BEBR

FACULTY WORKING PAPER NO. 1315

A Value Added Cash Conversion Cycle

James A. Gentry
R. Vaidyanathan

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

BEBR

FACULTY WORKING PAPER NO. 1315

College of Commerce and Business Administration

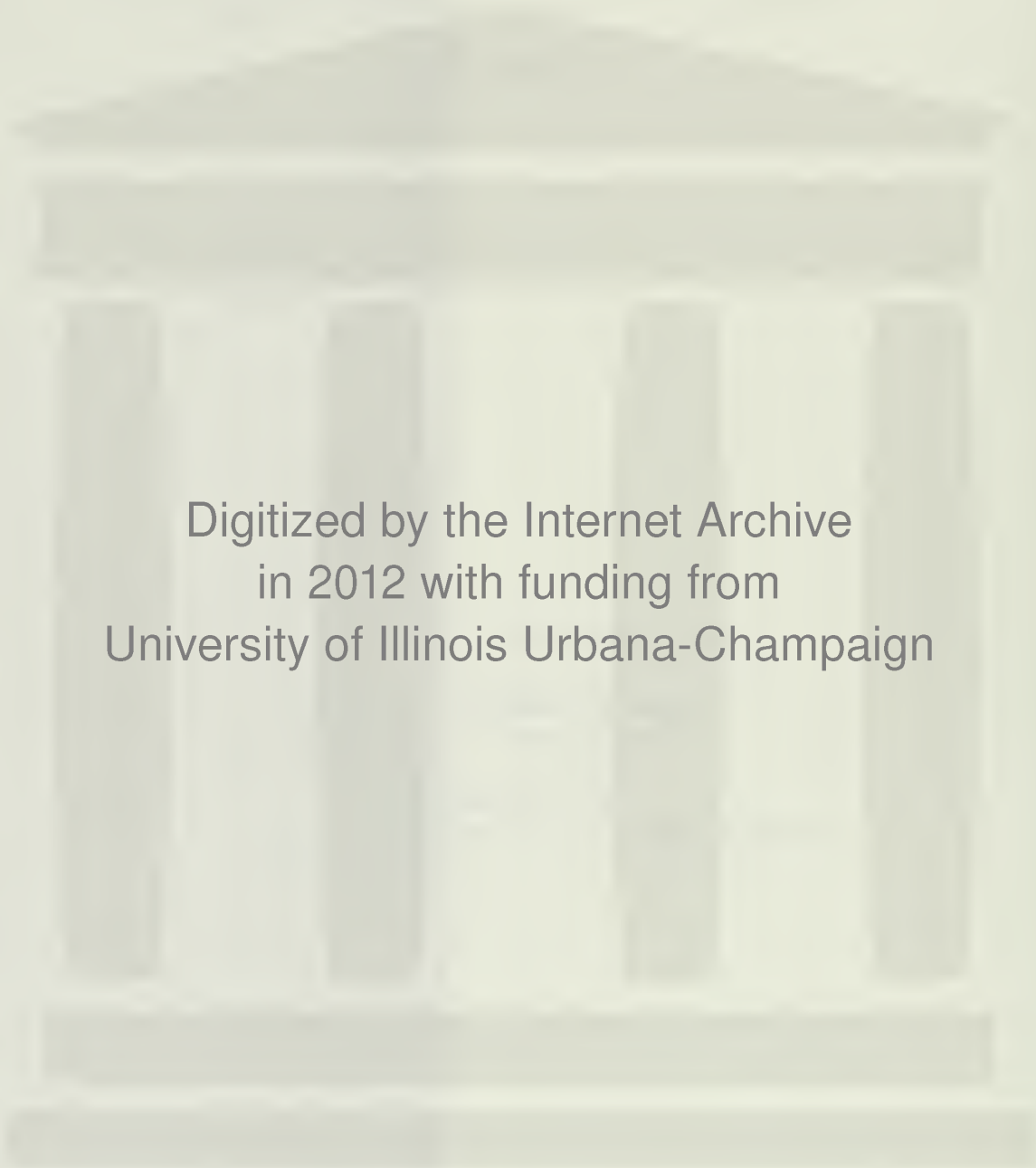
University of Illinois at Urbana-Champaign

December 1986

A Value Added Cash Conversion Cycle

James A. Gentry, Professor
Department of Finance

R. Vaidyanathan
Indian Institute of Management-Bangalore



A VALUE ADDED CASH CONVERSION CYCLE

ABSTRACT

The cash conversion cycle (CCC) is a measure of liquidity. It sums the number of days that cash is invested in inventories and receivables less the deferred payment period. The CCC is not adjusted for the economic value that is added to the product throughout the operating cycle. This article develops a value added operating cycle (VAOC) and a value added cash conversion cycle (VACCC) that combines the timing of the flows and the value added feature. The model shows the VAOC is less than the unadjusted operating cycle and the size of the gap between the two is dependent on the size of the value added weights and the number of days cash is tied up in the operating cycle. The causes of the overstatement or understatement of each value added component are developed and illustrated. Data from sample companies are used to illustrate the application of the model and to aid in the interpretation of the results. When used in conjunction with the unadjusted CCC, the VACCC provides management and credit analysts a more enlightened view of the cash operating cycle and a tool for improving the short-run financial forecasts. The bottom line result is a smaller planned investment in inventories and receivables.

A VALUE ADDED CASH CONVERSION CYCLE[1]

One principle of finance is to collect cash quickly and hold onto it as long as possible. This cash management principle is based on the traditional concept of the cash operating cycle (OC) and the cash conversion cycle (CCC) developed by Richards and Laughlin (RL) [1]. The cash conversion cycle is an additive function that measures the number of days funds are invested in inventories and receivables less the number of days the payment to suppliers is deferred. The trend of the CCC shows the result of management policies to speed up the flow of cash through the firm. Additionally, the path of the CCC provides a measure of corporate liquidity. The CCC focuses only on the time dimension of the investment and does not take into consideration the economic value added to a product throughout the operating cycle. The contribution of CCC to financial analysis can be enhanced substantially by taking into account the value added to a product throughout each stage of the production process.

The objectives of this paper are to provide an overview of the traditional (unadjusted) cash conversion cycle and the value added cash conversion cycle; to develop a model of the value added operating cycle (VAOC) and a value added cash conversion cycle (VACCC); to illustrate and compare the value added results to the unadjusted operating and cash conversion cycles; to use empirical information to develop the contributions of the VACCC and show how it translates into a smaller planned investment in receivables and inventories.

Overview of an Unadjusted and a Value Added CCC

An overview of the traditional CCC is presented in Exhibit 1. The 55 day inventory cycle is decomposed into 35 days of funds invested in raw materials (RM), 15 days in work-in-process (WIP) and 5 days in finished goods (FG). Cash is not collected from receivables for another 10 days, therefore, adding the 10 day receivable cycle to the inventory cycle results in a 65 day operating cycle. However, payments to the suppliers does not occur until 15 days after the invoice is shipped, thus this deferral in payment reduces to 50 (65-15) the number of days before cash is received from the investment in inventories and receivables. Although RL did not disaggregate the components of the inventory as presented above, we shall refer to the 50 day period as the unadjusted cash conversion cycle.

The concept underlying a value added cash conversion cycle is developed in Exhibit 2. The graphic example shows the linkage between the economic value added to the product and the time allotted to each phase of the production process. Exhibit 2 utilizes the same information used to calculate the 50 day CCC in Exhibit 1.

In the operating cycle, shown at the top of Exhibit 2, $5.0 million is invested in the product throughout the 65 day period. The horizontal base of the operating cycle in Exhibit 2 shows $1 million is invested in raw materials for 65 days. That is once the cash is tied up for 35 days in the raw material process it is naturally invested for the remaining 30 days of the operating cycle. The WIP adds $2 million of value to the product in 15 days and it is also committed for the remaining 15 days of the operating cycle. There was $.5 million of value added

to the product in the finished goods phase which was for five days plus the remaining 10 days before cash is collected. The $1.5 million invested in receivables was for the last 10 days of the operating cycle.

The VACCC is reduced because the $1.5 million deferred for payment to suppliers was for 15 days, thereby reducing the VACCC to 50 days. The VACCC is depicted in the bottom one-half of Exhibit 2. It illustrates that each component of the operating cycle is reduced by the 15 day payment deferral.

The external credit analysts does not have information concerning the exact date payments to the suppliers actually occur, but the inside staff would have that information. More-than-likely the payment terms would have the outflow of cash occurring during the raw material cycle. If management has a weak bargaining position with its suppliers, it may have to pay the suppliers early in the operating cycle. If superior bargaining conditions exist, the terms could be made for payment to be late in or even after the operating cycle. The later event would result in the suppliers providing the financing of the entire operation and a portion of the next operating cycle. The advance payment for college football tickets in February, when the cash does not flow out until the fall months, is a classic example of the competitive position of an Athletic Association (AA) and it illustrates the benefit gained by an AA with superior bargaining power.

THE MODEL

The VACCC is developed in a multiplicative model that measures the value added in each time period of the production and collection process.

The model is developed in a two stage process. The first phase determines the number of days funds are tied up in RM, WIP, FG and AR less the number of days the payment to suppliers is deferred. There are numerous ways to calculate the number of days cash is invested in inventories and receivables. For example the number of days in RM can be calculated using the value of RM at the end of the single period or an average, $RM_t + RM_{t-1}/2$ for period t. For ease of comparison to the RL cash conversion cycle results, we shall use the single period technique.

The number of days funds are tied up in raw materials is:

$$\frac{RM_t}{RMCPD_t} = DRM_t, \tag{1}$$

where $RMCPD_t$ is raw materials consumed per day for t days, e.g., a 30 day monthly consumption would be RM/30.

The number of days funds are committed to WIP is:

$$\frac{WIP_t}{CGSPD_t} = DWIP_t, \tag{2}$$

where $CGSPD_t$ is cost of goods sold per day.

Days funds committed to finished goods equals

$$\frac{FG_t}{OEPD_t} = DFG_t, \tag{3}$$

where $OEPD_t$ is total operating expenses per day.

Richards and Laughlin do not decompose inventories into the three component parts. When solving for the number of days funds are tied up in inventory (DI_t), RL use a widely accepted ratio of $inventories_t/CGSPD_t$. Thus the DI_t ratio is not directly comparable to the sum of

$DRM_t + DWIP_t + DFG_t$ because the denominators for DRM_t and DFG_t are not the $CGSPD_t$.

Days sales in accounts receivables is:

$$\frac{AR_t}{\text{Credit sales per day}_t} = DAR_t. \tag{4}$$

Days payment deferred to suppliers is:

$$\frac{AP_t}{RMCPD_t} = DAP_t. \tag{5}$$

These five measures represent the timing of the cash flows in the operating cycle. When the timing is multiplied times the value added weights for each of the components, the amount of cash invested in each component is determined. The next task is to develop the value added weights.

The second phase is to determine the value added during each phase of the cash conversion cycle. Sales (S) represent the final value of the product, therefore, the value added weight is the proportion each component contributes to the total value of the product. The weights for each of the components in the operating cycle are determined as follows.

The raw material weight is:

$$\frac{RMC_t}{S_t} = w_t, \tag{6}$$

where RMC_t is raw material consumed in period t.

The WIP weight is:

$$\frac{CGS_t - RMC_t}{S_t} = x_t. \tag{7}$$

The FG weight is:

$$\frac{OE_t - CGS_t}{S_t} = y_t, \tag{8}$$

where OE_t is the total operating expenses.

And the AR weight is

$$\frac{S_t - OE_t}{S_t} = z_t. \tag{9}$$

The sum of the four weights equals 1.0.

The value added operating cycle (VAOC) is determined by multiplying the weight of each component times the length of time cash is tied up in each component. In equation form

$$\begin{aligned} VAOC_t = {} & w_t[DRM_t + DWIP_t + DFG_t + DAR_t] + \\ & x_t[DWIP_t + DFG_t + DAR_t] + \\ & y_t[DFG_t + DAR_t] + \\ & z_t[DAR_t]. \end{aligned} \tag{10}$$

Using the information in Exhibit 2 the $VAOC_t$ is determined.

$$VAOC_t = .20[35 + 15 + 5 + 10] +$$

$$.40[15 + 5 + 10] +$$

$$.10[5 + 10] +$$

$$.30[10]$$

$$= 29.5 \text{ days.}$$

The unadjusted OC_t was 65 days:

$$65 \text{ days} = 35 \text{ days} + 15 \text{ days} + 5 \text{ days} + 10 \text{ days.}$$

The unadjusted OC_t overstates the $VAOC_t$ by 35.5 days. The reason for this 35.5 day overstatement is that the unadjusted OC does not take into consideration the percentage of value that is added at each phase of the operating cycle. The $VAOC_t$ will always be less than the OC_t, except when the entire cycle is raw materials. In that case

$$VAOC_t = 1.0 \text{ (65 days)} + 0 \text{ (0 days)} + 0 \text{ (0 days)} + 0 \text{ (0 days)} \quad (10b)$$

$$VAOC_t = 65 \text{ days.}$$

Under these circumstances the value added days in raw materials ($VADRM_t$) are 30 days greater than the unadjusted DRM_t which means the unadjusted DRM_t understates the contribution of the $VADRM_t$ by 30 days. For the remainder of the components in the OC_t the unadjusted values overstate the contribution of the value added components by the difference between the value added and unadjusted components. That is the difference between $VADWIP_t$ and DWIP is -15 days (0-15) which reflects the number

of days the unadjusted $DWIP_t$ overstates the $VAWIP_t$. The overstatement of the $VADFG_t$ and $VADAR_t$ is -5 days (0-5) and -10 days (0-10), respectively.

At the other extreme, when the entire cycle is composed of only accounts receivable, the $VAOC_t$ is:

$$VAOC_t = 0\ (0 \text{ days}) + 0\ (0 \text{ days}) + 0\ (0 \text{ days}) + 1.0\ (10 \text{ days}) \quad (10c)$$

$$VAOC_t = 10 \text{ days}.$$

The equation for determining the value added cash conversion cycle (VACCC) is:

$$VACCC_t = VAOC_t - DAP_t. \quad (11)$$

The $VACCC_t$ for the example in Exhibit 2 is:

$$VACCC_t = 29.5 \text{ days} - 15 \text{ days} \quad (11a)$$

$$VACCC_t = 14.5 \text{ days}.$$

This formulation of the equation assumes DAP_t is proportionately distributed among the four components in the operating cycle. The outflow of cash to suppliers may occur early or late in the operating cycle depending on the competitive position of the firm to its suppliers. If the firm has a strong bargaining position it may be able to establish credit terms with its suppliers that are longer than the days cash is tied up in raw materials. Naturally, the weakest position would be when the firm had to pay cash on or before delivery of the raw material. The internal management will know its payment patterns to the

suppliers, but the external credit analysts may not have this information. Thus a conservative approach in calculating the $VACCC_t$ is to assume the payments to suppliers occur proportionately among the four operating cycle components.

When the entire cycle is in raw materials, as in (10b), the VACCC for Exhibit 2 is:

$$VACCC_t = 65 \text{ days} - 15 \text{ days} \qquad (11b)$$

$$VACCC_t = 50 \text{ days}.$$

Under these circumstances the value added cash conversion cycle equals the unadjusted cash conversion cycle, ($VACCC_t = CCC_t$).

At the other extreme, when the entire cycle is in accounts receivable, as in (10c), the VACCC for Exhibit 2 is:

$$VACCC_t = 10 \text{ days} - 15 \text{ days} \qquad (11c)$$

$$VACCC_t = -5 \text{ days}.$$

That is the suppliers are funding the entire operating cycle and providing funds for 5 days in the upcoming operating cycle (OC_{t+1}).

EMPIRICAL RESULTS

Substantive insight is gained by analyzing empirical data for the differences between value added and unadjusted operating and cash conversion cycles. The Industrial Compustat tape containing financial information on approximately 2000 companies was used to select a sample of companies for the five year period 1980 through 1984. A series of screens were used to filter the information in selecting the sample

companies. The first screen was to determine all industrial companies that had used only a FIFO inventory valuation system in each of the five years. A similar set of tests were employed to select companies that used LIFO exclusively for the 1980-1984 period. Only a few companies survived the inventory valuation test. Finally, from the remaining companies, only those with the complete information required to do the necessary calculations in equations 1-9 were included in the sample. The final sample was 9 FIFO companies and 5 LIFO companies. The names of the companies are reported in Exhibit 3. With a small sample it is not possible to generalize concerning the total universe. However, the empirical information provides the basis for illustrating the components of the VACCC and for making observations that aid in interpreting the contributions of the VACCC.

The annual VACCC information for the 9 FIFO and 5 LIFO companies is reported in Exhibit 3 for each year 1980 through 1984. With one exception, the VACCC for the FIFO companies ranged from 8 to 80 days. Northern Telecom Ltd. had a VACCC ranging from -85 to -359 days. The VACCC for the LIFO companies ranged from 4 to 107 days for four of the five companies. Deluxe Check Printers had a VACCC ranging from -23 to -224 days. Both Northern Telecom and Deluxe Check Printers had a deferral payment period to suppliers in period t that was greater than the operating cycle in period t.[2]

Equation 10 showed that the unadjusted CCC is always greater than the VACCC. Although not directly comparable as explained after (3), the number of days the VACCC is overstated by RL's traditional CCC is reported in Exhibit 4 for each sample company. For the FIFO companies,

the mean overstatement of the VACCC ranged from 10 to 102 days. The mean and standard deviation are reported for each year. The annual mean overstatement for the FIFO companies is in a range of 42 to 45 days with a standard deviation of 56 to 60 days. The mean overstatement of the LIFO companies was 13 to 15 days with a standard deviation of 8 to 11 days. Exhibits 3 and 4 provide perspective on the size and variance of the VACCC for the sample companies and a general impression of the size and variance of the differences between the value added and the traditional CCC. The more interesting task is to explain the differences in the measures generated by the two models.

Receivables

The DAR_t measure is the same in both models, therefore, the number of days the unadjusted model overstates the $VADAR_t$ is inversely related to the size of the z coefficient. The $VADAR_t$ for the sample companies are found in Exhibit 5. The $VADAR_t$ ranges from slightly less than 2 days to 17 days for the FIFO companies and the mean $VADAR_t$ is approximately 8 days with a standard deviation of $\pm$ 10 to 12 days. As expected, the mean VADAR for the LIFO companies are between 2 and 3 days less than the VADAR for the FIFO companies. Also the standard deviation of the $VADAR_t$ for the LIFO companies is between $\pm$ 2 and 3.5 days.

The number of days that the unadjusted model overstates the $VADAR_t$ are presented in Exhibit 6. The overstatement ranges from 23 to 75 days for the FIFO companies with the mean being between 50 to 55 days with a standard deviation slightly greater than the mean. The overstatement for the LIFO companies is smaller than for the FIFO companies.

The mean declines from 48 days in 1980 to 38 days in 1984. The standard deviation is approximately 30 to 40 percent of the mean.

Inventories

The value added days in inventory (VADI) for the sample companies are found in Exhibit 7. The $VADI_t$ is the sum of the three value added components of inventories. The mean values of $VADI_t$ for the FIFO companies range from 118 to 128 days and the standard deviation is slightly greater than the mean in each year. Thus there is substantial variance in the $VADI_t$ among the 9 FIFO companies. The mean $VADI_t$ for the LIFO companies have declined from 94 to 76 days and the standard deviation is between 30 and 40 percent of the mean.

The value added inventory components are directly related to the size of the respective w, x and y coefficients multiplied by the timing of the cash flows, as shown in (10b). The w, x and y coefficients reflect a direct relationship between the size of the investment in raw materials, work-in-process and finished goods to the size of sales. The w, x and y coefficients and the DRM_t, $DWIP_t$, and DFG_t determine the amount and timing of the cash that flows into each inventory component as suggested in a short-run valuation model by Sartoris and Hill [2]. The larger the coefficient and the timing measure the greater the value contributed by that inventory component. For example when both w and DRM_t are high, as shown in (10b), the value added contribution, $VADRM_t$, will be greater than the unadjusted DRM_t. When these circumstances occur, $VADRM_t > DRM_t$, the unadjusted DRM_t understates the contribution of the $VADRM_t$. When the opposite circumstances occur, $VADRM_t < DRM_t$, the unadjusted DRM_t overstates the value added contribution of raw

materials and, thereby overstates the length of the unadjusted OC_t and CCC_t.

The relationship between $VADRM_t$ and DRM_t for the sample companies is presented in Exhibit 8. A quick inspection of Exhibit 8 reveals that for six of the FIFO companies the $VADRM_t < DRM_t$ in all five years. The six companies are Minnesota Mining, Standex International Corp., McGraw-Hill Inc., Tracor Inc., Northern Telecom Ltd. and Polaroid Corp. Also for two LIFO companies, Coors (Adolph) Co. Cl. B and Deluxe Check Printers, $VADRM_t < ARM_t$. For these companies management and credit analysts should realize that the cash invested in raw materials is for fewer days than an unadjusted model would indicate, which means a smaller commitment of cash needed to finance RM. Although the data are not comparable, Exhibit 4 shows the overstatement of the traditional CCC is highest for the six FIFO companies. Exhibit 8 also shows that the unadjusted DRM_t understates the importance of raw materials in all five years for one FIFO company, Curtice Burns Inc. Cl. A, and three LIFO companies, U.S. Steel Corp., Cooper Tire & Rubber and Robertshaw Chemicals. The $VACCC_t$ information in Exhibit 3 shows three of the four companies generally have a VACCC in excess of 50 days for all five years. In summary, the relative contribution of raw materials to the OC_t and CCC_t is valuable information to management and analysts.

The comparison of $VADWIP_t$ and $DWIP_t$ appears in Exhibit 9. The most noticeable observation concerning Exhibit 9 is that in 11 of the 14 companies the unadjusted WIP understates the number of value added WIP days. For the remaining three companies the overstatement was either a small number of days or the value varied from overstatement to

understatement during the five years. The FIFO companies had a mean understatement of 12 to 13 days with a standard deviation of ± 19 to 21 days. For the LIFO companies the mean understatement went from 14 days in 1980 to 10 days in 1984 with a standard deviation that was modestly smaller than the mean.

The relationship between the value added days in fixed goods and the unadjusted DFG is presented in Exhibit 10. The overstatement/ understatement relationship among the FIFO and LIFO companies is mixed. There are four FIFO companies and two LIFO companies with five years of overstated finished goods inventories that range from 4 to 52 days. There are two FIFO and two LIFO companies with five years of finished goods inventories that are understated from one to 11 days. In general for the remainder of the companies the results are mixed.

Weight and Timing Effects

A brief empirical example will highlight the affect that the w, x, y and z coefficients and the number of days funds are invested in RM, WIP, FG and AR will have on the VAOC and the VACCC. A comparison of a capital intensive company, Cooper Tire & Rubber, to a less capital intensive firm, Minnesota Mining & Manufacturing (MMM) illustrates that the value added weights and the timing of flows directly impacts on the VAOC and the VACCC.

Exhibit 11 shows 83.5 percent (.5678 + .2671) of the economic value added to the products of Cooper Tire & Rubber occurs in the raw material and work-in-process phases of production. Also cash is invested in raw materials for the full 147.5 days of the OC and is invested in WIP for 111.6 days of the OC. The RM and WIP components account for 113.6

[(.5678 x 147.52 days) + .2671(111.63 days)] of the 127.17 days in the VAOC, or approximately 90% of the total. A 60 day payment delay to suppliers results in a 67 day value added cash conversion cycle for Cooper Tire & Rubber.

In the case of, MMM, Exhibit 11 shows 51.5% of the value added weights are in the RM and WIP phase and the remaining weights are almost equally divided between FG and AR. The value added contribution in days by each of the operating cycle components to the total VAOC is:

RM = 46.29 days (.1490 x 311.38)

WIP = 50.32 days (.3666 x 164.57)

FG = 29.83 days (.2454 x 121.60)

AR = 25.96 days (.2390 x 66.17)

VAOC = 152.40 days

The 96.6 days cash is tied up in RM and WIP represents 62.0% of the total VAOC. Thus 51.5% of the total weights related to RM and WIP result in contributing almost 63% of the total value in the operating cycle because of the 311 days funds are tied up in RM and 165 days in WIP. The VACCC for MMM is only 8.39 days because the payment deferral period to MMM suppliers is 144 days, i.e., 152.4 days - 144.1 days = 8.39 days.

CONCLUSIONS

The VAOC and the VACCC provide a different perspective and interpretation to the length of time cash is invested in the OC and the CCC. The VAOC and the VACCC are always less than the unadjusted OC and CCC. The size of the gap depends on (1) the size of the value added in each

OC component and (2) the length of time funds are tied up in each component. Theoretically, the larger the commitment of resources in the early stages of production, i.e., RM and/or WIP, and the longer their OC, the more narrow the gap between the unadjusted and value adjusted cycles. However, the larger the commitment of resources in FG and AR combined with a smaller investment in RM and WIP, the larger the gap between the value added and the unadjusted cycles. In summary, the larger the gap, the smaller the total investment needed in the operating cycle and vice versa.

The size of the CCC's overstatement of the VACCC is dependent on (1) the size of the value added weights and (2) the length of time cash is tied up in a process. Where the size of the value added weights are relatively small and the length of time that cash is tied up is relatively short, a relatively large overstatement of the VACCC will occur. Alternatively, when value added weights are relatively large and the cash is locked in the process for a relatively long time period, a relatively small overstatement of the VACCC will occur.

The empirical information showed there is substantial variance in the VACCC. The data also revealed that the VADAR are always overstated by the unadjusted model and, generally, the VADWIP are understated in the adjusted model. Finally, the empirical data showed there was not a distinct pattern of the VADRM and the VADFG, but rather a mixed result among the companies.

In conclusion, the VAOC and VACCC provide management and credit analysts unique information for interpreting the timing and amount of funds tied up in the operating and cash conversion cycle. In order to

observe the value added effects, it is necessary to calculate the unadjusted and value added measures. The value added methodology provides a deeper appreciation of the complexities of the operating and cash conversion cycles. The bottom line result is that the length of the value added operating and cash conversion cycles will be shorter than the unadjusted cycles, which translates into a smaller planned investment in inventories and receivables.

FOOTNOTE

[1]The authors are grateful to Hei Wai Lee, a Ph.D. candidate at the University of Illinos, for his superior contributions in completing the computer work for this paper.

[2]We verified the accuracy of the Compustat information used in the examples for Northern Telecom and Deluxe Check Printers. In both cases the DAP increased more rapidly than DRM which resulted in the larger negative VACCC.

REFERENCES

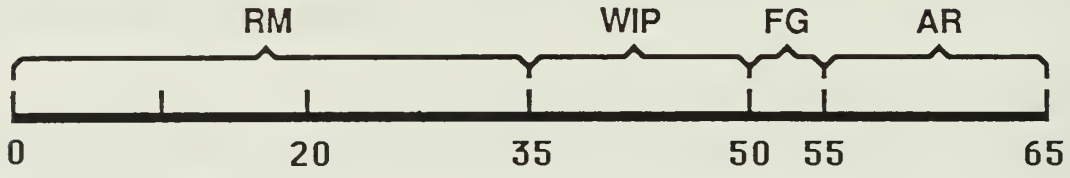
1. Verlyn D. Richards and Eugene J. Laughlin, "A Cash Conversion Cycle Approach to Liquidity Analysis," Financial Management, Vol. 9 (Spring 1980), pp. 32-38.

2. William Sartoris and Ned Hill, "A Generalized Cash Flow Approach to Short-Term Financial Decisions," Journal of Finance, Vol. 38 (May 1983), pp. 349-360.

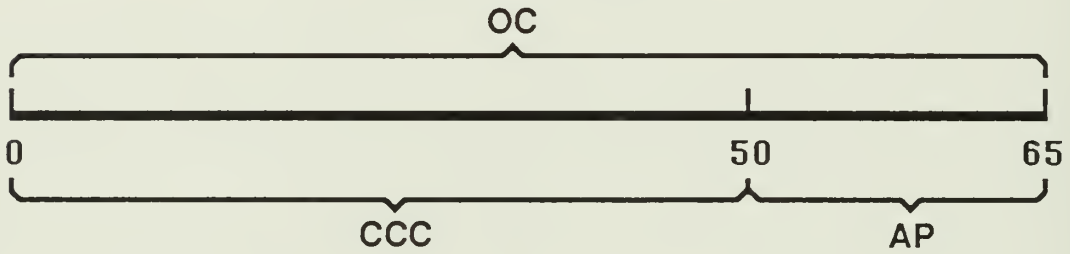
EXHIBIT 1

TRADITIONAL CASH CONVERSION CYCLE

Operating Cycle
(OC = RM + WIP + FG + AR)



Operating Cycle - Deferral of Payment to Suppliers
(CCC = OC — AP)



Cash Conversion Cycle
(CCC = OC — AP)

Legend

Number of days funds invested in . . .

RM = Raw Material

WIP = Work in Process

FG = Finished Goods

AR = Accounts Receivable

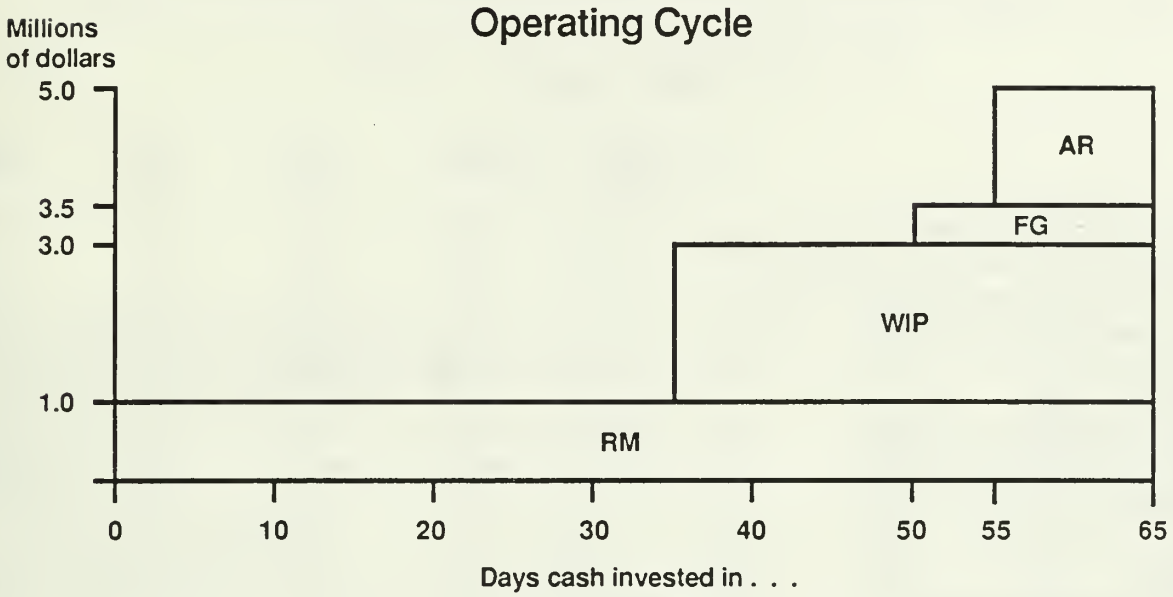
INV = Inventories

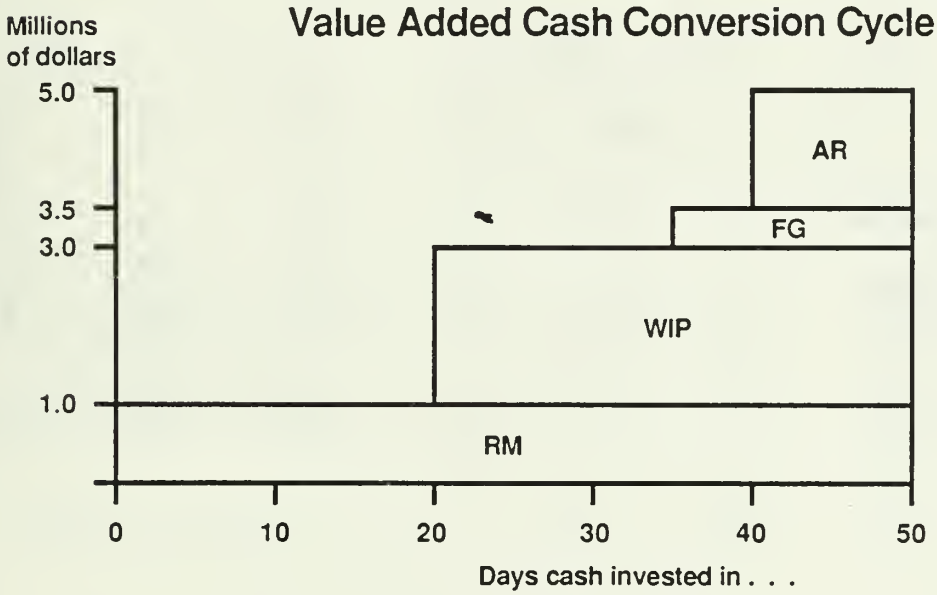
OC = Operating Cycle

AP = Deferral of Payment to Suppliers

CCC = Cash Conversion Cycle

EXHIBIT 2
VALUE ADDED CASH CONVERSION CYCLE





Legend

RM = Number of days $1 million invested in raw material

WIP = Number of days $2 million invested in work-in-process

FG = Number of days $.5 million invested in finished goods

AR = Number of days $1.5 million invested in accounts receivable

AP = Number of days deferral of $1 million payment to suppliers

EXHIBIT 3

VACCC FOR FIFO AND LIFO COMPANIES, 1980-1984

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	53.9	52.8	55.4	51.4	42.4
Minnesota Mining & Mfg. Co.	8.4	26.5	35.1	29.1	21.5
Standex International Corp.	71.4	65.7	66.5	62.1	59.4
McGraw-Hill Inc.	30.9	36.9	51.3	45.8	46.2
Volpex	21.2	31.8	18.2	10.2	14.9
Tracor Inc.	69.7	75.2	72.0	54.6	76.6
Acme Electric Corp.	79.5	67.1	73.5	65.6	64.9
Northern Telecom Ltd.	-110.6	-85.4	-156.6	-354.5	-358.8
Polaroid Corp.	73.7	64.9	65.5	40.6	62.6
Mean	33.1	37.3	31.2	0.56	3.3
Standard Deviation	90.6	78.9	107.5	189.8	194.2

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	31.2	29.3	20.6	3.9	11.2
Deluxe Check Printers	-23.3	-36.8	-73.2	-148.0	-224.2
U.S. Steel Corp.	21.1	20.5	23.8	20.6	15.3
Cooper Tire & Rubber	67.2	57.8	69.6	72.2	57.7
Robertshaw Controls	102.6	106.9	97.3	73.6	78.9
Mean	39.7	35.5	27.6	4.4	-12.2
Standard Deviation	47.7	52.6	64.9	90.7	121.9

EXHIBIT 4

NUMBER OF DAYS THE UNADJUSTED CCC'S OVERSTATE THE VACCC (-) FOR FIFO AND LIFO COMPANIES, 1980-1984
($VACCC_t - CCC_t$ = Overstated (-))

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	-20.0	-17.8	-20.4	-19.7	-15.6
Minnesota Mining & Mfg. Co.	-81.0	-77.7	-72.4	-68.9	-65.1
Standex International Corp.	-50.7	-47.7	-43.6	-44.4	-50.4
McGraw-Hill Inc.	-56.5	-52.1	-51.8	-50.5	-51.9
Volpex	-13.7	-13.1	-13.4	-12.5	-9.9
Tracor Inc.	-24.1	-19.5	-19.2	-18.7	-18.1
Acme Electric Corp.	-29.0	-27.7	-22.9	-21.2	-23.7
Northern Telecom Ltd.	-42.0	-42.8	-39.3	-51.3	-74.5
Polaroid Corp.	-88.6	-85.5	-98.8	-101.9	-84.9
Mean	-45.1	-42.7	-42.4	-43.2	-43.8
Standard Deviation	58.7	56.4	58.4	59.7	58.9

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	-32.5	-24.4	-25.1	-29.7	-23.2
Deluxe Check Printers	-8.3	-8.1	-7.9	-8.6	-8.7
U.S. Steel Corp.	-4.4	-4.6	-7.2	-7.8	-10.8
Cooper Tire & Rubber	-11.7	-9.6	-8.7	-10.8	-8.0
Robertshaw Controls	-16.7	-20.7	-16.9	-17.4	-20.8
Mean	-14.7	-13.5	-13.2	-14.9	-14.3
Standard Deviation	10.9	8.6	7.8	9.1	7.2

EXHIBIT 5

VALUE ADDED DAYS IN RECEIVABLES (VADAR) FOR FIFO AND LIFO COMPANIES, 1980-1984

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	1.8	1.6	2.0	1.8	1.9
Minnesota Mining & Mfg. Co.	15.8	14.4	12.7	15.2	14.0
Standex International Corp.	6.6	5.1	4.4	5.2	5.7
McGraw-Hill Inc.	14.8	14.9	14.9	16.2	17.6
Volpex	3.3	2.3	2.7	3.6	3.3
Tracor Inc.	9.3	9.8	10.8	10.9	13.7
Acme Electric Corp.	6.6	8.0	4.9	2.4	4.8
Northern Telecom Ltd.	4.9	8.5	8.6	11.6	15.1
Polaroid Corp.	10.4	7.5	8.1	8.2	5.8
Mean	8.2	8.0	7.7	8.1	9.1
Standard Deviation	10.7	10.4	10.0	10.9	12.4

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	3.9	3.6	3.3	4.8	3.2
Deluxe Check Printers	10.0	10.5	10.8	10.9	11.8
U.S. Steel Corp.	4.4	4.4	2.1	3.2	4.9
Cooper Tire & Rubber	5.6	5.6	6.8	7.1	5.6
Robertshaw Controls	5.6	5.6	4.6	6.8	7.0
Mean	6.2	5.9	5.5	6.6	6.5
Standard Deviation	2.4	2.7	3.4	2.9	3.2

EXHIBIT 6

NUMBER OF DAYS UNADJUSTED ACCOUNTS RECEIVABLE OVERSTATES (-) THE CONTRIBUTION OF AR IN THE CCC FOR FIFO AND LIFO COMPANIES, 1980-1984

($VADAR_t - DAR_t$ = Overstated (-))

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	-25.4	-23.1	-26.9	-25.1	-26.4
Minnesota Mining & Mfg. Co.	-50.4	-50.4	-48.5	-48.7	-50.0
Standex International Corp.	-44.3	-41.2	-42.3	-41.7	-42.8
McGraw-Hill Inc.	-63.9	-67.2	-65.0	-66.1	-67.4
Volpex	-42.0	-39.7	-27.5	-37.5	-38.5
Tracor Inc.	-67.6	-66.4	-70.6	-66.0	-74.9
Acme Electric Corp.	-43.3	-51.1	-45.2	-52.0	-48.5
Northern Telecom Ltd.	-69.4	-63.3	-57.6	-71.2	-78.2
Polaroid Corp.	-65.7	-66.9	-65.7	-62.0	-71.7
Mean	-52.5	-51.9	-49.9	-52.2	-55.4
Standard Deviation	56.6	56.2	54.9	56.6	61.1

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	-19.9	-22.6	-22.6	-19.2	-25.6
Deluxe Check Printers	-36.4	-35.3	-33.2	-32.4	-33.9
U.S. Steel Corp.	-49.5	-44.0	-24.7	-31.7	-27.2
Cooper Tire & Rubber	-61.0	-48.2	-55.3	-57.2	-51.0
Robertshaw Controls	-75.6	-70.1	-65.3	-57.2	-52.1
Mean	-48.5	-44.0	-40.2	-39.6	-38.0
Standard Deviation	21.9	17.5	19.1	16.9	12.8

EXHIBIT 7

VALUE ADDED DAYS IN INVENTORY (VADI) FOR FIFO AND LIFO COMPANIES, 1980-1984

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	108.8	97.4	105.7	99.0	87.2
Minnesota Mining & Mfg. Co.	136.6	138.0	133.1	129.4	126.2
Standex International Corp.	131.3	124.3	121.6	115.7	123.7
McGraw-Hill Inc.	114.5	112.8	110.3	108.7	109.8
Volpex	87.0	91.0	66.9	77.4	72.4
Tracor Inc.	124.5	114.3	118.7	109.4	117.2
Acme Electric Corp.	115.6	119.2	108.5	119.8	115.0
Northern Telecom Ltd.	166.9	150.6	127.2	145.2	173.7
Polaroid Corp.	165.4	173.0	174.8	170.3	170.7
Mean	127.8	124.5	118.5	119.5	121.8
Standard Deviation	133.0	129.8	125.1	125.4	130.6

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	81.3	68.0	69.9	61.7	67.3
Deluxe Check Printers	47.9	45.5	42.0	41.4	42.2
U.S. Steel Corp.	82.5	75.4	70.8	77.1	70.5
Cooper Tire & Rubber	120.1	98.8	99.0	110.8	95.5
Robertshaw Controls	136.8	140.0	120.6	106.8	105.2
Mean	93.7	85.6	80.5	79.6	76.2
Standard Deviation	35.1	35.9	30.2	29.6	24.9

EXHIBIT 8

NUMBER OF DAYS UNADJUSTED RAW MATERIALS OVERSTATE (-) OR UNDERSTATE (+) THE CONTRIBUTION OF RM IN THE CCC FOR FIFO AND LIFO COMPANIES, 1980-1984
($VADRM_t - DRM_t$ = Overstated (-) or Understated (+))

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	45.2	39.6	41.7	40.0	36.4
Minnesota Mining & Mfg. Co.	-100.4	-85.2	-73.4	-57.7	-48.9
Standex International Corp.	-31.5	-26.4	-13.7	-9.5	-24.0
McGraw-Hill Inc.	-5.7	2.1	0.3	7.8	-2.0
Volpex	12.9	-12.0	-23.4	-16.9	-14.1
Tracor Inc.	-12.8	-19.7	-27.1	-46.5	-23.3
Acme Electric Corp.	7.0	7.1	6.1	3.1	-5.9
Northern Telecom Ltd.	-51.2	-12.0	-57.2	-130.3	-171.6
Polaroid Corp.	-158.1	-145.7	-208.0	-184.0	-107.2
Mean	-35.6	-28.0	-39.4	-43.8	-40.1
Standard Deviation	43.3	83.0	108.9	110.4	97.4

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	-63.6	-41.5	-55.5	-52.2	-38.4
Deluxe Check Printers	-40.4	-35.5	-45.0	-63.4	-56.5
U.S. Steel Corp.	15.5	13.9	15.8	24.8	24.0
Cooper Tire & Rubber	47.9	43.3	49.7	52.0	40.6
Robertshaw Controls	14.2	4.2	1.4	2.3	-2.3
Mean	-5.3	-3.1	-6.7	-7.3	-6.4
Standard Deviation	45.5	35.4	43.6	49.5	40.9

EXHIBIT 9

NUMBER OF DAYS UNADJUSTED WIP OVERSTATE (-) OR UNDERSTATE (+)
THE CONTRIBUTION OF WIP IN THE CCC FOR FIFO AND LIFO
COMPANIES, 1980-1984
($VADWIP_t$ - $DWIP_t$ = Overstate (-) or Understate (+))

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	15.1	13.1	15.3	15.3	13.4
Minnesota Mining & Mfg. Co.	17.4	15.3	17.8	16.3	15.4
Standex International Corp.	-1.2	-1.5	1.1	2.3	3.6
McGraw-Hill Inc.	17.6	20.5	18.3	18.8	18.8
Volpex	10.4	10.8	9.3	9.5	11.9
Tracor Inc.	22.6	29.0	32.4	32.4	36.6
Acme Electric Corp.	14.8	16.1	15.2	15.0	9.3
Northern Telecom Ltd.	21.6	11.9	14.1	17.1	16.5
Polaroid Corp.	-2.0	-1.5	-11.2	-3.7	-3.9
Mean	12.9	12.6	12.5	13.7	13.5
Standard Deviation	18.2	18.6	21.2	20.0	20.8

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	-4.3	-1.6	1.0	-2.6	1.3
Deluxe Check Printers	16.6	15.5	15.0	14.5	14.5
U.S. Steel Corp.	18.0	16.4	9.2	10.0	7.0
Cooper Tire & Rubber	25.2	22.1	25.2	28.6	20.7
Robertshaw Controls	16.2	13.1	17.5	13.5	7.8
Mean	14.3	13.1	13.6	12.8	10.3
Standard Deviation	11.0	8.9	9.1	11.1	7.5

EXHIBIT 10

NUMBER OF DAYS UNADJUSTED FG OVERSTATE (-) OR UNDERSTATE (+)
THE CONTRIBUTION OF FG IN THE CCC FOR FIFO AND LIFO
COMPANIES, 1980-1984
($VADFG_t$ - DFG = Overstate (-) or Understate (+))

FIFO Companies

	1980	1981	1982	1983	1984
Curtice-Burns Inc. Cl. A	-52.4	-45.4	-48.2	-46.5	-36.9
Minnesota Mining & Mfg. Co.	-25.6	-24.7	-25.1	-24.3	-21.8
Standex International Corp.	-12.8	-12.4	-13.0	-13.9	-14.9
McGraw-Hill Inc.	0.3	4.1	3.7	4.4	6.3
Volpex	1.9	-2.5	-1.9	2.4	2.8
Tracor Inc.	-2.0	-4.1	-0.2	2.2	0.7
Acme Electric Corp.	-25.2	-19.6	-17.0	-10.2	-8.5
Northern Telecom Ltd.	-9.1	-13.2	-2.3	7.7	2.3
Polaroid Corp.	3.8	1.9	6.8	-1.1	8.5
Mean	-13.5	-12.9	-10.8	-8.8	-6.8
Standard Deviation	29.2	25.5	26.9	26.2	22.5

LIFO Companies

	1980	1981	1982	1983	1984
Coors (Adolph) Co. Cl. B	1.3	3.1	3.0	2.3	3.7
Deluxe Check Printers	9.5	9.8	10.0	10.4	11.5
U.S. Steel Corp.	-4.4	-5.7	-17.7	-19.1	-20.9
Cooper Tire & Rubber	-32.4	-32.4	-30.8	-37.9	-24.7
Robertshaw Controls	1.7	-0.8	0.6	-1.1	-21.3
Mean	-4.9	-5.2	-7.0	-9.1	-6.3
Standard Deviation	16.2	16.2	16.8	19.4	15.8

EXHIBIT 11

HOW W, X, Y AND Z INTERACT WITH TIME OF INVESTMENT IN EACH COMPONENT TO DETERMINE VAOC AND VACCC

Equations

$$VAOC_t = w_t[DRM_t + DWIP_t + DFG_t + DAR_t] + x_t[DWIP_t + DFG_t + DAR_t] + y_t[DFG_t + DAR_t] + z_t[DAR_t]$$

$$VACCC = VAOC_t - DAP_t$$

Cooper Tire & Rubber (1980)

$$VAOC_t = .5678[147.52] + .2671[111.63] + .0605[107.02] + .1046[68.09]$$

$$= 127.17 \text{ days}$$

$$VACCC = 127.17 - 59.96$$

$$= 67.21 \text{ days}$$

Minnesota Mining & Mfg. Co. (1980)

$$VAOC_t = .1490[311.38] + .3666[164.57] + .2454[121.60] + .2390[66.17]$$

$$= 152.40 \text{ days}$$

$$VACCC_t = 152.40 - 144.01$$

$$= 8.39 \text{ days}$$