ACTA
WASAENSIA

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Timo Salmi - Ilkka Virtanen

Economic Value Added

A simulation analysis of the trendy, owner-oriented management tool

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Abstract

Salmi, Timo and Ilkka Virtanen (2001). Economic Value Added: A simulation analysis of the trendy, owner-oriented management tool. *Acta Wasaensia No.* xx, 33 p.

The value-based management performance measure EVA® introduced by Stern Stewart & Co. is an incarnation of the underlying residual income (RI) concept. The concept is evaluated and compared with traditional profitability measures within a controlled simulation framework. It is observed that EVA is very sensitive to its cost of equity component, but it is unexpectedly insensitive to its cost of debt component under regular conditions. EVA and its variability are observed to be strongly affected by the firm's growth policies because of leverage effects. EVA is observed to be much more unstable than the traditional return on investment and directly related to the return on equity measure. Methodologically, the paper demonstrates the advantages of using a controlled simulation approach in financial research.

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Key words: Simulation; Residual income; Economic Value Added; Return on investment; Return on equity

Acknowledgments: We gratefully acknowledge the financial support from Jenny and Antti Wihuri foundation for the research. Our thanks are due to professors Teemu Aho and Erkki K. Laitinen for useful insights.

1. Introduction

The success of the firm depends on its management having theoretically sound and in practice operational tools for planning, decision making and monitoring. Developing new management accounting and decision tools is a very current subject both in business and consultation practice, as well as in academic research. During the last few years this development has become even more prominent thanks to several new techniques and concepts, both financial and non-financial. These include Activity Based Management, Balanced Scorecard, Benchmarking, Total Quality Management, and the Economic Valued Added (EVA) and Market Value Added (MVA) variants.

The firm has a number of stakeholders with differing, sometimes conflicting goals. The stakeholders include the owners, lenders, management, personnel, customers, suppliers and creditors, government and regulatory agencies. In corporate governance agency theory the managers are regarded as agents of the owners in stockholders' wealth-maximization. Among the management tools EVA, in particular, emphasizes the interests of the owners.

The concept of the economic value added is similar to the traditional accounting concept of Residual Income (RI); see Stark and Thomas (1998:446) and their references. The concept emerges in several variations and incarnations including the trade-marked Stern Stewart & Co's EVA® with its copious accounting adjustments (Stewart 1991, Stewart 1994, Stern, Stewart & Chew 1995, and Stern Stewart & Co. 1997).

In line with the theory of finance the RI derivative EVA is commonly advocated as a management tool because the goal of the firm is to add to the value of the owners' wealth. In other words, the owners expect a maximum compensation over the cost of the capital invested in the firm. A central question concerning EVA is how sensitive this management tool is to the changes in its various components, management policies and external economic factors.

Despite the unambiguous theoretical definition, applying EVA even in its pure, theoretical format is not straight-forward. EVA is defined as the difference between the firm's profit and cost of all capital employed, i.e. the weighted average cost of debt and equity. Measuring the profit of the firm and measuring the components of the cost of capital is problematic both in theory and in practice. In particular, measuring the cost of equity is a highly involved issue. A simulation approach is used in this paper to better facilitate investigating the behavior of EVA under varying management policies and cost conditions.

2. Categories of Previous Research

The origins of the value added concepts date all the way back to the early 1900's (Bromwich & Walker, 1998:392). The concept resurfaced in 1990's much thanks to the consulting firm Stern Stewart & Co's successful launching of the economic value added as the trademark EVA® and the subsequent adoption by several major corporations. The ensuing research work in literature roughly falls into three categories.

1. Mainly professional literature mostly aimed at presenting, promoting or discussing the EVA concepts in relation to consulting work. While most of this, partly anecdotal, literature looks at the advantages of the concept, a few critical views also occur in this category. The seminal work in this first category is Stewart (1991). Subsequent sources are too numerous for an extensive listing, but for instance there is material such as Milunovich & Tsuei (1996), Anctil, Jordan & Mukherji (1998), Damodaran (1999), Mouritsen (1998), Bowen & Wallace (1999), and Dodd & Johns (1999). There also is much WWW based material such as Mäkelä (1998), Weissenrieder (1999), and Stern Stewart & Co. (2000).

2. Empirical research literature measuring the strength of the relation between market returns (or market value) and EVA compared to the relation between market returns and the traditional income measures. O'Byrne (1996:125) concludes that "EVA, unlike NOPAT [net operating profit after taxes] or other earnings measures like net income or

earnings per share, is systematically linked to market value. It should provide a better predictor of market value than other measures of operating performance." Also Uyemura, Kantor & Pettit (1996) arrive at similar conclusions. Stark & Thomas (1998:445) provide "some support for the advocates of the use of RI for planning and control" from the market relation. However, Biddle, Bowen & Wallace (1997:331-332) find "little evidence to support the Stern Stewart claim that EVA is superior to earnings in its association with stock return or firm values". On the other hand, EVA or RI do not do decisively worse. Chen & Dodd (1997:331) conclude that EVA measures provide relatively more information than the traditional measures of accounting in terms of the stock return association, but that EVA should not entirely replace the traditional measures since measures such as E/P, ROA and ROE have incremental value in monitoring firm performance. They also observe that there is no significant difference between EVA and the traditional RI in terms of the association with stock returns. The most critical results are by Bao & Bao (1998).

3. Literature looking at EVA as a management tool from the point of view of the accounting measurement. O'Hanlon & Peasnell (1998) thoroughly discuss EVA as a value-based performance indicator, Stern Stewart Co's intricate adjustments, EVA benchmarks, and EVA-base bonuses. Bromwich & Walker (1998) add to the theoretical discussion by pondering the EVA debate all the way from Hicksian income concepts. Pfeiffer (2000) considers mathematically EVA vs. discounted cash flow methods for resolving internal agency problems in decentralized decision making. Besides the theoretical discussion understanding is needed about the numerical behavior of the EVA under different conditions and about EVA's numerical relationship to the accounting measures like Return on Investments (ROI), Return on Equity (ROE) and to economic profitability measures like the Internal rate of Return (IRR).

3. Research Problem and Approach Selection

The partly conflicting results in the earlier literature make it difficult to get a grasp of EVA's behavior vis á vis the traditional accounting measures. More information is needed of the behavior patterns of the EVA measure. The generic research task of this paper is to observe and assess how the EVA measure behaves under different, realistic financial conditions and compare it to the simultaneous behavior of the more traditional profitability indicators such as ROI, ROE and IRR. This general task involves the following, more detailed research questions:

- How sensitive is EVA to the level of the debt and equity cost components?
- Business firms typically assume different kind of growth strategies. Is EVA sensitive to the firm's alternative growth strategy choices?
- How steady is EVA? Will it be affected by cyclical business fluctuations and irregular events in the level of the firm's activities?
- What is the relationship between the behavior of EVA, ROE and ROI?
- Will EVA give consistent signals under different financial developments for the firm? In particular, will a bankruptcy-bound firm's EVA give a sufficient, early warning? On the other hand are there circumstances where EVA gives too prudent a picture under an auspicious future?

To tackle the posed problems suitable cases of firms are needed which highlight each of the above items. The ordinary option would be to search for representative, actual business data which would suit the questions. There are, however, complications: 1) suitable, unambiguous cases have to be found for achieving desired experimental designs, 2) the unavoidable problems in estimating the components of the cost of capital can affect the reliability of the results, 3) the practical accounting measurement problems of income determination and asset valuation must be tackled in the estimation. Instead, we adopt and extend an approach using simulated financial time-series in the spirit of Henderson, Peirson & Brown (1992) and Salmi & Virtanen (1997), which represent a controlled simulation approach. Also other simulation approaches have been applied, such as the "what-if" kind of simulation for EVA decisions in Taylor, Blackall & Haas (1999). The major advantage of using simulated data is being able to generate different business situations for observation at will. Simulation also more easily facilitates ceteris paribus observation of the different cases. The second important advantage of the simulation approach is the following. The true, economic profit of a business firm is not easily measured from financial statements. However, in our simulation approach the true profitability (IRR) of the simulated firm is readily known, since it can be defined as one of the model's input parameters. Furthermore, the difficulties in defining the correct cost of equity can consequently be avoided since, adapting Fama & French (1999), the true profitability of the simulated firm defines the cost of equity.

4. The Simulation Engine

The simulation engine used in Salmi & Virtanen (1997) is adopted. It is extended by incorporating financing into the model. The time-series data generated by the simulation model facilitates studying varying cost of capital situations, varying profitability situations, the firm's growth strategies, and various business cycle and irregularities conditions. In particular, the development of the EVA, and the key financial ratios such as the financial leverage, ROI, and ROE are observed using the chosen experimental design.

In the simulation model the capital investments are generated by the following multiplicative process with an exponential trend, a sinusoidal cycle, and an irregular variation made up of a normally-distributed noise component and a potential shock component

(1) $$g_t = g_0(1+k)^t\{1 + A \sin[(2\pi t/ \Psi) + \phi]\}(1 + \sigma z)(1 + \delta_{t\tau} Y) , \qquad t = 1,...,T.$$

The symbols are listed in Appendix 1. Using this capital investment generating process produces financial time series which closely resemble the time series profiles observed on actual business firms. See e.g. the sample of the time series drawn in Salmi et al. (1984:46-48).

The capital investments g_t induce subsequent cash inflows which can be defined in terms of a set of contribution coefficients b_i. The contribution coefficients fix a capital investment's cash flow pattern. The total contribution f_t in year t cumulates from the contributions from the capital investments made in the earlier years

$$(2) \quad f_t = \sum_{i=1}^{\min(N,t)} f_{ti} = \sum_{i=1}^{\min(N,t)} b_i \, g_{t-i}.$$

The run of the simulation years t = 1,...,T has been omitted for brevity since Formula (1).

Assuming constant returns of scale and constant profitability in the customary fashion, the contribution coefficients define the profitability of the firm in terms of the internal rate of return

$$(3) \quad \sum_{i=1}^{N} b_i \, (1+r)^{-i} = 1.$$

In the numerical simulation a distribution pattern i.e. the shape of the contribution coefficients must be fixed. The negative binomial distribution corresponding to a typical product life cycle is used (see Salmi & Virtanen, 1997)

$$(4) \quad b_i = s(i+1) \, q^2 \, (1-q)^i \, , \quad i = 1,...,N.$$

Other distribution patterns, such as a uniform pattern or a steadily declining pattern could also be adopted. Such alternatives are not, however, presented in this paper, since we observed that they do not substantially affect the nature of the numerical results.

The profit of the accounting period is defined by a simple income statement as the cash inflows less depreciation less the interest on loans

$$(5) \quad p_t = f_t - d_t - h_t.$$

The common straight-line depreciation method is applied by the simulated firm. Hence the depreciation, assuming a life-span of N years, is defined by

$$(6) \quad d_t = \sum_{i=1}^{\min(N,t)} (1/N) g_{t-i} \, .$$

The same goes for the alternative depreciation methods as goes for alternative contribution patterns. They can be omitted from the presentation, since they are not crucial from point of view of the nature of the numerical results. The interest payments in (5) are defined later by Formula (9).

The simplified balance sheet of the simulated firm is depicted by Figure 1.

	Assets	Liabilities + Owner's equity	
P_t	Working capital + Plant assets	Debt	B_t
		Common stock	S_t
		Retained earnings	R_t
V_t	Total	Total	V_t

Figure 1. The balance sheet in year t.

Ever since Salamon (1982:294) in defining the long-run profitability of the firm it has been conventional to regard the firm as a series of repetitive capital investments with a fixed life-span and a fixed cash-flow pattern. Furthermore, it is customary to assume that the working capital of the firm has the same profitability level as the firm's capital investments. Hence, we combine the simulated firm's plant assets and its working capital under the same caption. We define

$$(7) \quad P_t = P_{t-1} + g_t - d_t.$$

Debt on the ending balance sheet of a year is defined by the beginning debt balance less the amortization on the old loans plus the new loans

(8) $B_t = B_{t-1} - a_t + l_t.$

The interest payments on a year's outstanding initial debt are calculated using the loan interest rate

(9) $h_t = j \cdot B_{t-1}.$

The amortization is made in equal installments until the loans' maturity

(10) $$a_t = \sum_{i=1}^{\min(L,t)} (1/L) l_{t-i} \; .$$

The capital investment schedule of the simulated firm is defined by (1). The necessary funding for the capital investments, interest payments, and amortization comes from cash inflows, and, when not sufficient, from the new loans

(11) $$l_t = \begin{cases} g_t + h_t + a_t - f_t & \text{if } g_t + h_t + a_t - f_t > 0 \\ 0, & \text{if } g_t + h_t + a_t - f_t \leq 0. \end{cases}$$

If the firm generates enough funds internally, no new loans are taken. Instead, the potential extra funds are paid out as dividends

(12) $$o_t = \begin{cases} 0, & \text{if } g_t + h_t + a_t - f_t > 0 \\ f_t - g_t - h_t - a_{t,} & \text{if } g_t + h_t + a_t - f_t \leq 0. \end{cases}$$

The retained earnings are defined by

(13) $R_t = R_{t-1} + p_t - o_t.$

The level of common stock is kept constant in the simulation, i.e. no new stock issues are included in the model

(14) $S_t = S_{t-1}$.

The book value of the firm at the end of each year is calculated from the liabilities plus the equity side of the balance sheet as

(15) $V_t = B_t + S_t + R_t$.

5. Producing EVA and Key Financial Ratios

The previous section presented the construction of the actual simulation engine. The model involves three main constituents, the input parameters, the actual model with the model variables, and the output produced by the model. The financial time-series produced by the model make up its primary output. Furthermore, the model can be customized to produce the key financial information. This section presents the calculation of EVA and selected key financial ratios in the framework of the model.

In general terms EVA is defined in this paper in a manner similar to the RI (residual income) as (see e.g. Biddle et al., 1997:305-306)

(16) $EVA = NOPAT - WACC \cdot Capital$

where NOPAT is the net operating profit after taxes and WACC is the weighted average cost of capital. The trade-marked Stern Stewart & Co's EVA® includes accounting adjustments both in NOPAT and the capital. The adjustments are too proprietary to be carried out in this paper. Fortunately, it is not to be expected that this has a bearing on the nature of the results (see e.g. Biddle et al. 1997 and Chen & Dodd 1997). Furthermore, we do not include taxation in our model. Our NOPAT will be the accounting profit before the interest on loans. This will not affect the general pattern of the results.

In terms of our simulation model the EVA is the profit before interest payments net of a charge for the cost of all debt and equity capital employed

(17) $EVA_t = (p_t + h_t) - c_t V_{t-1}$

where the weighted average cost of capital for the year under observation is calculated from the cost j of debt and cost e of equity

(18) $c_t = j \cdot B_{t-1} / V_{t-1} + e \cdot (S_{t-1} + R_{t-1}) / V_{t-1}.$

An alternative format of (18) that emphasizes the effect of leverage on the average cost of capital can be written as

(18a) $c_t = e - (B_{t-1} / V_{t-1}) \cdot (e - j).$

In the above we have chosen to use the initial balances instead of e.g. annual averages of the balance sheets.

In the finance literature one of the most involved issues is the assessment of the cost of capital. In particular, assessing the cost of equity is a difficult question both in practice and theory. In our simulation two alternative ways of defining the cost of equity will be used. In the above formulas it is given as an external parameter. However, the cost of equity can also be defined as the firm's internal rate of return (see Fama and French, 1999). Here we can utilize an important advantage of our simulation approach. The IRR is accurately known in the simulation.

It is possible to define a theoretical version of the EVA using the economic profit on the assets net of a charge for the cost of all debt and equity capital employed.

(19) $TEVA_t = rV_{t-1} - \gamma_t V_{t-1}$

where the average weighted cost of capital is defined by the rate of interest and the firm's profitability

(20) $\gamma_t = j \cdot B_{t-1} / V_{t-1} + r \cdot (S_{t-1} + R_{t-1}) / V_{t-1}$.

The question naturally arises whether the practical EVA (17) vs. the theoretical EVA (19) will lead to substantially differing results.

The model calculates also traditional financial ratios for profitability. Return on (the capital) investments is defined by

(21) $ROI_t = (p_t + h_t) / V_{t-1}$.

Return on equity is

(22) $ROE_t = p_t / (S_{t-1} + R_{t-1})$.

The firm's financial standing is reflected in its leverage defined by

(23) $LEV_t = B_t / V_t$.

EVA is a measure that is expressed in absolute, monetary terms. Nevertheless, it will be interesting to compare the behavior of a relative EVA to the firm's ROE and ROI. The latter is left for the simulation, but the former relation is easily assessed analytically. Define the relative EVA as

(24) $EVAR_t = EVA_t / (S_{t-1} + R_{t-1})$.

Using EVA definition (17), the definition of the weighted average cost of capital (18), and the formula for the interest payments (9), it is readily seen that the relative EVA is just the return on equity less the cost of equity

(25) $EVAR_t = ROE_t - e.$

6. Input Data Description

The controllable variables and their variation ranges in the simulation experiments are given in Table 1. Appendix 2 gives one example of the simulated time-series constituting the cash flow statement, income statement, balance sheet, and the resultant EVA values and select financial ratios.

Table 1. The variation of the parameters in the simulation runs.

Parameter	Symbol	Values
First capital investment	g_0, P_0	100.00
First level of debt	B_0	70.00
First level of common stock	S_0	30.00
First level of retained earnings	R_0	0.00
Growth rate	k	0.04, 0.08, 0.12, 0.16
True internal rate of return	r	0.04, 0.06, 0.08, 0.12
Interest rate on loans	j	0.00 – r
Cost of equity	e	0.00, 0.05, 0.08, 0.12
Maturity of loans	L	5
Business cycle amplitude	A	0.50
Business cycle length	Ψ	6 years
Technical phase adjustment	ϕ	$\pi/6$
Noise term	σ	0.20
Shock timing	τ	∞ (no shock)
Shock coefficient	Y	0
Life-span of capital investments	N	20
Length of observation period	n	13 (years 22-34)

The selected combinations of the different input sets will become evident below in discussing the results for the research questions posed.

7. Effect of the Cost Components

To study the effect of the cost components, the behavior of EVA and the select financial ratios is simulated under different profitability situations. We fix here the growth rate at 8% and vary the profitability around the fixed growth figure to emulate different profitability situations. We consider a firm with a weak profitability (4%) situation, a modest profitability (6%), a reasonable profitability (8%) where profitability equals the growth rate, and a good profitability (12%).

The cost of loans can be considered an external variable determined by the interest rate on the markets. In the simulation runs the loan interest rate is varied all the way up from 0% (to see one end of an extreme case) to the long-run profitability of the firm's capital investments (the internal rate of return). Interest rates beyond the IRR are not considered, because a firm would not be viable under such circumstances.

The measurement of the cost of equity is an involved issue both in practice and theory. One relevant way of looking at the concept, especially in connection with EVA, is regarding the cost of equity as the owners' required return on the capital they invest in the firm. In the simulation runs the cost of equity is varied from the extreme case of 0% up to a maximum of 12%. In particular, in line with Fama & French (1999), the case where the cost of equity is made equal to the IRR is interesting as a benchmark. The special strength of the simulation approach, as compared to empirical data from actual business observations, is that the true IRR will be available without any bias.

The first question before it is conductive to observe EVA's behavior is to see under what loan costs the firm can stay generally viable. In a rudimentary framework one can observe what happens to the firm's leverage as a function of the load interest rate and the firm’s profitability. Figure 2 delineates the mean leverage for the observation period (years 22-34 in the simulation, c.f. Appendix 2). As is to be expected, if the firm’s growth rate constantly exceeds its profitability, the firm's situation is not tenable in the long run. In Figure 2, when the profitability of the firm is 4% and it tries to grow at a rate of 8%, not even practically costless loans can keep the firm afloat. On the other hand, when the profitability (12%) clearly exceeds the firm's growth rate (8%), the leverage curve is very flat until a sudden, steep upwards slope at the growth level. At normal profitability figures (6%, 8%) the leverage increases smoothly along the cost of loans.

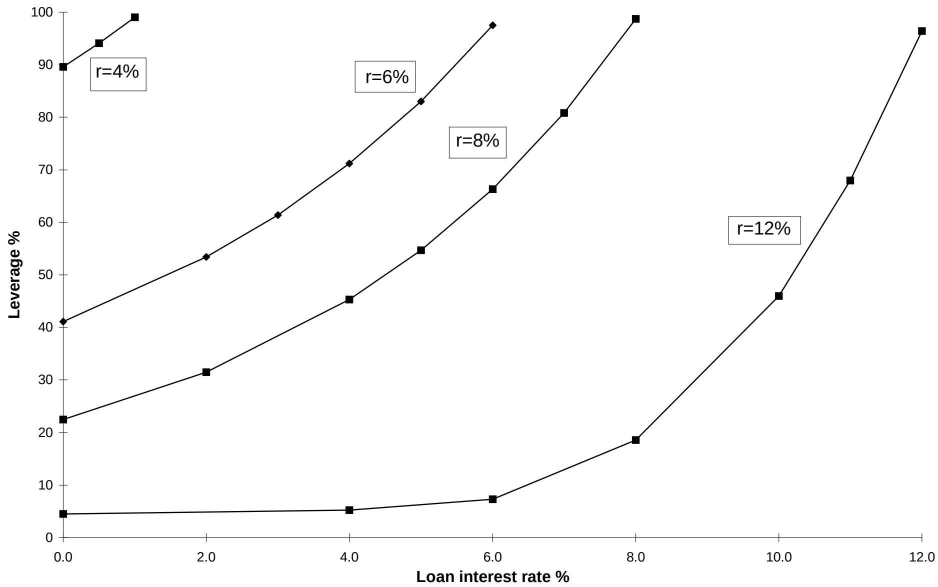

Figure 2. Leverage as a function of the loan interest rate and profitability; growth k=8%, cost of equity e=5%.

Next consider the behavior of EVA for the different levels of cost of loans under different levels of cost of equity, i.e. the shareholders' requirement of return. Figure 3 delineates the results for the case of balanced growth and profitability.

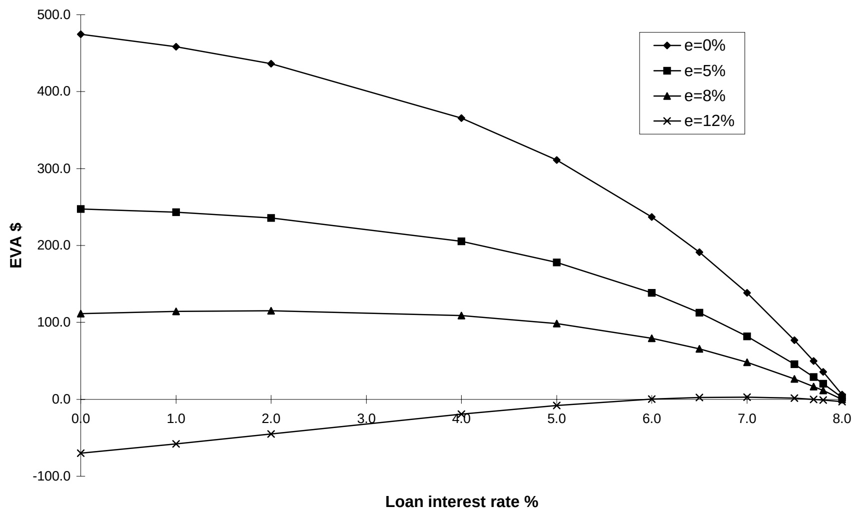

Figure 3. EVA as a function of the loan interest rate and the required rate of return on equity; growth k=8%, profitability r=8%.

When the required rate of return, i.e. the cost of equity equals the firm's true profitability (e = r = 8% in the figure) in line with Fama and French, it is evident from all our simulation results that the cost of loans has very little effect on the EVA of a viable firm.

The theoretically correct cost of equity is not necessarily available to the stakeholders. In actual practice the cost of equity / required rate of return is determined on an ad hoc basis or estimated from market based data. This situation is exemplified in Figure 3 by the case of e = 5%. It is readily seen that on the other hand EVA stays insensitive to the cost of loans, but on the other hand the absolute level of EVA is significantly affected.

It is also evident from the figure, that if the required rate of return is set unrealistically by the shareholders (e = 12% or e = 0% in Figure 3), EVA's behavior becomes more drastic.

By definition, a comparison of the practical EVA (17) and theoretical TEVA (19) is relevant only when the required rate of return is set at the (true, but in practice unknown) profitability of the firm. Under these circumstances the EVA and TEVA figures are very close. This result is similar to the results concerning the economist's vs. accountant's valuation of the firm's profits. For a further discussion and references see e.g. Salmi & Virtanen (1997:21).

The results in this section indicate, somewhat contrary to the intuitive expectations, that (as long loans can be secured at viable rates), EVA is almost unaffected by the cost of loans. To summarize, we draw the following conclusion

> Under normal circumstances EVA is determined foremost by the firm’s profitability as long as the required rate of return is set as the finance theory dictates.

8. Effect of Growth Strategies

The firm may adopt different growth strategies in relation to its profitability - as long as sufficient funds can be obtained to finance the growth. To examine the consequences of different growth strategies for a profitability of 8% we produce the cases of slow (k=4%), normal (k=8%), fast (k=12%) and very fast growth (k=16%).

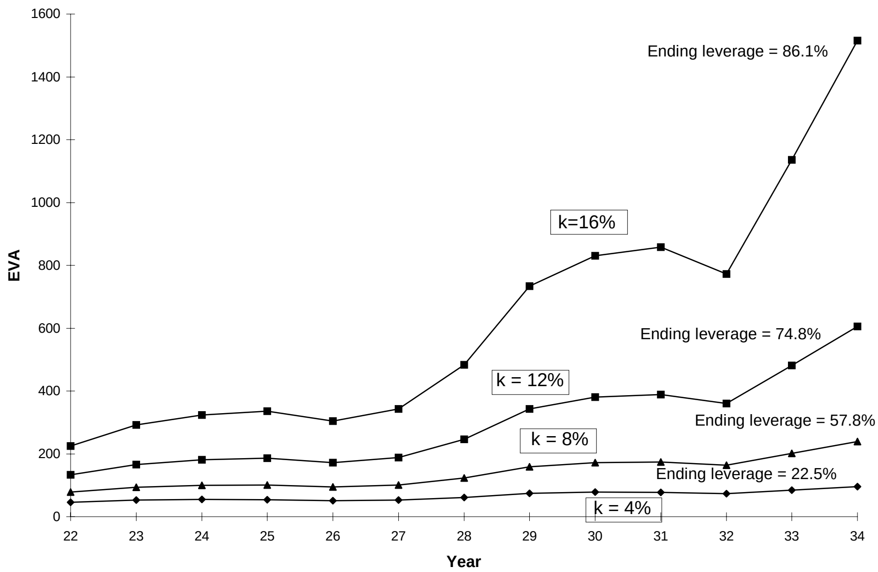

Figure 4. Annual EVA figures for different growth strategies; profitability r=8%, cost of equity e=5%, loan interest rate j=6%.

Figure 4 shows that the more aggressive the growth policy the more sensitive the EVA. This goes both for the level and the variability of the annual EVA figures.

The mechanism that causes this behavior is rather obvious. At higher growth rates (with respect to the firm's profitability) more and more financial leverage is needed to keep the firm and the growth going. The increase in EVA and its variability comes through two effects. As a physical phenomenon, the growth increases the level of the earnings component as such. As a financial phenomenon, the increasing financial leverage gears upwards the returns earned on the shareholder's equity and thus adds economic value to the shareholders.

It should be noted that the results in Figure 4 are obtained in a Modigliani-Miller type of setting. In other words, the calculations are performed under unchanging risk, fixed return requirements and non-increasing loan costs for the different growth levels.

To conclude

> The (absolute) EVA figure and its variability are strongly affected by the firm's growth policy choices.

In business practice EVA is a measure that is applied in absolute, monetary terms. Nevertheless, it is interesting to compare the behavior of a relative EVA to ROE and ROI. It was already shown in (25) that there is a one-to-one correspondence between the relative EVA and the firm's ROE, which are only separated by the firm's cost of equity. This fact may be a good explanation for the empirical results such as Biddle, Bowen & Wallace (1997) and Chen & Dodd (1997) not finding evidence of an EVA supremacy over net income in explaining the firms' stock returns.

Figure 5 delineates the behavior of the relative EVA at the different growth strategies in comparison with ROI.

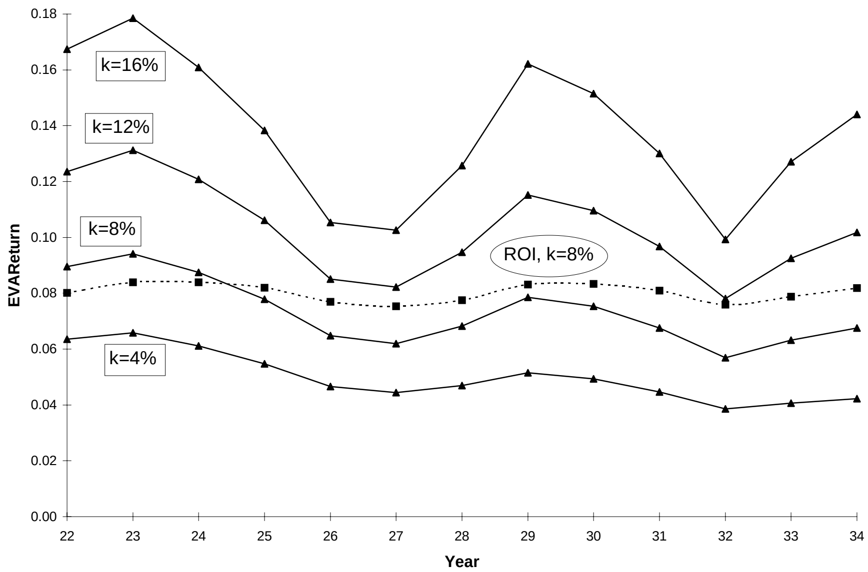

Figure 5. Annual relative EVA figures for different growth strategies; profitability r=8%, cost of equity e=5%, loan interest rate j=6%.

The behavior of the relative EVA shows both similar and different features as the absolute EVA. Again, the variability is significant. The more aggressive the growth policy the more sensitive the EVA. Despite the variability, the mean levels of the relative EVAs stay fairly constant. The mean levels are determined by the growth strategies.

ROI behaves differently. It is a very good approximation of the profitability of the firm’s capital investments, i.e. the firm's IRR. There is very little fluctuation in the ROI figure. ROI is a highly robust measure. This result is in line with the results in Salmi & Virtanen (1997).

> The relative EVA figure level and variability of the relative EVA are strongly affected by the firm's growth policy choices. The traditional ROI is a very robust measure of the firm’s underlying profitability.

Furthermore, the results show that on an annual level the EVA figures are affected by cyclical business fluctuations (and irregular events). On the other hand, the further, unreported simulation experiments done in the project, show that average nature of the EVA results are not affected by the cycles.

9. Signaling Financial Distress

Does EVA warn of an approaching bankruptcy? The different kinds of bankruptcy definitions have to be considered: The economic bankruptcy where the value of the firm becomes negative, and the legal bankruptcy where the firm is foreclosed.

Figure 3 indicates that, as is expected, if the firm is unable to earn profits in excess of the required return, EVA will go negative. However, the behavior under increasing loan interest rates is counter-intuitive. The answer would thus seem to be at most a qualified yes for EVA acting as a financial distress warning, as far as the economic value distress definition is used. The key issue is whether the owners have set a reasonable required return. If not, a perfectly sound firm will falsely appear to be in distress.

Consider legal bankruptcy in the light of Figure 4. In practice, firms that develop an extremely high leverage will in many cases either go bankrupt, or at could be taken over for a restructuring. At least if risk premiums are not included, strongly leveraged (growth) firms will have higher and higher EVAs. Hence, the absolute EVA measure could be dangerously susceptible as a distress warning device.

10. Conclusion

During the 1990's value based management has made a strong entry in the assortment of management tools in the form of EVA as marketed in particular by Stern Stewart & Co. Research literature on the subject has roughly taken three different lines: the practical advocating consultation-line literature, the empirical share-returns predictor performance literature, and the theoretical accounting measurement discussion approach. The current paper examined the behavior of EVA under different, characteristic circumstances using controlled, simulated financial data.

The central idea of EVA is subtracting the cost of capital from the firm's profits to measure, as the term indicates, the economic additional value produced by the firm to its owners over the weighted cost of the capital employed. This raised the question of the effect of the debt and equity cost components on the behavior of EVA. It was observed that under realistic (with respect to the firm's profitability) required returns (cost of equity) the loan interest rate has little effect on the EVA's behavior until the cost of loans approaches the firm's profitability. This insensitivity can be considered a somewhat unforeseen result with respect to the intuitive expectations of EVA's behavior. On the other hand, as is expected, EVA behaves in a linear fashion with respect to the cost of equity.

Business firms may and do adopt different growth strategies in relation to their profitability levels, ranging from conservative to aggressive. A interesting current example of the aggressive growth strategy choices have been the new information technology companies. It was confirmed in this paper that EVA and its variability are strongly affected by the firm's growth policy choices. This result is in line with expectations because the consequent increasing financial leverage gears up the return earned on the shareholders equity.

The results have also a bearing on the debate of the relative merits of the value-based measures against the properties of traditional accounting measures. It was observed that even under regular economic circumstances (the relative) EVA is much more unstable than the traditional return on investment (ROI) measure. Furthermore, as was shown in the mathematical derivations, there is one-to-one correspondence between (the relative) EVA and the traditional return on equity (ROE). These findings subject to doubt the potential claims on EVA's supremacy over the more traditional accounting measures.

Traditional financial ratios are commonly used also for distress prediction. It was observed that EVA does not have incremental value in the predicting.

Besides the results arrived at concerning EVA and its relation to the traditional accounting profitability measures, this paper goes to demonstrate the good applicability of the controlled simulation approach in financial research. The major advantages of the simulation approach are the ability to emulate different business situations at will and to facilitate a plausible ceteris paribus scrutiny of the relevant cases.

Appendix 1. List of Symbols

Input parameters

g_0 = initial level of capital investments
k = growth rate of the capital investments
A = amplitude of the cycle
Ψ = length of the cycle
ϕ = technical phase adjustment for the cycle
σ = standard deviation of the random fluctuation in the capital expenditures
Y = capital investment shock coefficient
τ = the year of the capital investment shock ($\tau = \infty$) for no shock in the simulation)
T = length of the simulation period
b_i = relative contribution from capital investment i years back
N = life-span of a capital investment project (the same for all capital investments)
r = internal rate of return of the simulated firm, for the given b_i and N
q = shape parameter for negative binomial distribution
s = scaling factor for negative binomial distribution
j = interest rate on loans
L = maturity of loans
e = cost of equity

Model variables

g_t = capital investments in year t
z = random variable following the (0,1)-normal distribution
$\delta_{t\tau}$ = Kronecker's delta, $\delta_{t\tau} = 1$ when $t = \tau$, and 0 otherwise
f_t = cash inflow in year t
f_{ti} = absolute contribution (cash-inflow) in year t from capital investment i years back
p_t = accounting profit in year t
h_t = interest on loans in year t
d_t = depreciation in year t
P_t = plant assets plus working capital at the end of year t
B_t = debt at the end of year t
S_t = common stock at the end of year t
R_t = retained earnings at the end of year t
V_t = book value of the firm at the end of year t
a_t = amortization of loans in year t
l_t = new loans taken in year t
o_t = dividends paid out in year t
c_t = weighted average cost of capital for year t
γ_t = "theoretical" weighted average cost of capital for year t

Output variables
EVA_t = economic value added in year t
$TEVA_t$ = economic value added in year t based on the internal rate of return
$EVAR_t$ = relative economic value added in year t
ROI_t = return on investments
ROE_t = return on equity
LEV_t = leverage

Appendix 2. Example Simulated Time Series.

Growth 8%, IRR 8%, interest rate on debt 6%, cost of equity 5%, negative binomial contribution distribution, straight-line depreciation, amplitude 50% for business cycles, noise 20%, no shock.

Table A1. Cash flow statement

Year	Funds from operations f_t	New loans l_t	Capital expenditure g_t	Amortization a_t	Interest on loans h_t
0	0.00	70.00	100.00	0.00	0.00
1	8.39	161.17	151.36	14.00	4.20
:	:	:	:	:	:
21	503.90	701.10	271.45	775.15	158.39
22	534.27	755.58	318.86	817.03	153.95
23	559.50	902.37	451.70	859.90	150.26
24	593.90	1047.66	604.02	884.72	152.81
25	640.33	1458.55	1048.43	887.85	162.59
26	723.53	1563.03	1116.67	973.05	196.83
27	819.94	1485.06	927.32	1145.44	232.23
28	905.95	1078.88	440.87	1291.33	252.61
29	951.64	1416.62	801.76	1326.63	239.86
30	1014.31	1789.43	1158.04	1400.43	245.26
31	1107.32	2596.99	1969.10	1466.60	268.60
32	1270.40	1877.67	1138.25	1673.40	336.42
33	1381.92	1715.30	996.62	1751.92	348.68
34	1467.61	1529.64	771.56	1879.20	346.48

Table A2. Income statement

Year	Cash inflows f_t	Straight-line depreciation d_t	Interest on loans h_t	Operating income p_t
0	0.00	0.00	0.00	0.00
1	8.39	5.00	4.20	-0.80
:	:	:	:	:
21	503.89	252.49	158.39	93.00
22	534.26	258.49	153.95	121.81
23	559.50	265.83	150.26	143.40
24	593.90	284.55	152.81	156.53
25	640.32	312.10	162.59	165.62
26	723.52	359.07	196.83	167.61
27	819.94	405.26	232.23	182.43
28	905.94	439.34	252.61	213.98
29	951.63	451.44	239.86	260.33
30	1014.31	482.78	245.26	286.26
31	1107.32	536.34	268.60	302.37
32	1270.40	626.88	336.42	307.08
33	1381.91	673.17	348.68	360.06
34	1467.61	704.84	346.48	416.27

Table A3. Balance sheet

Year	WC+Plant assets P_t	Debt B_t	Common stock S_t	Retained earnings R_t	Total assets V_t
0	100.00	70.00	30.00	0.00	100.00
1	246.36	217.17	30.00	-0.80	246.36
:	:	:	:	:	:
21	3439.20	2565.90	30.00	843.29	3439.20
22	3499.56	2504.45	30.00	965.11	3499.56
23	3685.44	2546.92	30.00	1108.51	3685.44
24	4004.92	2709.86	30.00	1265.05	4004.92
25	4741.24	3280.56	30.00	1430.68	4741.24
26	5498.84	3870.54	30.00	1598.30	5498.84
27	6020.90	4210.16	30.00	1780.73	6020.90
28	6022.43	3997.70	30.00	1994.72	6022.43
29	6372.76	4087.69	30.00	2255.06	6372.76
30	7048.02	4476.69	30.00	2541.32	7048.02
31	8480.78	5607.08	30.00	2843.70	8480.78
32	8992.15	5811.35	30.00	3150.79	8992.15
33	9315.60	5774.74	30.00	3510.85	9315.60
34	9382.32	5425.18	30.00	3927.13	9382.32

Table A4. EVA and financial ratios

Year	EVA_t	ROI_t	ROE_t	LEV_t	WACC c_t	$TEVA_t$	WACC γ_t
0	0.00	0.0000	0.0000	0.7000	0.0000	0.00	0.0000
1	-2.30	0.0339	-0.0270	0.8815	0.0570	1.40	0.0660
:	:	:	:	:	:	:	:
21	53.99	0.0735	0.1192	0.7461	0.0577	52.79	0.0646
22	78.15	0.0802	0.1395	0.7156	0.0575	51.31	0.0651
23	93.64	0.0839	0.1441	0.6911	0.0572	50.08	0.0657
24	99.61	0.0839	0.1375	0.6766	0.0569	50.93	0.0662
25	100.87	0.0820	0.1279	0.6919	0.0568	54.19	0.0665
26	94.58	0.0769	0.1148	0.7039	0.0569	65.61	0.0662
27	101.02	0.0754	0.1120	0.6993	0.0570	77.41	0.0659
28	123.45	0.0775	0.1182	0.6638	0.0570	84.20	0.0660
29	159.09	0.0831	0.1286	0.6414	0.0566	79.95	0.0667
30	172.01	0.0834	0.1253	0.6352	0.0564	81.75	0.0672
31	173.81	0.0810	0.1176	0.6612	0.0564	89.53	0.0673
32	163.40	0.0759	0.1069	0.6463	0.0566	112.14	0.0668
33	201.02	0.0788	0.1132	0.6199	0.0565	116.22	0.0671
34	239.23	0.0819	0.1176	0.5782	0.0562	115.49	0.0676
Mean	138.45	0.0803	0.1233	0.6634	0.0568	79.14	0.0665

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