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By Dr. H. Fred Walker, CQE, CQA, CSIT

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By Dr. H. Fred Walker, CQE, CQA, CSIT

H. Fred Walker is a faculty member in the Department of Technology at the University of Southern Maine. Fred develops and teaches courses in Quality, Cost Analysis and Control, Technical Writing, and Project Management. Dr. Walker's industrial experience includes 12 years with airborne weapons systems integration and automation, supervision and administration, project management, and program management in countries throughout the Pacific Rim, Australia, and Africa. Fred's consulting experience includes five years of continual involvement with internationally based manufactures from electronics, biomedical equipment, printing, farm implements, and machined component industries. This experience has enabled Fred to earn Certified Quality Engineer, Certified Quality Auditor, Certified Manufacturing Technologist, and Certified Senior Industrial Technologist designations.

Introduction

Industrial Technologists (ITs) are frequently required to enhance the competitiveness of their employers by identifying, justifying, and successfully implementing Advanced Manufacturing Technology (AMT) in operational settings. To accomplish the cost justification phase of AMT implementation, ITs rely, most commonly, on financial tools such as Present Worth and Annual Worth. Common factors between these financial tools include the time value of money, minimum attractive rate of return, investment length, and any potential salvage value. And while each of these tools are used to provide a quantitative value which indicates the attractiveness or unattractiveness of a capital investment project, they both neglect one very important aspect of capital equipment cost justification – the value of stakeholder equity!

This paper will present a new and evolving method for capital equipment cost justification of AMT – "Economic Value Added Analysis" (EVA). The key distinguishing feature of EVA is that it does account for the value of equity stakeholders have in such projects. Accordingly, EVA promises to help professionals from many functional backgrounds (i.e., Finance, Accounting, Production, Engineering, etc.) recalibrate the methods they use in the allocation of financial resources.

After describing in more detail the concept of EVA and the AMT, both of the common financial tools mentioned above will be reviewed, an analysis equating EVA to Present Worth and Annual Worth will be considered, a case applying EVA in an actual cost justification of AMT will be discussed, and relevant conclusions will be addressed in the end.

Background

Economic Value Added (EVA) is an analysis tool developed by a consultancy group known as "Stern-Stewart." Since its development in 1989, EVA has gained popularity as a means for establishing the value of organizations and for setting bonus levels for executive management. Regarding EVA, Baatz (1994) commented that it is but one of many tools being developed to account for the capital invested in an organization by the true owners of that organization – the shareholders.

Dodd and Chen (1996) explain that EVA is "...the difference between a company's adjusted net operating profit (after taxes) in a particular year and it total cost of capital." However, Rice (1996) indicates there is a growing movement that believe EVA is a tool which can, and should, be used on an organization-wide basis -- particularly in decisions related to the cost justification of capital equipment. More specifically, we are interested in this paper in how one organization has used EVA in the capital equipment cost justification process of AMT.

Identifying The Technology

The AMT discussed throughout this paper represents a first step in the process of creating a Computer-Integrated-Manufacturing (CIM) environment in a small manufacturing facility located in northern New England. The company is moving toward acquiring a series of machine tools which can be linked and integrated with various automated material handling devices enabling consistent, reliable operation with a minimum compliment of machine operators. Accordingly, the AMT for purposes of this paper can be identified as a MAZAK vertical machining center (VMC) with all supporting part pallets, automated fixtures, and tooling.

The MAZAK VMC model 20B is a machine tool capable of being interfaced with a variety of automated material handling devices, assuming a compatible CIM software is used for command and control of the system. The VMC model 20B has a 20" x 40" envelope of operation for machining, and is most commonly used to produce a wide variety of parts which are moderately complex. Materials processed on the VMC model 20B include softer steels and aluminum. Taken in the context of demands placed upon the machine for factors such as ability to meet tolerance, repeatability, reliability, and resale (i.e., salvage), the VMC model 20B is an excellent match for the intended application. Having identified the appropriate technology, cost justification becomes the next phase in the process of building the desired CIM environment.

Current Methods of Cost Justification

As is common financial practice in modern industry, Present Worth and Annual Worth were used to justify the cost of the MAZAK VMC. Park (1994) defines the algebraic formulae and variables for the Present Worth (PW) and Annual Worth (AW) respectively as follows in Table 1.

Present Worth

PW is used in the capital equipment cost justification process as a means by which to account for the time value of money. More specifically, as positive and negative cash flows associated with an investment occur over time, calculating the PW brings the respective values of those cash flows back in time to the origin or start point of the investment. Having established a common start point for the valuation of the cash flows enables decision makers to evaluate the attractiveness or unattractiveness of an investment such as the purchase of AMT. The key criteria for acceptance or rejection of an investment being, of course, a net positive value of the summed cash flows -- the more positive the value, the more attractive the investment.

Annual Worth

AW, commonly used in conjunction with PW, is used in the capital equipment cost justification process as a means to equalize and level the cash flows from an investment on an annual basis. In calculating AW, the PW of all cash flows associated with the investment are calculated. Assuming a net positive value is calculated from the PW analysis, the positive PW is theoretically leveled into a payment series of equal annual cash flows. Once the value of equal annual cash flows have been identified, theses values are brought back in time to the origin or start point of the investment. As in the PW analysis, the key criteria for acceptance or rejection of an investment being a net positive value of the equalized annual cash flows.

Method	Formula	Variables

Present Worth (PW)		A_n = Cash Flow
		n = # Periods
		i = Interest Rate
		P/F = PW of Discrete Amount

Annual Worth (AW)		PW = Present Worth
		n = # Periods
		i = Interest Rate
		A/P = PW of Uniform Cash Flow Series

Table 1. Current Methods of Cost Justification

Capital Investment*	=	$128,000
Salvage Value (end of year 6)	=	$35,000
Annual Expenses	=	$5,000
Gross Revenue/year	=	$40,000
Depreciation	=	MACRS 5 year schedule**
Equipment Life	=	6 years
Tax Rate	=	50%
After-Tax MARR***	=	12%

* Capital Investment = Equipment, Tooling, Delivery, & Installation
** MACRS = Modified Accelerated Cost Recovery System
*** MARR = Minimum Acceptable Rate of Return

Table 2. AMT Cost/Investment Structure: Mazak Vertical Machining Center

Year	BTCF (gross)	BTCF (net)	DEPR. DED.	TAXABLE INCOME	INCOME TAXES	ATCF
0	$-128,000	$-128,000	--------	--------	--------	$-128,000
1	40,000-5,000	$35,000	25,600	9,400	- 4,700	30,300
2	40,000-5,000	$35,000	40,960	-5,960	2,980	37,980
3	40,000-5,000	$35,000	24,576	10,424	-5,212	29,788
4	40,000-5,000	$35,000	14,746	20,254	-10,127	24,873
5	40,000-5,000	$35,000	14,746	20,254	-10,127	24,873
6	40,000-5,000	$35,000	7,373	27,627	-13,814	21,186
6**	35,000	$35,000	--------	35,000	-$17,500	17,500
TOTAL						$ 58,500

Table 3. AMT Investment Intermediate Values @ 12%
Year 6** Cash Flow: This cash flow represents the system salvage.

Applying The Concepts In An Operational Setting

For purposes of discussion, let us consider an investment in AMT which was considered in early 1998 by a company in northern New England.. The investment considered will serve as an example framing our discussion of each financial analysis tool identified in this paper (i.e., PW, AW, and EVA). The structure of the investment is provided in Table 2.

Having specified the cost/investment structure for the AMT, we will now calculate the cash flows associated with the investment as intermediate values in the PW analysis. The intermediate values, listed in Table 3 below, include the Before Tax Cash Flow (BTCF), Depreciation Deduction (Depr. Ded.) – based on the MACRS 5 year schedule --, Taxable Income, Income Tax Liability, and the After Tax Cash Flow (ATCF).

Now, using ATCF values calculated in TABLE 3, PW for the investment at 12% MARR is provided in TABLE 4.

TABLE 4 indicates the investment PW is a positive $54 at 12% MARR. Likewise, the investment AW is a positive $13 at 12% MARR. Even though marginally attractive, the investment was funded on the basis of the above analysis. However, immediately following the implementation of the project, management philosophy regarding the allocation of capital changed and the soundness of the decision to invest in the project was reconsidered in light of a new desire to maximize shareholder equity. Since all funds for the investment came from existing shareholder equity (i.e., no capital was borrowed to fund the investment), serious questions were raised regarding how the project was originally justified.

A Stark Realization That Shareholder Equity Is Not Free

Once the cost of shareholder equity was considered as a factor in the analysis process of capital equipment cost justification, it became evident that the funds for investments were not "free." What this means is that capital may be available for investments in an organization without the need for borrowing, however, those funds carry associated costs -- a point all too frequently overlooked. The costs associated with shareholder equity are related to the amount of money the shareholder equity could earn if placed in any other investment earning a commercially available rate of return. Accordingly, the project discussed in this paper appeared artificially attractive as the PW method of analysis failed to accurately reflect the true cost of shareholder equity. Accordingly, EVA analysis was considered as a means to obtain a more realistic cost value of the investment in AMT.

Year	ATCF	Time Value Factor	Time Value Factor	Present Worth
0	$-128,000	--------	--------	$-128,000
1	$30,300	(P/F, 12%, 1)	.8929	$27,055
2	$37,980	(P/F, 12%, 2)	.7972	$30,278
3	$29,788	(P/F, 12%, 3)	.7118	$21,203
4	$24,873	(P/F, 12%, 4)	.6355	$15,807
5	$24,873	(P/F, 12%, 5)	.5674	$14,113
6	$21,186	(P/F, 12%, 6)	.5066	$10,733
6**	$17,500	(P/F, 12%, 6)	.5066	$8,866
Total				$54

Table 4. PW Calculations of AMT Investment @ 12%

Year 6 ** Cash Flow: This cash flow represents the system salvage value ($35,000) after tax (50%), discounted 6 years @ 12%.

Net Annual Worth = PW (i = 12%) (A/P, 12%, 6)
= $54 (.24323)
= $13

YEAR	NOPAT [Taxable Inc.-Inc. Tax] = NOPAT		EVA [NOPAT-True Capital Cost(Beginning BV)] = EVA
1	$9,400-4,700	=$4,700	$4,700-0.12($128,000) = $-10,660
2	$-5,860-(-2,980)	=($2,980)	$-2,980.12($102,400) = $-15,268
3	$10,424-5,212	=$5,212	$5,212-0.12($161,440)=$-2,161
4	$20,254-10,127	=$10,127	$10,127-0.12($36,864)=$5,704
5	$20,254-10,127	=$10,127	$10,127-0.12($22,118)=$7,473
6	$27,627-13,814	=$13,814	$13,814-0.12($7,373)=$12,929
6**	$35,000-17,500	=$17,500	$17,500-0.12(0)=$17,500
TOTAL			$15,517

Table 5. EVA Analysis of AMT @ 12%

Year 6 ** Cash Flow: This cash flow represents the system salvage value ($35,000) after tax (50%), discounted 6 years @ 12%. This cash flow does not reflect any additional charge for the cost of capital as the life of the investment is complete.

Using EVA To Justify The Cost of AMT

So how does our investment in AMT look using the EVA analysis? As Sullivan (1997) noted, the results of PW and EVA analyses are equivalent when the interest factors are equivalent. In the case reported in this paper, the interest has been arbitrarily set at 12% which a very common value used as a standard or benchmark throughout industry. The PW of the EVA calculations at the 12% level are provided below in TABLES 5 and 6 below. It should be noted that the life of the investment remains the same as in the PW analysis (6 years), and the Net Operating Profit After Tax (NOPAT) remains the same.

Results

The EVA analysis conducted above produced a net positive PW result of $52 -- which equals the PW calculated in TABLE 4 ($54) after correcting for a slight rounding error. Likewise, the Annual Worth (AW) of the investment of $13 equals the Annual Equivalent EVA of the investment of $13. As Sullivan (1997) proved, the PW of the EVA and the PW of the initial investment at 12% are equivalent, as are both the AW values at the same interest rate. Further, since the EVA of the project is positive, the project should have been implemented based on financial reasons alone -- even though the strength of the results from the analysis were marginal.

However, we have a bit of problem. As mentioned earlier in the paper, the interest rate used in the analysis reported in this paper was arbitrarily set at 12% -- "... a standard or benchmark used throughout industry." This raises the question of the validity of using an "arbitrary" value whether it is a standard or benchmark or not. The investment normally used as a benchmark in EVA types of analyses is the long-term government bond. Tully (1996) states, "...shareholders have received, on average, a return that is six percentage points higher on stocks than on long-term government bonds. With bond rates around 6.3%, that puts the average cost of equity at 12.3%."

Tully's statement means the analysis was based on an interest factor which is 0.3% lower than the prevailing rate investors could have received if they invested not in the AMT, but rather in any other commercially available investment opportunity.

By setting the MARR at a level lower than 12.3%, (12% in this case) the true cost of capital is not being accurately reflected in the decision making process. Since the decision making process was revisited in light of a new concern for maximizing shareholder equity, the analysis was recalculated on the 12.3% prevailing interest rate commercially available. TABLE 7 below summarizes the results of the adjusted EVA analysis.

As TABLES 7 and 8 indicate, adjusting the cost of equity from 12% (the MARR set by the manufacturer during their initial cost justification) to 12.3% (the historic cost of equity), the PW of the investment dropped from $52 to $-1,016. The new analysis calculated at a 12.3% interest rate -- the true cost of capital -- highlighted a serious issue. The cost of the investment in AMT was not justified when the true cost of capital was considered!

Year	EVA	Time Value Factor	Time Value Factor	PW of EVA
1	$-10,660	(P/F, 12%, 1)	.8929	$-9,518
2	$-15,268	(P/F, 12%, 2)	.7972	$-12,172
3	$-2,161	(P/F, 12%, 3)	.7118	$-1,538
4	$5,704	(P/F, 12%, 4)	.6355	$3,625
5	$7,473	(P/F, 12%, 5)	.5674	$4,240
6	$12,929	(P/F, 12%, 6)	.5066	$6,550
6**	$17,500	(P/F, 12%, 6)	.5066	$8,866
Total				$52

Table 6. PW Calculations of EVA Analysis @ 12%

Year 6** Cash Flow: This cash flow represents the system salvage value ($35,000) after tax (50%), discounted 6 years @ 12%.

Annual Equivalent = {PW (12%) of EVA} { (A/P, 12%, 6) }
= $52 (.24323)
= $13

YEAR	NOPAT [Taxable Inc.-Inc. Tax] = NOPAT	EVA [NOPAT-True Capital Cost(Beginning BV)] = EVA
1	$9,400-4,700 =$4,700	$4,700-0.123($128,000) = $-11,044
2	$-5,960-(-2,980) =$2,980	$-2,980-.123($102,400) = $-15,575
3	$10,424-5,212 =$5,212	$5,212-0.123($61,440)=$-2,345
4	$20,254-10,127 =$10,127	$10,127-0.123($36,864)=$5,593
5	$20,254-10,127 =$10,127	$10,127-0.123($22,118)=$7,407
6	$27,627-13,814 =$13,814	$13,814-0.123($7,373)=$12,907
6**	$35,000-17,500 =$17,500	$17,500-0.123(0)=$17,500
TOTAL		$14,442

Table 7. EVA Analysis @ 12.3% Cost of Equity

Year 6** Cash Flow: This cash flow represents the system salvage value ($35,000) after tax (50%), discounted 6 years @ 12.3%. This cash flow does not reflect any additional charge for the cost of capital as the life of the investment is complete.

Summary & Conclusions

EVA analysis is but one of many tools being developed to assist decision-makers accurately consider the true cost of capital when allocating financial resources. While initially intended as a mechanism for valuing companies and setting bonuses in some companies, it appears EVA has more applications than originally thought possible. In fact, it appears that EVA, and related concepts, may eventually change the way we allocate financial resources -- right down to the shop floor level.

In fact, we have seen the most common financial tools used through-

Year	EVA	Time Value Factor	Time Value Factor	PW of EVA
1	$-11,044	(P/F, 12.3%, 1)	.8905	$-9,835
2	$-15,575	(P/F, 12.3%, 2)	.7929	$-12,350
3	$-2,345	(P/F, 12.3%, 3)	.7061	$-1,656
4	$5,593	(P/F, 12.3%, 4)	.6288	$3,517
5	$7,407	(P/F, 12.3%, 5)	.5599	$4,147
6	$12,907	(P/F, 12.3%, 6)	.4986	$6,435
6**	$17,500	(P/F, 12.3%, 6)	.4986	$8,726
Total				$-1,016

Table 8. PW Calculations of EVA Analysis @ 12.3%

Year 6** Cash Flow: This cash flow represents the system salvage value ($35,000) after tax (50%), discounted 6 years @ 12.3%. This cash flow does not reflect any additional charge for the cost of capital as the life of the investment is complete.

out industry today for capital equipment cost justification (i.e., PW and AW) are not inconsistent with the EVA analysis. Rather the analyses produce equivalent results when calculated at the same interest rate. What EVA does offer, however, is a more realistic picture of the true cost of using capital – whether that capital is borrowed or is available within an organization.

So what is the relevance of EVA for the practicing IT? As ITs continue to work in dynamic environments, the methods used to conduct business and remain competitive change! EVA represents a means to ensure capital is allocated in the most efficient and effective manner possible. And since ITs are frequently called upon to justify the cost of capital equipment and/or AMT, updating the tools we are able to bring to bear in the industrial environment must remain a priority.

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