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Discounted Downside Risk: The Time Dimension of Asset–Liability Management

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1. Introduction

Portfolio theory has produced many valuable insights for single period asset allocation. However, most institutions face a decision problem with two frequently neglected characteristics. First, the asset allocation decision depends critically on the relationship of assets with the institution's liabilities. Asset–liability management, as opposed to asset-only management, is a key ingredient to portfolio problems. Second, many portfolio decisions involve several subsequent future periods, whereas the standard portfolio model considers only a single period.

How can we incorporate these two critical factors into portfolio problems? Asset–liability relationships have been addressed in two methodologies. First, we can consider the "market value of liabilities" and base our investment policy on the net equity value, or surplus. As demonstrated by Sharpe and Tint (1990), liabilities can be incorporated by means of hedging credit adjustment to the expected rate of return on individual assets. Hedging credits are calculated from the co-variances between assets and liabilities after taking account of a risk tolerance parameter. By incorporating liability hedging credits we can still use the single period portfolio model for asset allocation purposes. The second approach favours downside risk as a decision parameter. Downside risk measures the risk of asset returns insufficient to meet future liability returns. By considering an expected return versus downside risk opportunity set we explicitly account for asset–liability relationships.

In this article we will argue that the liability hedging credit adjustment are insufficient for asset-allocation decisions. The key ingredient to this insight is that although we may be able to incorporate asset–liability relationships, we still omit a critical asset-allocation determinant: the added value from future business operations. As argued by several authors on risk management, without such a determinant the primary motive for risk management is absent. The added value from future operations, roughly equivalent to the firm's goodwill or franchise value, is typically dependent on the outcomes of the current asset–liability portfolio return. However, pay-offs are non-symmetric: only when the firm is sufficiently capitalized will future revenues be realized. Hence, the franchise value resembles an option dependent on the value of the firm's net worth. As is well known, portfolio theory does not lend itself easily to incorporating skewed distributions, and risk measures reflecting non-symmetric pay-offs should be used. Downside risk is such a measure and is relatively easy to use. However, as with the single period model, downside risk lacks time value. How do we compare the portfolio risk of period 1 to the portfolio risk of period 2? Since we think of downside risk as the cost of financial

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distress, ranging from the additional costs of raising new capital, the loss in net present value from foregone investment opportunities, to the cost of complete bankruptcy, we can compare downside risk across periods by simply discounting at a scenario dependent discount rate. Typically, the discount rate is determined by means of some contingent claims pricing model.

Our procedure is as follows. First, we will motivate the use of downside risk by means of insights from the functional perspective on financial intermediation. The key element is the franchise value of the firm. Second, we argue that downside risk is similar to an easy-to-understand cost of financial distress function. By using downside risk, we essentially calculate the cost to shareholders of possible scenarios under which the firm becomes financially distressed. Third, using this intepretation, we argue that the firm should balance the cost of financial distress with its other objectives, for instance the expected growth in net equity. Fourth, since dealing with costs we have a ready-to-use tool for evaluating multi-period portfolio problems, by discounting future costs at appropriate discount rates we account for the total cost of the asset-allocation decision. Moreover, we obtain an easy standard for evaluating alternative risk management strategies. Using two examples, one theoretical and one real, we illustrate our approach to financial risk management.

2. The functional approach and franchise value

Portfolio theory has been developed assuming perfect and efficient financial markets. Although the current state of financial markets resembles the theoretical fiction to a considerable extent, the state of the financial system (the combination of financial markets and financial institutions) does not and probably never will. As argued by Fama (1980), the role of financial intermediaries in a perfect and efficient financial system is merely that of low-cost transaction providers to market participants. Although for some financial institutions this is to some extent true – for instance open-end investment funds – it is not true for all institutions. It typically ignores the added value derived from services such as information processing (including costs associated with moral hazard and adverse selection problems), provision of payment systems, and reductions in search and switching costs.

These considerations have led to the development of a new theory of financial institutions, for example Bodie *et al.* (1994), and Beaver *et al.* (1995). Instead of focusing on the traditional institutional role of financial intermediaries (banking, insurance, etc.) the focus of the new theory is on the functional role of financial institutions as complimentary to (nearly perfect and efficient) financial markets. Competition and improved technology will continuously alter the functional role of institutions, thereby causing constant change in the operations of financial firms. However, by adapting to changing environments financial firms will continue to strive for added value obtained in their role of complementing financial markets. The market value of financial institutions reflects their ability to add value to the financial system. In fact, when evaluating the firms market value, we distinguish between:

- the present value of the asset–liability portfolio (the surplus, or economic – as opposed to actuarial, not relying on contingent claims theory – embedded value) as measured by the market value of assets minus the market value of liabilities (in fact when we use market value of liabilities we mean the market value of an asset portfolio that replicates the pay-offs from the liability portfolio, that is, with similar risk and maturity characteristics); and
- the present value of value added in future time periods (the franchise value).

The existence of franchise value is not only the key explanatory variable for the existence of financial institutions, it also serves as a key explanatory variable to its financial policy. It has been argued several times that when the franchise value of the financial institution is very small, or even negative, its portfolio policy may turn out to be risk-seeking, whereas positive franchise value guarantees the added value of risk management and hedging.

To determine the franchise value of a financial firm is a complex matter. In part as a result of regulation the franchise value is contingent on the realization of the surplus. Also, by choosing a particular asset–liability portfolio the firm implicitly affects it franchise value. Consider the Marcus (1984) model. Marcus assumes a fixed value, F, to be realized at time 1, conditional on the solvency of the firm (as monitored by regulators). Adopting a Black–Scholes option-pricing framework, Marcus shows that the market value of the frim's equity is given as:

$$E(0) = N(d1)A - N(d2)L + N(d1)F$$

where A is the market value of the asset portfolio and L is the market value of liabilities. The variables $d1$ and $d2$ are calculated as in the Black–Scholes equation. Since $d1$ depends on asset–liability portfolio volatility, the franchise's present value is directly affected by the choice of the current asset–liability portfolio.

3. Downside risk measuring the cost of financial distress

The Marcus model above is of interest as a conceptual tool. However, the model becomes impractical in real cases. For instance, if we are to apply the model to portfolio management decisions of a typical pension fund, what is the franchise value of the fund? Assuming the decision to maintain the fund is financially justified, the added value of the fund is to provide pension payments at lower expense as compared to pension insurance. However, to the fund's sponsor, the actual size of the fund's added value will be related to the costs of unforseen premium contributions by the sponsor. If we are to determine the franchise value of the fund we should also model the fund's sponsor. If we consider the decision problem of a banking or insurance firm, we should take into account the cost of raising new funds when conditions deteriorate. Relatively small amounts may be raised at little or no cost, thereby affecting the firm's franchise value only in a minor fashion. On the other hand, large deficits may cause the firm to become insolvent with a complete loss of franchise value. Since the franchise value may be realized in many, distant periods to come, under unpredictable financial market conditions, the franchise value is material yet difficult to quantify directly. Moreover, since we deal with essentially non-marketable assets, it is problematic even in theory to determine the appropriate value.

In summary, considering the problem of accurately assessing the franchise value of the firm, we may settle for an approximation. In general, as illustrated above by the impact of small versus large deficits, we can safely assume that the loss of franchise value increases disproportionately with the size of the deficit. If we assume costs are quadratic in the size of the deficit, the appropriate measure of the loss function is the downside risk, semi-variance or semi-standard deviation. Although this is necessarily an approximation, it has the advantage that it is relatively easy to use. As an example, suppose, as a pension fund, we associate a cost equal to the square of 5 per cent times the premium contribution increase. A premium increase of \$10 million receives a cost of \$0.25 million (presumably since it affects the sponsor only in a minor way), an increase of \$50 million obtains a cost of \$6.25 million (presumably since it causes the sponsor to forego some profitable new investment opportunities).

4. Balancing downside risk with firm objectives

The financial firm may adopt several objectives in setting its investment policy. For instance, a pension fund may seek to minimize the level of premium contributions paid by the fund's sponsor and employees. Financial corporations may, in addition to their shareholder value, pay attention to their return on equity, growth in assets and so on.

Whatever the particular objectives of the organization, several financial strategies may produce more or less similar results. Portfolio theory has highlighted the importance of the trade-off between expected return and risk. Suppose we assume that the objectives are stated in terms of the period's total rate of return on the firm's net equity or surplus. We can represent asset–liability choice as a trade-off between expected return on surplus and surplus risk. We obtain the familiar efficient frontier.

Our story goes further than this: what we learn from contingent claims pricing theory, if anything, is that the reduction of risk comes at a price. Risk corresponds to unequal pay-offs on the firm's net equity under alternative economic scenarios. If the pay offs (the return) on the surplus under some unfavourable scenarios increase, this comes at a cost. This cost can be calculated, at least in theory, as the price of an options portfolio that produces the required additional pay-offs.

When does a reduction in risk make sense economically? More specifically: when does a reduction in risk contribute to the value of the firm's equity? We have argued above that this makes sense in order to preserve the firm's franchise value. Clearly, a balance should be struck between increases in franchise value (by reducing risk) and decreases in value due to additional cost paid in expenses in order to reduce risk. Moreover, in real settings, other aspects, notably the tax treatment of assets, should be taken into account in order to provide the real value/cost trade-off. The particular outcome of such a trade-off will depend on the particular characteristics of the financial firm. But, in general, since the cost of risk reduction are small, the firm has a strong incentive to reduce risk in terms of downside risk, unless other value deteminant aspects (such as taxes) are important. In order to further illustrate our position we provide two examples: the first theoretical, the second a practical application.

Example 1: a stylistic ALM example

Assume that stocks follow a binomial process with upshifts equal to 30 per cent and downshifts equal to 10 per cent. Hence, the expected rate of return is 10 per cent p.a. and the standard deviation of return is 28.3 per cent p.a. We assume that the risk free rate equals 5 per cent p.a. Suppose we consider an asset–liability portfolio with net worth equal to $10. Further, the replication strategy for the liabilities is the risk-free security. We consider investment alternatives, assuming that we are concerned with shareholder value.

Figure 1 shows the evolution of the stocks and the liability. Consider a 100 per cent stocks investment strategy. At time 1 two possibilities may occur: we either have net worth equal to $138 or net worth equal to $6. In case of negative net worth serious financial problems can occur, yet it may be possible to mitigate distress by raising new capital. Of course the cost of raising new capital may be higher in case of distress and should be incorporated in financial decision making. At time 2 a possible deficit of $21.15 can result, when no action is taken with respect to the time 1 deficit.

Now, what is the downside risk and how do actions taken at time 1 affect the downside risk of time 2? We suggest that we quantify the value loss arising from the presence of a deficit. The larger the deficit, the larger the cost of mitigating distress and when deficits are huge,

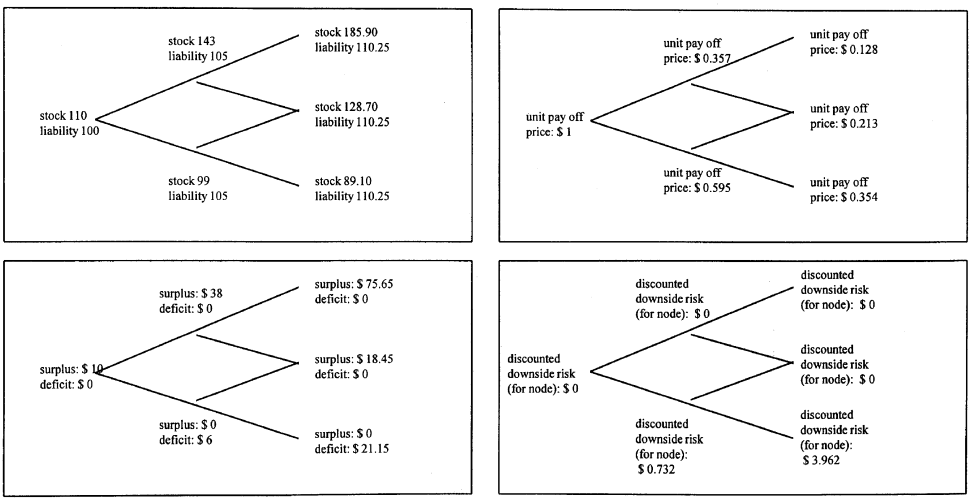

Figure 1: Stylized asset–liability projection

bankruptcy with a complete loss may be unavoidable. Suppose these considerations are reflected in the estimated cost of financial distress, equal to 2.5 per cent of the semi-variance of net worth. Now, the time 1 value of the potential deficit of \$6 implies a cost of \$0.90 to raise new capital or of foregone net present values from investment opportunities, at time 1. Using contingent claims theory, we calculate the present value of a pay-off at time 1 when stock returns are 10 per cent at \$0.595. Also, the present value of the cost from financial distress is \$0.732. Hence, we might be prepared to pay (at time 0) a positive insurance premium less or equal to \$0.732 in order to mitigate the deficit in this scenario. Note that the present value of surplus is not affected by the choice of investment policy since we assume that there are no arbitrage opportunities in the financial markets and there are no market imperfections (such as taxes).

However, since we seek to maximize shareholder value, we aim for cost minimization. In general, an asset–liability management study should determine whether it will be possible to obtain insurance at lower cost, for instance by means of market transactions. Suppose we obtain a put option that pays off \$6 at time 1 when stocks are down 10 per cent. The price of such an option is 6 times \$0.595 = \$3.571. Also, this is the present value of the deficit. In order to pay for the put option at time 0, we could, for instance, sell call options on the time 1 value of the stock paying \$10 when stocks are up 30%. The value of these options is 10 times \$0.357 = \$3.571. Note that the value of the options do not enter the cost function since they are part of the investment portfolio. Now, by means of such an option transaction we have eliminated all downside risk at time 1. This is the preferred strategy as long as the cost of setting up such a strategy is below \$0.595. Of course, we still have to deal with the deficit at time 2, but similar considerations help to find a solution for both time 1 and time 2 deficits.

Example 2: Discounted downside risk ALM model

Clearly, the above example is highly stylistic. We now turn to a more realistic example. Fortis is an international financial firm with banking, insurance and fund management activities. It has developed asset–liability management models for its core business activities — one of these is the so-called discounted downside risk model. In an operational environment we consider the evolution of the hypothetical life insurance operations. Based on a set of arbitrate-free scenarios, cash flow projections are made for each block of business.

In setting its investment policy three critical decision parameters are considered: the (economic) embedded value of the business, the return on equity, and the downside risk of the considered investment strategy. The embedded value equals the option adjusted present value of the distributable (free) cash flow to financiers. Besides the particular characteristics of the insurance portfolio, the required risk-based capital and the tax treatment of investment instruments are important. The return on equity equals the ratio of after-tax profits (including capital gains) to book equity and reserves, in addition to the embedded value, as a performance measure. As argued above, discounted downside risk can be considered as a multiple of the cost of financial distress.

As different investment strategies produce different outcomes in terms of these three parameters, a balance should be struck. Efficient frontier analysis is one method to illustrate the trade-off between discounted downside risk and performance (embedded value and return on equity). Figure 2(a) presents the efficient frontier for five different asset mixes, ranging from 100 per cent government bonds to 60 per cent government bonds and 40 per cent equity. Here we have plotted return on equity versus discounted downside risk. The higher expected rate of return on equities should be offset against a higher cost of distress. This is particularly clear from Figure 2(b), where we show the (economic) embedded value versus the discounted downside risk. Although the figure resembles the traditional efficient frontier it is critically different. Where the traditional efficient frontier presents expectations regarding future

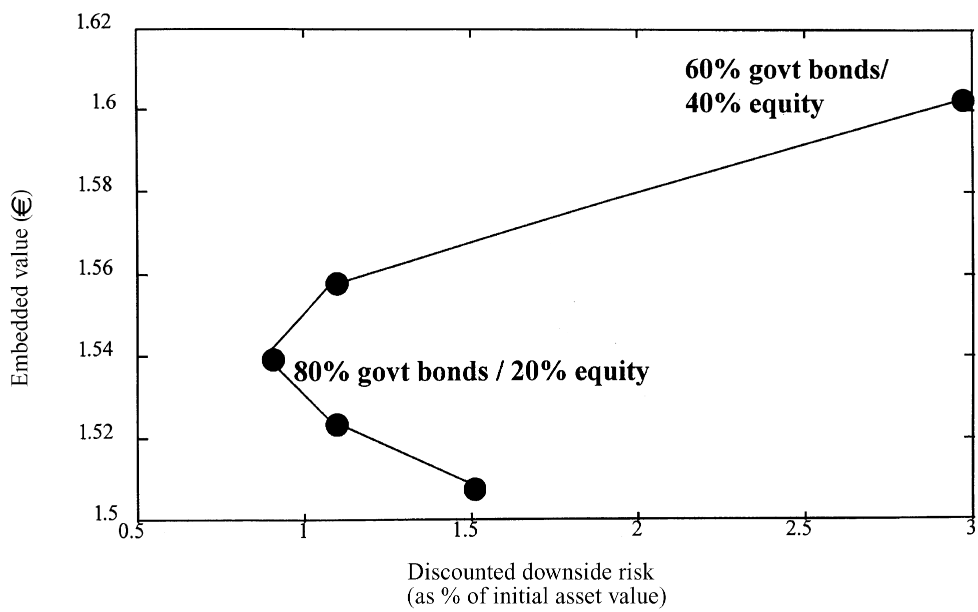

Figure 2:Cost/benefit curve: embedded value versus discounted downside risk

performance, our cost–benefit curve presents present values. Once we pick the cost to semi-variance multiple the curve presents a trade-off between market value (or cash) benefits and market value (or cash) expenses to the shareholders of the firm. Now, by picking the appropriate cost multiple (cost as a percentage of semi-variance) the optimal investment policy can be determined. Of course we do not have to limit ourselves to stocks and government bonds only; virtually any marketable financial asset can be incorporated in the model. The optimal strategy simply equates the gain in embedded value from equities (which is primarily tax driven) to the increased cost of financial distress.

5. Conclusion

In this article we have argued that downside risk is important since it measures the cost of financial distress and foregone investment opportunities. Founded on the function approach to financial intermediation we have highlighted the relationship between the firm's asset–liability management and its franchise value. In order to be economically viable, risk management should contribute to the firm's shareholder value. Since the cost of financial distress can be reduced by risk management, a trade-off between risk management expenses and the distress costs results. Discounted downside risk operationalizes this trade-off in a relatively simple and clear-cut way. In our examples we have not only illustrated the theoretical aspects involved, but we have also demonstrated how discounted downside risk can help set investment policy for financial institutions.

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