

DETERMINING THE VALUE OF A FIRM

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ABSTRACT

The value of a firm in computerized business gaming simulations can be determined through five different measures: book value, market value, capitalized value, deductive judgment, and adjusted net worth. The firm's book value may be an unreasonable measure of its true value because of the idiosyncrasies of accounting. True market value may be unavailable or unreliable. The capitalized value measure requires an arbitrary parameter, the deductive judgment measure requires subjective judgment, and the adjusted net worth measure requires detailed knowledge of the gaming simulation's model. Developers are in the best position to apply the adjusted net worth measure, so they should code it into their simulation's computer programs.

INTRODUCTION

The question of how to determine the value of a firm in a computerized business gaming simulation is an interesting one that has received little attention. Firm valuation is essential for deriving stock prices, an item of significance in many simulations (Keys & Biggs, 1990). Sometimes, stock price is the sole measure of performance in the simulation (Biggs, 1978). More commonly it is major component of a weighted average that includes other measures. Certainly, no total enterprise simulation can be complete without a measure of the value of firms.

Firm valuation can be obtained through different measures, each of which is likely to give a value that differs from that obtained by another measure. The task of the simulation designer is to incorporate the measures that best fit the requirements of the particular simulation. To guide the task, this paper presents a firm-valuation typology consisting of five measures, and shows how the fifth measure may be especially suitable for business gaming simulations.

The first and most readily available measure of the value of a firm is its accounting net worth, or book value. This measure is problematic, however, because the accounting rules in a simulation may be at variance with generally accepted principles of financial accounting (Goosen, Jensen, & Wells, 1999), and because conformance with some generally accepted principles, such as historical cost and conservatism, can lead to values that are far removed from what is reasonable.

The second measure is the market value of all its outstanding shares. This is a popular everyday-world method of valuating public corporations. Its application, however, requires an efficient real market for shares. This condition is not met in simulations that do not allow participants to trade shares, and even when such trading is allowed, the trades are generally too few and too infrequent for reliable valuation.

The third measure is the capitalized value of its projected future performance. Miller and Modigliani (1961) pointed out that although four distinct methods of capitalization can be applied for this purpose, all four give rise to precisely the same valuation when markets are perfect, people are completely rational, and the future is known with perfect certainty.

The fourth measure is the deductive application of human judgment. With this method, firms are rated along a psychometric scale. The results are then converted by formula to monetary values.

The fifth measure is the firm's accounting net worth adjusted for intangibles and the idiosyncrasies of the accounting rules used in the simulation. Although general principles can be laid out for the adjustment, the specific must depend upon the particulars of the simulation.

The first and second measures are clear-cut, so they will not be discussed further. The last three, however, are not as obvious. They will be covered in detail in the discussion to follow.

CAPITALIZED VALUE MEASURE

Following the argument of Miller and Modigliani (1961), the basic idea behind the capitalized value measure is that the value of a firm to its owners at time 0 is equal to the discounted value of net cash inflow from the firm to its owners at time 1, plus the discounted value of the remaining value of the firm. Thus, if V_0 is the value of the firm at time 0, if F_1 is the net cash inflow from the firm to its owners at time 1, if V_1 is the value of the firm at time 1, and if r is the cost of capital between time 0 and time 1, then

$$V_0 = \frac{F_1 + V_1}{1 + r} \quad (1)$$

Likewise, expressing V_1 in terms of F_2 and V_2 , V_2 in terms of F_3 and V_3 , and so forth, and then successively substituting these latter expressions into Equation 1, the value of a firm can be expressed as follows:

$$V_0 = \frac{F_1}{1+r} + \frac{F_2}{(1+r)^2} + \frac{F_3}{(1+r)^3} + \dots + \frac{F_n}{(1+r)^n} + \frac{V_n}{(1+r)^n}. \quad (2)$$

Inasmuch as the last term of Equation 2 approaches zero as the number of future periods, n , approaches infinity, Equation 2 can be written concisely as follows:

$$V_0 = \sum_{t=1}^{\infty} \frac{F_t}{(1+r)^t}. \quad (3)$$

Net cash inflow to owners, F_t , is the difference between the dividend paid to owners, D_t , and the additional capital supplied by owners, K_t , thus,

$$F_t = D_t - K_t. \quad (4)$$

Furthermore, the additional capital supplied by owners is the difference between the firm's investment net of depreciation, I_t , and its undistributed earnings, which in turn is the difference between its profit, X_t , and its dividend. Thus,

$$F_t = D_t - [I_t - (X_t - D_t)] = X_t - I_t. \quad (5)$$

Substituting Equation 5 into Equation 3, the value of a firm therefore is as follows:

$$V_0 = \sum_{t=1}^{\infty} \frac{X_t - I_t}{(1+r)^t}. \quad (6)$$

A practical valuation formula cannot depend upon an infinite number of forecasts into the future, so Equation 6 must be simplified. If net investment is set to zero for all periods and if profit is likewise set to a constant, X^* , then Equation 6 reduces to the following:

$$V_0 = \frac{X^*}{r}. \quad (7)$$

Goosen, Foote, and Terry (1994) suggested computing the constant profit term, X^* , by multiplying the most recent profit figure, X_0 , by a growth factor, w , which is derived from a forecast of the profit growth rate, g , projected to an arbitrary future time, m , as follows:

$$w = 1 + \frac{(1+g)^m - 1}{(1+r)^m}. \quad (8)$$

The computed value of a firm would then be as follows:

$$V_0 = \frac{X_0 w}{r}. \quad (9)$$

Goosen et al. (1994) did not present the growth factor, w , as given in Equation 8, but it can be derived from their work. According to Goosen et al.

$$MVPS = \frac{NIPS + DINIPS}{ECC} = \frac{NIPS + \frac{NIPS(1+GR)^{FP} - NIPS}{(1+ECC)^{FP}}}{ECC}. \quad (10)$$

Equation 10 reduces to:

$$MVPS = \frac{NIPS \left(1 + \frac{(1+GR)^{FP} - 1}{(1+ECC)^{FP}} \right)}{ECC}. \quad (11)$$

Considering that $MVPS$ corresponds with V_0 , $NIPS$ with X_0 , GR with g , ECC with r , and FP with m , it follows that the collection within the parentheses of Equation 11 is w .

Goosen et al. (1994) also suggested that the profit growth rate, g , should be based on the profits of the last three time periods, but they suggested no objective means of deriving m , "the number of future periods that stockholders are willing to extend growth" (p. 66). Critiquing the method, Gold (2003) suggested exponentially smoothing recent profit figures so that

the computed measure would be less sensitive to the possibly unrepresentative profit of the last period. Nevertheless, the model remains dependent upon m , an arbitrary parameter.

DEDUCTIVE JUDGMENT MEASURE

The deductive judgment measure reverses the customary procedure of computing an index of company performance by combining market value with accounting values. Two such indices have been the subject of recent studies involving business simulations (Suaia & Castro, 2002; Wolfe & Suaia, 2003), the Tobin q (Tobin, 1971) and the Altman Z (Altman, 1968).

The Tobin q is the "value of capital relative to its replacement cost" (Tobin, 1971, p. 330). If "capital" is taken to refer to the sum of the true value of the firm, V , and the firm's

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liabilities, L ; and if “replacement cost” is taken to refer to the firm’s total assets, A , then

$$q = \frac{V + L}{A}. \quad (12)$$

When the value of the firm’s capital ($V + L$) is identical to its replacement cost (A), the Tobin q is unity. When the firm is managed by especially capable people, the Tobin q should rise above unity; when managed by especially incapable people, it should fall below unity. Accordingly, the Tobin q can be seen as a measure of the capability of the firm’s managers relative to their peers. This interpretation of the Tobin q allows one to obtain an independent measure of the managers’ capabilities, convert it to the q scale, and use the converted result to obtain the value of the firm. Thus, rearranging the terms of Equation 12 gives

$$Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5, \quad (14)$$

where

X_1 : Working capital divided by total assets

X_2 : Retained earnings divided by total assets

X_3 : Earnings before interest and taxes divided by total assets

X_4 : Value of firm, V , divided by total liabilities, L

X_5 : Total revenues divided by total assets.

Re-arranging Equation 14 to isolate the value of the firm results in the following:

$$V = \frac{ZL}{0.006} - 0.012X_1 - 0.014X_2 - 0.033X_3 - 0.999X_5. \quad (15)$$

Firms with higher Z values are stronger. Altman found that the Z value of 2.675 “discriminates best between bankrupt and non-bankrupt firms” (p. 607).

The Altman Z is an absolute index of likely insolvency, rather than a measure of relative capability, so those asked to make an independent judgment of a firm’s likelihood of insolvency should be asked an absolute question of the form, “What is your estimated likelihood of the firm becoming insolvent within the foreseeable future?” An estimated likelihood of 50% would then translate into an Altman Z of 2.675.

The problem with applying the Altman Z centers on how estimated likelihoods of other than 50% should be translated, on how firms that are already insolvent should be scored, and on the concern that people may not be able to supply good likelihood estimates for generally successful firms, whose likelihoods of insolvency in the foreseeable future may be in the fractions of a percent. Altman (1968) did assert that a Z score of 3.0 is “very high” (p. 609), and further study of Altman Z s in simulations may give a better sense of how likelihood scores should be translated to Z scores, but considering the ease with which the Tobin q can be applied to the problem of valuating firms, the

$$V = qA - L. \quad (13)$$

Independent measures of q can come from the collective judgment of competitors in a gaming simulation, as Thorelli (1997) has suggested, or from a panel of disinterested outsiders, as used in case-analysis competitions (Reed, 1979). These would be asked to give the firm’s management a numerical rating, based possibly on observations of participants’ interactions, on business plans and other writings, and on presentations. The several ratings of each firm would be averaged and divided by the global average of all firms combined to derive the judged q value. A multiplicative scaling factor also may be applied to moderate for sensitivity. Then if the book values are taken as the measures of A and L , the value of the firm can be computed using Equation 13.

As for the Altman Z , its original construction (Altman, 1968, p. 594) is as follows:

expenditure of efforts in trying to apply the Altman Z may not be worthwhile.

Even so, half a century of psychological research has shown subjective judgment to be inferior to objective methods whenever the two have been compared (Grove & Meehl, 1996). The use of deductive judgment to obtain the value of a firm therefore is defensible only when an objective method is unavailable.

ADJUSTED NET WORTH MEASURE

Adjusting the book value of a firm’s assets and liabilities is a common everyday-world method of deriving the value of a firm. This method is used when liquidating the firm is under consideration, in which case the adjusted value is known as the firm’s liquidation value. This method also is used when acquiring the firm is under consideration, in which case the acquiring party adjusts book value to obtain replacement value, because one alternative to the acquisition is to build an equivalent firm from scratch. Accordingly, one can sensibly obtain a measure of a firm’s value by examining its assets and liabilities in detail, adjusting each as needed, and arriving at the

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adjusted net worth by subtracting the sum of the adjusted liabilities from the sum of the adjusted assets.

Firms of the everyday world can have hidden liabilities in the form of long-term leases, contractual obligations, and the like. These issues generally do not affect simulated firms.

Everyday-world firms and simulated firms, however, share the common problem of hidden assets and unreasonably valued assets. A firm may have hidden assets because its investments, due to quirks in accounting, have not been capitalized. Hidden assets also may arise from the firm's position along the industry's learning curve, which may be sufficiently advanced so that its cost of production and volume of output are superior to other firms with the same fixed-asset base. Unreasonably valued assets can arise when market shifts or technological changes affects the utility of assets or makes available equivalent assets at other than historical cost.

The adjustment of assets can be approached either by capitalizing investments that have been expensed or by finding the replacement cost of the tangible or intangible assets. The first approach is sensible in some situations; the second approach, in other situations. Both approaches, however, should not be applied to any single situation, for that would overcompensate.

Based upon the principle of conservatism, generally accepted accounting rules of the everyday world call for the expensing of expenditures in intangibles, such as advertising, employee training, and research and development. These rules are sensible in the context of the everyday world, because the effects of those expenditures are speculative. In the context of business simulations, however, the effects are generally determined by a mathematical model, so they are not speculative at all.

Accordingly, in the general case when the effects are mathematically determined, the expenditures should be capitalized as investments for valuation purposes, but not necessarily for financial reporting purposes. The capitalization should follow the form of the simulation's model. For example, if advertising, Y , has an exponentially declining effect, such that an advertising expenditure of one period affects sales in the following period, with a residual effect that declines by α in successive periods such that the effect of advertising in any one period, E_t , is defined by the relationship,

$$E_t = f(Y_{t-1}, \alpha Y_{t-2}, \alpha^2 Y_{t-3}, \dots). \quad (16)$$

Then the capitalized value of the advertising expenditure, Y_t^* , from the start of the exercise to any period t should be as follows:

$$Y_t^* = Y_{t-1} + \alpha Y_{t-2} + \alpha^2 Y_{t-3} + \dots \quad (17)$$

$$R_n = \frac{C_1 n^{(\log_2 \phi + 1)}}{\log_2 \phi + 1} - n C_1 n^{\log_2 \phi} = C_1 n^{(\log_2 \phi + 1)} \left(\frac{1}{\log_2 \phi + 1} - 1 \right). \quad (22)$$

In adjusting the balance sheet, Y_t^* should be added to the firm's assets and to its net worth.

Finding the replacement cost of a tangible asset of a simulated firm is generally not difficult. That replacement cost is simply the cost of re-acquiring the same as given of the simulated setting.

Finding the replacement cost of an intangible asset, however, can be more of a challenge. Consider the case of learning, which is commonly modeled by the established learning-curve formula:

$$T_n = T_1 n^{\log_2 \phi}. \quad (18)$$

The exponent of n can be calculated by relying on the identity:

$$\log_2 \phi = \frac{\log \phi}{\log 2}. \quad (19)$$

For the right side of Equation 19, any logarithm will do, including natural and common logarithms.

In this common formulation, T_n represents the time to produce one unit of an item, T_1 represents the time to produce the first unit of the item, n represents the n th item, and ϕ is the learning coefficient, a parameter that ranges from 0.0 to 1.0, with smaller numbers associated higher rates of learning.

Inasmuch as production time is directly related to production cost, a reasonable application of the formula is to replace production time with production cost, C , as follows:

$$C_n = C_1 n^{\log_2 \phi}. \quad (20)$$

The cost that must be borne to bring the firm to the n th level of learning is the cumulative cost of production up to the n th level less the base cost, which is the cost at the n th level taken over n units of production. This difference is the extra cost that a firm with no learning experience must absorb before it will be as competitive as the firm with experience. This difference is illustrated by the shaded area of Figure 1, where n^* represents the firm's level of experience.

The cumulative cost of production up to the n th level can be found either discreetly by summing the unit costs up to the n th level, or continuously by integrating Equation 20. Thus,

$$\int C_n = \int C_1 n^{\log_2 \phi} dn = \frac{C_1 n^{(\log_2 \phi + 1)}}{\log_2 \phi + 1}. \quad (21)$$

The extra or replacement cost, R_n , of reaching the n th level is therefore as follows:

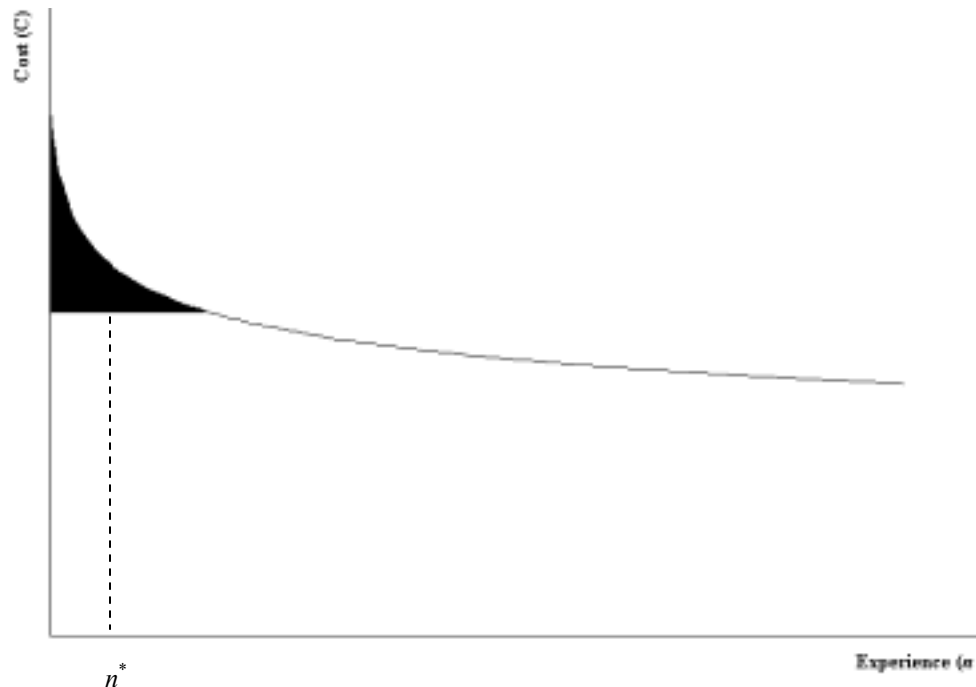


Figure 1
Learning Curve

Table 1
Costs by Levels of Experience

Experience (<i>n</i>)	Unit Cost (<i>C</i>)	Cumulative Cost		Base (<i>nC</i>)	Replacement Cost	
		Discreet (<i>X</i>)	Continuous (<i>Y</i>)		Discreet (<i>X - nC</i>)	Continuous (<i>Y - nC</i>)
1	100.0	100.0	117.9	100.0	0.0	17.9
2	90.0	190.0	212.2	180.0	10.0	32.2
4	81.0	355.6	382.1	324.0	31.6	58.1
8	72.9	657.4	687.7	583.2	74.2	104.5
16	65.6	1,204.0	1,237.9	1,049.8	154.2	188.2
32	59.0	2,191.1	2,222.8	1,889.6	301.5	338.7
64	53.1	3,970.8	4,010.9	3,401.2	569.5	609.7
128	47.8	7,176.8	7,219.6	6,122.2	1,054.6	1,097.4

Table 1 shows cost figures for various levels of experience given a learning coefficient of 0.9 and an initial unit cost of \$100. The discreet values are more correct, but the differences between them and the continuous values diminish rapidly, becoming about 4% of replacement cost by the 128th item.

CONCLUSION

Five measures of the value of a firm in a simulation have been considered, and three have been discussed in detail. Each measure is accompanied by a problem. The capitalized value measure requires at least one arbitrary parameter, *m*, if Goosen’s method is applied. The deductive judgment measure requires subjective judgment. The adjusted net worth measure avoids

both problems. It does not require an arbitrary parameter and it can be completely objective. Its problem, however, is that it requires detailed knowledge of the models used in any particular simulation.

Detailed knowledge of the simulation obviously is not a problem for the simulation developer, so the adjusted net worth measure is one that developers can use. Considering that the calculations required for the adjustments would be tedious and prone to error, developer should bear the burden of the computations by coding them into the simulation’s computer program.

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