Exercising real options: the case of voluntary liquidations

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Abstract

This paper presents a theoretical and empirical model of voluntary liquidation. Using the insight from real options literature, we examine the rationale and optimality of US corporate voluntary liquidations for 1990-2000. We test the key predictions from the optimal option exercise boundary. OLS regressions suggest that both the interest effect and the variance effect are at work. However, it seems that performance variability is the key to liquidation decision. We therefore conclude that real options models have explanatory power.

Key Words: real options; voluntary liquidations; asset sale; first passage time

JEL Classification: G31, G33

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1. Introduction

A voluntary liquidation, according to Kudla (1988) "involves selling all of the firm's assets for cash, paying all outstanding debts from the proceeds, and distributing the remaining funds to stockholders as liquidating dividends. The corporate entity of the liquidating firm ceases to exist after liquidation."

This is in contrast to sell-offs, where the selling firm remains as a going concern and retains its corporate identity. Liquidations both can be voluntary and involuntary. Involuntary liquidations concern companies that are bankrupt or unable to pay their fixed contractual debts. If a company fails to pay its bondholders the company is in default and the bondholders may force the company into bankruptcy. However, voluntary liquidations mostly concern financially healthy companies. The purpose of voluntary liquidations is to increase shareholders wealth, which means that the company is worth more to the stockholders dead than alive. The act to voluntarily liquidate a company is therefore rational, well planned, and in the best interest of the common stockholders. The main reason for voluntary liquidation according to Kudla (1988) is that the liquidation proceeds distributed to the stockholders exceed the market value of the stocks.

According to Kudla (1988), Fleming and Moon (1995), Petty, Martin, and Kensinger (1999), voluntarily liquidated companies have three features in common. First, they had a favorable tax treatment for gains on sale of corporate assets. Second, the liquidating firm had a buyer for the company or the assets in the company and often the buyer was willing to pay a premium because the company or the assets were worth more to them than to the seller. Buyers that pay a premium for the company expect to benefit from synergies with the acquired company. Third, companies that liquidated showed a high degree of insider ownership, which facilitated the liquidation decision.

While voluntary liquidation is among the most important decisions that company directors may have to make, few papers have been written on it. Among this small number of papers, a variety of approaches are adopted. Fleming and Moon (1995) adopts a discrete choice model and investigates features of companies that have gone into voluntary liquidations and those that have not. The paper by Mehran *et al* (1998) studies the effects of CEO compensation plans on voluntary liquidation decision. They show that all parties involved gain from voluntary liquidations. This includes directors and shareholders. The debt capacity and industry equilibrium approach in Shleifer and Vishny (1992) focuses on resale price determination for corporate assets. John and Ofec (1995) regard asset sale as an integral part of corporate refocusing program. In a hitherto most comprehensive study of corporate asset sale, Maksimovic and Philips (2001) examine characteristics of companies engaged in asset sale and asset purchase and conclude both sides of the transaction gain from asset sale and liquidations. Schlingemann *et al* (2002) considers the impact of market liquidity on corporate divestiture decisions.

In this paper we pursue a real options approach, exploiting an analogy between liquidation decisions and exercising a put option, first indicated in Song and Gao (2000). Voluntary liquidation is analytically similar to an American put option. Two special cases have been solved by Samuelson (1965), McKean (1965) and Merton (1973). Song and Gao (2000) apply a standard result from this literature to the case of asset sale and scrapping. Under the assumption of going-concern, we may regard the company in possession of a perpetual American put option that confers the right to liquidate the company at any time in the future during the life of the company. Based on this insight, we derive and test a simple rule that depends on a few observable variables. Our model is in line with the real options tradition of Dixit and Pindyck (1994), Trigeorgis (1996), McDonald and Siegel (1986), Holland, Ott and Riddiough (1995), Bernardo and Chowdhry (2002). Compared to other approaches to voluntary liquidations, the real options approach has three advantages. First, it is based on rational and maximizing behavior. Second, the model predictions in our case are testable, as we shall show in this paper. Third, all information required to test the model are readily available in the annual reports or liquidation reports, or can be easily estimated. Since there is a general lack of empirical tests of the real options models, this paper also provides a simple methodology for testing real option predictions. Related approaches have been developed by Pollillo (1998), Moel and Tufano (2002).

Section two contains a brief description of the theoretical model in which optima liquidation rule is presented and the testable predictions are derived. These propositions are tested in section three. Test results indicate that company performance variability explains liquidation decisions well. Concluding remarks are offered in section four.

2. Voluntary liquidation as a put option

Using standard results in option pricing, Song and Gao (2000) show in the context of asset sale and scrapping, that when the operating profit of an asset reaches a critical level, it is rational and optimal to sell the asset at its resale price rather then by continuing to operate it. The model is based on the uncertainty of future cash flows generated by the asset. Uncertainty of operating profit creates an incentive to wait to sell the asset. Song and Gao (2000) indicate that the case of single asset sale may also be extended to decisions relating to a whole company. In this paper, we reinterpret the model of Song and Gao (2000) for studying voluntary liquidation.

We make three assumptions. First, following Song and Gao (2000), we assume that present value of company profit follows a geometric Brownian motion process:

$$\frac{d\pi_0}{\pi_{0\ \ 1}} = \mu_0 dt + \sigma_0 dz_0 \tag{1}$$

π_0- present value of operating profit from asset

μ_0- the mean growth rate

σ_0- the variance rate of operating profit

dz_0- standard Wiener process

Second, the company does not depreciate in that we treat the company as a going-concern. This is a durability assumption. This assumption is reasonable in that it conforms to the usual and standard going-concern in accounting and auditing. Lastly, the company may be liquidated at any time at a constant price. For empirical purposes, the assumption of constant resale price may be a first approximation. However, this last assumption may be weakened, as in Song and Gao (2001).

As we have indicated, our essential insight is to value the decision to liquidate as a put option. Like an American put option, whether to liquidate a company is an entirely voluntary decision and it is made to maximize share holder value. Using this analogy and following standard arguments of Black and Scholes (1973), Merton (1973), as applied to asset sale, it may be shown that value of the option to liquidate F satisfies the differential equation:

$$\frac{1}{2}\sigma_0^2\pi_0^2F_{\pi\pi}+r\pi_0F_\pi-rF=0 \tag{2}$$

The solution to (2) subject to appropriate boundary conditions is:

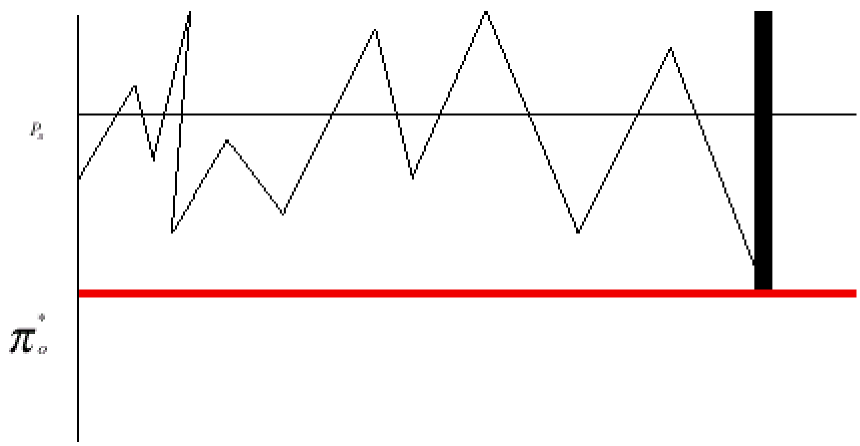
$$F=(\frac{P_S}{1+\gamma})^{1+\gamma}(\frac{\gamma}{\pi_0})^{\gamma} \tag{3}$$

with $\gamma=\dfrac{2r}{\sigma^2}$

$$\pi_0^*=\frac{2r}{\sigma_0^2+2r}P_s \tag{4}$$

In (3) and (4), r denotes the rates of interest and Ps is the proceeds from liquidation.

(4) is the optimal liquidating rule to be tested in this paper. It states that voluntary liquidation will take place when company profit fall below its liquidation value. This optimal rule is very intuitive and is the bases of our test. The following diagram, adopted from Song and Gao (2000), depicts optimal liquidation policy, where P_s denotes liquidation value and π_0^* represents the critical level of profits at which liquidation tales place.



Rearranging (4) and taking natural logarithms, we have:

$$\ln\left(\frac{P_S}{\pi_0^*}-1\right)=\ln\left(\frac{1}{2r}\right)+\ln\sigma_0^2 \qquad (5)$$

To implement (5), we have the following test specification:

$$Y=\alpha X_1+\beta X_2+\varepsilon(0,1) \qquad (6)$$

Y- logarithm of the ratio of liquidation value to accounting profit minus one

X_1- interest rate

X_2-the variance rate of accounting profit

Where

$$Y = \ln(\frac{P_S}{\pi_0^*} - 1)$$

H0: The normalized ratio of liquidation value over company profit is inversely related to risk-free rate of interest and positively correlated to performance variability.

3. Empirical tests

3.1 Sample selection

From Moody's Company Database, we search for a section called special event and identified 19 cases of voluntary liquidations for the period of 1990-2000. Our first screening process includes all companies that have liquidated. Then every company is evaluated by itself. All companies that have filed for bankruptcy and have liquidated all their assets are deducted from the sample as well as companies that have only partially liquidated. The companies that have remained have liquidated all their assets and the proceeds have been paid to the shareholders. The final sample includes 20 companies that have voluntarily liquidated.

To test the model, we use the following proxies. First, we use accounting profit to calculate performance variability. One might also calculate share performance variability as an alternative measure. However, we have not attempted this task. It is obviously better if we could use high frequency data to calculate the variance rate. Because we have decided to use accounting profit, we have to use low frequency data. Few companies in the sample have information about their gross profit of the last six quarters. This compels us to use annual gross profit. One company does not even have yearly data.

Second, the liquidation value of the company is needed as the constant resale price in the model. The value of the company at liquidation is collected from *interim report* from Moody in which liquidation value is referred to as either net assets in liquidation, total stockholders or shareholders equity, or simply net assets. The final sample includes nineteen voluntary liquidations. Compared to an early study by Fleming and Michael (1995), our sample is small. This is by no means unusual, however. Mehran, *et al* (1998) also has a small sample. Our testing methodology is different from both papers, as we shall show.

3.2. Estimation results and discussions

There are different methods and measurements to use when testing how well the independent variables explain the difference in the dependent variable. To test (8), the coefficient of determination (R^2), the significance of the f-value, and P-value will be used. The coefficient of determination determines how much of the variability in Y that is explained by the independent variables in the model. This value should be high if the model has a good fit, as Wetherill (1986) indicates. The significance of F measures how much of the error variance in the model compared to the variance in Y is explained by the independent variables. The unexplained part of the variance in Y is the error variance. The P-value expresses the reliability of the relationship between the independent variables and the dependent variable in the regression. The lower this value is the more reliable is it that the independent variable actually affects the dependent variable.

The results reported in Tables 1-3 show that the data describe our model rather accurate. All independent variables explain the variations in Y with high regression coefficients, as in Table 1. Note that due to our small sample size, the high coefficients might have resulted from low degrees of freedom. However, F test in ANOVA analysis indicates that out result is significant at 1% level. Note that this way of testing does not appear to have a highly intuitive interpretation for Y due to the way we calculated Y. However, as we shall suggest, there are other ways of testing voluntary liquidations using the same framework.

Table 3 shows the coefficients for X_1 and X_2, α and β, that describe how much of the variability in Y is explained by the interest rate and variance rate of the accounting profit. The constant for the model is not statistically significant which can be concluded by the significance level of the t-test. This means that the constant should not be included in the

model because it cannot be explained statistically if it is different from zero and thereby how it affects Y. It is neither an important measure. As indicated by Song and Gao (2000) the coefficient for the interest rate, α, should be less than zero and the coefficient for the variance rate of the accounting profit, β, should be greater than zero.
The coefficient for the interest rate, α, is positive but is not statistically significant, as Table 3 shows. There are two reasons for this result. First, it may suggest that interest rate, although affects option value, is not as significant in liquidation decisions. Second, this wrong sign may have to do with our formulation of test model.

The variance rate, on the other hand, does have an explanatory power and the coefficient is of the right sign at the significant level of 1%. This suggests that performance variability does explain voluntary liquidation decisions in practice. This can easily be understood since the variance rate of accounting profit affects the critical level of operating profit negatively, which will result in an increase in the value of Y, resulting in the positive relationship between Y and β. To our best knowledge, no previous study has demonstrated this relationship empirically. This is not surprising as no model has considered the decision as explicitly as we do.

3.3. Additional test

To further test the above result, we run a new model that excludes interest rate assuming that only performance variability affects liquidation significantly. The results, reported in Tables 4-6, show that the new model has the same explanatory power as our theoretical model predicts. Table 5 displays high statistical significance at the 1% level, indicating a good fit of the model and that the proxy, variance rate of gross profit well explains change in Y. Another result is that the intercept is better in the new model than the other model (compare table 3 and Table 6). However, it is not statistically significant and not very important for the fit of the overall model.

There may be several reasons for the difference in model performance. First, it may be that companies in the sample did not liquidate when it was most profitable for them, or the interest rate at the time of liquidation is not the best interest rate to use. Both of these are affected by the time of liquidation. The process of liquidating a company can be assumed to lag the decision to liquidate. The time lag between the decision to liquidate and the time when liquidation is completed and proceeds received may be considerable. Also, we have assumed a constant variance rate for gross profit. It is well known that the variance rate of the company changes over time. It may well be that our model does not capture this time-varying effect.

Subject to these caveats, our simple model does predict liquidations with the right sign and the regression coefficient for the variance rate is at the same 1% level in both the models. As far as we know, no paper has documented this relationship.

4. Conclusions

We have set up and tested a simple model of voluntary liquidations. Using the real options approach and employing standard results in option pricing theory, we derive some testable propositions. Our tests broadly are consistent with our option interpretation of voluntary liquidation.

Our theoretical model suggests two variables relevant to the exercise of liquidation decisions. Empirical results indicate that the interest rate effect may not be as significant in liquidation decision as for financial options. The coefficient for the variance rate, however, is highly significant at the 1% level. A modified model dropping interest rates results a better fit to the data. This may indicate that it's the fluctuation of current performance that is a key variable in liquidation decision and interest rate, although affects the value of the option, may only have a secondary effects in practice. On the other hand, there may be other effects at work which our model does not capture, such as agency factors and the market for liquidated companies. These are interesting issues for future research.

Various extensions of our methodology are possible. The one that immediately spring to mind is sample size. Second, the framework can be tested for voluntary liquidations in other economies. Second, other proxies may be used. This includes share price movement, total market value of the company and time-varying variance rate.

We have assumed a constant liquidation value. In practice, this is high unlikely. Previous studies have suggested variable resale prices. Theoretically, Song and Gao (2001) show that it is straight forward to incorporate the case of variable liquidation value. However, this begs questions for empirical implementations.

To conclude this paper, we should point out that within the same theoretical framework, it is possible to test voluntary liquidation decision in another way. This new way, developed and emphasized by Song (2001) for a class of real option exercise models, employ information contained in the optimal option exercise rule and the stochastic process. It is based on the first passage time in stochastic process. Song (2001), Huw and Song (2001) have developed more testable propositions based on this approach. They have also applied the approach to other problems such as asset life, and optimal convertible bond call policy. We shall report our results in separate papers.

Table 1. Model summary analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.910 [a]	.828	.806	.4880

a Predictors: (Constant), X2, X1

Note. X1 represents the interest rate at the time of liquidation and X2 represents the variance rate of the gross profit.

Table 2. ANOVA[b] variance analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.315	2	9.157	38.457	.000[a]
	Residual	3.810	16	.238		
	Total	22.125	18			

a Predictors: (Constant), X2, X1

b Dependent Variable: Y

Note. X1 represents the interest rate at the time of liquidation and X2 represents the variance rate of the gross profit.

Table 3. Regression coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.116	2.209		-.053	.959
	X1	6.232E-02	.375	.019	.166	.870
	X2	1.426	.185	.901	7.721	.000

a Dependent Variable: Y

Note. X1 represents the interest rate at the time of liquidation and X2 represents the variance rate of the gross profit.

Table 4. Model summary excluding interest rate

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.910[a]	.828	.817	.4738

a Predictors: (Constant), X2

Note. X2 represents the variance rate of the gross profit.

Table 5. Variance analysis excluding interest rate

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.308	1	18.308	81.551	.000[a]
	Residual	3.817	17	.225		
	Total	22.125	18			

a Predictors: (Constant), X2

b Dependent Variable: Y

Note. X2 represents the variance rate of the gross profit.

Table 6. Regression coefficients[a] with no interest

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.249	.169		1.474	0.159
	X2	1.440	.159	.910	9.031	.000

a Dependent Variable: Y

Note. X2 represents the variance rate of the gross profit.

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