li>Globalisation of supply chains</li> <li>Reduction of inventory holding</li> <li>Centralised distribution</li> <li>Reduction of the supplier base</li> <li>Outsourcing</li> <li>Centralised production</li> </ul>	

Table 6: Literature review of supply chain risk management (continued)

#	Year	Author	Object of investigation	Drivers level 1	Drivers level 2
12	2005	Peck	Risk drivers	<ul style="list-style-type: none"> <li>• Demands for shorter lead-times</li> <li>• Outsourcing</li> <li>• Increasing use of global sourcing and supply</li> <li>• Irregular demand patterns</li> <li>• Measures introduced to reduce costs</li> <li>• Changes and upgrades to product specifications</li> <li>• Customer determined network reconfigurations</li> <li>• Continous improvement initiatives</li> <li>• Internal network redesigns</li> <li>• IT upgrades</li> <li>• Changing process technology</li> <li>• Supplier rationalisations</li> <li>• Industry consolidations</li> <li>• Ongoing regulatory changes</li> </ul>	
13	2005	Zsidisin, Ragatz et al	Risk sources	<ul style="list-style-type: none"> <li>• Inbound Supply Processes</li> </ul>	<ul style="list-style-type: none"> <li>• Supplier network</li> <li>• Cash Management</li> <li>• Order Fulfillment</li> <li>• People &amp; Knowledge</li> <li>• Business Planning</li> <li>• Customer Solutions</li> </ul>
14	2006	Wagner, Bode	Risk drivers	<ul style="list-style-type: none"> <li>• Customer dependence</li> <li>• Supplier dependence</li> <li>• Supplier concentration</li> <li>• Single sourcing</li> <li>• Global sourcing</li> </ul>	
			Risk sources	<ul style="list-style-type: none"> <li>• Demand side risks</li> <li>• Supply side risks</li> <li>• Catastrophic risks</li> </ul>	<ul style="list-style-type: none"> <li>• Unanticipated or very volatile demand</li> <li>• Insufficient or distorted information from your customer</li> <li>• Poor logistics performance of suppliers</li> <li>• Supplier quality problems</li> <li>• Sudden demise of a supplier (e.g. due to bankruptcy)</li> <li>• Poor logistics performance of logistics service providers</li> <li>• Capacity fluctuations or shortages on the supply markets</li> <li>• Political instability, war, civil unrest, socio-political crises</li> <li>• International terror attacks</li> <li>• Diseases or epidemics</li> <li>• Natural disasters</li> </ul>
15	2008	Manuj, Mentzer	Global Supply Chain risks	<ul style="list-style-type: none"> <li>• Supply</li> <li>• Demand</li> <li>• Operational risks</li> </ul>	<ul style="list-style-type: none"> <li>• Supplier Opportunism</li> <li>• Inbound product quality</li> <li>• Transit time variability</li> <li>• Risks affecting suppliers</li> <li>• Demand variability</li> <li>• Forecast error</li> <li>• Competitor moves</li> <li>• Risks affecting customers</li> <li>• Inventory ownership</li> <li>• Asset and tools ownership</li> <li>• Product quality and safety</li> </ul>
16	2008	Wagner, Bode	Risk sources	<ul style="list-style-type: none"> <li>• Demand side risks</li> <li>• Supply side risks</li> <li>• Regulatory, legal and bureaucratic risks</li> <li>• Infrastructural risks</li> <li>• Catastrophic risks</li> </ul>	<ul style="list-style-type: none"> <li>• Unanticipated or very volatile demand</li> <li>• Insufficient or distorted information [...]</li> <li>• Poor logistics performance of suppliers</li> <li>• Supplier quality problems</li> <li>• Sudden default of a supplier</li> <li>• Poor logistics performance [...]</li> <li>• Capacity fluctuations or shortages [...]</li> <li>• Changes in the political environment [...]</li> <li>• Administrative barriers [...]</li> <li>• Downtime or loss of own production capacity [...]</li> <li>• Perturbation or breakdown of internal IT [...]</li> <li>• Loss of own production capacity [...]</li> <li>• Perturbation or breakdown of external IT [...]</li> <li>• Political instability, war, civil unrest, socio-political crises</li> <li>• Diseases or epidemics</li> <li>• Natural disasters</li> <li>• International terror attacks</li> </ul>

Norrman et al. (2004) identified "increased demand for on-time deliveries", "shorter lead times" and "shorter product life cycles" as risk drivers with growing importance.<sup>214</sup> This aspect has been taken up by several other authors as well.<sup>215</sup> Items such as "irregular demand patterns", "customer dependence" and "financial strength of customers" have been presented too.<sup>216</sup>

The aspect of supply chain risk research that has even received more attention is the supply chain risk sources construct. Unlike the drivers of supply chain risk, its sources can be quantified in terms of probability and impact. Indeed, this aspect has undoubtedly captured attention in part due to the quantification of strategic and operating risks in many risk reports. Here again, researchers have come up with numerous potential risk sources. Following the classification used by Wagner et al. (2008), five main categories of supply chain risk sources exist: "demand side risks", "supply side risks", "regulatory, legal and bureaucratic risks", "infrastructural risks" and "catastrophic risks".<sup>217</sup> This classification seems to the author to be reasonable, as all the risk sources identified by researchers up to now can be assigned to one or other of the groups defined by Wagner et al. (2008). Jüttner (2005) defines the first group, "demand side risks", as all risks that emerge from the downstream supply chain and result in a mismatch of demand and supply. Potential disruption can occur during physical distribution to customers or can originate from customers' unforeseeable demand for certain products.<sup>218</sup> One much-discussed phenomenon in this respect is the bullwhip effect, which describes how customers for haberdashery materials or products tend to order more than required for the immediate future in order to secure a lasting supply. This effect is one explanation of why demand fluctuates so markedly.<sup>219</sup> Wagner et al. (2008) thus named "unanticipated or very volatile demand" and "insufficient or distorted information from your customer [...]" as potential demand-side risks.<sup>220</sup> A broad spectrum of supply-side risk items is likewise documented in the literature. Generally speaking, supply-side risks cover all risks relating to uncertainty with regard to supplier activities.<sup>221</sup> Zsidisin (2003) defines supply-side risk as "[...] an incident associated with inbound supply from individual supplier failures or the

---

<sup>214</sup> Norrman/Jansson (2004), p. 434.

<sup>215</sup> E.g. Peck (2005), 215.

<sup>216</sup> Peck (2005), p. 214; Wagner/Bode (2006), p. 305; Chopra/Sodhi (2004), p. 54.

<sup>217</sup> Wagner/Bode (2008), p. 323.

<sup>218</sup> Jüttner (2005), p. 122-123.

<sup>219</sup> Lee/Padmanabhan/Whang (1997), p. 1875.

<sup>220</sup> Wagner/Bode (2008), p. 310.

<sup>221</sup> Jüttner (2005), p. 122.

supply market occurring [...]".<sup>222</sup> This definition therefore includes all risk sources in the entire upstream supply chain of a company: purchasing, suppliers, supplier networks and supplier relationships.<sup>223</sup> In particular, researchers have named supplier quality issues as a potential source of risk.<sup>224</sup> Quality issues occur when a supplier is not able to meet predefined specifications, resulting in production failure, waste production and, ultimately, delivery problems. Other factors named are the sudden demise of a supplier, poor logistics performance by suppliers and/or logistics providers, price/cost increases, raw materials shortages and the inability to change technological or product design.<sup>225</sup> "Sudden demise" refers to a situation in which, for example, a supplier goes bankrupt and is therefore unable to meet its contractual commitments, with all the negative consequences that this entails for the purchasing party. Poor logistics performance includes shortcomings regarding punctual and accurate delivery, order fill capacity and reliability caused either by the supplier or the logistics provider. Price/cost increases may occur due to capacity shortages or to a situation in which the supplier has gained market power that enables it to increase margins. In cases where input price rises cannot be passed on to the end customer, higher purchasing prices may have to be absorbed. Material shortages occur when demand exceeds supply, leading to less capacity on the supply side. Suppliers that cannot cope with technological advances likewise represent a source of risk as the competitiveness of final products is at risk. The same goes for the inability to cope with product design changes: In an age of reduced lifecycles and increasing product variants, this is a competitive disadvantage. Moreover, as outsourcing increases, especially to low-cost countries, this risk may become even more important in the future.<sup>226</sup> In a highly regarded paper, Kraljic (1983) was one of the first researchers to emphasize the need to develop proper mitigation strategies for supply risk sources. He introduced a decision matrix to assess procurement groups according- to their importance and to the underlying complexity of the supply market. Based on his assessment of procurement categories, Kraljic calls for a tailored sourcing mitigation strategy.<sup>227</sup>

The third group named above comprised regulatory, legal and bureaucratic risks. This category contains all risk sources that relate to the actions of public authorities. Changes in laws and policies can have a significant impact on links in the supply chain network. For

---

<sup>222</sup> Zsidisin (2003), p. 222.

<sup>223</sup> Wagner/Bode (2008), p. 310.

<sup>224</sup> Spekman/Davis (2004), p. 419.

<sup>225</sup> Miller (1992), p. 319; Wagner/Bode (2006); p. 304-305.

<sup>226</sup> Wagner/Bode (2008), p. 311.

<sup>227</sup> Kraljic (1983), p. 111.

instance, the new road pricing schedules for freight vehicles in many European countries have significantly impacted the price structure for logistics services. Changes effected by administrative, legislative or regulatory agencies can thus severely impact the supply chain – especially as they tend to occur suddenly and are difficult to predict.<sup>228</sup> Specifically, Wagner et al. (2008) name two risk sources in this group: the "[...] introduction of new laws, stipulations etc." and "administrative barriers for the setup or operation of supply chains". Infrastructural risks are defined as fourth group of potential risk sources. This cluster covers all breakdowns in the supply chain that are linked to the operations of a company. Potential sources can be of a technical nature, such as machine outages, or of a human nature, such as strikes. A more extensive list of potential technical failures would also include incidents such as interference, breakdowns in IT infrastructures and the results of fire or accidents, for example.<sup>229</sup> Human-related network risk sources include labor disputes, sabotage and occupational accidents.<sup>230</sup>

The last group of potential risk sources covers all risks that relate to catastrophes or disasters that can be seen as *force majeure*. The potential spectrum of such risk sources is broad. Epidemics, natural disasters, political instability, civil unrest and even terrorism are risk sources that have the potential to significantly impact supply chains.<sup>231</sup> Literature on such disasters as a source of risk has increased lately as their frequency has increased and the resultant monetary losses have risen sharply.<sup>232</sup> Reinsurer Munich Re, for instance, reports that the average cost of unpredictable disasters has risen by a factor of 10 since the 1960s.<sup>233</sup> Epidemics include all diseases such as BSE in the UK in 2001 and SARS, which broke out in China in 2002 and ultimately affected the whole world.<sup>234</sup> Potential risk sources arising from natural disasters are flooding, earthquakes, storms (such as hurricanes, typhoons or tornadoes), tsunamis, aridity and fires. Several such disasters are still fresh in the memory of most people: Hurricane Katrina in 2005, the Asian tsunami and, more recently, the destructive flooding in Thailand are just three of many examples.<sup>235</sup> Instances of political instability and civil unrest have likewise been observed of late in the context of what has become known as the "Arab Spring". Political instability and a lack of transparency about future developments

---

<sup>228</sup> Wagner/Bode (2008), p. 311.

<sup>229</sup> Jüttner/Peck/Christopher (2003), p. 201-202.

<sup>230</sup> Wagner/Bode (2008), p. 311.

<sup>231</sup> Jüttner (2005), p. 122.

<sup>232</sup> Steckel/Kumar (2009), p. 1.

<sup>233</sup> Tang (2006), p. 33.

<sup>234</sup> Norrman/Jansson (2004), p. 120; Steckel/Kumar (2009), p. 2.

<sup>235</sup> Steckel/Kumar (2009), p. 1-2.



in the transition process also force many supply chains to modify their existing structures. Terrorist attacks are yet another issue with the potential to affect global supply chains that has gained increased attention over the past decade. At the latest in the wake of the 9/11 attacks on the World Trade Center, Western countries woke up to the new dimension of risk posed by modern terrorism. Since then, the tightening of safety regulations has directly impacted global supply chains. All these catastrophic risks have in common that they pose a substantial risk to supply chains, as production facilities and transport systems are very vulnerable to the resultant disruptions. Handling and containing such events, however, is very challenging, as their probability is comparatively low. Accordingly, supply chains are forced to prepare for events whose probability is low but whose impact could be very severe. Many companies struggle to calculate the probability of this kind of events as the basis on which to justify risk reduction programs or contingency plans.<sup>236</sup> Due to their very low probability of occurrence, such events have become known in literature as "black swan events".<sup>237</sup>

#### 2.5.3.2 A literature review of manufacturing performance

Empirical literature on manufacturing performance is very mature. This maturity is reflected first by the number of papers published on this topic. A literature search based on the term 'manufacturing performance' yielded a total of 36 papers that present empirical studies on the specific subject, as shown in table 7. However, the maturity of research into this discipline is also reflected by the comparatively long history of relevant research: The first paper was published in 1985.

Nor has attention to the topic yet waned, as a dozen papers have been published in the current decade. As to be expected, the majority of papers investigate the US manufacturing industry. This dominance, however, has not been at the expense of papers covering other economic areas. Europe, for example, has been a target for investigation, with a focus on Germany, Italy, Spain and the UK. Studies have likewise focused on Australia, New Zealand, Japan and China. In terms of sample size, the huge variety continues. Small-scale studies containing case studies with just six participants have been conducted, as have studies of up to around 3,000 companies.

---

<sup>236</sup> Tang (2006), p. 36.

<sup>237</sup> Taleb (2010), p. 1-480.

The objects of investigation are many and varied but tend to center around three key aspects. The majority of publications focus on existing success factors or drivers of manufacturing performance. Second, some authors tackle the question of whether certain trade-offs exist in the different dimensions of manufacturing performance existing and, if so, whether they can be ignored. Lastly, only a handful of researchers investigate the correlation between manufacturing performance and overall firm performance. This section outlines the current status of literature on these three aspects.

Regarding existing success factors or drivers of manufacturing performance, academics have tested numerous constructs. It is conspicuous that most papers covering that pursue this goal investigate the correlation between certain manufacturing concepts (such as integrated manufacturing as such, or its component parts: advanced manufacturing, just-in-time production and total quality management) and manufacturing performance. Other trends examined include lean production, automation, manufacturing flexibility, total productive maintenance and process technology fit. Regarding integrated manufacturing as a success factor, studies suggest that there is a positive correlation with manufacturing performance.

**Table 7: Literature review of manufacturing performance**

#	Year	Author	Area	Sample size	Object of investigation	Drivers level 1	Drivers level 2
1	1985	Richardson, Taylor, Gordon	n.a.	n.a.	Corporate Mission/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Volume of Output</li> <li>• Cost per unit</li> <li>• Quality</li> <li>• Delivery on schedule</li> <li>• Labor productivity</li> <li>• Ability to introduce new products</li> <li>• Flexibility to product changes</li> <li>• Flexibility to volume changes</li> </ul>	
2	1989	Cleveland, Schroeder, Anderson	USA	6	Production competence/ Business Performance	<ul style="list-style-type: none"> <li>• Adaptive Manufacturing</li> <li>• Cost-Effectiveness</li> <li>• Delivery Performance</li> <li>• Logistics</li> <li>• Production Economies of Scale</li> <li>• Process Technology</li> <li>• Quality Performance</li> <li>• Throughput and Lead Time</li> <li>• Vertical Integration</li> </ul>	
3	1990	Ferdows, de Meyer	Europe	167	Manufacturing Performance trade-offs	<ul style="list-style-type: none"> <li>• Quality conformance</li> <li>• Cost</li> <li>• Delivery dependability</li> <li>• Speed of new product introduction</li> </ul>	<ul style="list-style-type: none"> <li>• Quality conformance</li> <li>• Unit production cost</li> <li>• Overhead costs</li> <li>• Inventory turnover</li> <li>• On-time delivery</li> <li>• Delivery speed</li> <li>• Development speed</li> </ul>
4	1992	Corbett, Harrison	Australia, New Zealand	209	Employee involvement/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Quality improvement</li> <li>• Inventory turnover</li> <li>• Market share</li> <li>• Profitability</li> </ul>	
5	1993	Appleyard, Brown	World	23	Employment practices/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Defect density</li> <li>• Line yield</li> <li>• Direct labor productivity</li> <li>• Stepper throughput</li> <li>• Cycle time</li> </ul>	
6	1996	Dean, Snell	USA	512	Integrated Manufacturing/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Quality</li> <li>• Delivery Flexibility</li> <li>• Scope Flexibility</li> <li>• Cost</li> </ul>	<ul style="list-style-type: none"> <li>• Product quality</li> <li>• High product reliability</li> <li>• Exceptional product performance</li> <li>• Conformance to specifications</li> <li>• Dependability</li> <li>• Zero defects</li> <li>• Product serviceability</li> <li>• Durability</li> <li>• On-time delivery</li> <li>• Meeting release dates for new products</li> <li>• Flexibility</li> <li>• Scale up/down production quickly</li> <li>• Short lead time from order to delivery</li> <li>• High efficiency/productivity</li> <li>• Economies of scale</li> <li>• Adapting to changes in product mix</li> <li>• Handling difficult/nonstandard orders</li> <li>• Products made to order</li> <li>• Small lots</li> <li>• Low unit costs</li> <li>• Low labor costs</li> <li>• Low material costs</li> </ul>
7	1997	Bozarth, Edwards	USA	24	Market requirement focus/ Manufacturing characteristics/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Cost</li> <li>• Conformance quality</li> <li>• Delivery speed</li> <li>• Reliability</li> <li>• Product range</li> <li>• Design capability</li> </ul>	
8	1997	Mapes, New, Szwajkowski	United Kingdom	782	Manufacturing Performance trade-offs	<ul style="list-style-type: none"> <li>• Cost</li> <li>• Quality</li> <li>• Time</li> <li>• Flexibility</li> </ul>	<ul style="list-style-type: none"> <li>• Number of changes in projects</li> <li>• <math>\Delta</math> average time between two subsequent innovations</li> <li>• Development time for new products</li> <li>• Adherence to due dates</li> <li>• Incoming quality</li> <li>• Distance travelled</li> <li>• Value added time/Total time</li> <li>• Schedule attainment</li> <li>• Outgoing quality</li> <li>• Manufacturing cost</li> <li>• Complexity of procedures</li> <li>• Size of batches of information</li> <li>• Cycle time</li> <li>• Bid time</li> </ul>
9	1997	Sakakibara, Flynn, Schroeder, Morris	USA, Japan	822	JIT/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Lead time</li> <li>• Cycle time</li> <li>• Inventory turnover ratio</li> <li>• On-time delivery</li> </ul>	
10	1997	Lowe, Delbridge, Oliver	Europe	71	Lean Production/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Productivity (unit per labour hour)</li> <li>• Quality (parts per million)</li> <li>• Internal defect rate (% of total volume)</li> <li>• Space utilization (units per m<sup>2</sup>)</li> </ul>	

**Table 7: Literature review of manufacturing performance (continued)**

#	Year	Author	Area	Sample size	Object of investigation	Drivers level 1	Drivers level 2
11	1998	Flippini, Forza, Vinelli	Italy	43	Manufacturing Performance	<ul style="list-style-type: none"> <li>• Economic</li> <li>• Quality</li> <li>• Time</li> </ul>	<ul style="list-style-type: none"> <li>• Invested capital turnover</li> <li>• Return on Sales</li> <li>• Quality consistency</li> <li>• Quality capability</li> <li>• Delivery time</li> <li>• Delivery Punctuality</li> </ul>
12	1998	Ettlie	World	600	R&D/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Number of employees</li> <li>• % improved market share</li> <li>• Computerization</li> <li>• % change in agility</li> </ul>	
13	1999	Iltner, Lanen, Larcker	USA	2,789	Activity-Based-Costing/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• ROA</li> <li>• Quality</li> <li>• Time</li> </ul>	<ul style="list-style-type: none"> <li>• ROA</li> <li>• Finished products pass first quality yield [%]</li> <li>• Scrap or rework cost / Sales</li> <li>• Manufacturing cycle time</li> <li>• Standard lead time order to shipment</li> </ul>
14	2001	Bozarth, McCreery	USA	13	Market requirements focus/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Cost</li> <li>• Conformance quality</li> <li>• Delivery reliability</li> <li>• Delivery speed</li> <li>• Product range</li> <li>• Design capability</li> </ul>	
15	2001	McKone, Schroeder, Cua	USA, Italy, Germany, Japan	117	Total productive maintenance/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Low cost</li> <li>• Inventory turnover</li> <li>• Quality</li> <li>• On-time delivery</li> <li>• Fast delivery</li> <li>• Flexibility</li> </ul>	
16	2001	Das, Narasimhan	USA	322	Process-technology fit/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Manufacturing cost reduction</li> <li>• Quality performance</li> <li>• New product introduction time reduction</li> <li>• Delivery performance</li> <li>• Customization responsiveness</li> </ul>	
17	2001	Das, Narasimhan	USA	322	Purchasing integration/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• Manufacturing cost reduction</li> <li>• Quality performance</li> <li>• New product introduction time reduction</li> <li>• Delivery performance</li> <li>• Customization responsiveness performance</li> </ul>	
18	2002	Challis, Samson, Lawson	Australia, New Zealand	1,289	Integrated Manufacturing/ Manufacturing performance	<ul style="list-style-type: none"> <li>• High customer satisfaction</li> <li>• Positive Cash Flow</li> <li>• Total cost per unit</li> <li>• On time delivery to customers</li> <li>• Lost time due to industrial accidents</li> </ul>	
19	2002	Schroeder, Bates, Junttila	USA	164	Manufacturing strategy/ Manufacturing performance	<ul style="list-style-type: none"> <li>• Manufacturing cost (% of Sales)</li> <li>• Scrap rate (conformance quality)</li> <li>• Total cost per unit</li> <li>• Percentage of deliveries on time</li> <li>• # days receipt raw material to customer receipt</li> <li>• Length of fixed production schedule</li> </ul>	
20	2002	Boyer, Lewis	USA	110	Operations strategy trade-offs	<ul style="list-style-type: none"> <li>• Cost</li> <li>• Quality</li> <li>• Delivery</li> <li>• Flexibility</li> </ul>	<ul style="list-style-type: none"> <li>• Reduce inventory</li> <li>• Increase capacity utilization</li> <li>• Reduce production costs</li> <li>• Increase labor productivity</li> <li>• Provide high-performance products</li> <li>• Offer consistent, reliable quality</li> <li>• Improve conformance to design spec.</li> <li>• Provide fast deliveries</li> <li>• Meet delivery promises</li> <li>• Reduce production lead time</li> <li>• Make rapid design changes</li> <li>• Adjust capacity quickly</li> <li>• Make rapid volume changes</li> <li>• Offer a large number of products features</li> <li>• Offer a large degree of product variety</li> <li>• Adjust product mix</li> </ul>
21	2003	Merino-Diaz de Cerio	Spain	965	Quality Management/ Operational Performance	<ul style="list-style-type: none"> <li>• Cost</li> <li>• Product Quality</li> <li>• Time based improvements</li> </ul>	<ul style="list-style-type: none"> <li>• Productive hours to total number of hours</li> <li>• Percentage of returned products over sales</li> <li>• Percentage of defective finished products</li> <li>• Percentage of defective products in process</li> <li>• Punct (delivery dates complied)</li> <li>• Speed (time from material received to moment product is delivered to customer)</li> </ul>
22	2004	Henderson, Swamidass, Byrds	USA	1,000	Integrated Manufacturing/ Manufacturing Performance/ ROI	<ul style="list-style-type: none"> <li>• Production planning, scheduling and control</li> <li>• Employee involvement and motivation</li> <li>• Automation and process technology</li> <li>• Just-in-time production</li> <li>• Labor productivity</li> <li>• Quality control/assurance</li> <li>• Decentralization of manufacturing decisions</li> <li>• Product design</li> <li>• Overall evaluation of our manufacturing</li> </ul>	
23	2004	Rosenzweig, Roth	World	867	Competitive progression theory/ Manufacturing performance	<ul style="list-style-type: none"> <li>• Conformance quality</li> <li>• Reliability of delivery times (on time)</li> <li>• Ability to rapidly change production volumes</li> <li>• Manufacture products at lower internal costs than competition</li> </ul>	
24	2005	Challis, Samson, Lawson	Australia, New Zealand	1,024	Integrated Manufacturing/ Manufacturing Performance	<ul style="list-style-type: none"> <li>• High customer satisfaction</li> <li>• Positive Cash Flow</li> <li>• Total cost per unit</li> <li>• On time delivery to customers</li> <li>• Lost time due to industrial accidents</li> </ul>	

**Table 7: Literature review of manufacturing performance (continued)**

#	Year	Author	Area	Sample size	Object of investigation	Drivers level 1	Drivers level 2
25	2005	Fynes, Voss, Burca	Ireland	202	Supply chain relationship dynamics/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Quality performance</li> <li>Delivery performance</li> <li>Cost performance</li> <li>Flexibility performance</li> </ul>	<ul style="list-style-type: none"> <li>Frequency of customer complaints</li> <li>Adequacy of customer complaint tracking</li> <li>Speed of delivery relative to competitors</li> <li>Percentage of orders delivered on-time</li> <li>Unit cost of product over life cycle</li> <li>Volume flexibility</li> <li>Variety (product line) flexibility</li> </ul>
26	2005	Cordero, Walsh, Kirchhoff	USA	105	Financial incentives/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Productivity</li> <li>Product quality</li> <li>Speed to complete manufacturing orders</li> <li>Customer satisfaction</li> <li>Flexibility to manufacture new products</li> <li>Diversity of product line</li> </ul>	
27	2005	Narasimhan, Swink, Kim	USA	58	Manufacturing practices/ Manufacturing Performance	<ul style="list-style-type: none"> <li>New product development</li> <li>Flexibility</li> <li>Efficiency</li> <li>Market-based performance</li> </ul>	
28	2006	D'Souza	USA	193	Manufacturing flexibility/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Delivery Performance</li> <li>Quality Performance</li> <li>Cost Performance</li> </ul>	<ul style="list-style-type: none"> <li>Percentage of on-time delivery finished products</li> <li>Extent of non-conformance with design specs</li> <li>Cost of production per unit</li> </ul>
29	2007	Swink, Nair	USA	224	Advanced Manufacturing Technologies/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Cost efficiency</li> <li>Quality</li> <li>Delivery</li> <li>New Product Flexibility</li> <li>Process Flexibility</li> </ul>	
30	2008	Liao, Tu	USA	303	Automation & integration/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Cost performance</li> <li>Quality performance</li> <li>Delivery performance</li> <li>Flexibility performance</li> <li>Innovation performance</li> </ul>	
31	2008	Karim, Smith, Halgamuge, Islam	Australia, Malaysia	46	Manufacturing practices/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Product capacity utilization</li> <li>Product yield rate</li> <li>Customer return rate</li> <li>On time delivery</li> </ul>	
32	2008	Naor, Goldstein, Linderman, Schroeder	USA	189	Organizational culture/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Cost</li> <li>Quality</li> <li>Delivery</li> <li>Flexibility</li> </ul>	<ul style="list-style-type: none"> <li>Inventory turnover</li> <li>Cycle time</li> <li>Unit cost of manufacturing</li> <li>Product capability and performance</li> <li>Conformance to product specifications</li> <li>On time delivery performance</li> <li>Fast delivery</li> <li>Flexibility to change product mix</li> <li>Flexibility to change volume</li> </ul>
33	2008	Karim, Smith, Halgamuge	Australia	40	Advanced Quality Practices/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Improvement in quality over the previous 2 years</li> <li>Product capacity utilization</li> <li>Production yield rate</li> <li>Customer return rate</li> <li>On time delivery</li> </ul>	
34	2009	Fullerton, Wempe	USA	121	Lean Manufacturing/ Manufacturing Performance/ ROS	<ul style="list-style-type: none"> <li>Inventory turns</li> <li>Equipment downtime</li> <li>On-time delivery</li> <li>Scrap</li> <li>Rework</li> <li>Setup times</li> <li>Labor productivity</li> <li>Throughput time</li> <li>Manufacturing cycle efficiency</li> <li>Vendor performance - Product Quality</li> <li>Vendor performance - On-time delivery</li> </ul>	
35	2009	Qi, Sum, Zhao	China	301	Functional involvement & improvement programs/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Ability to offer reliable products</li> <li>Having good product/service image</li> <li>Ability to offer durable products/services</li> <li>Ability to offer good product/service design</li> <li>Ability to meet customer specifications</li> <li>Ability to offer effective after-sale service</li> <li>Ability to introduce new products to market</li> <li>Ability to offer a broad product line</li> <li>Ability to respond to changes in new products</li> <li>Ability to modify existing products/services</li> <li>Ability to respond to volume changes quickly</li> <li>Ability to offer shorter delivery lead time</li> <li>Ability to meet scheduled due date</li> <li>Ability to provide low-price products</li> <li>Ability to produce at low-unit cost</li> </ul>	
36	2010	Naor, Linderman, Schroeder	Japan, South Korea, Germany, USA, Finland, Sweden	189	National & Organizational culture/ Manufacturing Performance	<ul style="list-style-type: none"> <li>Cost</li> <li>Quality</li> <li>Delivery</li> <li>Flexibility</li> </ul>	<ul style="list-style-type: none"> <li>Inventory turnover</li> <li>Cycle time</li> <li>Unit cost of manufacturing</li> <li>Product capability and performance</li> <li>Conformance to product specifications</li> <li>On time delivery performance</li> <li>Fast delivery</li> <li>Flexibility to change product mix</li> <li>Flexibility to change volume</li> </ul>

In other words, firms that implement integrated manufacturing strategies outperform those that do not in terms of manufacturing performance.<sup>238</sup> At the same time, studies conclude that total quality management and just-in-time production were found to have the greatest impact.<sup>239</sup>

The impact of these manufacturing concepts on manufacturing performance is rooted mainly in their positive impact on product design and development and on the fact that they indirectly improve manufacturing infrastructures, e.g. by fostering targets and discipline within the organization.<sup>240</sup> Lean production is found to contribute to strong manufacturing performance.<sup>241</sup> Surveys conducted also find that process control throughout the manufacturing system and the supply chain drives success. This process control is supported by lean manufacturing practices, and a positive correlation to manufacturing has been established. The same applies for automation: In low- and high-uncertainty environments, the automation of manufacturing systems will have a significant positive impact on manufacturing performance.<sup>242</sup> With regard to manufacturing flexibility, D'Souza (2006) concludes that not all elements of manufacturing flexibility drive manufacturing performance to the same extent. The strongest impact is associated with market mobility flexibility.<sup>243</sup> Total productive maintenance and process technology fit were also found to boost manufacturing performance.<sup>244</sup>

Another field of relevance to drivers of manufacturing performance is cross-functional collaboration. Researchers have analyzed the effects of R&D intensity, purchasing integration, supply chain relationships, financial incentives, activity-based costing, functional involvement and improvement programs on manufacturing performance. In most cases, cross-functional collaboration has been found to have a positive effect on manufacturing performance, leading to the conclusion that the exchange and optimization of information across a company's functions supports manufacturing performance.<sup>245</sup> In one specific case, Ettlie (1998) concludes that R&D intensity, measured as the proportion of sales spent on

---

<sup>238</sup> Dean Jr./Snell (1996), p. 476; Challis/Samson/Lawson (2005), p. 103; D'Souza (2006), p. 750; Sakakibara/Flynn/Schroeder/Morris (1997), p. 1256; de Cerio (2003), p. 2781.

<sup>239</sup> Challis/Samson/Lawson (2002), p. 1960.

<sup>240</sup> Sakakibara/Flynn/Schroeder/Morris (1997), p. 1256; de Cerio (2003), p. 2781.

<sup>241</sup> Lowe/Delbridge/Oliver (1997), p. 795.

<sup>242</sup> Liao/Tu (2007), p. 48.

<sup>243</sup> D'Souza (2006), p. 509.

<sup>244</sup> McKone/Schroeder/Cua (2001), p. 52; Das/Narasimhan (2001), p. 539.

<sup>245</sup> Ettlie (1998), p. 8-10; Ittner/Lanen/Larcker (2002), p. 724-725; Narasimhan/Das (2001), p. 607; Fynes/Voss/de Burca (2005), p. 14-15; Cordero/Walsh/Kirchhoff (2005), p. 96-97; Qi/Sum/Zhao (2009), p. 657-658.

R&D, shows a significant positive correlation to improvements in both market shares and agility.<sup>246</sup> A further important function is purchasing. Research supports the view that purchasing integration serves as a moderator of purchasing practices and manufacturing performance.<sup>247</sup> One last example is provided by the paper published by Qi et al. (2009), who found that cross-functional collaboration – especially between human resources, information systems, research and development and public relations units and manufacturing – drives manufacturing performance.<sup>248</sup>

Finally, academics have also tested factors relating to the organization as drivers of manufacturing performance. As far back as the early 1990s, the factors employee involvement and employment practices were tested for statistical relevance in relation to manufacturing performance.<sup>249</sup> Later, studies of organizational and national cultures followed.<sup>250</sup> Corbett et al. (1992), for example, conclude that firms experience higher manufacturing performance if they succeed in anchoring a deeper understanding of goals and strategies in lower levels of the organization. Similarly, firms can raise performance by attaching importance to workforce-related programs.<sup>251</sup> These basic findings have been confirmed in other studies as well. Appleyard et al. (2001) reports that involving skilled workers in problem solving under the leadership of engineers improves manufacturing performance.<sup>252</sup> Similarly, Naor et al. (2008) confirm that organizational culture correlates positively to manufacturing performance.<sup>253</sup> Naor et al. (2010) complemented their initial study by adding the construct of national culture to their investigation. According to their findings, organizational culture affects manufacturing performance significantly more than national culture. This finding supports the hypothesis that organizational culture has a powerful influence on performance and should therefore be managed properly.<sup>254</sup>

Alongside drivers of manufacturing performance, the question of the existence and potential mitigation of trade-offs in manufacturing performance constitutes the second line of research. As shown by Skinner (1966), simultaneously optimizing manufacturing in terms of

---

<sup>246</sup> Ettlie (1998), p. 8.

<sup>247</sup> Narasimhan/Das (2001), p. 606.

<sup>248</sup> Qi/Sum/Zhao (2009), p. 657.

<sup>249</sup> Corbett/Harrison (1992), p. 27-31; Appleyard/Brown (2001), p. 463-465.

<sup>250</sup> Naor/Goldstein/Linderman/Schroeder (2008), p. 693-694; Naor/Linderman/Schroeder (2010), p. 194.

<sup>251</sup> Corbett/Harrison (1992), p. 27-31.

<sup>252</sup> Appleyard/Brown (2001), p. 463.

<sup>253</sup> Naor/Goldstein/Linderman/Schroeder (2008), p. 693.

<sup>254</sup> Naor/Linderman/Schroeder (2010), p. 194.

production cost, time to market and product quality does not appear to be possible. Skinner argues that companies are facing pressures from the outside, from the inside and from the impact of accelerating technology that makes traditional concepts of mass production obsolete.<sup>255</sup> According to him and many scholars who concur in his views, increasing a firm's competitive strength in one of these dimensions will be at the expense of another.<sup>256</sup> In light of this conclusion, decision-makers must choose which dimension to optimize, as the resultant trade-off will affect manufacturing performance. Increasingly, however, scholars are now taking the view that manufacturers can indeed achieve outstanding performance in all three dimensions at the same time. One of the most prominent proponents of this idea was Schonberger (1986), who outlined his understanding of world-class manufacturing.<sup>257</sup> Later, numerous academics generally supported his hypotheses by conducting empirical studies. Ferdows et al. (1990), Mapes et al. (1997) and Filippini et al. (1998), to name but a few, all claim that the supposedly strict trade-off does not exist.<sup>258</sup> Others, such as Boyer et al. (2002), report evidence in empirical data in support of the arguments of Skinner (1966).<sup>259</sup> The issue remains controversial.

The remaining aspect of relevant literature deals with the impact of manufacturing performance on overall firm performance. Only a limited number of papers have empirically tested whether a significant correlation exists. Based on the search parameters used, three papers were found to have covered this research question. To the knowledge of the author, the first of these was submitted by Henderson et al. (2004). Based on a sample containing the data for 1,042 plants in the USA, these authors statistically calculated a positive correlation between non-financial manufacturing performance and the return on investment.<sup>260</sup> Although a different KPI for firm performance was used by Fullerton et al. (2009), their results confirm the conclusion drawn by Henderson et al. (2004). The non-financial manufacturing performance measures setup time, cellular manufacturing and quality correlate positively to firm performance measured as the return on sales. Accordingly, the initial hypothesis – that lean methods entail both costs and benefits – is accepted.<sup>261</sup> Along the same lines, Qi et al. (2009) reported a positive link between manufacturing performance and financial

---

<sup>255</sup> Skinner (1966), p. 139-146.

<sup>256</sup> Ferdows/de Meyer (1990), p. 169.

<sup>257</sup> Schonberger (1986), p. 1-252.

<sup>258</sup> Ferdows/de Meyer (1990), p. 181; Mapes/New/Szwejczewski (1997), p. 1031; Filippini/Forza/Vinelli (1998), p. 3399.

<sup>259</sup> Boyer/Lewis (2002), p. 18.

<sup>260</sup> Henderson/Swamidass/Byrd (2004), p. 1947.

<sup>261</sup> Fullerton/Wempe (2009), p. 228.



performance, measuring the latter as the return on investment and the return on sales. In their conclusion, they emphasized that, according to their sample, manufacturing performance quality and flexibility were the aspects that had the biggest impact on financial performance.<sup>262</sup>

Scholars point more or less *unisono* to four key elements of manufacturing performance: cost, quality, delivery and flexibility.<sup>263</sup> Alongside these four key elements, however, researchers have also developed an infinite number of other aspects of manufacturing performance. Although the terminology sometimes changes from study to study, the underlying measures remain the same in most cases. The same goes for the designations of the key elements. Slight differences in the nomenclature should, however, not obscure the fact that, conceptually, these scholars are referred to the same things. With regard to manufacturing costs, the literature lists items such as unit production cost, labor cost, capacity utilization, labor productivity and cycle time.<sup>264</sup> The listed items indicating manufacturing quality are conformance to specifications, defect density, outgoing quality, finished products, first-pass quality yield, scrap/rework costs and customer satisfaction.<sup>265</sup> For delivery, academics have identified aspects such as on-time delivery, delivery speed, throughput time and compliance with release dates for new product launches.<sup>266</sup> Manufacturing flexibility has been described in terms of items such as flexibility to change product, flexibility to change volumes, adaptation to changes in the product mix, the number of product features, and the duration of the fixed production schedule.<sup>267</sup>

---

<sup>262</sup> Qi/Sum/Zhao (2009), p. 657.

<sup>263</sup> E.g. Naor/Linderman/Schroeder (2010), p. 204; Boyer/Lewis (2002), p. 19.

<sup>264</sup> Ferdows/de Meyer (1990), p. 172; Dean Jr./Snell (1996), p. 480; Boyer/Lewis (2002), p. 19; Naor/Linderman/Schroeder (2010), p. 204.

<sup>265</sup> Dean Jr./Snell (1996), p. 480; Appleyard/Brown (2001), p. 457; Mapes/New/Szwejczewski (1997), p. 1027; Ittner/Lanen/Larcker (2002), p. 714; Challis/Samson/Lawson (2002), p. 1950.

<sup>266</sup> Ferdows/de Meyer (1990), p. 172; Bozarth/Edwards (1997), p. 166; Rosenzweig/Roth (2004), p. 367; Fullerton/Wempe (2009), p. 240; Dean Jr./Snell (1996), p. 480.

<sup>267</sup> Richardson/Taylor/Gordon (1985), p. 21; Dean Jr./Snell (1996), p. 480; Boyer/Lewis (2002), p. 19; Schroeder/Bates/Junttila (2002), p. 117.

### 2.5.3.3 A literature review of supply chain performance

A modern supply chain is expected to operate efficiently and effectively.<sup>268</sup> Supply chains that manage to do so in practice are considered to perform at a high level. Numerous scholars have sought to answer the questions what drives the performance of a supply chain and how can it be measured. A summary of all identified relevant scholars and the objects of their investigation is presented in table 8. The main objectives of existing scholars in this field can be divided into papers that investigate the impact of certain enablers on supply chain performance and papers that examine the nature of the supply chain as driver for success. Correlations have been tested in empirical studies with sample sizes ranging from 54 to 760 respondents. The USA is the dominant focal area, followed by emerging Asian countries such as Taiwan and Malaysia. The research topic is clearly on the rise, however: There were no empirical studies at all on this subject until 2005. Of late, though, a steady stream of studies has been published, indicating growing attention to the construct of supply chain performance.

---

<sup>268</sup> Fawcett/Osterhaus/Magnan/Brau/McCarter (2007), p. 358.

**Table 8: Literature review of supply chain performance**

#	Year	Author	Area	Sample size	Object of investigation	Drivers level 1	Drivers level 2
1	2005	Eng	UK	112	Cross-functional orientation/ supply chain performance	<ul style="list-style-type: none"> <li>Customer satisfaction</li> <li>Supply chain responsiveness</li> </ul>	<ul style="list-style-type: none"> <li>Product quality</li> <li>Delivery performance</li> <li>Sales, service, and/or technical support</li> <li>Speed in reacting to customer service problems</li> <li>Management of distant facilities</li> <li>Reduce the level or paperwork in a supply chain system</li> <li>Track shipments</li> <li>Develop innovative new products/services</li> </ul>
2	2007	Forslund, Jonsson	Sweden	136	Forecast information quality/ supply chain performance	<ul style="list-style-type: none"> <li>Corrective actions</li> <li>Preventive actions</li> <li>Customer service performance</li> </ul>	<ul style="list-style-type: none"> <li>Subcontracting</li> <li>Expediting</li> <li>Part delivery</li> <li>Re-scheduling</li> <li>Reservation breaking</li> <li>Overtime</li> <li>Express transports</li> <li>Safety stock in raw material inventory</li> <li>Safety stock in finished goods inventory</li> <li>Safety capacity</li> <li>Safety lead time</li> <li>Over-planning (demand hedges)</li> <li>Promised lead time</li> <li>On-time delivery</li> <li>Rush orders when needed</li> <li>Promised inventory availability</li> <li>Accurate orders</li> <li>Availability of delay information</li> </ul>
3	2007	Lee, Kwon, Severance	USA	122	Linkage of supplier, internal integration & customer/ supply chain performance	<ul style="list-style-type: none"> <li>Cost-containment variables</li> <li>Reliability variables</li> </ul>	<ul style="list-style-type: none"> <li>Reduce inbound cost</li> <li>Reduce outbound cost</li> <li>Reduce warehousing cost</li> <li>Increase in asset turnover</li> <li>Increase inventory turn</li> <li>Reduce safety stock</li> <li>Increase in order fill rate</li> <li>Reduce order obsolesces</li> </ul>
4	2007	Fawcett, Osterhaus, Magnan, Brau, McCarter	USA	588	Connectivity & willingness/ supply chain performance	<ul style="list-style-type: none"> <li>Operational performance</li> <li>Competitive performance</li> </ul>	<ul style="list-style-type: none"> <li>Responsiveness to customer requests</li> <li>On-time delivery/due-date performance</li> <li>Overall customer satisfaction</li> <li>Cost of purchased items</li> <li>Profitability</li> <li>Inventory costs</li> <li>Order fulfillment lead times</li> <li>Overall product cost</li> <li>Productivity</li> <li>Overall product quality</li> <li>Transportation costs</li> <li>Market penetration</li> <li>Product innovation lead times</li> <li>Cost of new product development</li> <li>Sales growth in the last three years</li> <li>Market share growth in the last three years</li> <li>Growth in return on assets in the last three years</li> <li>Overall competitive strength</li> </ul>
5	2008	Wagner, Bode	Germany	760	Supply chain risk/ supply chain performance	<ul style="list-style-type: none"> <li>Order fill capacity</li> <li>Delivery dependability</li> <li>Customer satisfaction</li> <li>Delivery speed</li> </ul>	
6	2009	Liu	Taiwan	54	Quality management system/ supply chain performance	<ul style="list-style-type: none"> <li>Expenses of cost</li> <li>Assets/utilization</li> <li>Supply chain reliability</li> <li>Flexibility and responsiveness</li> </ul>	
7	2009	Ryu, So, Koo	South Korea	141	Buyer-Supplier partnership/ supply chain performance	<ul style="list-style-type: none"> <li>Reduction of product delivery cycle time</li> <li>Improvement of productivity such as working relationships [...]</li> <li>Decreasing cost such as operating costs and labor cost</li> <li>Raising revenue such as the relative market share or return on assets</li> </ul>	
8	2009	Zeibst, Green Jr., Sower, Reyes	USA	145	Supply chain linkage/ supply chain performance	<ul style="list-style-type: none"> <li>Zero-defect products to final customer</li> <li>Value-added services to final customer</li> <li>Eliminate late, damaged and incomplete orders to final customers</li> <li>Quickly respond to and solve problems of the final customers</li> <li>Deliver products precisely on-time to final customers</li> <li>Deliver precise quantities to final customers</li> <li>Deliver shipments of variable size on a frequent basis to final customers</li> <li>Deliver small lot sizes and shipping case sizes to final customers</li> <li>Minimize total product cost to final customer</li> <li>Minimize all types of waste throughout the supply chain</li> <li>Minimize channel safety stock throughout the supply chain</li> </ul>	

**Table 9: Literature review of supply chain performance (continued)**

#	Year	Author	Area	Sample size	Object of investigation	Drivers level 1	Drivers level 2
9	2010	Ramayah, Omar	Malaysia	58	Operational & strategic information exchange/ supply chain performance	<ul style="list-style-type: none"> <li>• Delivery per required date</li> <li>• Time taken to respond to any customer's request</li> <li>• Volume flexibility to fulfill demand upside or downside</li> <li>• Cost related to operating the supply chain</li> </ul>	
10	2010	Lin, Wang, Yu	Taiwan	84	Innovation in channel integration/ supply chain performance	<ul style="list-style-type: none"> <li>• Flexibility of delivery systems to meet the customer needs</li> <li>• Strengthen the supplier partnerships</li> <li>• Cost competitiveness</li> <li>• Shorter order cycles</li> <li>• Flexible customer response</li> </ul>	
11	2010	Vijayasathiy	USA	276	Technology use in supply chain/ supply chain performance	<ul style="list-style-type: none"> <li>• Delivery performance</li> <li>• Order fill rates</li> <li>• Order fulfillment lead times</li> <li>• Out-of-stock situations</li> <li>• Total supply chain management costs</li> <li>• Production flexibility</li> <li>• Inventory days of supply</li> </ul>	
12	2011	Srinivasan, Mukherjee, Gaur	USA	127	Buyer-Supplier partnership/ supply chain performance	<ul style="list-style-type: none"> <li>• Customer order cycle time performance</li> <li>• Customer order fill rate performance</li> <li>• Customer on time delivery performance</li> <li>• Supplier delivery performance</li> <li>• Inventory turnover performance</li> <li>• Supply chain/logistic costs as a percentage of sales</li> </ul>	

Concerning enablers that potentially impact a firm's supply chain performance, academics have identified a cross-functional orientation, the specific dimensions of information sharing, connectivity, willingness and information exchange at sight. The quality of forecast information and quality management systems too have been on the agenda of researchers. Eng (2005) identified a strong positive correlation between cross-functional orientation, consistent interfunctional cooperation, operational linkages, information sharing, a participative management style and technology integration on the one hand and supply chain performance on the other.

When firms nurture a cross-functional orientation, the key is clearly to facilitate and exchange information flows to optimize both resource dependencies and intra-firm and inter-firm business relationships.<sup>269</sup> The issue of information exchange in supply chains was later taken up by other academics as well.

Forslund et al. (2007) found evidence that companies with a make-to-stock business model use their finished goods inventory as a way to cope with forecast uncertainty. As forecast information quality is limited to certain suppliers, especially further upstream in the supply chain, this policy triggers preventive action by increasing safety stock levels and thereby affecting supply chain performance as a whole.<sup>270</sup> Fawcett et al. (2007) headed in the same direction, likewise focusing on information exchange as an enabler of supply chain performance. According to their findings, companies can manage existing obstacles to information exchange by focusing simultaneously on the connectivity of information

<sup>269</sup> Eng (2005), p. 14.

<sup>270</sup> Forslund/Jonsson (2007), p. 104.

technologies and the willingness of the organization.<sup>271</sup> On this subject, Ramayah et al. (2010) emphasized the strategic asset value of information: Availability with minimum delays encourages tactical and strategic decision-making, which in turn fosters sustainable supply chain performance. In light of the growing need for confidentiality due to competitive reasons, relationships of trust throughout the supply chain are, of course, an imperative.<sup>272</sup> Superior quality management is also regarded as an enabler of supply chain performance. Liu et al. (2009) thus described the link between adopting a quality system and supply chain performance. In line with their hypothesis, their data confirmed a positive impact on supply chain performance.<sup>273</sup>

Besides the primarily internal enablers that encourage an organization to maximize its supply chain performance, the nature and structure of the chain are equally important, as evidenced by the multiplicity of papers that have examined this issue. The extent to which the entire supply chain is integrated – from the lowest-tier suppliers through internal stakeholders to end customers – and the consequences thereof for supply chain performance has been analyzed by Lee et al. (2007). According to their conclusions, supply chain integration is a key determinant in improving supply chain performance. Their conclusion is that untapped opportunities can be realized through supply chain integration involving customers, internal stakeholders and suppliers.<sup>274</sup> These findings were later confirmed by Zelbst et al. (2009), who examined three supply chain integration variables: power, benefits and risk reduction. The authors concluded that these variables do indeed drive supply chain performance. More specifically, Ryu et al. (2009) and Srinivasan et al. (2011) singled out the links between buyers and suppliers in the upstream supply chain. Their conclusions reflect with the holistic view: "A buyer-supplier relationship must feature reciprocal trusting behavior and committed effort".<sup>275</sup> Based on the statistical findings, superior performance will be the result. In this respect, the study conducted by Srinivasan et al. (2011) adds one important note: One reason why integrated supply chains perform to a higher level is the opportunity to bypass additional transaction costs as relationship operate based on the "arm's-length principle".<sup>276</sup> Regarding the nature of the supply chain, Wagner et al. (2008) measured the effect of supply chain risk sources on supply chain performance. They identified a negative correlation between both

---

<sup>271</sup> Fawcett/Osterhaus/Magnan/Brau/McCarter (2007), p. 367.

<sup>272</sup> Ramayah/Omar (2010), p. 49.

<sup>273</sup> Liu (2009), p. 288-292.

<sup>274</sup> Lee/Kwon/Severance (2007), p. 450.

<sup>275</sup> Ryu/So/Koo (2009), p. 509.

<sup>276</sup> Srinivasan/Mukherjee/Gaur (2011), p. 267.

demand- and supply-side risks and supply chain performance. Their results must nevertheless be kept in perspective, however, as the identified impact is rather low.<sup>277</sup> Lastly, Vijayasarathy (2010) revealed of the role that the moderators process innovation and partnership quality play in fostering the correlation between the use of technology in supply chains and underlying performance.<sup>278</sup>

The question what actions should be taken to improve supply chain performance has been discussed widely among scholars. However, despite the fact that they have come up with plenty of ways to operationalize this construct, there is little homogeneity in their findings. Some authors, notably, have clustered actions in subgroups reflecting certain aspects of supply chain performance. Examples of these subgroups include "customer satisfaction", "reliability variables" and "cost-containment" variables.<sup>279</sup> Other scholars have preferred not to do so.<sup>280</sup> As mentioned above, a wide variety of aspects has been identified. The following indicators that reflect the responsiveness and reliability of the supply chain have emerged in research to date: "increase order fill rate", "reduce order obsolescence", "flexibility and responsiveness", "quickly respond to and solve problems for end customers", "out-of-stock situations", "shorter order cycles" and "production flexibility".<sup>281</sup> This list is inclusive, not exclusive. As an incremental aspect of supply chain performance, customer satisfaction has been found by academic studies to be influenced by items such as "product quality", "delivery performance", "sales, service and/or technical support", "promised lead time", "on-time delivery", "availability of delay information", "overall customer satisfaction", "zero-defect to final customer" and "time taken to respond to any customer's request".<sup>282</sup> A selection of aspects that constitute cost-containment variables in the context of supply chain performance includes "reduce inbound cost", "reduce outbound cost", "inventory costs", "operating and

---

<sup>277</sup> Wagner/Bode (2008), p. 317.

<sup>278</sup> Vijayasarathy (2010), p. 365.

<sup>279</sup> Eng (2005), p. 10; Forslund/Jonsson (2007); p. 97; Lee/Kwon/Severance (2007), p. 447; Fawcett/Osterhaus/Magnan/Brau/McCarter (2007), p. 361.

<sup>280</sup> Wagner/Bode (2008), p. 324; Liu (2009), p. 291, Ryu/So/Koo (2009), p. 514; Zelbst/Green Jr/Sower/Reyes (2009), p. 671; Ramayah/Omar (2010), p. 43; Lin/Wang/Yu (2010), p. 328, Vijayasarathy (2010), p. 370; Srinivasan/Mukherjee/Gaur (2011), p. 266.

<sup>281</sup> Lee/Kwon/Severance (2007), p. 447; Liu (2009), p. 291, Zelbst/Green Jr/Sower/Reyes (2009), p. 671; Lin/Wang/Yu (2010), p. 328; Vijayasarathy (2010), p. 370.

<sup>282</sup> Eng (2005), p. 10; Forslund/Jonsson (2007); p. 97; Fawcett/Osterhaus/Magnan/Brau/McCarter (2007), p. 361; Zelbst/Green Jr/Sower/Reyes (2009), p. 671.

labor costs", "minimize all types of waste throughout the supply chain", "inventory turnover ratio" and the "cost of new product development".<sup>283</sup>

## 2.6 Discussion

Despite the fact that academic research into working capital management has its roots back in the 19<sup>th</sup> century, researchers have for decades neglected the importance of short-term assets. This is perhaps because most managers have focused their attention to long-term financial decisions – understandably, given the superimposing effects and the associated high sunk costs of single decisions. Aided and abetted by the financial crisis, however, working capital is now back on the agenda of most decision-makers, serving as a tool to leverage both cash and profitability. This attention is all the more pronounced since most assets in manufacturing companies have short-term maturities. The range of measurements needed to constantly monitor working capital levels and performance is seemingly infinite. In theory and practice, however, dynamic measurements such as the cash conversion cycle have prevailed. Their advantage lies in their value as a basis from which to assess and anticipate future financing requirements. Pervasive historic static measurements such as the current ratio or the quick ratio are used nowadays to complement the information gained from flow concepts. This shift of focus represents a fundamental change of thinking in business management: Companies are now regarded as going concerns rather than based on liquidation assumptions.

Modern working capital management has to satisfy a number of purposes. First, the operating cycle – the sequence of cash flows generated by the physical activities of the firm's operations – must be maintained. Malfunctions in complex interrelations can have serious implications. Yet, driven by increasing competition, companies cannot simply absorb the costs associated with excessive buffer stocks in their inventories, for instance. Accordingly, working capital management has to square the circle of being cost-competitive while also sustaining operational needs. For managers, the trick is to match this underlying trade-off. A transparent view of the underlying drivers of working capital requirements and how they interact with related operational disciplines is needed if this venture is to succeed. This transparency is the precondition to accurately assess the consequences of so many cogs, gears and levers.

---

<sup>283</sup> Lee/Kwon/Severance (2007), p. 447; Fawcett/Osterhaus/Magnan/Brau/McCarter (2007), p. 361; Ryu/So/Koo (2009), p. 514; Zelbst/Green Jr/Sower/Reyes (2009), p. 671.

To be able to judge working capital decisions in the context of the entire firm, the effect on firm performance indicators such as ROE or ROA is of relevance too. Scientists have addressed this link in numerous global studies. With the exception of one study, academics have so far concluded that the correlation between working capital levels, operationalized as the cash conversion cycle, and firm performance is negative. Given the high degree of conformity in existing literature, it is highly likely that working capital management represents an effective lever to boost firm performance. As outlined above, academics are expected to develop drivers that will steer working capital and, by consequence, maximize firm performance. Scholars have risen to the challenge and reviewed several hypothetical drivers. To date, however, the drivers investigated have been limited to accessible primary data, as there are virtually no empirical studies that gather secondary data on the operations of a firm. Scholars have in particular analyzed the impact on working capital levels of certain KPIs reflecting company characteristics. Size, cash flow and growth rates have been investigated, to name but a few. On top of KPIs reflecting a company's characteristics, researchers have also assessed parameters such as industry influence or competitive position in terms of financing costs or the market-to-book ratio, say.

No less relevant is the question whether related operational disciplines impact requirements and what effect they have. Past literature reviews have singled out three related operational disciplines – manufacturing performance, supply chain management and supply risk management – as researchers in these areas have referenced and emphasized existing correlations. As an example, academics in the field of supply risk management have explicitly referred to the function of safety stocks in absorbing supply risk. Further examples linking other topics to working capital management are presented in the above review.

In manufacturing performance research, theorists have focused to a large extent on existing trade-offs within the discipline or the effects on performance of integrated manufacturing technologies such as total quality management. Only three papers have so far addressed the effect of outstanding manufacturing practice on firm performance. Irrespective of the comprehensive research question, existing papers have developed a profound operationalization of manufacturing performance as a general construct. In numerous papers, different items reflecting different aspects of manufacturing performance have been proposed. Even so, research on links to specific related operational disciplines remains conspicuous by its absence. In the context of supply chain performance, research academics have focused to a large extent on the nature of the supply chain, on enablers and on their impact on overall



supply chain performance. Statements have also been made about manufacturing performance, and different constructs have largely backed up the hypotheses and been tested with certain aspects. Links to manufacturing and risk management, however, remain uncharted territory. With respect to supply chain risk management, apparently only a handful set of papers have ever empirically tested the identified hypothesis. Classification mainly consists of separating risk drivers from risk sources. Risk drivers characterize the exposure of a supply chain to disruptions, while risk sources identify concrete triggers of supply chain breakdowns. This separation is crucial for practitioners, as risk can be quantified only if risk sources are assessed, whereas mitigation strategies must address risk drivers. Research in the area presented is less mature, although supply chain risk drivers and sources have been the subject of intensive discussion. Predominantly, literature refers to risk drivers such as global sourcing, supplier concentration and supplier dependency. Prominent risk sources include demand-side risks such as volatility and supply-side risks such as supplier default. In addition, infrastructural risks like machine outages, catastrophic risks and regulatory risks are also cited frequently.

The Configurational Theory postulates that the alignment of different design parameters in the organization and its environmental context drives efficiency and effectiveness. According to the underlying concept of "fit", companies that are not able to properly align organizational parameters will experience inefficiency and ineffectiveness. Subsuming the above reviews of working capital management, manufacturing performance, supply chain performance and supply chain risk management under the Configurational Theory, its key elements postulate optimized firm performance if all disciplines are aligned and matched with the environmental context. Working capital, manufacturing and the supply chain must be optimized based on an approach that integrates a company's environment, e.g. supply risk drivers. Only an integrated approach covering all disciplines simultaneously will ultimately serve to maximize profit and competitiveness.

## 2.7 Conclusion

A review of the literature revealed three main deficiencies. First, scholars have named and, to some extent, empirically tested drivers of working capital management. As far as production system, company characteristics, company environments and industry specifics are concerned, scholars have developed any number of drivers, including capacity utilization, company size and market power. Despite the fact that these identified drivers have been tested empirically, the current list appears to be far from comprehensive. The motivation, in the opinion of the author, has essentially been pragmatic: Most scholars have focused on primary data, to which they readily have access on a large scale. Drivers of academic research areas at the interface to working capital management – areas that undoubtedly affect working capital levels – have yet to be incorporated in the body of research. These areas are manufacturing performance, supply chain performance and supply risk management. These, to some extent only, drive the requirements for working capital levels. Another reason for such poor treatment to date may lie in the time-consuming process and the potential bias in any survey of required empirical data. Secondary data is particularly in the context of working capital difficult to obtain, since hardly any primary data is available on purely operational topics such as quality performance in manufacturing. The gap in the literature has persisted despite the fact that postulated links have been stated by some academics. Empirical research is still missing, however. More surprisingly, while the listed constructs have been operationalized and empirically tested in numerous papers, the link to working capital management is still missing. Here again, to the knowledge of the author, no empirical study is yet available. Research is therefore needed on empirically testing the impact of manufacturing performance, supply chain performance and supply chain risk management on working capital requirements.

Second, although scholars have indeed analyzed the correlation of working capital levels, measured in terms of cash conversion cycle, and overall firm performance, no existing research traces effects back to specific drivers of working capital management. By consequence, even though the effects of working capital levels on firm performance have been interpreted, no study has yet suggested which specific drivers of working capital levels have what degree of impact. This is a deeply unsatisfactory situation, as practitioners must aim for a detailed analysis of interdependencies if they are to be able to adjust their operations. Nor does the missing link between drivers of working capital levels and firm performance only concern the drivers mentioned explicitly in the literature. In the area of

manufacturing performance, very limited information has ever been published at all on the effect on overall firm performance. The author knows of no scholars at all who have evaluated the putative correlations between supply chain performance or supply chain risk management and firm performance.

Third, based on the literature review, no model incorporating correlations between manufacturing performance, supply chain performance, working capital performance, supply chain risk management and firm performance exists at the present time. As outlined earlier, the listed constructs are expected to affect each other. Optimization, however, necessitates integration. Furthermore, to make existing interactions and potential trade-offs transparent, all constructs must be incorporated simultaneously.

The literature review presented has its limitations with regard to the research engine selected and the applied search criteria. The search engine used – EBSCO Business Source Premier – covers the majority of academic publications in economic literature. However, it may not cover scholars whose work relates to areas such as natural science. Similarly, the literature review is based on specific word stems that were rated to best fit the purpose of the research question. The applied word stems were searched for in the title or the abstract. Relevant scholars may therefore have been overlooked in the study for two reasons. First, theorists may have used different terms to actually describe the same constructs or correlations. Second, authors may have not have specified the relevant terms in the title or abstract, despite the fact that a given work contains relevant statements on the topic.

Optimizing Firm Performance  
Alignment of Operational Success Drivers on the Basis  
of Empirical Data

Faden, C.

2014, XV, 176 p. 19 illus., Softcover

ISBN: 978-3-658-02745-2