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# Testing Liquidity Measures as Bankruptcy Prediction Variables

## ABSTRACT

*The main purpose of this article was to test the ability of two new liquidity measures' ability to predict bankruptcy, both as separate financial ratios and as part of different combinations of financial ratios. The liquidity measures cash conversion cycle and comprehensive liquidity index, which have not been used before in bankruptcy prediction, classified the companies selected for study into the two categories failed and non-failed rather inaccurately. The liquidity measures working capital/total assets and current ratio classified significantly better than the two new liquidity measures one and two years before bankruptcy. Of the individual financial ratios the degree of indebtedness, total debts/total assets, had the best classifying ability. The classifying result obtained from the tests of the estimated models indicates that none of the liquidity measures working capital/total assets, current ratio, comprehensive liquidity index or cash conversion cycle serves better as a component of a bankruptcy prediction model than the other.*

## INTRODUCTION

The ultimate goal for the bankruptcy researcher has been, and still is, to find the perfect procedure to predict a company's failure. This is due to the fact that several interested parties, for example, stockholders, financiers, employees, contractors, customers and the Government would economically be affected by a possible bankruptcy. A good bankruptcy prediction model could, for example, be used by an auditor who wants to know how vulnerable a company is

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when the auditor is making the statement about the company's possibilities to continue as a going concern (Jones 1987: 131).

The traditional liquidity measure current ratio has been criticized because it mixes assets and liabilities that are quite different in terms of their maturity time. The traditional liquidity measures "may give the wrong signals, contradictory signals, or no signals at all of actual changes in liquidity position" (Scherr 1989: 351–354). Several improved liquidity measures have appeared in the literature, among others *Cash conversion cycle* (Richards and Laughlin 1980: 32–38) and *Comprehensive liquidity index* (Melnik and Birati 1974: 162–65). As far as I know, no empirical tests of these liquidity measures have been reported in the literature despite the fact that these measures have existed for quite some time. One way to test them is to test their ability to predict bankruptcy (Beaver, Kennelly and Voss 1968: 675).

The main purpose of this article is to test the ability of these liquidity measures to predict bankruptcy, both as individual financial ratios and as parts of different combinations of financial ratios. The different combinations of financial ratios consist of the same capital structure ratio and profitability ratio, while the liquidity ratio varies. The liquidity measures used in this study consist on the one hand of traditional liquidity measures (working capital and current ratio), and on the other hand of the two liquidity measures (cash conversion cycle and comprehensive liquidity index) that have not been used before in bankruptcy prediction research. According to Scherr (1989), the latter liquidity measures should be more accurate than the traditional liquidity measures (Scherr 1989: 354–358). The two new liquidity measures and the two other financial ratios (long-term debt ratio and current liability ratio), distinguish this study from earlier bankruptcy prediction studies.

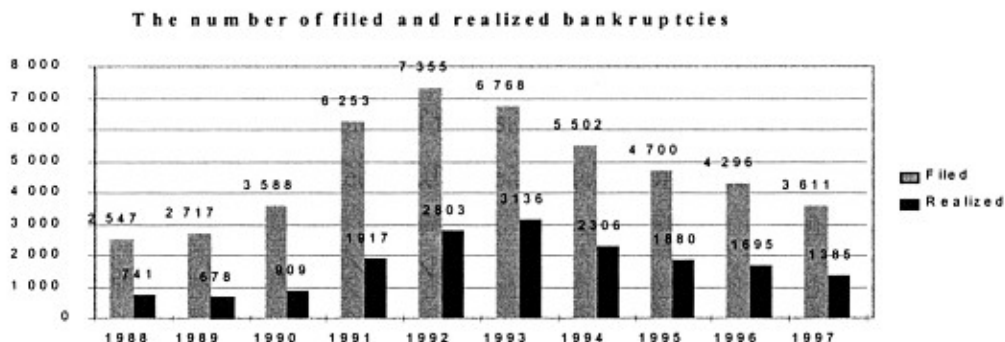
This article has the following structure: First there is a section about business failure in Finland, followed by the choice of ratios, the data and the selected methods. Then the results of the logistic analysis are presented. The article is concluded with a summary.

## BUSINESS FAILURE IN FINLAND

In 1992, the number of companies filing for bankruptcy was 7355, which represented 5.4 percent of the total number of companies in Finland. Since 1993<sup>1</sup>, the number of filed bankruptcies has continuously decreased. In 1997, the number was 3611. What is noticeable is that the number of filed bankruptcies is not the same as the number of realized bankruptcies (Statistical yearbook, 1998). Figure 1 illustrates the relationship between the number of filed and realized bankruptcies.

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<sup>1</sup> In 1993 (25.1.1993/47) the "Reorganization law" (Lag om företagssanering) was established. This made it possible for companies to file for company reorganization instead of bankruptcy.



**FIGURE 1.** *The number of filed and realized bankruptcies 1988–1997.*

The most common reasons for a filed bankruptcy not leading to a bankruptcy decision by the courts are that the company is impecunious (1191 cases in 1997), or that the application has been annulled (925 cases in 1997). Impecunious means that the company is unable to pay for the costs of the bankruptcy procedure (Statistical yearbook, 1998).

## CHOICE OF RATIOS

The typical definition of failure in prior studies is either liquidating bankruptcy or reorganization, as in Altman (1968). However, Beaver (1966) defined financial distress as “the inability of a firm to pay its financial obligations as they mature”. In the study by Abdel-Khalik and El-Sheshai (1980), the event of “default on debt” was predicted. As in prior Finnish studies, liquidating bankruptcy was used as the dependent variable in this study (as in Prihti (1975) and Laitinen (1993)).

Due to the lack of theoretical support, researchers have had to search for other procedures in the selection of independent variables (Jones 1987: 136–137). Most researchers, for example Beaver (1966) and Altman (1968), have selected financial ratios based on their popularity and predictive success in earlier studies. In this study, the financial ratios are selected in accordance with Beaver (1966), Altman (1968), Prihti (1975) and Laitinen (1993), supplemented with Richards's & Laughlin's (1980) liquidity measure cash conversion cycle and the liquidity measure comprehensive liquidity index, as in Melnyk & Birati (1974). The advantage of the two new liquidity measures is explained in the next two paragraphs. Further, the financial ratios *Long-term debts/Total assets* and *Current liabilities/Total assets* were selected. Table 1 shows the financial ratios used in this study and how they are calculated.

The liquidity measure cash conversion cycle measures the ‘net time interval’ between the expenditure of cash for short-term liabilities, and the receipt of cash from inventories and ac-

**TABLE 1.** *The financial ratios used in this study as well as how they were calculated and in which studies they have been used before.*

Financial ratios	Calculation	Previous studies
<i>Capital structure:</i>		
Debt ratio	The total amount of current liabilities and long-term debt divided by total assets.	Beaver (1966), Prihti (1975) and Laitinen (1993).
Long-term debt ratio	The total amount of long-term debt divided by total assets.	
Current liability ratio	The total amount of current liabilities divided by total assets.	
<i>Liquidity:</i>		
Working capital	The sum of inventories and current financial assets minus current liabilities, all divided by total assets.	Beaver (1966) and Altman (1968).
Current ratio	The sum of inventories and current financial assets divided by current liabilities.	Beaver (1966).
Cash Conversion Cycle	See footnote <sup>2</sup> .	Richards & Laughlin (1980).
Comprehensive Liquidity Index	See footnote <sup>3</sup> .	Melnyk & Birati (1974).
<i>Profitability:</i>		
Operating income ratio	Net income before extraordinary items divided by total assets.	Beaver (1966) and Laitinen (1993).
EBIT/Total assets	Net income plus interests and taxes divided by total assets.	Altman (1968).
Cash flow <sup>4</sup> /Total debts	Net income before depreciation and extraordinary items divided by total debts.	Beaver (1966) and Laitinen (1993).

**2** A calculation example of the Cash Conversion Cycle: The firm's accounts receivable turnover is 18 days and inventory turnover is 30 days (or average collection time for accounts receivable and inventories). And finally the accounts payable turnover is 68 days (or the firm's deferral period). This gives a Cash Conversion Cycle for the firm on minus 20 days ( $18+30-68=-20$ ) (Scherr 1989: 356-357).

**3** A calculation example for the Comprehensive Liquidity Index using the following financial statement numbers: Cash (\$15,000), accounts receivable (\$50,000), inventories (\$75,000), accounts payable (\$110,000) and wages payable (\$60,000). The turnover (times per year) for accounts receivable, inventories, accounts payable and wages payable are 20, 12, 3.64 and 8.33, respectively.

This gives us the following calculation: The cash amount needs no adjustment. The adjusted accounts receivable is  $\$50,000 \times (1 - (1/20)) = \$47,500$ . When adjusting the inventories, both turnover for inventories as well as turnover for receivables is needed (first from turnover of inventory to receivables and then turnover of receivables to cash), or  $\$75,000 \times (1 - (1/20) - (1/12)) = \$65,000$ . The adjusted accounts payable is  $\$110,000 \times (1 - (1/3.64)) = \$79,750$  and the adjusted wages payable is  $\$60,000 \times (1 - (1/8.33)) = \$52,800$ . This gives a Comprehensive Liquidity Index of  $(\$15,000 + \$47,500 + \$65,000) / (\$79,750 + \$52,800) = 0.96$ . Comparing this with the common liquidity measure Current ratio a clear difference can be spotted  $(\$15,000 + \$50,000 + \$75,000) / (\$110,000 + \$60,000) = 0.82$  (Scherr 1989: 357-358).

**4** Not exactly cash flow since changes in accounts receivable, accounts payable, prepaid expenses and accrued income, and deferred income and accrued expenses are missing.

counts receivable. The cash conversion cycle is calculated as the sum of the average collection period for accounts payable and the inventory conversion period, minus the payment deferral period (see footnote 2 for an example). Therefore, the lower the cash conversion cycle is, the more liquid the company is said to be. A possible weakness affecting the cash conversion cycle is the fact that the most liquid asset, cash, is not included (Richards and Laughlin 1980: 32–38). However, in previous empirical bankruptcy prediction literature, the conventional wisdom suggests that larger current assets imply higher liquidity, and larger current liabilities imply lower liquidity (Beaver 1966, Altman 1968 and Ohlson 1980). In contrary, the cash conversion cycle implies better liquidity when current asset decreases and current liabilities increases. Following previous corporate bankruptcy studies, the assumption is made that the lower the cash conversion cycle is, the lower the liquidity of a firm is.

The liquidity measure comprehensive liquidity index is a liquidity-weighted version of the current ratio (see footnote 3 for an example). The problem with the traditional current ratio is that it treats all assets and liabilities as being of equal degree of liquidity. This is avoided in the comprehensive liquidity index by weighting each current asset or liability based on its turnover (nearness to cash). In calculating the comprehensive liquidity index, the amount of each current asset or liability is multiplied by one, minus the inverse of the asset or liability's turnover ratio. In cases of more than one turnover required to generate cash from the asset, the inverse of each of these ratios is subtracted (Melnyk and Birati 1974: 162–65).

The long-term debt ratio and current liability ratio were merged into the debt ratio. The latter of the two financial ratios is interesting because companies with financial difficulties tend to increase the amount of current liabilities in relation to total debts for fear of losing the confidence of their creditors, who as a result, may cease to grant long-term debts.

## DATA

The data<sup>5</sup> used for this study were received from a bank in Finland. It consisted of 42 failed (filed for bankruptcy) companies and 42 non-failed companies. The non-failed companies were selected according to the "matching" procedure, i.e., the non-failed companies operate in the same line of business and have financial statements from the same fiscal period as the failed companies. The non-failed companies were randomly selected according to the stated restrictions.

The size of the companies, measured by total assets and turnover, was on average 36 million marks and 34 million marks for failed companies, and for non-failed companies 78

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5 This data has earlier been used by Sundgren (1996) in *"Identification of Failing Firms with Financial Ratios"*.

million marks and 252 million marks, respectively<sup>6</sup>. The bankruptcy filings were made during the time period 1.6.1986–10.10.1991. Of the 42 failed companies, eight are retailers, seven are from the wholesale sector, ten are construction companies and seventeen are manufacturers.

The financial statements of the companies, both failed and non-failed companies were adjusted for differences in accounting practices concerning depreciation and hidden inventory reserves. If the fiscal period for the companies was not equal to twelve months, income statement items were adjusted to correspond with a twelve-month period. These adjustments were made in order to make the data comparable. Finally, the transformed data was used for the liquidity measure cash conversion cycle to avoid the effects of extreme values<sup>7</sup>.

## METHOD

Firstly, the financial ratios were tested for differences in mean values between failed and non-failed companies using a t-test. Secondly, the separate financial ratios' ability to classify companies into two categories – failed and non-failed companies – one to three years before bankruptcy was tested using logistic regression<sup>8,9</sup>. Thirdly, a test of the ability for different combinations of financial ratios to predict bankruptcy and to classify companies into the two categories, namely failed or non-failed companies, one to three years before bankruptcy, was made. The different combinations of financial ratios consisted of the same capital structure ratio and

**6** There were no statistically significant differences in average assets or turnover between the two categories of firms.

**7** For example the *Cash conversion cycle*-value for one of the failed companies was 817 days, which is over 2 years in time. One of the non-failed companies had an even higher ratio, or 981 days (almost 3 years). The transformed data was calculated as the natural logarithm of the original financial ratio (I used the absolute value of the financial ratios to be able to calculate the logarithm values for financial ratios with negative signs. Financial ratios with negative signs before the transformation were given a negative sign after the transformation as well). The transformed data for the cash conversion cycle was used throughout the study.

**8** Using the logistic regression each company receives a value (likelihood) within the interval [0,1]. For example, if the value is close to one the likelihood for bankruptcy is high. Laitinen (1993) among others have used this method.

**9** The estimated models have the following formulation:

$$Z_t = a + b_1 x_1 + \dots + b_p x_p$$

where  $Z_t$  is the estimated logit model  $t$  year before bankruptcy,  $a$  is the estimated constant,  $b$  are the estimated parameters and  $x$  stands for the independent variables.

The probability is computed according to the following formula:

$$\text{Prob (event)} = \frac{1}{1 + e^{-Z}}$$

Using the estimated logistic regression models in practice makes it necessary to adjust the constant ( $a$ ) to reflect the true population proportion of individuals with the event (Afifi & Clark, 1996: 296–299). This is due to the fact that the number of failed companies of the total number of companies in Finland is about two percent, which it approximately was during the period 1986–1990 (Statistical yearbook, 1998). This is not adjusted for in this study because the main purpose is to test the ability of different liquidity measures to predict bankruptcy, not to develop the best practical bankruptcy prediction model.

profitability ratio while the liquidity ratio varied. Finally, the separate financial ratios, as well as the four estimated models, were tested for differences in their ability to classify companies into failed and non-failed categories using the z-test<sup>10</sup>.

The classification is unlikely to be perfect, i.e. some prediction errors will exist. These errors are called type-I and type-II errors. A type-I error occurs when a failed company is classified as a non-failed company, and a type-II error occurs when a non-failed company is classified as a failed company. Assuming that the cost<sup>11</sup> of misclassification of the types I and II is the same, then the cut-off point should be 0.5, i.e. companies with a probability of bankruptcy greater than 0.5 should be classified as bankrupt. The cut-off point will change if the costs of errors are considered (Jones 1987: 154). In this study the cut-off point is set to 0.5, i.e. the assumption is made that the costs of type-I and type-II errors are the same.

## EMPIRICAL RESULTS

### Descriptive statistics

The differences between the mean values of the ratios for the two categories of companies were tested using a t-test<sup>12</sup>. The descriptive statistics for the variables and the results from the t-tests are reported in table 2. The results from the t-test show that the liquidity measure cash conversion cycle did not significantly differ between failed and non-failed companies. The other new liquidity measure, comprehensive liquidity index, was significant at the ten percent level one year before bankruptcy.

The debt ratio differs between failed and non-failed companies as early as three years before bankruptcy (statistically significant at the one-percent level). A probable reason for this is that failed companies have generated losses and that credits have been used to finance business operations. A further analysis of the debt ratio was conducted in which the ratio was split into a long-term debt ratio and a current liability ratio. The observation can be made that it is

10 Formula:

$$z = \frac{p_1 - p_2}{\sqrt{p(1-p)\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

where  $p_1, p_2$  = the compared groups classifying ability,  
 $n_1, n_2$  = the number of companies in the case in question, and  
 $p$  = the weighted average of  $p_1$  and  $p_2$  (Mendenhall et al. 1986: 297).

11 "If the cost of a type-I error were five times that of a type-II error, classification costs would be minimized by using a cutoff of 0.167, such that firm with probability of bankruptcy greater than 0.167 would be presumed bankrupt. At this point the relative expected cost of a type-I error (0.167\*5=0.833) would be equal to the expected cost of a type-II error (0.833\*1=0.833)." (Jones 1987: 154)

12 I also tested for differences with the non-parametric Wilcoxon Rank sum test. The result showed the same result as the t-test with an exception for the current ratio, which differed significantly one and two years before bankruptcy.

**TABLE 2. Descriptive statistics for each of the financial ratios and the results from the t-tests of differences in mean values between failed and non-failed companies one, two and three years before bankruptcy.**

Financial ratios	Year	Failed companies				Non-failed companies				T-test
		Mean	Min	Max	Stdev	Mean	Min	Max	Stdev	T-values
Debt ratio	1	0.977	0.56	2.08	0.232	0.748	0.30	1.24	0.201	4.840***
	2	0.935	0.50	1.83	0.199	0.746	0.19	1.27	0.228	4.041***
	3	0.916	0.43	1.42	0.206	0.755	0.27	1.49	0.231	3.372***
Long-term debt ratio	1	0.364	0.02	0.81	0.221	0.293	0.02	0.66	0.187	1.598
	2	0.353	0.03	0.90	0.230	0.297	0.01	0.74	0.205	1.171
	3	0.332	0.00	1.10	0.253	0.265	0.00	0.65	0.182	1.398
Current liability ratio	1	0.613	0.30	1.26	0.216	0.455	0.01	0.76	0.184	3.598***
	2	0.582	0.23	1.26	0.250	0.448	0.01	0.82	0.198	2.711***
	3	0.583	0.15	1.09	0.222	0.489	0.01	1.02	0.217	1.960*
Working capital	1	0.076	-0.37	0.70	0.208	0.184	-0.29	0.58	0.18	2.519**
	2	0.096	-0.30	0.56	0.211	0.215	-0.32	0.64	0.187	2.724***
	3	0.127	-0.24	0.57	0.198	0.179	-0.42	0.69	0.200	1.207
Current ratio	1	1.220	0.49	3.33	0.506	3.148	0.37	71.81	10.860	1.149
	2	1.299	0.56	3.23	0.566	3.779	0.52	92.44	14.030	1.145
	3	1.357	0.68	2.69	0.497	4.303	0.59	119.70	18.250	1.046
Cash conversion cycle	1	4.105	-4.67	6.71	2.562	4.539	-3.94	6.88	1.920	0.879
	2	3.622	-6.66	6.32	3.156	4.516	-3.93	6.29	1.780	1.597
	3	3.593	-5.12	6.36	2.939	4.431	-5.09	6.44	2.296	1.456
Comprehensive liquidity Index	1	-0.220	-33.30	5.37	6.577	1.737	-2.28	13.32	2.286	1.822*
	2	-0.590	-84.90	6.85	13.49	1.696	-0.52	4.74	1.095	1.099
	3	0.319	-41.50	7.24	6.952	1.518	-1.43	3.12	1.041	1.106
Operating income ratio	1	-0.070	-0.36	0.29	0.118	-0.010	-0.26	0.13	0.082	3.143***
	2	-0.040	-0.39	0.18	0.099	0.009	-0.32	0.37	0.119	2.304**
	3	-0.020	-0.36	0.33	0.130	0.011	-0.31	0.28	0.112	1.279
EBIT/TA	1	0.071	-0.22	0.34	0.105	0.052	-0.16	0.18	0.072	2.301**
	2	0.031	-0.20	0.21	0.087	0.076	-0.18	0.43	0.105	2.127**
	3	0.049	-0.29	0.48	0.129	0.077	-0.16	0.31	0.092	1.158
Cash flow/TD	1	-0.010	-0.19	0.30	0.090	0.07	-0.21	0.44	0.128	3.652***
	2	0.009	-0.24	0.29	0.090	0.147	-0.17	2.30	0.371	2.333**
	3	0.055	-0.18	0.84	0.171	0.128	-0.18	1.23	0.247	1.589

\* Statistically significant at the 10% level

\*\* Statistically significant at the 5% level

\*\*\* Statistically significant at the 1% level

the current liabilities (accounts payable, deferred income and accrued expenses, and advances received) that differ. The current liability ratio significantly differed at the one-percent level one to two years before, and at the ten percent level, three years before bankruptcy.

The relation between the financial ratios is reported in appendix 1. Briefly, the correlation between the traditional liquidity measures working capital and current ratio, and the new liquidity measure cash conversion cycle, was significantly positive all three years before bankruptcy.



### Logistic univariate tests

Next, the ability of the ratios to classify the companies into the failed and non-failed categories is studied. The liquidity measures cash conversion cycle and comprehensive liquidity index, classified the companies into the two categories failed and non-failed rather poorly (see Table 3 for results from the univariate logistic regressions). The cash conversion cycle misclassified 46.4, 41.7 and 42.9 percent of the companies one, two and three years before bankruptcy, while the comprehensive liquidity index misclassified 46.4, 51.2 and 45.2 percent of the companies one, two and three years before bankruptcy.

Comparing the common liquidity measure current ratio with the comprehensive liquidity index, it can be observed that the current ratio classifies the companies significantly better at the 10 percent level, one and two years before bankruptcy. No significant difference exists between the two ratios three years before bankruptcy (see Appendix 2 for the results from the z-test). The current ratio as well as the working capital ratio, classified the companies significantly better than the cash conversion cycle one year before bankruptcy. The traditional liquidity measures (current ratio and working capital) are to a certain extent better than the new liquidity measures (cash conversion cycle and comprehensive liquidity index) when it comes to classifying failed and non-failed companies.

The results indicate that the debt ratio has the best classifying ability. Using the debt ratio as bankruptcy predictor, 23.8, 27.4 and 35.7 percent, respectively, of the companies was misclassified one, two and three years, respectively, before bankruptcy. The same financial ratio used by Beaver (1966), which in his study had the third best classifying ability, misclassified 19 and 32 percent, respectively, of the companies one and three years, respectively, before failure.

The current liability ratio classified the companies slightly better than the long-term debt ratio (not significantly better). Using the first of these 35.7 and 44 percent, respectively, and the latter 39.3 and 45.2 percent, respectively, of the companies was misclassified, one and three years, respectively, before bankruptcy (see Table 3).

The classifying ability for the profitability ratios is approximately the same. The misclassification percent varies between 29.8 percent one year before bankruptcy to 45.2 percent three years before bankruptcy. There exist no significant differences between the profitability ratios classifying ability.

A common feature of all separate financial ratios is that the classifying ability weakens as the number of years before the bankruptcy moment increases. The group of financial ratios with the best classifying ability was the capital structure ratios, followed by the profitability ratios and finally the liquidity measures. In Beaver's (1966) study the financial ratio measuring the cash flow/total debts, showed the best classifying ability, followed by a profitability ratio, a capital structure ratio and finally by two liquidity measures.

**TABLE 3. Classification results based on separate financial ratios, one to three years before bankruptcy. The parameter values for each of the logistic regression are presented as well as the significance level of the parameters.**

Financial ratios	Misclassifications (%) 1 year before bankruptcy			Misclassifications (%) 2 years before bankruptcy			Misclassifications (%) 3 years before bankruptcy					
	Type-I	Type-II	Total	Parameter value	Type-I	Type-II	Total	Parameter value	Type-I	Type-II	Total	Parameter value
Debt ratio	16.7	31.0	23.8	6.462***	23.8	31.0	27.4	4.8924***	35.7	35.7	35.7	3.572***
Constant				-5.565***				-4.120***				-2.986***
Long-term debt ratio	42.9	35.7	39.3	1.726	54.8	42.9	48.8	1.195	54.8	35.7	45.2	1.428
Constant				-0.566				-0.388				-0.425
Current liability ratio	38.1	33.3	35.7	4.116***	47.6	42.9	45.2	2.685	40.5	47.6	44.0	1.986*
Constant				-2.181***				-1.375**				-1.066*
Working capital	33.3	33.3	33.3	-2.910	38.1	31.0	34.5	-3.046**	42.9	35.7	39.3	-1.356
Constant				0.379				0.477				0.209
Current ratio	23.8	40.5	32.1	-1.068**	28.6	45.2	36.9	-0.978**	35.7	61.9	48.8	-0.454
Constant				1.449**				1.428**				0.668
Cash Conversion Cycle	61.9	31.0	46.4	-0.088	61.9	21.4	41.7	-0.149	64.3	21.4	42.9	-0.129
Constant				0.384				0.620				0.526
Comprehensive Liq. Index	57.1	35.7	46.4	-0.177	61.9	40.5	51.2	-0.093	64.3	26.2	45.2	-0.084
Constant				0.204				0.122				0.099
Operating income ratio	35.7	26.2	31.0	-7.148***	47.6	35.7	41.7	-4.942**	47.6	33.3	40.5	-2.380
Constant				-0.276				-0.083				-0.015
EBIT/Total assets	38.1	21.4	29.8	-5.822**	45.2	42.9	44.0	-5.099**	40.5	45.2	42.9	-2.337
Constant				0.177				0.273				0.148
Cash flow/Total debts	28.6	30.9	29.8	-7.630***	26.2	40.4	33.3	-6.211***	30.9	59.5	45.2	-1.863
Constant				0.210				0.324				0.160

\* Significantly different from 0 at the 10% level

\*\* Significantly different from 0 at the 5% level

\*\*\* Significantly different from 0 at the 1% level

### Logistic multivariate tests

Four different prediction models were estimated, one to three years before bankruptcy, all consisting of the same capital structure ratio and profitability ratio, while the liquidity ratio varied. This procedure resulted in twelve different models.

The following variables were included in the model: the capital structure ratio, *Total debts/Total assets*, and the profitability ratio, *Cash flow/Total debts*, were selected because earlier in this study they showed the best individual classifying results within their group of ratios<sup>13</sup>. The liquidity measure was different for all four models. The liquidity measures in the models were the *Cash conversion cycle* and *Comprehensive liquidity index*, along with two common liquidity measures *Working capital/Total assets* and *Current ratio*. Beaver (1966) used the current ratio and the working capital ratio in his research; Altman (1968) also used the latter in his study. Tests of the separate financial ratios' classifying ability showed that the cash conversion cycle and the comprehensive liquidity index had a weaker classifying ability than the current ratio and the working capital ratio (significantly one year before bankruptcy). Of particular interest is the possible difference between the comprehensive liquidity index and the current ratio, since the comprehensive liquidity index is an adjusted version of the current ratio.

The model that was estimated first consisted of the debt ratio, the ratio cash flow/total debts and the liquidity measure cash conversion cycle (see Table 4, Panel A). The debt ratio received a positive sign, which means that the probability of bankruptcy increases with higher values of the ratio. When it comes to the liquidity measure cash conversion cycle and the profitability ratio cash flow/total debts, the results are a little ambiguous. The company is supposed to enjoy better liquidity the higher the cash conversion cycle value is. Therefore the sign of the parameters ought to be negative. In this case, the signs are positive one and two years before, and negative three years before bankruptcy. The profitability ratio ought to have negative signs, but in this study the profitability ratio received a negative sign one and two years before, and a positive sign three years before bankruptcy. The debt ratio is the only significant variable at the one-percent level one year before, and at the five-percent level two and three years before bankruptcy.

In estimating a logistic regression model, each of the parameters receives a value R that indicates the contribution of the variables to the model<sup>14</sup>. The R-value for the debt ratio was

<sup>13</sup> I also estimated models where EBIT/Total assets and Operating income/Total assets were used as independent variables instead of Cash flow/Total debt. The overall results from these models were qualitatively the same as those reported in table 4 for Cash flow/Total debt.

<sup>14</sup> The R-value can range from -1 to +1. A positive value on R indicates that as a variable increases the probability of an event occurring also increases. A small R-value indicates that the variables contribution to the model is small (SPSS 1994: 5-6).

**TABLE 4. Estimated logistic regression model parameters, R-values, Chi-squares and classifying results for all the models.**

<b>PANEL A: The estimated logistic regression model with the debt ratio, the cash flow/total debts ratio and the liquidity measure cash conversion cycle.</b>									
Variable	1 year before bankruptcy			2 years before bankruptcy			3 years before bankruptcy		
	Parameter value	R-value		Parameter value	R-value		Parameter value	R-value	
Constant	-5.7497***			-3.2562*			-3.4732***		
Debt ratio	6.0973***	0.2703		3.9863**	0.1507		4.1464**	0.1798	
Cash flow/TD	-3.0172	0.00		-2.1692	0.00		1.0466	0.00	
CCC	0.1284	0.00		0.0016	0.00		-0.0190	0.00	
Chi-Square	26.742***			17.271***			11.611***		
Misclassification (%)	Type-I	Type-II	Total	Type-I	Type-II	Total	Type-I	Type-II	Total
	19.0	26.2	22.6	23.8	31.0	27.4	35.7	38.1	36.9
<b>PANEL B: The estimated logistic regression model with the debt ratio, the cash flow/total debts ratio and the liquidity measure comprehensive liquidity index.</b>									
Variable	1 year before bankruptcy			2 years before bankruptcy			3 years before bankruptcy		
	Parameter value	R-value		Parameter value	R-value		Parameter value	R-value	
Constant	-4.3341***			-3.0581*			-3.5610**		
Debt ratio	5.2319***	0.2287		3.7957**	0.1466		4.2266***	0.2041	
Cash flow/TD	-3.3818	0.00		-2.2502	0.00		1.1961	0.00	
CLI	-0.0966	0.00		-0.0247	0.00		-0.0633	0.00	
Chi-Square	27.926***			17.608***			12.634***		
Misclassification (%)	Type-I	Type-II	Total	Type-I	Type-II	Total	Type-I	Type-II	Total
	19,0	21,4	20,2	23,8	31,0	27,4	38,1	33,3	35,7
<b>PANEL C: The estimated logistic regression model with the debt ratio, the cash flow/total debts ratio and the liquidity measure current ratio.</b>									
Variable	1 year before bankruptcy			2 years before bankruptcy			3 years before bankruptcy		
	Parameter value	R-value		Parameter value	R-value		Parameter value	R-value	
Constant	-4.6825***			-3.1612*			-3.5484**		
Debt ratio	5.5688***	0.2520		3.9208**	0.1507		4.1748***	0.2003	
Cash flow/TD	-2.7334	0.00		-2.0860	0.00		1.2032	0.00	
Current ratio	-0.0292	0.00		-0.0237	0.00		-0.0226	0.00	
Chi-Square	25.847***			17.334***			11.851***		
Misclassification (%)	Type-I	Type-II	Total	Type-I	Type-II	Total	Type-I	Type-II	Total
	21.4	26.2	23.8	23.8	31.0	27.4	35.7	38.1	36.9
<b>PANEL D: The estimated logistic regression model with the debt ratio, the cash flow/total debts ratio and the liquidity measure working capital.</b>									
Variable	1 year before bankruptcy			2 years before bankruptcy			3 years before bankruptcy		
	Parameter value	R-value		Parameter value	R-value		Parameter value	R-value	
Constant	-4.9671***			-3.3824*			-4.8831***		
Debt ratio	5.8028***	0.2340		4.1060**	0.1358		5.3724***	0.230	
Cash flow/TD	-2.7902	0.00		-2.2065	0.00		1.0520	0.00	
Working capital	0.3023	0.00		0.0178	0.00		1.9943	0.00	
Chi-Square	25.816***			17.288***			13.113***		
Misclassification (%)	Type-I	Type-II	Total	Type-I	Type-II	Total	Type-I	Type-II	Total
	21.4	26.2	23.8	23.8	31.0	27.4	35.7	33.3	34.5

\* Significantly different from 0 at the 10% level

\*\* Significantly different from 0 at the 5% level

\*\*\* Significantly different from 0 at the 1% level

between 0.1507 and 0.2703. The profitability ratio, cash flow/total debts and the liquidity measure cash conversion cycle received an R-value equal to zero, meaning that their contribution to the model is insignificant (see Table 4, Panel A).

Using these estimated models, each of the companies receives a Z-value, which is used to compute the probability of a certain company belonging to the failed or non-failed group of companies.

Using the model for classification, it was found that only 22.6 percent of the companies were misclassified one year before bankruptcy, and 36.9 percent three years before bankruptcy<sup>15</sup>. The misclassifications of the two types, I and II, are relatively equal in magnitude.

The second estimated model consisted of the debt ratio, cash flow/total debts and the liquidity measure comprehensive liquidity index. The signs of the coefficients were the same as in the previous model concerning the capital structure ratio and the profitability ratio. The liquidity measure comprehensive liquidity index received negative signs, one to three years before bankruptcy. Of the financial ratios in the model, it is only the debt ratio that is significant. The R-value for the variables is approximately the same as in the first model (see Table 4, Panel B).

This model misclassified 20.2 percent of the companies one year before bankruptcy, and 35.7 percent three years before bankruptcy. The classifying ability of this model is slightly better than the first model (not significantly). The results of the estimated logistic regression models and the classifying results are given in table 4 (Panel B).

The third and fourth of the estimated models include the same capital structure ratio and profitability ratio as the two previous models. In the third model, the traditional liquidity measure current ratio was included, and in the fourth, the liquidity measure working capital/total assets.

The signs are the same as in the previous two models for the debt ratio (positive one to three years before bankruptcy), and for the ratio cash flow/total debts (negative one and two years and positive three years before bankruptcy). The R-values for the variables occurring in the third and fourth estimated models are approximately the same as in the first two estimated models. The chi-square shows that all the estimated models are significant at the one-percent level, all three years before bankruptcy.

Using the third estimated model, 23.8 percent of the companies were misclassified one year before bankruptcy, 27.4 percent two years before and 36.9 percent three years before bankruptcy (see Table 4, Panel C).

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15 The same sample as was used to estimate the models because of the small sample size.

The fourth model misclassified 23.8 percent of the companies one year before bankruptcy, 27.4 percent two years before and 34.5 percent three years before bankruptcy (see Table 4, Panel D).

To summarise, the classifying results of the estimated models indicate that none of the liquidity measure working capital/total assets, current ratio, comprehensive liquidity index or cash conversion cycle serves better as a component of a bankruptcy prediction model than the other. The four estimated models were tested for differences in their ability to classify companies into failed and non-failed categories. This ability was tested using a z-test. The results of this test (see Appendix 3) indicate that there are *no significant* differences between the estimated models in terms of classifying ability.

## SUMMARY AND CONCLUSIONS

The main purpose of this article was to test the ability of two new liquidity measures (cash conversion cycle and comprehensive liquidity index) to predict bankruptcy, both as separate financial ratios and as part of different combinations of financial ratios. The liquidity measures used in the study consisted on the one hand of traditional liquidity measures (working capital and current ratio), and on the other hand of the two liquidity measures (cash conversion cycle and comprehensive liquidity index), that have not been used before in bankruptcy prediction research. According to Scherr (1989), the latter liquidity measures should be more accurate than the traditional liquidity measures. No empirical tests of these liquidity measures have been reported in the literature despite the fact that these measures have existed for quite some time. One way to test them is to test their ability to predict bankruptcy (Beaver et al. 1968).

The liquidity measures cash conversion cycle and comprehensive liquidity index misclassified the companies into failed and non-failed categories rather inaccurately. The misclassification percentages were between 41.7 and 51.2 percent. Comparing the traditional liquidity measure current ratio with the comprehensive liquidity index, it can be observed that the current ratio classifies the companies better one and two years before bankruptcy. The liquidity measures working capital/total assets and the current ratio classified the companies significantly better one year before bankruptcy than the two new liquidity measures cash conversion cycle and comprehensive liquidity index. The comprehensive liquidity index classified significantly worse than the current ratio and the working capital ratio two years before bankruptcy. Finally, three years before bankruptcy, no significant differences between the liquidity ratios existed.

In addition, these liquidity measures were tested as parts of a model consisting of the same capital structure ratio and profitability ratio. The estimated model consisting of the capi-

tal structure ratio, total debts/ total assets, the profitability ratio, cash flow/total debts and the liquidity ratio, comprehensive liquidity index, classified the companies marginally better one year before bankruptcy than the other three estimated models. Using this model, 20.2 and 35.7 percent, respectively, of the companies was misclassified one and three years, respectively, before bankruptcy. The classifying results for the models estimated in this study, indicate that none of the traditional liquidity measures, current ratio or working capital ratio, serves better as a component of a bankruptcy prediction model than the other two new liquidity measures, cash conversion cycle or comprehensive liquidity index, which have not been used before in bankruptcy research (statistically there are *no significant* differences between the estimated models classifying results). What is also noticeable, is that when the separate financial ratios are used as bankruptcy predictors, the liquidity measure current ratio classified the companies better than the comprehensive liquidity index one and two years before bankruptcy. However, when using the comprehensive liquidity index as part of a model, it classifies the companies slightly better than the current ratio.

The current liability ratio classified the companies slightly better than the long-term debt ratio. This indicates the fact that it is the current liabilities that are increasing for companies with financial difficulties. Using the first of these, 35.7 and 44 percent, and the latter, 39.3 and 45.2 percent of the companies were misclassified, one and three years, respectively, before bankruptcy.

The result shows that the debt ratio has the best classifying ability one to three years before bankruptcy. The classifying ability of the separate debt ratio, in this study, is approximately as good as for any of the estimated models covering all years before bankruptcy. The conclusion can be made that by using the debt ratio you can reasonably predict a bankruptcy up to three years before it occurs. ■

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**APPENDIX 1: The correlation matrix of the financial ratios. The correlations are estimated separately for one, two and three years before bankruptcy from a pooled sample of failed and non-failed firms.**

	TD/TA	CL/TA	LTD/TA	WC/TA	Current Ratio	CCC	CLI	OI/TA	EBIT/TA	CF/TD
<b>1 year before bankruptcy</b>										
Debt ratio	1.000									
Current liability ratio	0.601***	1.000								
Long-term debt ratio	0.558***	-0.328***	1.000							
Working capital	-0.568***	-0.516***	-0.136	1.000						
Current ratio	-0.201	-0.307***	0.081	0.245**	1.000					
Cash Conversion Cycle	-0.341***	-0.063	-0.337***	0.496***	0.034	1.000				
Comprehensive Liquidity	-0.133	-0.254**	0.107	0.165	0.061	-0.161	1.000			
Operating income ratio	-0.604***	-0.187	-0.520***	0.488***	0.145	0.467***	-0.089	1.000		
EBIT/Total assets	-0.421**	-0.165	-0.327***	0.405***	0.139	0.369***	-0.086	0.928***	1.000	
Cash flow/TD	-0.559***	-0.376**	-0.271**	0.306***	0.280***	0.239**	-0.003	0.840***	0.827***	1.000
<b>2 years before bankruptcy</b>										
Debt ratio	1.000									
Current liability ratio	0.562***	1.000								
Long-term debt ratio	0.466***	-0.469***	1.000							
Working capital	-0.692***	-0.580***	-0.119	1.000						
Current ratio	-0.289***	-0.277**	-0.013	0.305***	1.000					
Cash Conversion Cycle	-0.436***	-0.230**	-0.219**	0.453***	0.023	1.000				
Comprehensive Liquidity	-0.169	-0.324***	0.166	0.186	0.025	0.438***	1.000			
Operating income ratio	-0.722***	-0.274**	-0.478***	0.630***	0.130	0.337***	0.018	1.000		
EBIT/Total assets	-0.624***	-0.313***	-0.332***	0.589***	0.130	0.261**	0.076	0.940***	1.000	
Cash flow/TD	-0.563***	-0.326***	-0.252**	0.461***	0.196	0.150	0.076	0.697***	0.718***	1.000
<b>3 years before bankruptcy</b>										
Debt ratio	1.000									
Current liability ratio	0.527***	1.000								
Long-term debt ratio	0.517***	-0.455***	1.000							
Working capital	-0.665***	-0.565***	-0.128	1.000						
Current ratio	-0.278**	-0.291***	0.001	0.327***	1.000					
Cash Conversion Cycle	-0.366***	-0.286***	-0.096	0.510***	0.036	1.000				
Comprehensive Liquidity	-0.071	0.073	-0.147	-0.072	0.022	-0.151	1.000			
Operating income ratio	-0.702***	-0.244**	-0.490***	0.521***	0.165	0.238**	0.080	1.000		
EBIT/Total assets	-0.588***	-0.206	-0.408***	0.435***	0.157	0.172	0.083	0.946***	1.000	
Cash flow/TD	-0.639***	-0.440***	-0.226**	0.442***	0.314***	0.104	0.093	0.776***	0.774***	1.000

\*\* Correlation is significant at the 5% level  
 \*\*\* Correlation is significant at the 1% level

**APPENDIX 2: The z-test for differences between classifying abilities for the separate financial ratios. The reported figures below are z-values and significance levels one, two and three years before bankruptcy.**

	LTD/TA	CL/TA	WC/TA	Current ratio	CCC	CLI	OI/TA	EBIT/TA	CF/TD
<b>1 year before bankruptcy</b>									
Debt ratio	-2.071**	-1.613	-1.303	-1.146	-2.97***	-2.97***	-0.988	-0.828	-0.826
Long-term debt ratio		0.466	0.779	0.936	-0.926	-0.926	1.095	1.254	1.256
Current liability ratio			0.314	0.472	-1.389	-1.389	0.631	0.791	0.793
Working capital				0.158	-1.700*	-1.700*	0.317	0.478	0.480
Current ratio					-1.856*	-1.856*	0.159	0.320	0.321
Cash Conversion Cycle					0.000	0.000	2.012**	2.170**	2.171**
Comprehensive Liquidity							2.012**	2.170**	2.171**
Operating income ratio							0.161	0.161	0.162
EBIT/Total assets								0.002	0.002
<b>2 years before bankruptcy</b>									
Debt ratio	-2.79***	-2.336**	-0.960	-1.270	-1.882*	-3.09***	-1.882*	-2.185**	-0.799
Long-term debt ratio		0.466	1.852	1.543	0.929	-0.314	0.929	0.621	2.011**
Current liability ratio			1.391	1.080	0.463	-0.780	0.463	0.155	1.551
Working capital				-0.312	-0.930	-2.161**	-0.930	-1.237	0.162
Current ratio					-0.619	-1.854*	-0.619	-0.926	0.474
Cash Conversion Cycle						-1.241	0.000	-0.309	1.091
Comprehensive Liquidity							1.241	0.934	2.319**
Operating income ratio								-0.309	1.091
EBIT/Total assets								-0.309	1.397
<b>3 years before bankruptcy</b>									
Debt ratio	-1.235	-1.082	-0.466	-1.697*	-0.928	-1.235	-0.620	-0.928	-1.230
Long-term debt ratio		0.155	0.772	-0.466	0.309	0.000	0.617	0.309	0.005
Current liability ratio			0.617	-0.621	0.154	-0.155	0.463	0.154	-0.150
Working capital				-1.236	-0.463	-0.772	-0.155	-0.463	-0.767
Current ratio					0.775	0.466	1.082	0.775	0.471
Cash Conversion Cycle						-0.309	0.309	0.000	-0.304
Comprehensive Liquidity							0.617	0.309	0.005
Operating income ratio								-0.309	-0.612
EBIT/Total assets								-0.309	-0.304

\* Statistically significant at the 10% level

\*\* Statistically significant at the 5% level

\*\*\* Statistically significant at the 1% level

**APPENDIX 3: The z-test of differences between the four models classifying results. Z-values and significance levels stated for the model consisting of the debt ratio, the ratio cash flow/ total debts and one of the liquidity measures current ratio, working capital, cash conversion cycle or comprehensive liquidity index one, two and three years before bankruptcy.**

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**1 year before bankruptcy**

	WC	CCC	CLI
CR	0.000	0.122	0.526
WC		0.173	0.526
CCC			0.354

**2 year before bankruptcy**

	WC	CCC	CLI
CR	0.000	0.000	0.000
WC		0.000	0.000
CCC			0.000

**3 year before bankruptcy**

	WC	CCC	CLI
CR	0.312	0.000	0.156
WC		-0.313	-0.156
CCC			-0156

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\* Statistically significant at the 10% level

\*\* Statistically significant at the 5% level

\*\*\* Statistically significant at the 1% level