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Relationships Between the Two Sides of the Balance Sheet: A Canonical Correlation Analysis

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I. Introduction

AN INDEPENDENCE OF THE asset and liability composition of the firm is implied in much modern financial theory; the independence of investing and financing decisions is a prominent part of Modigliani and Miller's classic capital structure research. While the separation of financing and investing decisions is an invaluable assumption which greatly simplifies many corporate financial decisions, the actual balance sheets of modern corporations do not exhibit an independence between the two sides of the balance sheet. The purposes of this paper are (1) to identify relationships between the two sides of the balance sheet exhibited by these corporations and (2) to explain the nature of these relationships.

The independence of asset and liability composition is explicit in Modigliani and Miller's capital structure propositions [15]. In their 1958 article, they demonstrate that, given a stream of risky earnings, the total market value of the firm and cost of capital are independent of capital structure (M & M's Proposition I). Furthermore, the cutoff rate for an investment project is completely independent of the way an investment is financed (M & M's Proposition III), thus implying a complete separation between the investing and financing decisions of the firm.[1]

The teaching of corporate finance, as reflected in the major textbooks, compartmentalizes the decision areas of finance and, within each compartment, management is assumed to attempt to maximize the firm's wealth, holding the other areas of the firm constant. For example, capital budgeting decisions are made given a cost of capital or required rate of return (a capital project is evaluated independent of how it is financed), or the capital structure is chosen given the character of the firm's assets. Cash, receivables, and inventory balances tend to be optimized independently. There is a tradeoff between the rigor afforded by global models of the firm (such as the CAPM) versus the realism afforded by

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[1] The separation theorem simply means that an individual's risk preferences are independent of the optimal portfolio of risky assets. In the Sharpe-Lintner capital asset pricing model [13, 19], the individual's choice of assets and financing is dichotomized: first, the optimal combination of risky assets (where the capital market line is tangent to the efficiency frontier) is determined, and, second, the optimal amount of borrowing or lending at the risk free rate (where the capital market line is tangent to the individual's highest indifference curve) is chosen. In the capital asset pricing model, the combination of risky assets is independent of the individual's risk preferences and also dichotomized from the amount of borrowing/lending (leverage). Of course, if the borrowing rate had a nonzero correlation with the returns on at least one asset, the optimum mix of risky assets would be affected by the amount of borrowing.

the various approaches used in the compartmented models (e.g., cash management models, equipment replacement models, leasing, etc.). Business practice has the same dilemma; complex organizations must decompose the overall wealth maximization problem into subproblems which, when solved, allow the firm to make satisfactory decisions.

Business executives may be uncomfortable with an assumption of independence between investing and financing decisions for two reasons. First, even if the decisions were independent, the decisions may occur simultaneously because of the necessity of raising the funds to invest. Second and more importantly, the assumptions necessary to obtain independence may not be obtained.

Several interdependencies might be anticipated between the two sides of the balance sheet:

1. Hedging is commonplace, where firms match the maturity structure of their assets and liabilities (i.e., short-term assets tend to be financed with short-term obligations and long-term assets tend to be financed with long-term obligations).
2. Some assets are used as collateral for loans. For example, accounts receivable can be used as collateral for short-term bank loans or factor loans and real estate as collateral for mortgages.
3. Commodity-producing firms will maintain inventories which may be financed with credit from suppliers (accounts payable) while service-providing firms may have little of either inventories or accounts payable.
4. High risk businesses may try to manage risk by using less leverage on the right-hand side of the balance sheet (high equity) and by maintaining larger liquidity balances on the left-hand side. This process may enable management to reduce the probability of insolvency.

It is the intent of this paper to determine if relationships such as these between the two sides of the balance sheet are exhibited by a sample of large corporations. We use canonical correlation analysis to identify and examine the nature of relationships between the structures of the left- and right-hand sides of the balance sheet. While canonical correlation analysis is very similar to discriminant and factor analysis, it has not been widely employed in finance.[2]

II. Sample Data and Rationale for Canonical Correlation Analysis

Balance sheet data for a cross-section of 510 firms for 1977 was used in this study. This sample included all firms on Standard and Poor's Compustat Tapes with at least 500 million dollars in sales except for 47 firms which were eliminated because of missing data. In addition, all purely financial firms were excluded. For each firm, a common size (or percentage breakdown) balance sheet is constructed with

[2] Exceptions were Fraser, Philips, and Rose [5], who used canonical analysis to find the correlation between a set of bank performance measures and a set of banking structure variables, and Hester [7], who used canonical correlation analysis to study the relationship between bank terms of lending and borrower characteristics.

Table I

Balance Sheet Proportions for 510 Firms

Variable	Mean	Standard Deviation
Assets		
X_1 Cash and securities	.086	.073
X_2 Receivables	.187	.086
X_3 Inventories	.237	.133
X_4 Long-term assets	.490	.180
Total	1.000	
Liabilities		
Y_1 Accounts payable	.110	.074
Y_2 Other current debt	.148	.075
Y_3 Long-term debt	.270	.129
Y_4 Stockholders' equity	.472	.123
Total	1.000	

Table II

Correlations Between Asset and Liability Proportions

Liabilities	Assets			
	X_1 Cash	X_2 Receivables	X_3 Inventories	X_4 Long-term Assets
Y_1 Accounts payable	.082	.157	.355	−.371
Y_2 Other current debt	.278	.379	.227	−.462
Y_3 Long-term debt	−.461	−.333	−.449	.678
Y_4 Stockholders' equity	.266	.026	.119	−.208

four asset and four liability accounts.[3] The definitions of these accounts, the mean proportions of total assets for each, and their standard deviations are given in Table I.

Of course, a great diversity of balance sheet structures is present among the 510 firms. The simple correlations between each asset account and each liability account are presented in Table II. A number of interesting relationships can be found in Table II. For example, inventories are positively correlated to accounts payable and long-term assets are correlated to long-term debt. On the other hand, stockholders' equity is not highly correlated to any of the asset proportions. However, these correlations are of limited value because the optimal balance of an asset or liability account is not simply determined, but it is jointly determined with balances of other accounts on the same side of the balance sheet as well as

[3] Four asset and liability accounts were used for reasons of parsimony; that is, we seek to explain as much variation as possible while using as few variables as practicable. In order to examine more information on a finer breakdown of accounts, a nine asset and fourteen liability analysis was undertaken and the results were similar to those reported here. These results are available from the first author upon request.

on the opposite side. Consequently, we use canonical correlation analysis to investigate the types of interaction between the two sides of the balance sheet.

In a canonical analysis, vectors of weights for each of the two sets of variables, the criterion set and the predictor set, are derived so that the correlations between the linear combinations obtained using the derived canonical weights, are maximized. The linear combinations are known as the canonical variables. More than a single pair of weight vectors may be derived and each additional pair of canonical weights produces scores which are uncorrelated with the previous scores. As many canonical variates can be derived as there are variables in the smaller set, if the variables are not perfectly multicollinear. An overall test of any linear relationship between the two sets of variables can be conducted. The derived canonical variates need not all be statistically significant, however. The tests for an overall relationship and for each canonical variate have been provided by Bartlett [3].

The variables of the asset side are denoted X_{i1}, X_{i2}, X_{i3}, and X_{i4} and the variables of the equity/liability side are Y_{i1}, Y_{i2}, Y_{i3}, and Y_{i4}. The scores of an observation, i, for each canonical variate pair, as i increases from 1 to n can be expressed as:

$$\begin{aligned} u_1 &= a_1X_{11} + a_2X_{12} + a_3X_{13} + a_4X_{14} \\ &\vdots \\ u_n &= a_1X_{n1} + a_2X_{n2} + a_3X_{n3} + a_4X_{n4}, \end{aligned}$$

and

$$\begin{aligned} v_1 &= b_1Y_{11} + b_2Y_{12} + b_3Y_{13} + b_4Y_{14} \\ &\vdots \\ v_n &= b_1Y_{n1} + b_2Y_{n2} + b_3Y_{n3} + b_4Y_{n4}. \end{aligned}$$

The a's and b's are the canonical weights. A canonical correlation is obtained for each of the canonical variate pairs by correlating u and v across observations.

The nature of the canonical variates, derived to have maximum correlations, can be examined by utilizing canonical loadings [6]. Canonical loadings are the correlations between the original variables and the canonical scores.

The nature of the structure of the canonical loadings may be simplified using the canonical rotation analysis methods described by Cliff and Krus [4] and also by Perreault and Spiro [17]. The canonical loadings for both sets of variables can be rotated simultaneously using Kaiser's normalized varimax criterion [8]. The total predictable variance remains the same and the rotated canonical correlations will be allocated more evenly across the canonical variates using these methods. More importantly, the examination of the nature of the canonical variates generally will be simplified.

III. Results

Canonical correlation analysis was employed to investigate empirically the interrelationships between the two sides of the balance sheet. The two sets of variables were the asset variables and the liability/equity variables. One variable from each

Table III

Test Statistics for Residual Canonical Functions

Roots	Canonical Correlations	Chi-Square	Degrees of Freedom	Probability
1 through 3	.777	504.6	9	0.00
2 through 3	.203	37.5	4	0.00
3 through 3	.178	16.2	1	0.00

Table IV

Canonical Loadings

Function:	Loadings		
	I	II	III
Assets			
Cash and securities	.58	−.35	.73
Receivables	.54	−.57	−.62
Inventories	.64	.71	−.29
Long-term assets	−.97	−.11	.22
Liabilities			
Accounts payable	.45	.74	−.51
Other current debt	.61	−.69	−.38
Long-term debt	−.92	−.07	−.39
Stockholders' equity	.32	.05	.95

Table V

Varimax Rotated Canonical Loadings

Function:	Loadings		
	I	II	III
Assets			
Cash and securities	.97	−.16	.19
Receivables	−.11	.12	.99
Inventories	.07	.99	.02
Long-term assets	−.39	−.73	−.57
Liabilities			
Accounts payable	−.22	.97	−.00
Other current debt	.14	−.01	.99
Long-term debt	−.85	−.46	−.26
Stockholders' equity	.94	−.09	−.33

set was dropped to eliminate singularities; thus, the number of canonical variate pairs which were derived was three, the number of variables on either side minus one.[4] Table III summarizes the results of the canonical correlation analysis. All three of the canonical functions were significant at the .01 level of significance using Bartlett's Chi-square test [3]. The canonical correlations do not give the variance shared between the asset and liability variables. The proportion of the variance in the asset variable predictable from or shared with the liability variables is 0.32 as computed using Stewart and Love's redundancy index [20]. The proportion of the variance in the liability variables shared with the asset variables is 0.25. The interpretations which follow will be for the three significant canonical functions and their associated canonical loadings.[5] The canonical loadings and the varimax rotated canonical loadings are presented in Table IV and V.

[4] The asset and the liability variables in this analysis are constrained to sum to unity; hence, the covariance matrices are singular. This condition can be shunted with impunity by dropping one variable from each set. The computation of canonical loadings for the variables, including the variables which are dropped during computation of the canonical variates, is not precluded when this procedure is used. Since the informational content of any $N - 1$ (3 in this case) of the variables of each set remains intact, the values of the canonical correlations and the canonical loadings are invariant with respect to which variable is excluded.

[5] Because canonical loadings may be unstable from one sample to the next, cross-validation was accomplished by splitting the sample and comparing the results of the two separate canonical analyses of the validation and analysis subsamples. Computing rank correlations as explained in [1, 11] for the asset variables as they loaded on the analysis and validation subsamples resulted in coefficients of 0.98, 0.93, and 0.71, respectively, for the three pairs of canonical variates.

The interdependencies between asset and liability structures suggested in the introduction are exhibited in the unrotated canonical loadings for our 510 firm sample. Hedging behavior is shown in Canonical Function I of Table IV. For this canonical variable, all three short-term asset proportions (cash and securities, receivables, and inventories) have positive loadings on the asset side while both short-term liability proportions (accounts payable and other current debt) have positive loadings on the liability side, and both long-term assets and long-term debt have negative loadings. The firms in our sample do tend to match the maturity structure of their assets and liabilities. Of course, the relationship between long-term assets and long-term debt implied by their negative loadings on Canonical Variable I may occur both because of hedging and because long-term plant and equipment is collateral for mortgages.

Inventories on the asset side are associated positively with Canonical Variable II and accounts payable on the liability side are associated positively with Canonical Variable II in Table IV. This may result when commodity-producing firms maintain inventories which are partially financed by accounts payable from their suppliers. Service-providing firms would have low inventories and low payables. Negative associations between accounts receivable and Canonical Variable II and other current debt with Canonical Variable II are also seen. The firm may be financing receivables with short-term debt (such as bank or factor loans) for two reasons; because receivables are collateral for such loans and because of hedging.

A final trait exhibited in our sample of firms is how firms use both sides of he balance sheet to manage risk. For example, in Canonical Variable III of Table IV both cash and securities and stockholders' equity have positive loadings. By using less financial leverage and maintaining higher liquidity balances management can reduce the probability of insolvency.

In order to simplify these canonical relationships, the canonical loadings were rotated and are presented in Table V. The rotated loadings structure is more parsimonious and frequently makes interpretation easier.

Canonical Variable I of Table V has high positive rotated loadings for cash and securities on the asset side and stockholders' equity on the liability side; long-term debt has a high negative loading. The loadings of the other variables have decreased on this function facilitating our previous interpretation that risk management decisions are made on both sides of the balance sheet. The rotated loadings on Canonical Variable II are very high positively for inventories on the asset side and accounts payable on the liability side, which facilitates the interpretation that inventories are financed by accounts payable. The interpretation is the same as it was for the unrotated loadings. On rotated Canonical Variable III receivables has a very high loading on the asset side while current debt loads high on the liability side. This indicates that receivables may be collateral for short term bank or factor loans. Furthermore, financing receivables with short term debt is consistent with hedging.

IV. Implications

There are two general conclusions from this study. The first is that the basic purpose of this paper is satisfied; there are basic relationships between the two sides of the balance sheet which were identified with canonical correlation analysis. The assumptions behind much of modern financial theory allow us to separate investing and financing decisions. Relaxation of these assumptions can admit interdependencies between the two sides of the balance sheet and several interdependencies were found in our empirical study. These relationships across the balance sheet include (1) hedging, (2) the use of collateral for loans, (3) inventories associated with accounts payable, and (4) managing risk with simultaneous use of lower leverage and greater liquidity balances. The capital structure research since M & M's original irrelevance argument has attempted to utilize the effect of the present value of the interest tax shelter due to debt financing [16] and the effect of expected bankruptcy costs [9, 10, 18, 21] on the firm's optimal capital structure.[6] The interdependencies between the two sides of the balance sheet found in this empirical study could be incorporated into models of capital structure.

The second general conclusion is to recommend canonical correlation analysis of financial statement data for other research topics. Much of the published empirical research concerning financial statements is on topics with a single, well defined dependent variable; these topics would include predicting bankruptcy, bond ratings, or loan defaults and explaining market risk measures. Canonical analysis, where there is a set of dependent variables, would allow empirical analysis to proceed where no unique variable can be chosen as the dependent variable. Furthermore, variables which are linear combinations of financial statement proportions might be employed instead of the usual financial ratios.[7] Canonical variate scores for a firm could be associated with its bond ratings, probability of default, or systematic risk. These topics usually have been investigated using financial ratios as predictor variables.

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[6] Miller [14] has shown how the present value of the interest tax shelter on debt financing is affected by differential personal tax rates on interest income and capital gains.

[7] One modern technique which does rely on balance sheet proportions is statistical decomposition analysis. One application of this technique provides a measure of the amount of change in the proportions of a firm's balance sheet between two points in time. For an explanation of statistical decomposition analysis of financial statement data see Lev [12, Ch. 4] and Ball, Lev, and Watts [2].

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