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THE DETERMINANTS OF INTEREST RATES ON HIGH YIELD BONDS

BY

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ABSTRACT

The Determinants of Interest Rates on High Yield Bonds

By

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The aim of this paper is to examine the determinants of interest rates on high yield bonds. To that end, a model describing the forces driving the high yield market is derived. Equilibrium framework for the supply and demand functions of new high yield issues will produce a forecasting formula for the return on high yield investments. The results show the individual effects of the determinants of interest rate and their impact on market return. The model yields a small error when comparing the actual and forecasted values of the return on the bonds. The model is also able to predict turning points in the actual interest rate series with a high degree of accuracy.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

No other financial market experienced as much controversy and was the target of criticism as the high yield bond market. Public and professional opinions ranged from a strong belief in the viability and importance of this market to a complete distrust in the integrity of below investment grade debt. Critics of high yield securities underscored the status of below investment grade bonds by giving it names such as "junk bonds" and "securities swill". Nevertheless, the size of the high yield market increased rapidly in the last twenty years. During the years 1980-1996, the return on high yield bonds peaked at over 400 basis points above comparable treasury bonds.

High yield securities are debt instruments issued by corporate borrowers that are rated below investment grade. In most cases, other methods of raising capital such as bank lending or equity offering were either not available or more costly to these companies. Below investment grade companies are those who receive a rating of Ba or lower by Moody's or BB or lower by Standard and Poor. Bond rating measure the risk associated with the issue, in other words, the probability that the issuer will default on interest payments or on the principal. Bond rating alone is not an accurate measure as to the tangible risk, and therefore value, of the investment. Suffice to say that

companies like IBM, General Motors, Time Warner, and even the U.S. government where at one point rated below investment grade.

Despite the mixed opinions regarding below investment grade debt, investors found high yield bonds attractive hence the rapid increase of the market.[1] Historically, over 90% of the bonds issued by companies with revenues above $35 million and all of the those issued by companies with revenues below that amount are rated below investment grade. The official legitimization of the high yield debt occurred in 1977 when Bear Stems underwrote the first public sale of below investment grade bond. Prior to that year, high yield issues were privately placed with the exception of falling angels, which are issues that were rated investment grade and than downgraded to below investment grade. Publicly sold bonds carry a lower interest than privately placed bonds since they are more easily resold. This made high yield financing more attractive to issuers since they had to pay lower interest on the debt. Other investment houses followed Bear Stems and by 1983, 35% of all corporate issues were below investment grade, 65% of which were new issues.[2] Therefore, investments yielding higher returns became available to a wider range of investors. Consequently, the market experienced an increase in both the demand and the supply of high yield capital. The high yield-issuing craze

[1] See figures 1 and 2.
[2] Yago, 1991.

continued uncontrollably and resulted in the collapse of the market in 1989.[3] In that year, a massive number of issuers defaulted on their high yield debt. These defaults and the bankruptcy of Drexel Burnham Lambert, the biggest underwriters of below investment grade bonds, caused high yield new issues to virtually disappear in 1990. The high yield bond market was criticized by the financial press and Washington. Government regulations were imposed in an attempt to control the market yet the market recuperated a year later. By 1992, the high yield market reached its pre crash peak and continued to climb.

A significant amount of research was done on the effects of high yield financing both on the issuing companies and on the U.S. economy. Other research concentrated on the effects of government regulations of the high yield market. The return of the high yield market is the underlying reason for both the performance of the market, hence its effects on the economy, and government intervention. Despite the importance of the return on the bonds, little is known about the determinants of interest rates on high yield bonds.

The aim of this study is to identify these determinants and their impact on the rate of return of high yield investments. To that end, a model describing the forces driving the high yield market is derived. The model will introduce a new measure of risk that include default risk, credit risk, and the

[3] See figure 2.

various provisions on the bond. Effects of credit availability, general economic conditions, and LBO transactions will be accounted for. The model will also look at the supply and demand of capital and their relations with the return of the high yield market. Equilibrium framework for the supply and demand functions of new issues will produce a forecasting formula for the return on high yield bonds.

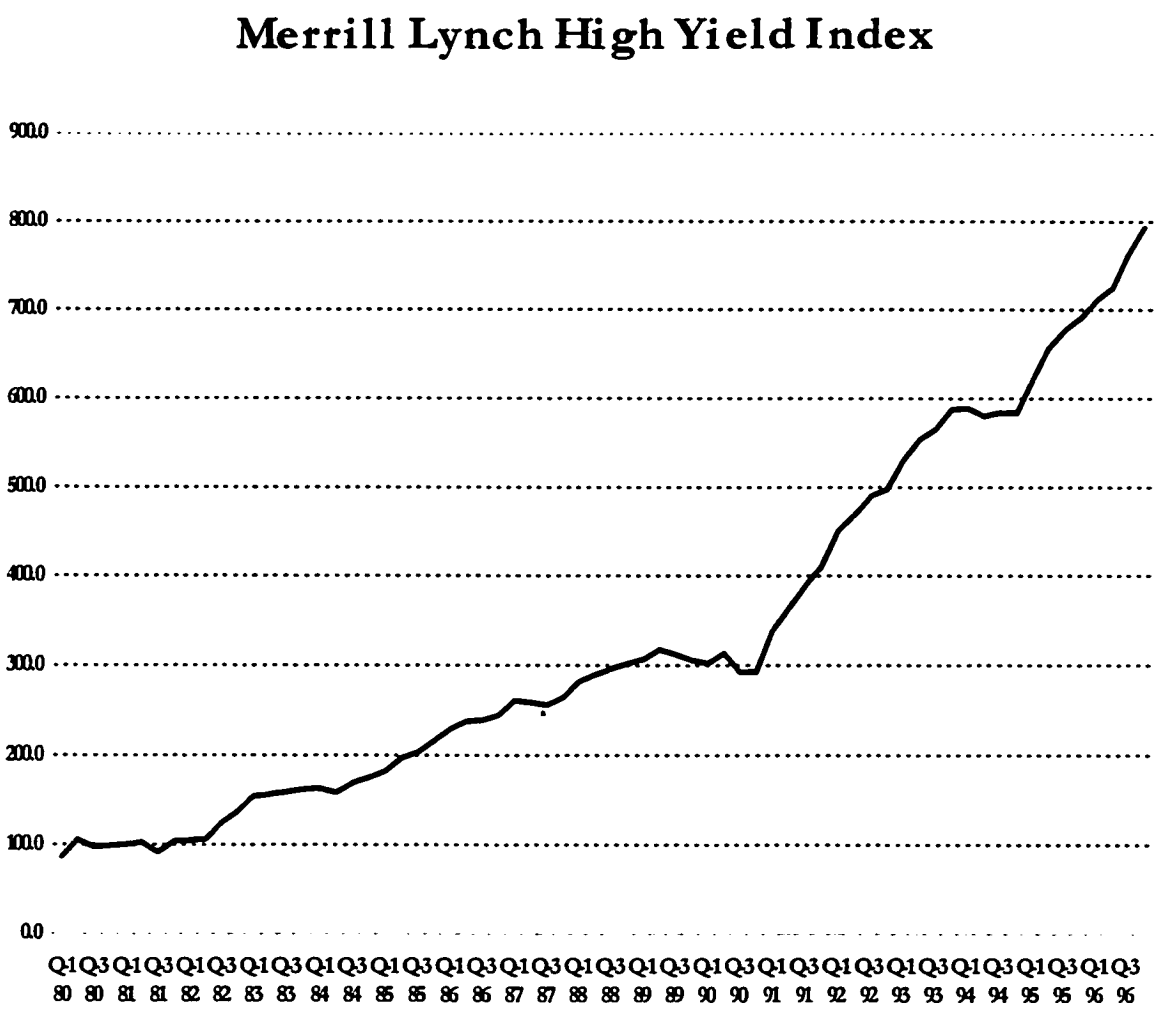

Figure 1: Return on high yields bonds.[4]

[4] For a complete description of the data, refer to Appendix A (I).

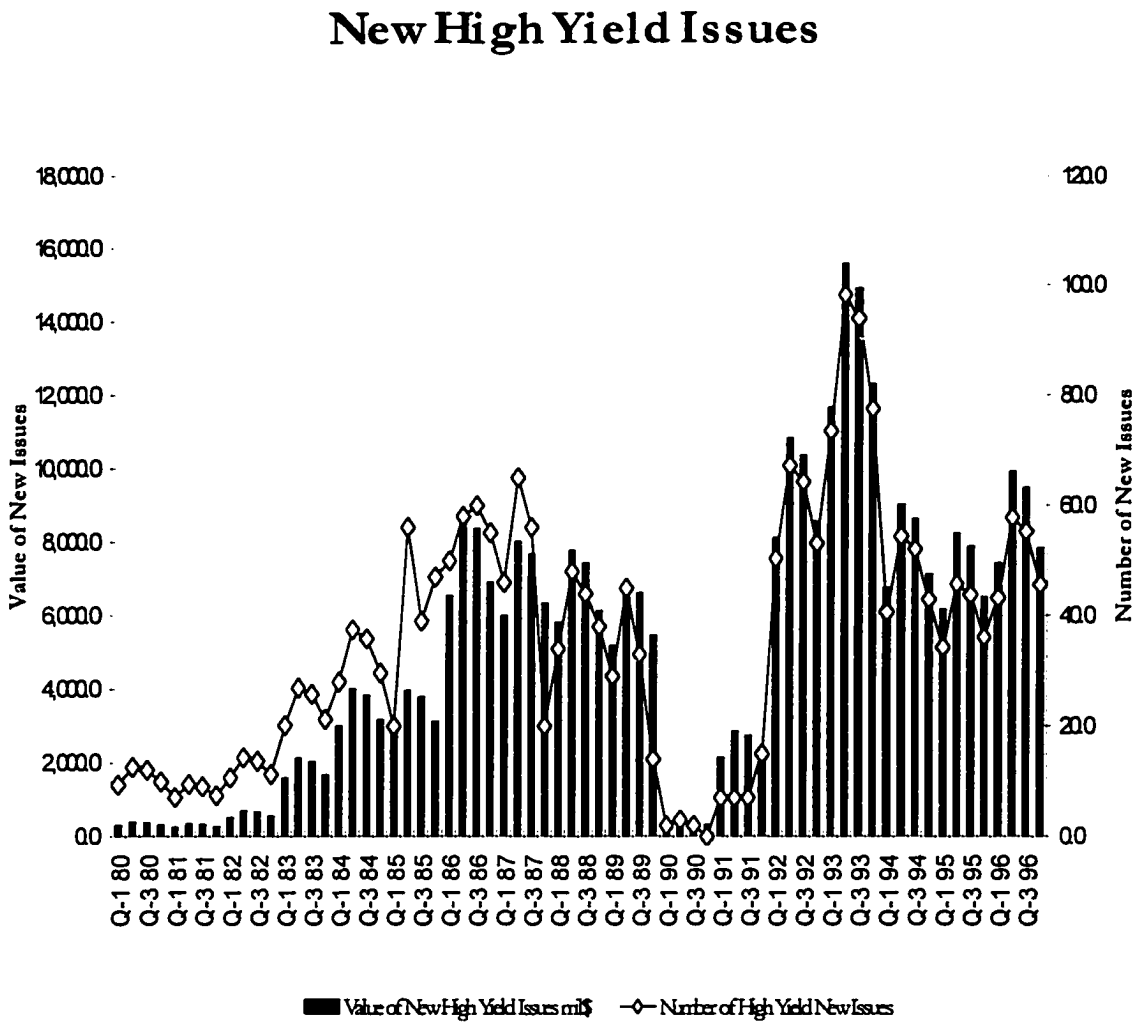

Figure 2: New High Yield Bonds Issues.[5]

[5] For a complete description of the data, refer to Appendix A (VII).

LITERATURE REVIEW

The current literature pertaining to the return on the high yield market can be grouped into two major areas of research. The first concentrates on the impact of below investment grade financing on issuing companies, capital markets, and the economy. While critics of this instrument call for regulation and even legislation restricting the market, supporters of high yield bonds argue that it is the interference with the natural forces driving the market that cause temporary contractions. The first section in the literature review is a brief summarization of empirical finding concerning these subjects.

The second area of research related to the high yield market, is theoretical framework and models of security pricing. Although most of the work on the pricing of corporate liabilities and the measurement of risk was done in a general format, some determinants of risk and return are relevant to the high yield market. One area specifically concerning below investment grade bonds that was explored in detail is the measurement of default rates. In the second part of this chapter, a survey of theoretical literature related to these issues is provided.

THE HIGH YIELD MARKET

The main concern of the literature regarding high yield financing is the relations between the risk and return of below investment grade debt. Blume and Keim [1987] found that high yield bonds, although risky if viewed alone, could produce conservative portfolios when combined with other assets. Their analysis, which concentrated on the years 1977-1987, showed that a portfolio of below investment grade securities outperformed the S&P 500 and treasury bills. Moreover, the inclusion of high yield bonds in the portfolio increases diversification and lowers the overall risk of the portfolio. Another important result was that the volatility of high yield issues was lower than that of the stock market.

The fact that the high yield market outperformed the treasure bills and the stock market was also note by Ma, Rao, and Peterson [1989], Yago [1991]. Yago and Siegel [1994] and DeAngelo et. al. [1993] who also noted that the high yield market outperformed the real estate and mortgage markets as well. However, Blume and Keim finding that the high yield market outperform the equity market with lower volatility was of special interest to the literature. In an updated version of the original study, Blume and Keim [1991] extended the analysis to 1990 and found their original finding to hold true for the entire period of 1977-1990.

As to the recovering power of the high yield market, Ma, Rao, and Peterson [1989] found the market extremely flexible. A comparison of default probabilities and yield spreads in both new issues and secondary markets revealed that high yield bonds are resilient with respect to major adverse economic events. The most complete historical overview of the high yield market and new methods of financing debt provided by Yago [1991]. Yago looked at the origin of high yield financing and its affect of corporate financing. Yago also contradicted the common notion that high yield debt was the major method of financing LBOs and hostile takeovers.

Another area of research was the effect of government regulations on the high yield market. Yago and Siegel [1994] showed, using tests of structural instability on an econometric model, that the high yield market experienced temporary declines in time of increased regulatory interventions. These interventions interfered with the market mechanism that responds to changes in default rates, yield spreads, credit availability, and general economic conditions. This paper also showed that the bad publicity that the high yield market received not only deterred investors from buying bonds but also created panic among holders of debt. Yago and Siegel found that the effects of media sentiment on the return of the high yield market were crucial.

DeAngelo, DeAngelo and Gilson [1993] examined the case of First Executive Corporation, the collapse of the biggest buyer of high yield debt issued by Drexel Burnham Lambert. They found that although the collapse of the high yield market clearly presented a problem for First Executive, it was the regulations along with adverse publicity that caused First Executive to collapse. Yago [1990] examined the public policy responses to the expansion of the high yield market. Local and federal governments restricted issuing, holdings, and tax deductibility of high yield bonds. Yago postulates that these regulations are detrimental to capital markets and economic growth.

Peter Tufano [1989] examined the relations between financial innovations and the price of the instrument. He found that investment banks that create new financial products do not charge a higher price for these innovations. The innovators advantage lies in capturing a larger market share before imitators copy and market the new product. This paper also provides a concise definition of price and quantity in the investment-banking context. The empirical evidence in this paper clearly shows that innovations permits a bank to create a differentiated service but do not create a monopoly, innovators charge a lower price than competitors before and after the innovation was imitated.

SECURITY PRICING MODELS

The first model formulating the pricing of a bond when there is a significant probability of default was written by Merton [1974] where he presented the theory of the risk structure of interest rates. According to Merton, the value of an issue depends of the return of a risk free asset, the default probability of the issue, and restrictions contained in the indenture.

Cox, Ingersoll, and Ross [1994] derived a rational asset-pricing framework to model the term structure of interest rates. They incorporated into the model expectations, risk aversion, investment alternative and consumption preferences. All of which play an active role in determining the term structure. This was the first time that these contingencies were accounted for.

The risk of default associated with high yield bonds was initially calculated as the default rate. Investment houses used the standard accounting method of combined losses on principal and interest due to defaulting bonds. Altman [1989] postulated that this measure overstates the actual loss to investors since defaulting bonds seldom lose all their value. Altman and Kishore [1997] indicated that common practice in measuring default rates is to use a finite period of time, usually one year, and average the

annual rates over longer periods. This method does not account for the effects the length of the issue has on default rates. Altman mortality rate notion, better measures default risk, and accounts for the length of the issue along with other provisions of the bond.

Another important model representing the behavior of interest rate was presented by Heller and Khan [1979]. In this paper, Heller and Khan incorporated the term structure, based on seven interest rates on government securities of different maturities, into a money demand function. By applying tests of parameter stability, they were able to show that the approximation appeared to be stable during period when standard functions that use only one interest rate were unstable. The relations between the term structure and real return on bonds were explored by Fama [1990]. Since the spread of the five-year bonds over the one-year spot changes with the one-year inflation rate, expected return and expected inflation move in opposite directions. Fama concluded that the short-term yield spreads, one to three years, show little forecasting power.

An important attempt to relate risk neutral models to high yield corporate issues was done by Fons [1987]. Fons derived a model to describe the relations between default premiums of bonds yields and actual default rates. The model tried to estimate expected default rates on high yield bonds.

Fons found that highly diversified portfolios reduce default risk but his model came short attempting to predict default rates. Fons [1989] studied the effects of new high yield issues on bonds return and found lack of funds mobility between the different markets due to adjustment costs. Fons also derived supply and demand formulas for high yield bonds as a function of interest rates spreads.

Levy and Livingston [1995] showed that many portfolios are based on a small number of securities despite of the fact that investment theory implies that broad diversification is the preferred method. They proved that lower transaction costs and better information provide an incentive to investors to minimize diversification.

Blume, Keim, and Patel [1991] examined the return on high yield bonds and compared it to the return on high-grade bonds and the stock market. They found that high yield bonds offered a higher return than high-grade bonds but lower then common stocks. Furthermore, the length of the issue had no bearing on the return or the default rate and there was no evidence that high yield bonds either were under or over priced.

Cornell and Green [1991] used low-grade mutual funds data to examine the performance of high yield bonds. They chose the mutual funds data since

it eliminates the selection bias problem. There is, however, some error in this measurement since mutual funds are not composed of solely high yield bonds, a small percentage of the portfolio contains high-grade bonds. Using a two-factor model, they found that over time, the return on high yield bonds approximately equals the return on high-grade issues. The main difference between the two classes was their risks. High yield bonds are less sensitive to movements in interest rates due to their shorter duration but are more sensitive to changes in the stock market.

DETERMINANTS OF INTEREST RATES

VARIABLES

The risk, R, that is associated with a corporate issue is a function of three components: interest rate risk, default risk, and the liquidity of the bond i.e.,

$$R = f(Ir, D, L).^{6}$$

Interest rate risk, Ir, refers to the interest earned by investing in a risk free asset such as government bonds. Every investment in a risk-bearing asset must carry a risk premium. A risk premium is the additional return earned from investing in a risky asset i over the return on a risk free investment, r_f.

$$Rp = r_i - r_f$$

The risk premium is an incentive for investors to assume the additional risk associated with investing in r_i. If r_f increases during the investment period T, consequently lowering Rp, the corporate issue looses from initial value. A measure for Rp is the interest rates spread of the high yield market over 10-year government treasury bonds.[7]

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[6] Merton, 1974.

[7] For a complete description of the data, refer to Appendix A (IV).

Default risk D is the probability that the issuer will not be able to pay back the debt on maturity. The issuing firm might not have the funds required to pay back the loan. In some cases, the issuing firm might even go bankrupt prior to the maturity date. Liquidity L measures the provisions on the bond. A bond that carry a call option usually yields a higher return since the issuer can redeem the bond at any time even above par. The opposite is true in the case of a put options. Other liquidity factors are various provisions on the bond. Provisions such as fixed or variable interest rate, the length of the issue, credit enhancements associated with the issue and the priority on collecting the debt in case of default, influence the risk associated with the issue.[8]

The risk components, D and L, are related since they both measure the probability that an investor will not collect fully on the investment. Bonds can exit the population of viable issues by default, calls, sinking funds, and of course maturity.[9] In order to account for D and L, I will define the mortality of a bond as the value of defaulted high yield debt at a given time D_t divided by the total value of outstanding high yield bonds at the same time HY_t.[10]

$$MR_t = \frac{D_t}{HY_t}$$

[8] Grossman, Goldman, Nesbitt and Mobila, 1993.
[9] Altman, 1989.
[10] Altman and Kishore, 1997.

Than I will calculate the cumulative mortality rate as

$$CMR_t = 1 - \prod SR_t$$

where the survival rate is

$$SR_t = 1 - MR_t$$

The cumulative mortality rate is a good measure of the effects of historical defaults in the high yield market on current and future risk associated with new issues.[11] By considering both CMR_t and Rp, the model will account for all the major components of the risk associated with investing in bonds.[12]

Historically, there was a positive relation between the performance of the stock market and the flow of funds into the bond market. When the stock market is booming, more funds are invested in diversified stock portfolios. These portfolios are hedged with fixed income securities such as high yield bonds. A standard measure of the equity market performance in a stock index. The variable WIL measure the performance of the stock market.[13] During periods of economic contraction or recession, investors will be concerned with future ability of the issuing company to pay back the debt. In

[11] For a complete description of the data, refer to Appendix A (VI).
[12] See table 1.
[13] For a complete description of the data, refer to Appendix A (II).

times of overall expansions in the economy, the demand for capital by way of debt financing is lower since companies revenues and higher. To measure general economic conditions I will use GDP.[14] Credit availability will affect the high yield bonds market. At times where credit is readily available in the market, the flow of capital into the high yield market will increase.[15] Credit availability, *CR*, is measured by the total market funds raised in the privet sector, excluding corporate and foreign bonds.[16]

A leverage buyout is a process in which a group of investors buys a company. The investors group makes a tender offer to buy the company's stock usually at a price of 20%-40% above the market price.[17] The next step in the LBO is to finance the acquisition. Since the final payment involves cash and issuance of preferred stock of the newly formed company, bonds are often used as the method of financing the transaction. Most bonds issues for the purpose of LBO are rated below investment grade. Higher LBO activity will increase both the number of newly issued bonds and the total dollar value of the new high yield issues. The variable LBO will measure leverage buyout activity.[18]

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[14] For a complete description of the data, refer to Appendix A (III).
[15] Yago and Siegel, 1994.
[16] For a complete description of the data, refer to Appendix A (V).
[17] Tufano, 1993.
[18] For a complete description of the data, refer to Appendix A (VIII).

In the last 15 years, both institutional and private investors have been increasingly willing to consider highly speculative high yield bonds. These investments, although risky if viewed alone, can produce conservative portfolios when combined with other assets.[19] A good measure for the return on the market is a mutual fund based on high yield securities or a high yield market index.[20] To measure the return on high yields, HYR, the Merrill Lynch high yield index will be used.[21] HYN will measure capital flow into the high yield bond market, i.e.; the total dollar amount of newly issued high yield bonds.[22]

[19] Blume and Keim, 1987.
[20] Yago and Siegel, 1994. DeAngelo, DeAngelo and Gilson, 1993.
[21] For a complete description of the data, refer to Appendix A (I).
[22] For a complete description of the data, refer to Appendix A (VII).

Mortality Rates By Original Rating – Corporate Bonds

1971-1996

Years after issuance

	1	2	3	4	5	6	7	8	9	10
AAA										
Yearly	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Cumulative	0.00	0.00	0.00	0.00	0.06	0.06	0.06	0.06	0.06	0.06
AA										
Yearly	0.00	0.00	0.47	0.27	0.00	0.00	0.01	0.00	0.04	0.04
Cumulative	0.00	0.00	0.47	0.74	0.74	0.74	0.74	0.74	0.78	0.82
A										
Yearly	0.00	0.00	0.05	0.15	0.08	0.16	0.06	0.17	0.12	0.00
Cumulative	0.00	0.00	0.05	0.19	0.27	0.43	0.50	0.67	0.79	0.79
BBB										
Yearly	0.03	0.39	0.41	0.67	0.40	0.54	0.21	0.10	0.10	0.46
Cumulative	0.03	0.42	0.82	1.49	1.88	2.41	2.62	2.72	2.81	3.27
BB										
Yearly	0.44	0.98	3.41	1.78	2.80	1.33	2.75	0.29	1.69	4.22
Cumulative	0.44	1.41	4.77	6.47	9.09	10.30	12.76	13.01	14.49	18.09
B										
Yearly	1.41	4.31	7.27	6.93	7.06	6.24	3.76	1.96	1.26	1.64
Cumulative	1.41	5.65	12.51	18.58	24.33	29.05	31.72	33.06	33.90	34.99
CCC										
Yearly	2.46	16.57	17.69	12.17	4.50	12.98	1.63	5.71	0.00	4.41
Cumulative	2.46	18.62	33.02	41.17	43.82	51.11	51.91	54.65	54.65	56.65

Table 1: Mortality rates.[23]

[23] Source: Edward Altman, New York University.

EMPIRICAL EVIDENCE

The first step in the analysis of the determinants of high yield interest rates is to measure the relations HYR and its components. Changes in the independent variables will affect HYR after a lag of one time period. Formulating this idea will yield the following formula:

$$(1)\quad HYR_t = a_0 + a_1 Rp_{t-1} + a_2 CMR_{t-1} + a_3 CR_{t-1} + a_4 WIL_{t-1} + a_5 GDP_{t-1} + a_6 LBO_{t-1} + a_7 HYN_{t-1} + \psi_t$$

After running the regression, I got the following results:

Variable	Coefficient	Standard Error
Constant	-28.526	2.772*
Rp	0.092	0.026*
CMR	0.022	0.025
CR	-0.046	0.027**
WIL	0.089	0.097
GDP	3.791	0.466*
LBO	-0.088	0.010*
HYN	0.115	0.012*

Table 2: Interest rates determinants regression. *Significant at 99%. **Significant at 90%.

The $\overline{R^2}$ was 98.78% and the standard regression error was 0.06 which indicate a very good accuracy in estimation. The Durbin-Watson test did not show any existence of autocorrelation in the model.

The results show positive relations between the return on the high yield market and the interest rate spreads, Rp. This finding is consistent with the theory behind the model since higher spreads imply a higher relative rate of

return. Furthermore, since the volatility of the risk free asset is significantly smaller than that of the high yield bonds, an increase in the spread is usually associated with an increase in the return on the high yield securities. Lower credit availability in the market forces borrowers to finance through high yield issues. Therefore, the demand for high yield capital increases and so does its price. There is a positive and significant relation between the performance of the market measured by GDP, and the return on high yield bonds as indicated in the positive coefficient of GDP. In times of good economic performance, the issuing company is able to pay back its debt. This reduces defaults and increases the overall return on high yield issues. The negative value of the coefficient of LBO transactions needs to be carefully examined. Since LBOs are often financed with the issuing of high yield bonds, higher LBO activity increases the demand for high yield capital. The increase in the demand for high yield capital presumably should increase the price of that capital. Since the results indicate the opposite, it proves that LBO transactions often result in default. Therefore, higher LBO activity will ultimately lower the total return on high yield bonds. The positive value for the coefficient of HYN indicated that as the market increased in size, the performance of the market increased as well.

MARKET EQUILIBRIUM MODEL

The return on high yield investments in defined as a function of interest spread, cumulative mortality rate, credit conditions, equity market performance, economic conditions, and LBO transactions. The measure of capital flow into the market is in the same time period as the return. This is different from HYN_{t-1} which was used in the previous chapter. In the equilibrium analysis that examines the supply and demand of high yield capital, the price and quantity are affected simultaneously.

$$(2)\quad HYR_t = \alpha_0 + \alpha_1 Rp_{t-1} + \alpha_2 CMR_{t-1} + \alpha_3 CR_{t-1} + \alpha_4 WIL_{t-1} + \alpha_5 GDP_{t-1} + \alpha_6 LBO_{t-1} + \alpha_7 HYN_t + e_t$$

The supply of capital, or the demand for high yield bonds, is a functions the return on these bonds in the same period. The supply also depends on interest rate spread and credit availability in the market, cumulative mortality rate, and equity market performance at the previous period.

$$(3)\quad HYN_t^s = \beta_0 + \beta_1 HYR_t + \beta_2 Rp_{t-1} + \beta_3 CR_{t-1} + \beta_4 CMR_{t-1} + \beta_5 WIL_{t-1} + u_t$$

The demand for high yield capital by the issuing firms is a function of the return on the bonds in the same period. It is also depends on credit conditions, LBO transactions, and general economic conditions in the market existed at the previous period.

(4) $HYN_t^d = \gamma_0 + \gamma_1 HYR_t + \gamma_2 CR_{t-1} + \gamma_3 LBO_{t-1} + \gamma_4 GDP_{t-1} + \varepsilon_t$

In equilibrium, the market will clear so that the supply and demand of high yield capital will be equal. In other words, all bond issues by companies in need of capital will be purchased by investors. Therefore, the equilibrium condition is:

(5) $HYN_t^s = HYN_t^d$

By substituting into equation (5) the supply and demand functions (3), (4), and solving for HYR we get:

(6) $HYR_t = \Pi_0 + \Pi_1 CR_{t-1} + \Pi_2 LBO_{t-1} + \Pi_3 GDP_{t-1} + \Pi_4 Rp_{t-1} + \Pi_5 CMR_{t-1} + \Pi_6 WIL_{t-1} + \Omega_t$

Equation (6) represents the determinants of the interest on high yield bonds. Since the function contains a lagged dependent variable, it can be used to forecast the return on the high yield market. This framework for simulating market behavior provides a dynamic model that accounts for the stochastic term Ω_t, which is guided by a certain probability distribution. This model is the structural form of simultaneous equations with nonlinearly in parameters.[24]

[24] For a complete derivation of the model, refer to appendix B.

ESTIMATION

Equation (6), which is the reduced form of the equilibrium model, was estimated using OLS and the estimation results are presented in the following table:

Variable	Coefficient	Standard Error
Constant	-18.963	3.956*
CR	0.023	0.040
LBO	-0.046	0.014*
GDP	2.099	0.660*
Rp	0.004	0.038
CMR	0.086	0.037
WIL	0.466	0.136*

Table 3: Reduced form regression. *Significant at 99%.

The $\overline{R^2}$ was 97.10% and the standard regression error was 0.106. The coefficients indicate negative relations between the return on the high yield market and LBO transactions, LBO. This finding is consistent with the theory presented in the previous section that LBO transactions often result in default and therefore, higher LBO activity will ultimately lower the total return on high yield bonds. There is a positive and significant relation between the performance of the market measured by GDP, and the return on high yield bonds as indicated in the positive coefficient of GDP. In times of poor economic performance, the issuing company is less able to pay back its debt. This increases defaults on the debt and decreases the overall return on high yield issues. The relations between the bonds and equity market are positive.

This fact is consistent with the theory behind the model that many portfolios are stock portfolios are hedged with high yield bonds.

FORECAST

The reduce form of the simultaneous equations model presented in the last chapter and its solution yield an econometric forecast formula:

$$HYR_t = \Pi_0 + \Pi_1 CR_{t-1} + \Pi_2 LBO_{t-1} + \Pi_3 GDP_{t-1} + \Pi_4 Rp_{t-1} + \Pi_5 CMR_{t-1} + \Pi_6 WIL_{t-1} + \Omega_t$$

Since the HYR is lagged, we can calculate the forecasted value at $t+1$ gives the available data of the independent variables at time t. The numerical values of the coefficients Π_i are:

$$HYR_t = -18.963 + 0.023 CR_{t-1} - 0.046 LBO_{t-1} + 2.099 GDP_{t-1} + 0.004 Rp_{t-1}$$

$$+ 0.086 CMR_{t-1} + 0.466 WIL_{t-1}$$ [25]

By applying ex-post forecast for the estimation period using the above equation we get the forecasted return on the high yield market.

FORECAST RESULTS

The forecast values are presented in the following table:

Date	HYR	Forecast	Abs. Error
Q1 80	4.45680		
Q2 80	4.65935	4.48410	0.17525
Q3 80	4.57779	4.46650	0.11129

[25] For complete derivation of coefficients in the forecast formula, see appendix B.

Date	HYR	Forecast	Abs. Error
Q4 80	4.59169	4.53665	0.05504
Q1 81	4.60227	4.65317	0.05090
Q2 81	4.62767	4.81344	0.18577
Q3 81	4.51580	4.79244	0.27664
Q4 81	4.63802	4.77139	0.13337
Q1 82	4.65070	4.72061	0.06991
Q2 82	4.65913	4.78139	0.12226
Q3 82	4.81691	4.78168	0.03523
Q4 82	4.92397	4.75499	0.16898
Q1 83	5.03467	4.84800	0.18667
Q2 83	5.04987	4.95597	0.09390
Q3 83	5.06586	5.04219	0.02367
Q4 83	5.08548	5.10743	0.02195
Q1 84	5.09181	5.14839	0.05658
Q2 84	5.06471	5.15326	0.08855
Q3 84	5.12843	5.11889	0.00954
Q4 84	5.16169	5.10160	0.06009
Q1 85	5.20395	5.16174	0.04221
Q2 85	5.28238	5.23282	0.04956
Q3 85	5.31164	5.28171	0.02993
Q4 85	5.37461	5.32953	0.04508
Q1 86	5.43424	5.32914	0.10510
Q2 86	5.46943	5.38964	0.07979
Q3 86	5.47504	5.44322	0.03182
Q4 86	5.49807	5.47414	0.02393
Q1 87	5.56394	5.46335	0.10059
Q2 87	5.55405	5.53696	0.01709
Q3 87	5.54401	5.62802	0.08401
Q4 87	5.57585	5.64546	0.06961
Q1 88	5.64075	5.72292	0.08217
Q2 88	5.66814	5.61838	0.04976
Q3 88	5.69057	5.64547	0.04510
Q4 88	5.71057	5.66228	0.04829
Q1 89	5.72578	5.69548	0.03030
Q2 89	5.76091	5.74084	0.02007
Q3 89	5.74411	5.77290	0.02879
Q4 89	5.72189	5.80227	0.08038
Q1 90	5.71101	5.86043	0.14942
Q2 90	5.74798	5.99368	0.24570
Q3 90	5.68107	5.96477	0.28370
Q4 90	5.67862	5.96874	0.29012
Q1 91	5.82485	5.89509	0.07024
Q2 91	5.89817	5.96434	0.06617
Q3 91	5.96439	6.03975	0.07536
Q4 91	6.01664	6.02841	0.01177
Q1 92	6.11092	6.06301	0.04791

Date	HYR	Forecast	Abs. Error
Q2 92	6.15146	6.14378	0.00768
Q3 92	6.19398	6.10810	0.08588
Q4 92	6.20851	6.14658	0.06193
Q1 93	6.27271	6.17546	0.09725
Q2 93	6.31543	6.23606	0.07937
Q3 93	6.33810	6.24719	0.09091
Q4 93	6.37587	6.25716	0.11871
Q1 94	6.37863	6.31496	0.06367
Q2 94	6.36279	6.36343	0.00064
Q3 94	6.36969	6.35481	0.01488
Q4 94	6.36898	6.35789	0.01109
Q1 95	6.42961	6.39969	0.02992
Q2 95	6.48677	6.43377	0.05300
Q3 95	6.51771	6.46789	0.04982
Q4 95	6.53850	6.51111	0.02739
Q1 96	6.56690	6.55595	0.01095
Q2 96	6.58607	6.58366	0.00241
Q3 96	6.63715	6.63103	0.00612
Q4 96	6.67682	6.62997	0.04685

Table 4: Forecasted high yield market returns.

By graphing the forecasted vs. actual values we see the model was able to follow the true behavior of the market.

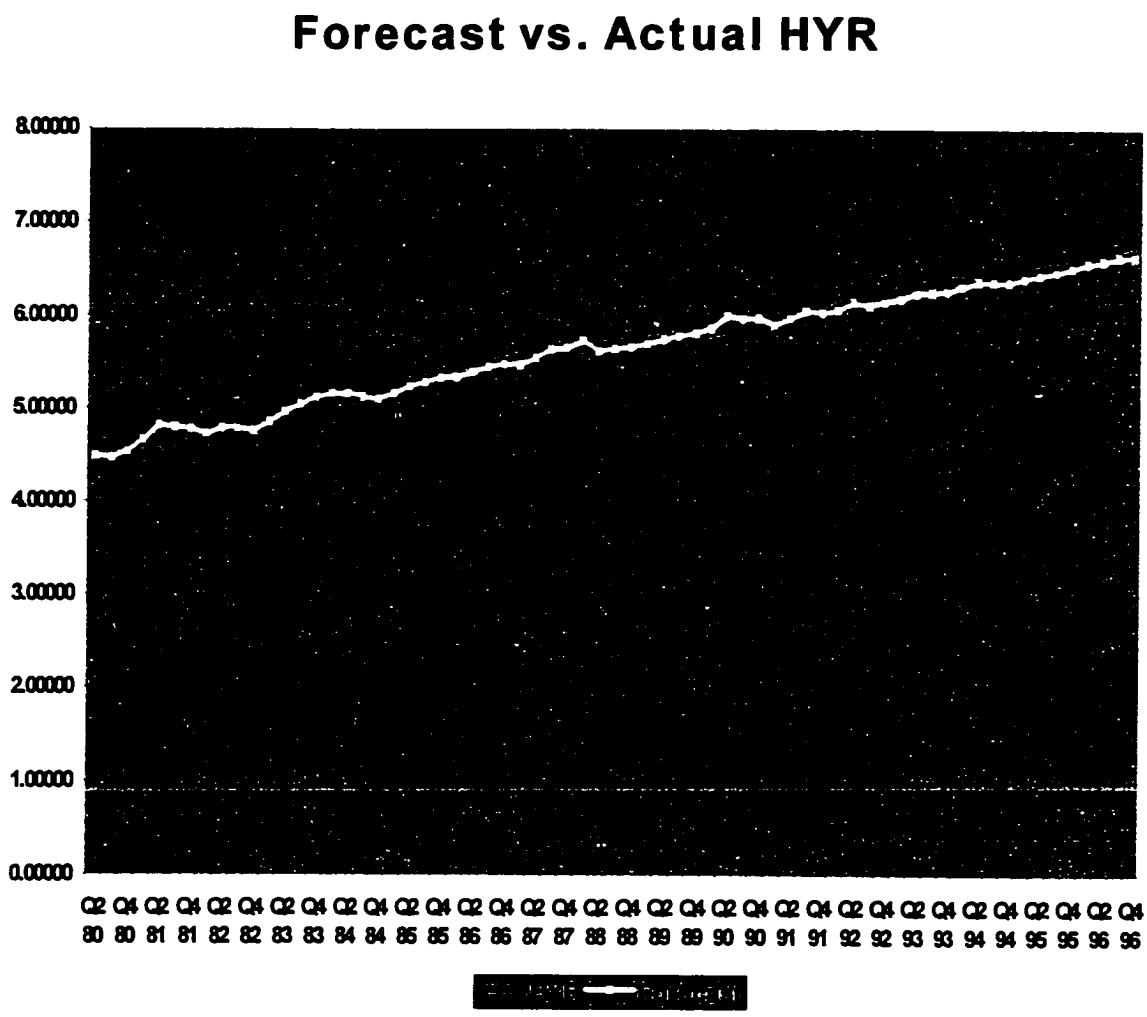

Figure 3: HYR forecast vs. actual values.

Not only the forecasted values are close to the actual values; the forecasted series was able to closely simulate the market trend. There are three, relatively

small, intervals in which the forecasted series fails to pick up upward or downward trends in the actual series. The overall trend of the return of the high yield market was simulated by the forecasted data.

MODEL EVALUATION AND FORECAST ERROR

The use of quarterly observation raises concerns about possible autocorrelation problems. In that regard, autocorrelation tests did not show the error to be an autoregressive process. Another measure taken to assure the estimators are efficient was re-running the model with the assumption that autocorrelation exists. Again, there was no evidence that autocorrelation was a problem in the model.

Since data involving time series tends to move in the same direction, often a good fit in the regression may not reflect the true association between the variables. One particular extension to the model would be to examine the data series and to determine if they are stationary. Unfortunately, this research paper experienced some data restrictions. Although I am aware of the literature, the data available did not allow me to perform adequate stationary tests.

The problem of spurious correlation was a concern as well.[26] To that end, a de-trended version of the regression was run. A high R^2 and significant coefficients showed that no spurious correlation problem is present.

[26] Gujarati, 1995. Mill, 1996.

The results of the regressions used to estimate the model where significant. However, the model as a whole has a much richer dynamic structure than any individual equation. Fit tests for the complete model are presented in this section.

Mean simulation error (MSE) and mean percent error (MPE) are used to measure the discrepancy between the forecasted and actual values.

$$MSE = \frac{1}{T}\sum_{t=1}^{T}\left(Y_t^f - Y_t^a\right) = 0.101$$

$$MPE = \frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^f - Y_t^a}{Y_t^a}\right) = 0.019$$

The value of MSE, 0.101, indicates that the mean deviation of the forecasted value from the actual was very small. We must consider this value with relation to the size of HYR, which ranges from 4.45 to 6.67. The MPE of 0.19% is a better indication as to the small forecasting error in the model. Mean error present a possible problem if the forecasted and actual series intersect over T. Large positive and large negative errors may cancel each other so that an error value close to zero might misrepresent the forecast error. For this reason, mean absolute error (MAE), mean absolute percent error (MAPE), root mean square error (RMS), and root mean percent error (RMSP) are calculated.

$$MAE = \frac{1}{T}\sum_{t=1}^{T}\left|Y_t^f - Y_t^a\right| = 0.07$$

$$MAPE = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{Y_t^f - Y_t^a}{Y_t^a}\right| = 0.01$$

$$RMS = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^f - Y_t^a\right)^2} = 0.000000008$$

$$RMSP = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\frac{Y_t^f - Y_t^a}{Y_t^a}\right)^2} = 0.0003$$

We see that the value error measure, MAE and RMS, are very low. The percent errors are low as well, 1.4% and 0.003%.[27] The other standard test for errors in forecast is the Theil inequality.[28]

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^f - Y_t^a\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^f\right)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_t^a\right)^2}} = 0.008$$

where $0 \le U \le 1$.

This value shows that the forecast is relatively accurate since if $U = 0$, than $Y_t^f = Y_t^a$. The variance of U over t can be approximated by

$$Var(U) \approx \frac{U^2}{T} = 0.000001$$

[27] Pindyck and Rubinfeld, 1991.
[28] Theil, 1961.

All error measures indicate that the model has a low forecast error. The deviation of the forecasted value from the actual value is one aspect of an accurate forecasting model. The other aspect is the ability of the model to predict turning points. A turning point error occurs when the model either predicted a false turning point (type I error) or failed to predict a turning point (type II error). Since the forecasted value Y_t^f is available before the actual value Y_t^a, Y_t^a has a probability distribution with mean Y_t^f and variance σ_ε^2, where the actual value can be written as $Y_t^a = Y_t^f + \varepsilon_t$.[29] If we assume ε_t to have $\mu_\varepsilon = 0$ and constant variance σ_ε^2, we can use the regression:

(7) $$Y_t^a = \alpha + \beta Y_t^f + \omega_t$$

Where ω_t is the disturbance with variance σ_ω^2. If the forecast error ε_t is uncorrelated with Y_t^f, β will equal one and $\sigma_\omega^2 = \sigma_\varepsilon^2 = MSE$. This means that the forecast is efficient when $\alpha = 0$ and $\beta = 1$.

The results of regression (7) are presented in the table below:

	α	β
Coefficient	0.000	1.00
Standard Error	0.11	0.02

Table 5: Turning points regression analysis.

[29] Su, 1996.

The regression results show that the model was able to predict with a high degree of accuracy turning points in the actual series. Both hypotheses $H_0 : \alpha = 0$ and $H_0 : \beta = 1$ were accepted with 99% confidence. The regression had $\overline{R^2} = 97.3\%$ and error of 0.102.

ESTIMATING SUPPLY AND DEMAND FUNCTIONS

The model contains two endogenous variables HYR and HYN. The method of two stage least square was used to evaluate the coefficients α, β, and γ. The procedure was run twice, first on equations (2) and (3), and than on equations (2) and (4).

THE SUPPLY OF CAPITAL

The results of the first regression analysis regarding the return on high yield securities and the supply of capital were:

Dependent Variable HYN_t^S

Variable	Coefficient	Standard Error
Constant	26.601	7.695*
HYR	3.852	0.757*
Rp	-0.393	0.244
CR	0.877	0.237*
CMR	0.397	0.253
WIL	-3.058	0.740*

Table 6: Supply function estimation, HYN_t^S dependent variable. * Significant at 99%.

The regression estimation of HYN_t^S, the supply function, had an error of 0.69 and $\overline{R^2} = 0.69$. With the exception of interest rate spreads and CMR, all the coefficients where significant. There is a positive relation between the return on the bonds and the supply of capital. In other words, the higher the return on the bonds the more investors are willing to invest in below

investment grade securities. The results also support the theory that demands for high yield bonds is lower when credit conditions are relatively tight, as it is more difficult to raise capital. At such periods, the supply of capital in general, and for high yield securities in particular, is lower. The negative relations between the equity market and the supply of high yield capital indicates that investors will direct more funds into the bonds market when the stock market performs poorly. In other words, investors decide where to invest according to expected returns. This does not contradict the positive relation between the return of high yield bonds and the stock market performance.

The above results are a good estimation of the supply function of the high yield capital. It measures the effect of each component of the supply function. Since the series are in logarithmic form, the coefficients measure the individual elasticities of each determinant and the supply of high yield capital.

THE DEMAND FOR CAPITAL

The results of the second regression analysis dealing with the demand for high yield capital were:

Dependent Variable HYN_t^d

Variable	Coefficient	Standard Error
Constant	174.156	21.167*
HYR	5.698	0.533*
CR	0.691	0.199*
LBO	0.362	0.077*
GDP	-23.696	2.802*

Table 7: Demand function estimation, HYN_t^d dependent variable. * Significant at 99%.

The coefficients of the high yield capital demand function, HYN_t^d, are significant. The regression error was 0.54 and $\overline{R^2} = 81.26\%$. The relation between the rate of return in the market and the demand for high yield capital is positive. This paradoxical result stating that as the price of high yield financing increased, the demand for this capital also increased. The data used in this analysis did not provide an adequate measure for the demand on high yield capital. The demand function presented here should be viewed with caution.

Credit conditions have a positive effect on the rate of return in the market. Companies issues more high yield debt at times when this debt can be sold. More expansions within companies are made when credit is available;

expansions that are financed with high yield bonds. LBO transactions are partially financed with high yield debt. As the value of these transactions increase, so does the demand for high yield debt used to finance the buyouts. GDP is negatively related to the demand of capital. In times of overall expansions in the economy, the demand for capital by way of debt financing in lower since companies revenues and higher. Therefore, companies already own the capital needed for R&D, acquisitions, or expansion and their demand for the more expensive high yield capital is lower.

CONCLUSION

The determinants of interest rates on high yield corporate bonds are a mixture of standard components relating to debt issues and unique elements specific to below investment grade issues. Bond rating by investment houses is not an accurate measure of the risk associated with the issue. Risk, which determines the value of the bond, depends on risk free interest rates, default risk, and provisions on the issue. By measuring all aspects of the risk affiliated with these investments and accounting for the major forces driving the market, the model presented in this paper described the behavior of interest rates on high yield bonds. There exists a significant relation between the return on high yield investments and capital flows into the market. Equity markets performance and general economic conditions also play a major role in determining the interest rate on the bonds.

The forecasting formula presented in this paper was able to simulate the high yield market behavior with a substantial degree of accuracy. The forecasting error was small both in value and in relative terms. The forecasted series was able to predict turning points in the actual series.

APPENDIX A

DATA SOURCES AND CONSTRUCTION OF VARIABLES

This appendix provides information on the data used in this study. Details about the methods used in constructing the variables are provided as well. The data for the analysis was quarterly figures for the years 1980 through 1996. Natural logarithm values of the series were used in the regression analysis.

I. *High Yield Return* – For the measure of the return on high yield bonds, the Merrill Lynch 175 index was used. This index, which calculates the return on high yield debt, has been normalized to a base of 100 in December 1979. (Source: Merrill Lynch.)

II. *Stock Market Performance* – Data on the Wilshire 5000 Index is used as an indicator of the stock market performance. This series in chosen because it provides the broadest measure for the equity market's performance. (Source: Dow Jones.)

III. *General Economic Performance* – Gross Domestic Product was used for a proxy of general economic conditions. Since the model concentrates on domestic debt, the GDP is a good measure of changes in economic

conditions affecting the performance of the issuing company and its need to raise capital. (Figures in billions, Source: Federal Reserve Bank.)

IV. *Interest Rates Spread* – The measure used for interest rates spread, or risk premium, was the spread of high yield securities over 10 year treasury bonds. (Source: Merrill Lynch.)

V. *Credit Availability* – The estimate for credit availability in the market was defined as total non-federal funds raised excluding corporate and foreign bonds. These figures are published by the FED in its Z1 release. (Figures in billions, Source: Federal Reserve Bank.)

VI. *Mortality Rates* – Two series were used in calculating the mortality rate. These series were outstanding high yield debt and defaulting high yield debt. Both series accounted for straight debt only and excluded defaulted issues from par value outstanding. (Source: Edward Altman, New York University.)

VII. *New Issues* – This study used both the dollar value and the number of new high yield issues while analyzing the determinants of the return on the high yield bonds. In the regression analysis, the dollar value series

was used as a measure of capital flows in the high yield market. (Figures in millions, Source: The Milken Institute.)

VIII. *Leverage Buyouts* – This study used both number and total dollar value of LBO transactions. To measure LBO activity in the financial markets, the dollar value of LBOs was used. (Figures in millions, Source: Morgan Stanley.)

DATA SERIES

Date	HYR	Rp	CR	WIL	GDP	LBO	HYN	CMR
Q1 80	86.2	3.12	189.4	637690	4814.9	1736.4	293.7	0.01486
Q2 80	105.6	6.15	209.7	620142	4696.6	2473.7	392.3	0.02940
Q3 80	97.3	4.40	149.5	700709	4697.6	3253.1	375.3	0.04405
Q4 80	98.7	3.04	147.0	775868	4784.3	2742.2	309.9	0.05866
Q1 81	99.7	2.77	180.3	835244	4842.7	363.0	249.0	0.06014
Q2 81	102.3	2.41	199.5	839907	4817.4	517.2	332.5	0.06160
Q3 81	91.5	0.55	142.3	821844	4849.6	680.1	318.1	0.06309
Q4 81	103.3	2.18	139.9	755757	4787.2	573.3	262.7	0.06459
Q1 82	104.7	2.03	204.3	783938	4718.7	281.9	517.9	0.09413
Q2 82	105.5	1.59	226.1	753340	4744.0	401.6	691.7	0.12254
Q3 82	123.6	3.57	161.2	717427	4733.7	528.2	661.7	0.15067
Q4 82	137.5	5.39	158.5	819924	4749.5	445.2	546.4	0.17824
Q1 83	153.6	5.42	313.8	948344	4775.9	372.2	1584.4	0.18716
Q2 83	156.0	5.07	347.2	1061114	4877.7	530.2	2116.1	0.19592
Q3 83	158.5	4.27	247.6	1180581	4955.2	697.3	2024.3	0.20478
Q4 83	161.7	4.09	243.4	1170135	5036.3	587.8	1671.6	0.21365
Q1 84	162.7	3.59	408.5	1215917	5126.9	2361.1	2999.6	0.22020
Q2 84	158.3	2.34	452.1	1105278	5184.6	3363.7	4006.1	0.22665
Q3 84	168.8	3.39	322.3	1073505	5216.6	4423.4	3832.4	0.23319
Q4 84	174.5	3.47	317.0	1156108	5255.4	3728.7	3164.6	0.23975
Q1 85	182.0	2.76	611.6	1183748	5303.5	2319.5	2959.9	0.25262
Q2 85	196.8	3.73	676.9	1299075	5339.4	3304.4	3953.2	0.26518
Q3 85	202.7	3.45	482.6	1397136	5418.5	4345.4	3781.7	0.27781
Q4 85	215.9	4.09	474.5	1330671	5445.0	3663.0	3122.8	0.29037
Q1 86	229.1	4.86	434.8	1540544	5509.6	8339.4	6540.0	0.31497
Q2 86	237.3	4.45	481.2	1755171	5512.3	11880.4	8734.6	0.33854
Q3 86	238.7	4.81	343.1	1889657	5541.5	15623.4	8355.7	0.36182
Q4 86	244.2	5.02	337.4	1751674	5572.1	13169.8	6899.8	0.38456
Q1 87	260.8	4.34	474.0	1844227	5600.2	7826.7	5995.3	0.41980
Q2 87	258.3	3.90	524.6	2187221	5652.7	11150.0	8007.1	0.45280
Q3 87	255.7	3.57	374.0	2262832	5698.0	14662.9	7659.7	0.48462
Q4 87	264.0	4.42	367.8	2435489	5778.7	12360.2	6325.1	0.51496
Q1 88	281.7	4.53	423.7	1852100	5811.2	10922.2	5814.6	0.52775
Q2 88	289.5	3.97	468.9	1934017	5865.6	15559.8	7765.8	0.54012
Q3 88	296.1	4.04	334.3	2031597	5900.6	20462.1	7428.9	0.55244
Q4 88	302.0	4.08	328.7	2027263	5970.5	17248.6	6134.5	0.56457
Q1 89	306.7	4.17	413.2	2044354	6023.4	12565.7	5173.0	0.58306
Q2 89	317.6	5.10	457.3	2176713	6062.2	17901.2	6908.9	0.60065
Q3 89	312.3	5.68	326.0	2350278	6095.1	23541.2	6609.2	0.61787
Q4 89	305.5	6.54	320.6	2587987	6103.3	19844.1	5457.5	0.63455
Q1 90	302.2	6.59	315.4	2662595	6162.0	2545.1	298.8	0.67128
Q2 90	313.6	6.28	349.1	2519966	6182.3	3625.8	399.1	0.70408

Date	HYR	Rp	CR	WIL	GDP	LBO	HYN	CMR
Q3 90	293.3	8.15	248.9	2682369	6155.2	4768.2	381.8	0.73428
Q4 90	292.5	9.32	244.7	2345644	6089.8	4019.3	315.2	0.76173
Q1 91	338.6	7.15	268.3	2437650	6050.9	1079.8	2135.5	0.78599
Q2 91	364.4	5.95	297.0	2884768	6078.2	1538.3	2852.1	0.80763
Q3 91	389.3	6.05	211.7	2898165	6092.6	2022.9	2728.4	0.82752
Q4 91	410.2	6.02	208.2	3028995	6106.1	1705.2	2253.0	0.84557
Q1 92	450.8	4.29	242.7	3307361	6175.7	1280.0	8103.9	0.85078
Q2 92	469.4	4.05	99.5	3227371	6213.4	1823.5	10823.3	0.85577
Q3 92	489.8	4.43	215.9	3342086	6260.7	2398.0	10353.8	0.86071
Q4 92	497.0	4.49	173.7	3364044	6328.0	2021.4	8549.7	0.86554
Q1 93	529.9	4.50	222.8	3643762	6327.3	1382.9	11657.2	0.86701
Q2 93	553.0	3.91	316.9	3722027	6357.2	1970.1	15568.9	0.86846
Q3 93	565.7	4.46	246.5	3839906	6397.7	2590.8	14893.6	0.86992
Q4 93	587.5	3.85	285.2	4021210	6475.7	2184.0	12298.4	0.87139
Q1 94	589.1	3.35	446.7	4040434	6517.3	1339.6	6750.1	0.87324
Q2 94	579.9	3.53	369.3	3924845	6596.7	1908.4	9015.2	0.87505
Q3 94	583.9	3.36	318.5	3922104	6658.6	2509.6	8624.1	0.87688
Q4 94	583.5	3.46	317.0	4057998	6715.3	2115.5	7121.4	0.87871
Q1 95	619.9	3.53	313.5	4012805	6726.1	977.2	6164.1	0.88099
Q2 95	656.4	3.87	378.1	4379402	6741.6	1392.1	8232.5	0.88321
Q3 95	677.0	3.83	262.2	4813361	6807.1	1830.7	7875.4	0.88544
Q4 95	691.2	3.99	279.8	5130305	6824.2	1543.2	6503.1	0.88765
Q1 96	711.2	3.53	463.8	5406752	6865.5	2415.8	7422.6	0.88902
Q2 96	724.9	3.01	486.1	5851811	6952.4	3441.6	9913.4	0.89037
Q3 96	762.9	2.78	243.2	6027456	6999.8	4525.9	9483.4	0.89172
Q4 96	793.8	3.08	357.6	6167584	7090.4	3815.2	7830.9	0.89308

Table 8: Data

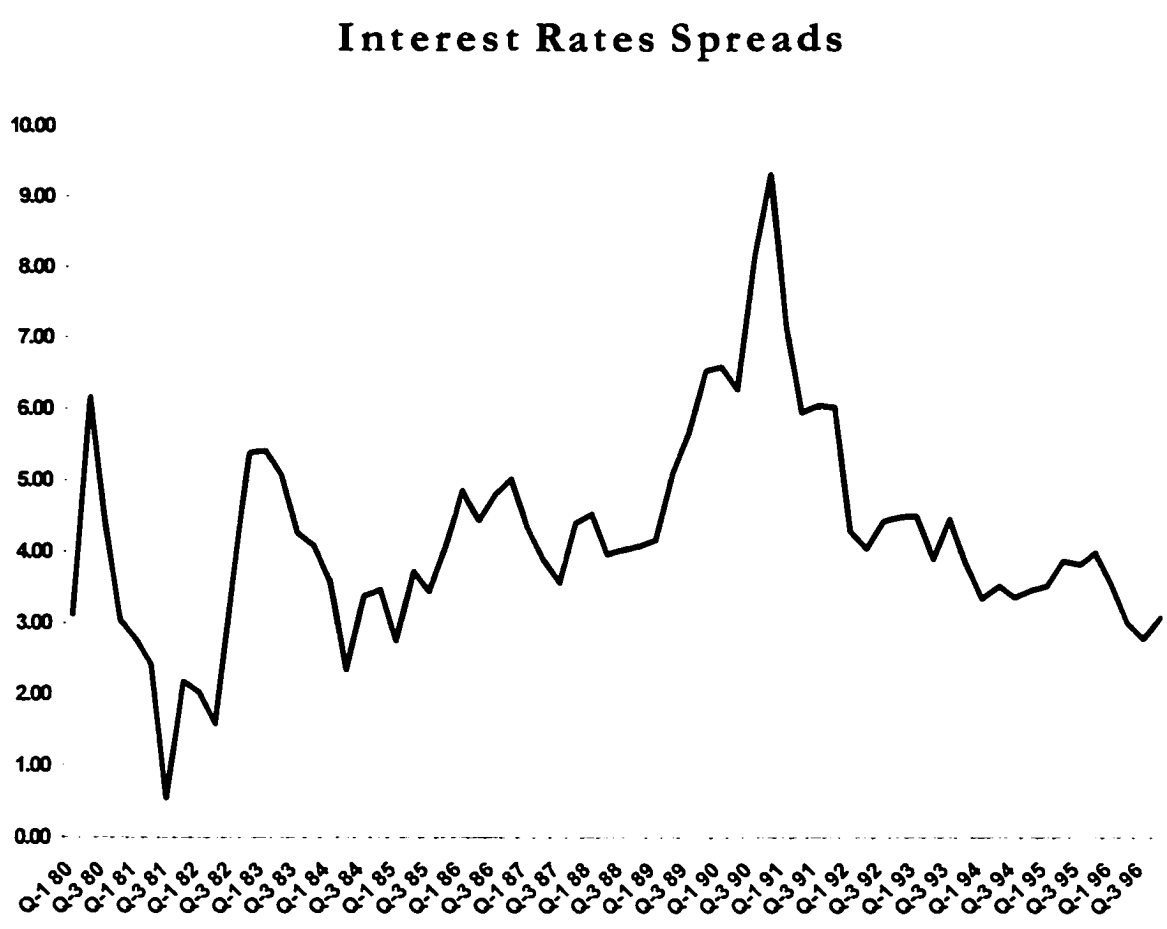

Figure 4: Interest rates spreads.

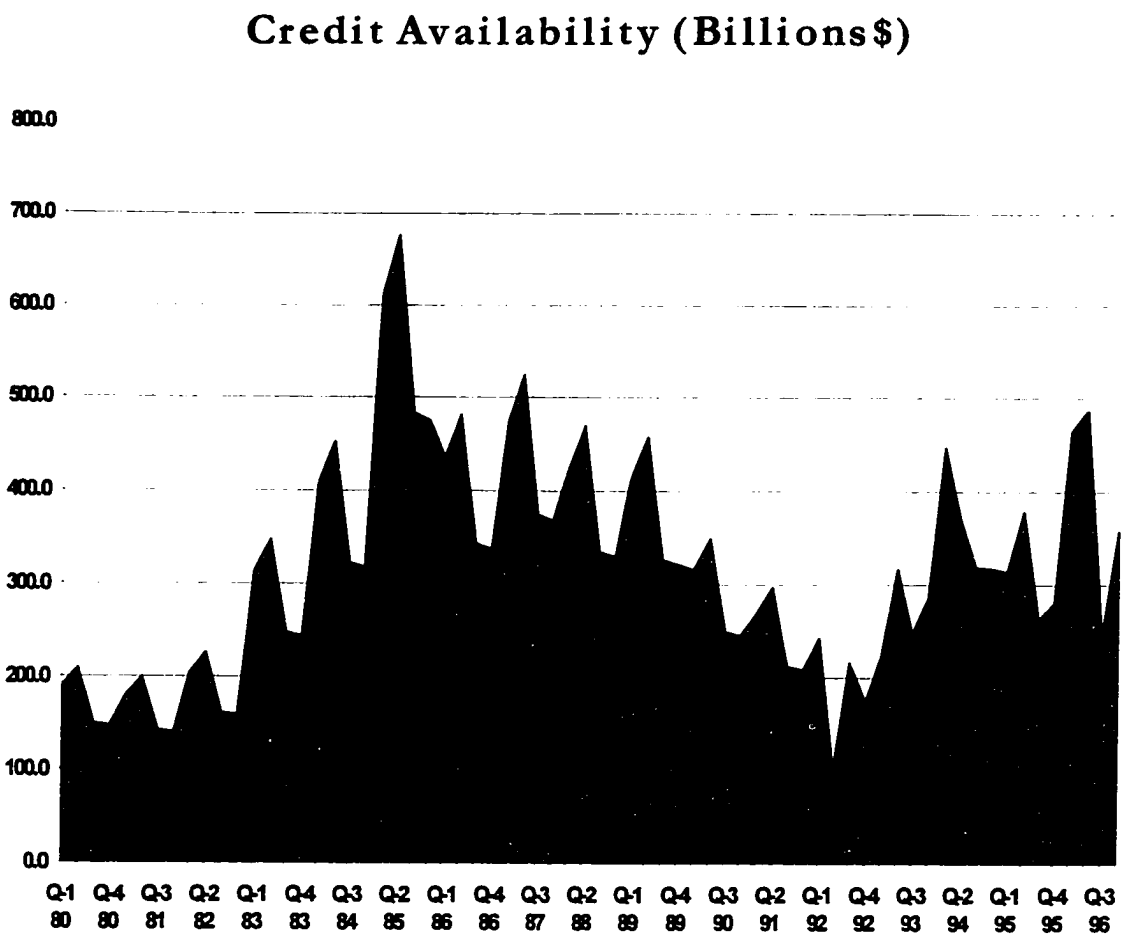

Figure 5: Market credit conditions.

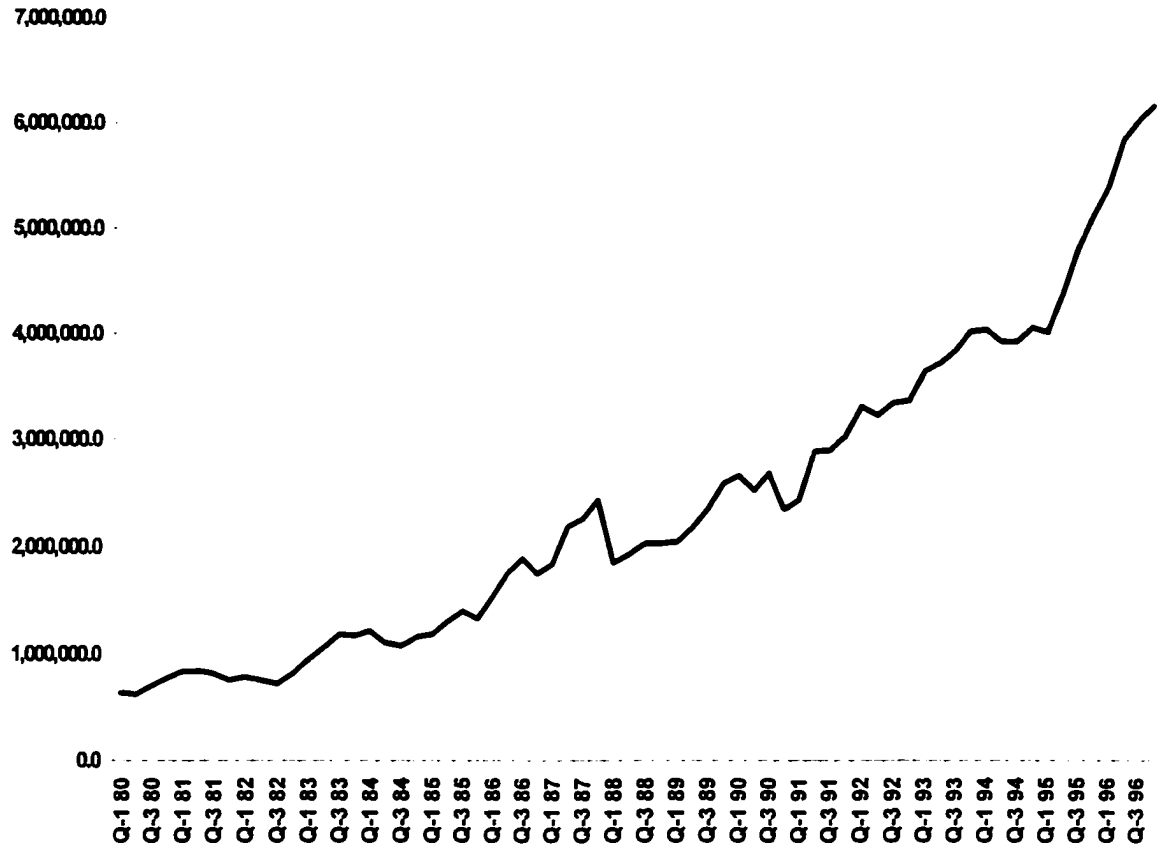

Figure 6: Wilshire 5000 index.

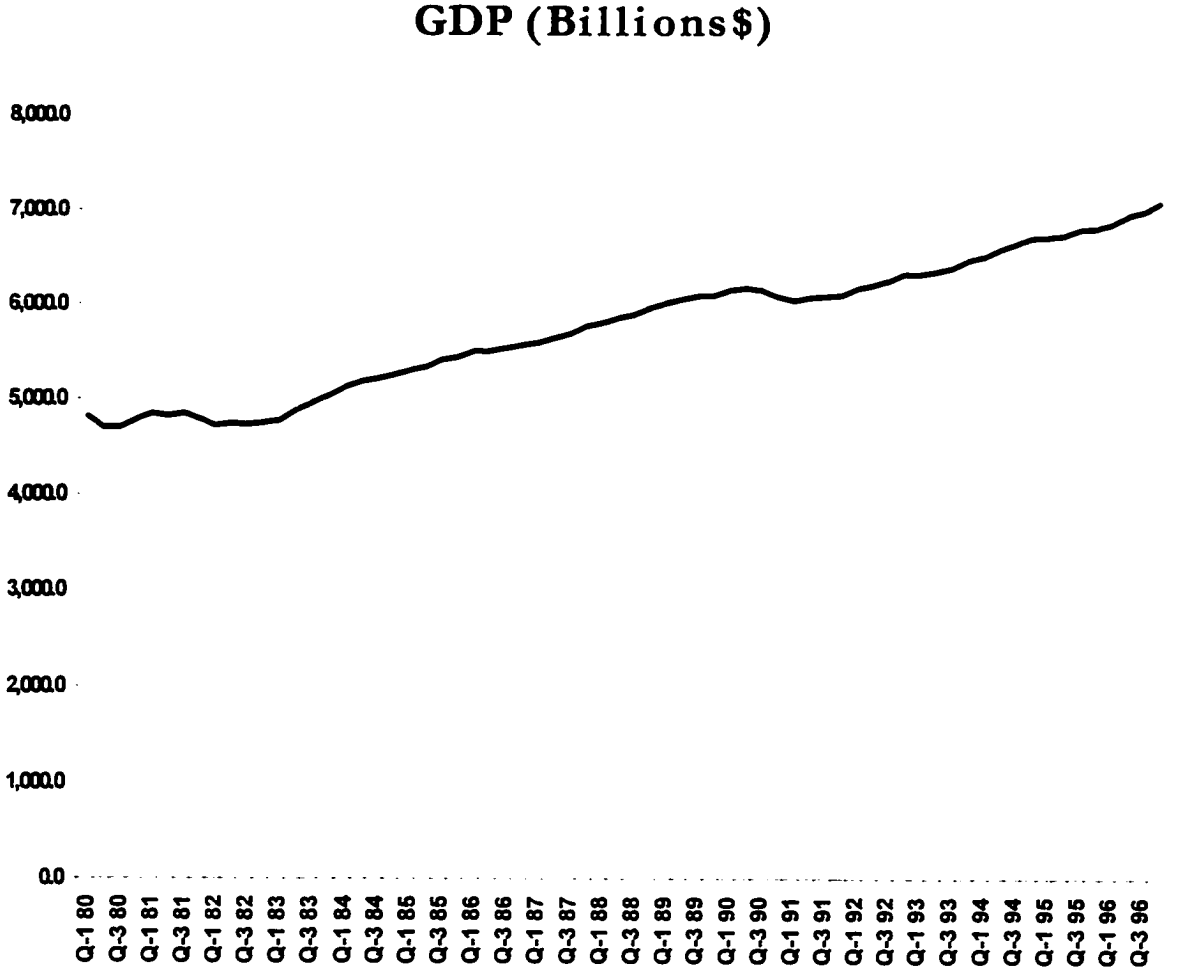

Figure 7: Gross domestic product.

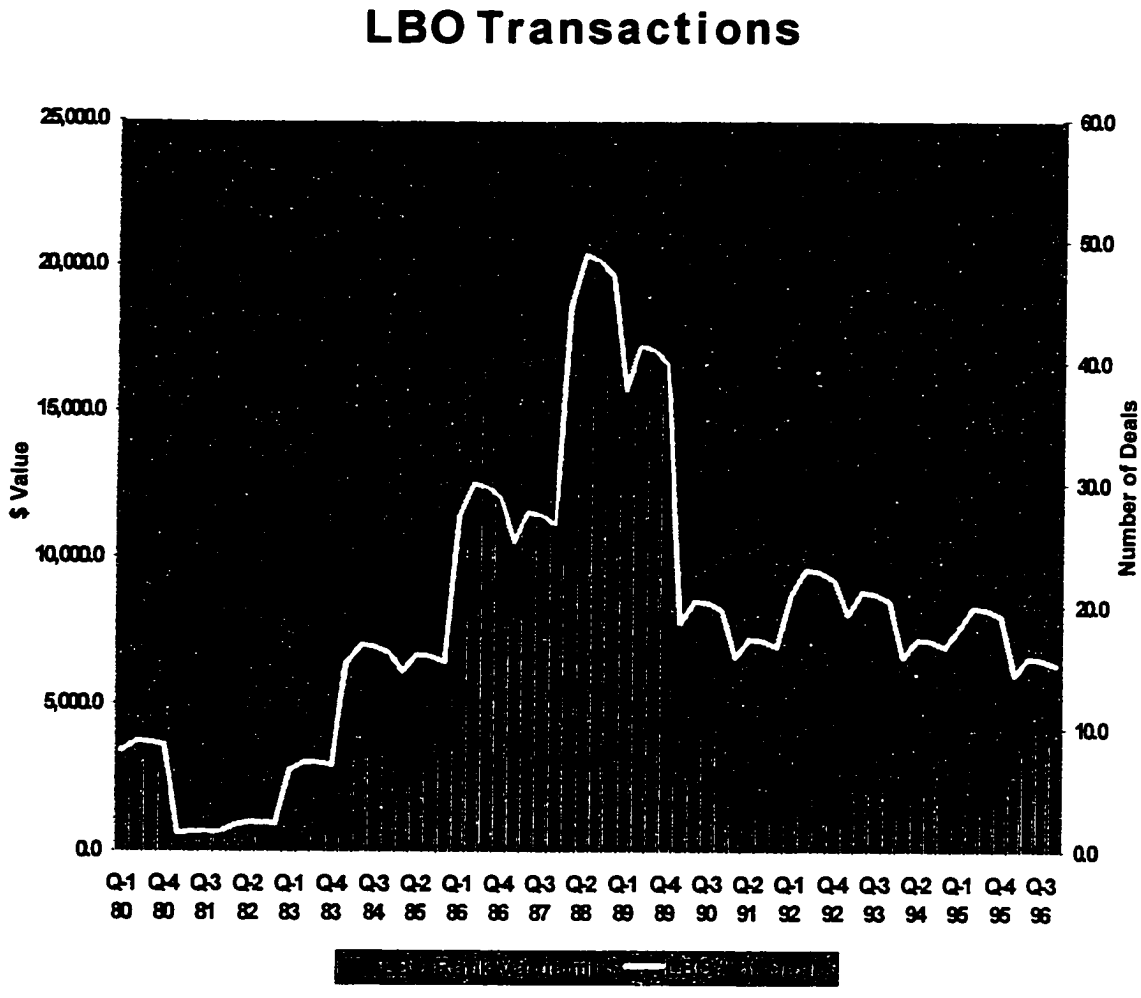

Figure 8: LBO Transactions.

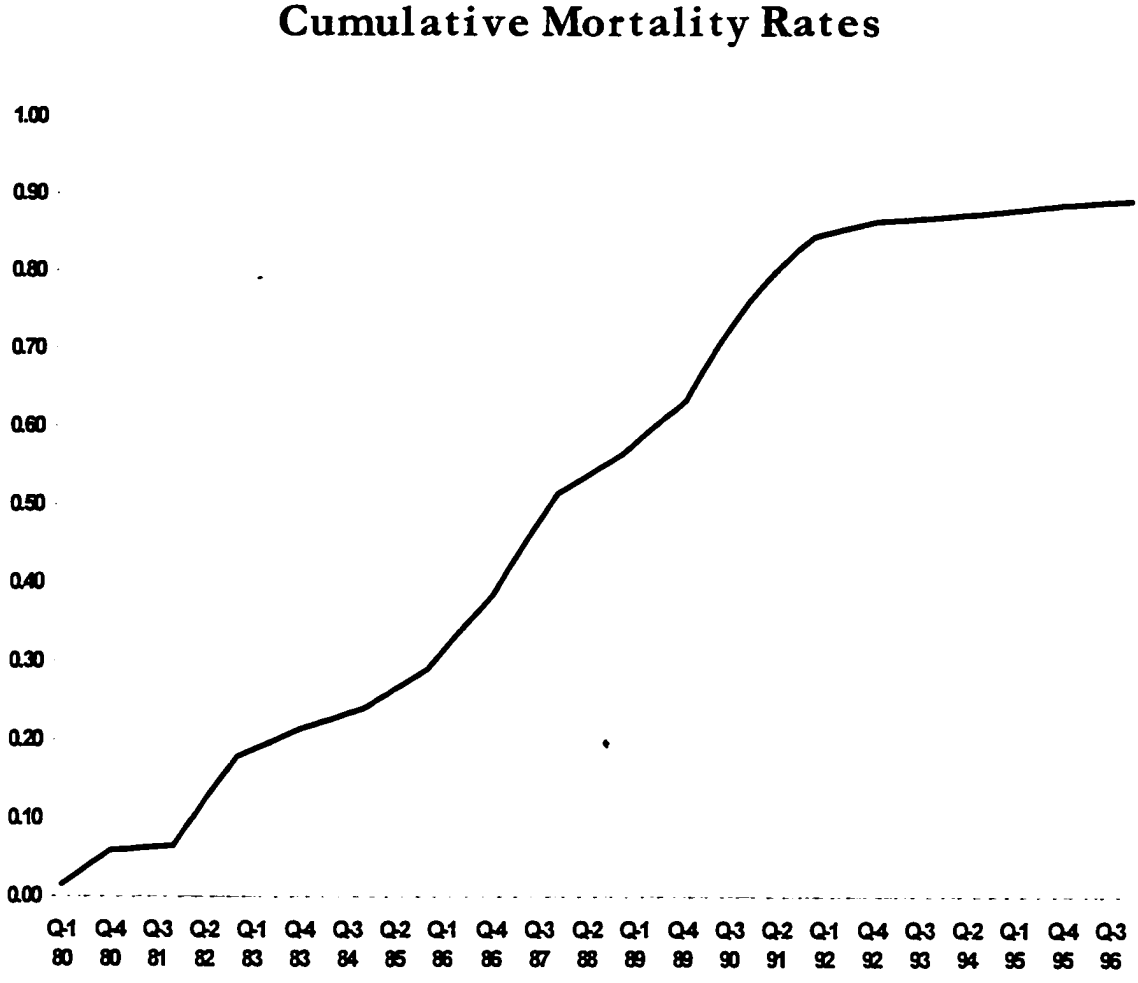

Figure 9: Cumulative mortality rates.

APPENDIX B

DERIVATION OF THE FORECAST FORMULA

(2) $$HYR_t = \alpha_0 + \alpha_1 Rp_{t-1} + \alpha_2 CMR_{t-1} + \alpha_3 CR_{t-1} + \alpha_4 WIL_{t-1} + \alpha_5 GDP_{t-1} + \alpha_6 LBO_{t-1} + \alpha_7 HYN_t + e_t$$

(3) $$HYN_t^s = \beta_0 + \beta_1 HYR_t + \beta_2 Rp_{t-1} + \beta_3 CR_{t-1} + \beta_4 CMR_{t-1} + \beta_5 WIL_{t-1} + u_t$$

(4) $$HYN_t^d = \gamma_0 + \gamma_1 HYR_t + \gamma_2 CR_{t-1} + \gamma_3 LBO_{t-1} + \gamma_4 GDP_{t-1} + \varepsilon_t$$

(5) $$HYN_t^s = HYN_t^d$$

From (3), (4), and (5) we get:

$$\beta_0 + \beta_1 HYR_t + \beta_2 Rp_{t-1} + \beta_3 CR_{t-1} + \beta_4 CMR_{t-1} + \beta_5 WIL_{t-1} + u_t = \gamma_0 + \gamma_1 HYR_t + \gamma_2 CR_{t-1} + \gamma_3 LBO_{t-1} + \gamma_4 GDP_{t-1} + \varepsilon_t$$

Solving for HYR:

$$HYR_t = \frac{\beta_0 - \gamma_0}{\gamma_1 - \beta_1} + \frac{\beta_3 - \gamma_2}{\gamma_1 - \beta_1} CR_{t-1} - \frac{\gamma_3}{\gamma_1 - \beta_1} LBO_{t-1} - \frac{\gamma_4}{\gamma_1 - \beta_1} GDP_{t-1} + \frac{\beta_2}{\gamma_1 - \beta_1} Rp_{t-1} + \frac{\beta_4}{\gamma_1 - \beta_1} CMR_{t-1} + \frac{\beta_5}{\gamma_1 - \beta_1} WIL_{t-1} + \frac{\varepsilon_t - u_t}{\gamma_1 - \beta_1}$$

Rewrite the formula as:

$$(6)\quad HYR_t = \Pi_0 + \Pi_1 CR_{t-1} + \Pi_2 LBO_{t-1} + \Pi_3 GDP_{t-1} + \Pi_4 Rp_{t-1} + \Pi_5 CMR_{t-1} + \Pi_6 WIL_{t-1} + \Omega_t$$

where:

$$\Pi_0 = \frac{\beta_0 - \gamma_0}{\gamma_1 - \beta_1},\ \Pi_1 = \frac{\beta_3 - \gamma_2}{\gamma_1 - \beta_1},\ \Pi_2 = -\frac{\gamma_3}{\gamma_1 - \beta_1},\ \Pi_3 = -\frac{\gamma_4}{\gamma_1 - \beta_1},$$

$$\Pi_4 = \frac{\beta_2}{\gamma_1 - \beta_1},\ \Pi_5 = \frac{\beta_4}{\gamma_1 - \beta_1},\ \Pi_6 = \frac{\beta_5}{\gamma_1 - \beta_1},\ \Omega_t = \frac{\varepsilon_t - u_t}{\gamma_1 - \beta_1}.$$

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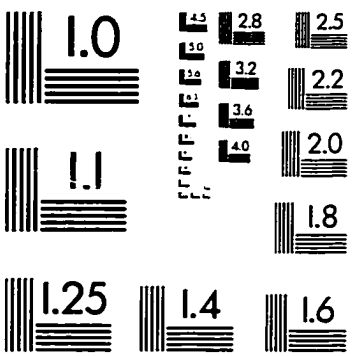
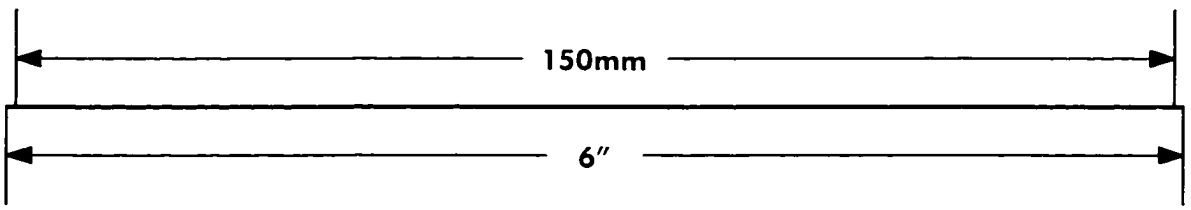
IMAGE EVALUATION TEST TARGET (QA-3)





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