Measurement of a Financial Model of the Firm: A Field Study

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Abstract

A financial model of the firm is a useful tool for corporate management in formulating and executing strategic company operations and in understanding past managerial actions. Yet, while financial models have evolved to simultaneously-determined systems which portray the myriad of interdependencies among accounting variables, measurement of their parameters typically relies on simple parsimonious techniques which are theoretically inferior. Accurate measurement of the parameters is important for reliable application of the model, including "what-if" analyses, managerial planning exercises, and production of pro forma reports. This article reports on a field study of the implications associated with using the commonly-employed ordinary least squares technique of parameter measurement for a financial model of the firm. The results show that parameter measurements using this simple estimation method are significantly different from those obtained from a theoretically superior technique. Decomposition of the measurement differences demonstrates an association with characteristics of both the firm and its environment; moreover, the differences are shown to be primarily attributed to the earnings-based relations of the model.

1. Introduction

The application of financial models to better understand the financial performance of firms has steadily increased over the past two decades (e.g., see Gershefski, 1970; Naylor and Schauland, 1976; Naylor, 1981; Shim and McGlade, 1984). Financial models link the internal operations of companies to industry and macro-economic factors and are valuable tools in strategic management decision making. The models have matured from systems comprised of single-equation relations to simultaneously-determined equation models which account for the interdependencies between accounting variables. The more intricate models are capable of capturing the dynamic interplay among financial operations and, hence, permit management to discern the full ramifications of any strategic actions. Nevertheless, while the structural composition of financial models has progressed, most models rely on parameter measurement methods not theoretically appropriate for financial systems comprised of simultaneously-determined relations (Naylor, 1981).

The purpose of this article is to provide empirical evidence on the effects of using a parsimonious parameter measurement technique in relation to the theoretically preferred multi-equation technique for the financial model. For this purpose, a field study is conducted on a financial model of the firm. The structural composition of the model is consistent with conventional formulations (Elliott and Uphoff, 1972; Ang et al., 1983; Wild, 1987), and consists of fourteen behavioral relations and several financial identities. The direction and magnitude of the differences between the parsimonious and advanced measurement technique are examined in relation to the characteristics of the firm and its environment, including variable type (endogenous or exogenous), the functional activity which a relation represents, and the extent of endogenous influence within a relation.

The results indicate the presence of significant differences between the parsimonious and theoretically superior parameter measurement techniques. These measurement differences are attributed to certain firm characteristics, but primarily are related to earnings-based relations and the endogenous determinants. This evidence demonstrates the potential to significantly enhance the quality of managerial decision making, and the opportunity to minimize error in strategic management actions, through accurate measurement of the model. The results also indicate that certain types of relations are more prone to significant variation in parameter measurement owing to the estimation technique chosen. The article demonstrates that the technique adopted for measurement of the financial model has significant consequences for its application.

2. Background

2.1 Prior Research

There has been a dramatic growth in the advancement and application of financial models during the past two decades. In 1970 there were relatively few companies relying on financial models; for example, Gershefski (1970) reported that only 63 companies, or 20 percent of his sample, were developing or using a financial model. By the early 1980s, however, this number jumped to over 70 percent in two independent surveys (Naylor and Schauland, 1976; Naylor, 1981). The number of users of financial models has similarly grown, and now frequently consists of top management; e.g., the Chief Executive Officer and Chairman of the Board (see Naylor (1981, his table 5)).

Commensurate with the increasing role of financial models in strategic decision making is the enhanced sophistication of financial models. While nearly all financial models were deterministic systems only 20 years ago, the vast majority are now stochastic in nature and use formal least squares estimation of parameters (Gershefski, 1970; Naylor, 1981). Nevertheless, the inherent simultaneous nature of these models is not accompanied with use of theoretically superior parameter measurement techniques. Specifically, less than 25 percent of the companies were identified as using the more appropriate two-stage least squares technique, while other advanced methods were rarely employed (Naylor, 1981, p. 81).

The limited use of theoretically superior measurement techniques for simultaneously-determined financial models is an enigma. One potential explanation is that the superior technique does not yield significantly different parameter measures in practice. However, evidence on the performance of alternative measurement techniques is limited due to the absence of necessary information to design and test their performance. Specifically, the required quarterly disclosures (10Qs) of listed U.S. companies are not of sufficient detail for development of financial models, and the annual reports (10Ks), although yielding sufficient information for developing and testing the models, yield obvious problems of stationarity in the structural relations. Therefore, the research is often limited to two types: (1) the voluntary disclosure of model performance from individuals employed (or associated) with the companies, or (2) field study research by persons independent of the firm. For purposes of this article, both types of research are reviewed contingent on (1) the existence of a stochastic financial model, and (2) a focus on financial accounting variables which are endogenous to managerial decision making.[1]

One of the first rigorous analyses of a stochastic simultaneously-determined financial model was conducted by Saltzman (1967). Saltzman acquired financial information from a division of a corporate conglomerate to design and test the performance of a financial model. The model consisted of ten behavioral relations and five definitional relations. Saltzman concluded that in a direct "comparison of ordinary least squares estimates and two-stage least squares estimates of the parameters of the model ... there was not a great deal of difference" (p. 332).[2] Two subsequent studies, Elliott and Uphoff (1972) and Elliott (1972), investigated the prediction performance of financial models. While their models relied on a mixture of simple and more advanced measurement techniques, neither article provided evidence on a comparison of the two parameter measurement techniques.[3] In another study, Davis et al. (1973) reports on the success and capabilities of the financial model for American Telephone and Telegraph. The AT&T model is measured using simple least squares and no comparison is made with, nor is there even recognition of, more advanced measurement methods. Similarly, Ang et al. (1983) relied exclusively on simple least squares to measure the parameters of their financial model. Finally, although Wild (1987) used two-stage least squares estimates in an investigation of the prediction performance of a financial model, no comparative analysis was conducted on the parameter measurement technique. Consequently, prior research does not provide an answer to the question: <u>Does the parameter measurement technique matter</u>?

The lack of systematic research on the parameter measurement technique is surprising given the avoidable costs from inferior managerial decision making based on erroneous estimates. Yet, while advanced measurement techniques are theoretically preferred, their superior properties might not be realized in practice due to nonstationarity of structural relations, errors in variables, or data aggregation. Hence, there is a critical need for empirical evidence on this question.

2.2 Hypothesis Formulation

The purpose of this article is to provide empirical evidence on the differences between the parsimonious ordinary least squares technique and the theoretically superior two-stage least squares parameter measurement technique for estimation of a simultaneously-determined financial model of the firm. Evidence of significant differences in parameters measured using these techniques is a necessary condition for the superiority of two-stage least squares. For this purpose, both the direction and magnitude of differences in parameters between these two measurement techniques are investigated.

The primary hypothesis is (in alternative form): <u>Statistically significant differences exist between the</u>

ordinary least squares and two-stage least squares parameter measurements of a simultaneously-determined financial model of the firm. The tests of this hypothesis are empirical in nature and are based on a field study application of the financial model. The criteria include investigation of the "bias" in ordinary least squares parameter measurements in relation to those from the two-stage least squares technique.

3. The Financial Model

3.1 Model Development and Specification

Schendel and Patton (1978) argue that the strategic activity of the firm is related to three components: (1) the goals of the firm, (2) the available means or resource allocations, and (3) the environmental constraints. They assert that a system of explanatory equations, each reflecting a separate dimension of desired performance (goals), better represent firm behavior. The strategic or operating variables, which comprise the "controllable" management variables, determine the direction of the firm. In general, the performance and controllable variables are endogenous to the firm, whereas the environmental variables are exogenous to the firm and not under the control of management (although managerial decisions can influence them).

The theory of firm behavior is not sufficiently developed to permit a clear distinction between performance and controllable variables and, consequently, prior financial models regard both as endogenous (e.g., Saltzman, 1967; Elliott and Uphoff, 1972; Ang et al., 1983; Wild, 1987). This permits management to exercise their own views in identifying the set of performance measures. This article adopts the same approach and, thus, the simultaneous and interdependent nature of the financial relations are expressed as:

$$\begin{aligned} EN_1 &= f(EN_2, EN_3, \ldots, EN_n, EX_1) \qquad (1) \\ EN_2 &= f(EN_1, EN_3, \ldots, EN_n, EX_2) \\ &\vdots \\ EN_n &= f(EN_1, EN_2, \ldots, EN_{n-1}, EX_n) \end{aligned}$$

where EN_i is the i-th endogenous variable reflecting firm performance, EX_i is the set of exogenous variables which determine the i-th endogenous variable, and n is the number of relevant factors endogenous to firm performance. This model permits the system of financial relations to be simultaneous in nature, and recognizes multiple interdependent endogenous factors of firm performance.

The selection of the firm for the field study was based on two criteria: (1) that the company maintain reliable monthly records of financial accounts, and (2) that the company possess sufficient historical records of financial accounts for model measurement purposes. The first criterion is necessary since monthly reports are not required disclosures and are typically unaudited. Use of monthly reports reduces the likelihood of nonstationarity in the financial relations since more observations are obtained from a shorter time period. The second criterion is necessary to ensure a reasonably sufficient number of observations for parameter measurement. The company ultimately selected (a U.S. domestic manufacturer) provided extensive proprietary information for this research, and in return was assured anonymity.

After an extensive investigation of the operations of the firm and its industry, the financial data were assembled (with management assistance) for over fifty accounting variables spanning a nine year time period. The necessary exogenous data on industry and economic factors were obtained from publicly available sources (e.g., *Survey of Current Business*). Table 1 lists all variables collected.

The specification of the structural relations is consistent with prior financial models (e.g., Saltzman, 1967; Elliott and Uphoff, 1972; Wild, 1987) with obvious modifications for the unique characteristics of this firm and industry. The final form structural relations represent a simultaneously-determined system of fourteen endogenous financial variables including earnings, earnings components, and measures of the firm's financial position (assets and liabilities).

3.2 Model Estimation

The structural relations are measured using both ordinary least squares and two-stage least squares. The latter technique is the most widely used of the consistent and asymptotically efficient estimation procedures for simultaneously-determined relations of financial models in practice (Naylor, 1981, p. 81). Among its desirable properties, the technique yields the same asymptotic distribution as the limited information maximum likelihood estimator, and yields the minimum asymptotic variance-covariance matrix in the class of instrumental variables estimation (Goldberger, 1991; Judge et al., 1988). Since several of the structural relations are nonlinear in the parameters, it is important that the optimality (efficiency) properties of two-stage least squares generalize to a nonlinear environment (Amemiya, 1974). The asymptotic properties of more advanced methods, such as three-stage least squares, are not yet established in a nonlinear environment and, therefore, are not considered here.

Table 1

Variables Comprising The Financial Model

Endogenous Variables[a]

ADM	Administrative Expenditures	LA	Liquid Assets*
ADV	Advertising Expenditures	MKT	Marketing Expenditures
AR	Accounts Receivable*	NS	Net Sales*
CA	Current Assets*	NSU	Net Sale Units
CL	Current Liabilities	OA	Other Assets
CMS	Cash & Marketable Securities	OP	Operating Profit*
COG	Cost of Goods Sold	PPE	Property, Plant & Equipment*
CPE	Capital Expenditures	PRC	Product Price
DPR	Depreciation Expense	PRD	Production Costs
DST	Distribution Costs	REC	Receipts (Cash) from Sales
GM	Gross Margin*	TA	Total Assets*
INV	Inventory*		

Exogenous Variables[b]

CI1	Advertising Cost Index (1)	LTI	Long-Term Interest Rate
CI2	Advertising Cost Index (2)	PF	Periodicity Factor
CI3	Special Equipment Cost Index	PI	Personal Income per Person
CI4	Machinery Cost Index	RM1	Raw Materials(1) Cost
CI5	Employee Wage Index	RM2	Raw Materials(2) Cost
CI6	Overhead Cost Index	STI	Short-Term Interest Rate
COM	Competitors' Prices	USI	U.S. Inventory of Product
IE	U.S. Import-Export Ratio	USP	U.S. Production of Product
IF	Intervention Factor		

[a]The asterisk (*) designates a deterministic (residual) account computed using one of the following definitions: NS=NSU•PRC; GM=NS-COG; CA=CMS+AR+INV; OP=GM-DIST-MKT-ADV-DPR-ADM; TA=CA+PPE+OA; LA=CMS+AR; AR=ARL+NS-REC; INV=INVL+PRD-COG; and PPE=PPEL+CPE-DPR.

[b]The list of exogenous variables includes certain lagged exogenous and lagged endogenous variables. These variables are designated (in tables 2 and 3) with the suffix "L" attached to the end of their respective acronym.

4. The Empirical Evidence on Parameter Measurement

4.1 Estimation of Model Parameters

The two-stage least squares estimation results for the structural relations of the financial model are displayed in table 2. In general, the parameters are significant and consistent in sign with *a priori* expectations, and the explanatory power of the relations, as reflected in the coefficient of determination from the reduced form relations, is similar to the findings of prior research.[4]

For brevity reasons, a comprehensive equation by equation discussion of these results is not provided here. Nevertheless, certain strategic information is readily apparent. First, the sales-based variables (NSU, PRC, COG) are shown to be driven by both sales-generating activities (ADV and MKT) and factors exogenous to the firm. For example, marketing and advertising along with the level of consumer income are among the set of sales' determinants; product prices are determined by unit costs, promotional activities, and the competitive price structure; and cost-of-sales is affected by unit sales and other cost factors unique to its activity. Second, certain sales-generating activities (ADV, MKT, DST) are positively related to unit sales, but are inversely related

Table 2

Measurement of The Financial Model of The Firm[a]

Financial Measure	Parameter Estimates On The Explanatory Variables								R^2
NSU =	MKT	ADV	DST	PI	IF	NSUL			
	0.10	0.06	0.28	54628.	99.7	0.08			0.89
	(4.15)	(3.15)	(5.97)	(1.88)	(1.34)	(1.23)			
PRC =	COG/NSU	ADV	MKT	CPE	COM	PRCL			
	0.97	0.001	0.001	0.001	0.12	-0.05			0.94
	(13.3)	(1.65)	(1.74)	(1.53)	(2.10)	(-1.10)			
PRD =	NS	ADV	PRC/COM	INVL	PRDL				
	0.89	1.17	-12042.	-0.13	0.03				0.84
	(16.5)	(0.68)	(-0.84)	(-1.95)	(0.61)				
COG =	NSU	RM1	RM2	CI6	COGL				
	105.	386.	816.	17.6	0.06				0.88
	(21.8)	(5.82)	(14.8)	(1.24)	(1.54)				
REC =	NS	ΔSTI	RECL						
	0.94	-813.	-0.02						0.92
	(26.8)	(-0.79)	(-0.57)						
ADV =	GM	GML	OP	PRC/COM	CI1	CI2	USIL	ADVL	
	0.16	0.02	-0.18	970.	5.96	7.59	1.53	0.08	0.83
	(5.59)	(2.46)	(-4.64)	(1.69)	(1.39)	(1.76)	(4.27)	(0.92)	
MKT =	NSU	GM	OP	DST	INVL				
	1.09	0.09	-0.07	0.59	0.004				0.81
	(1.42)	(2.21)	(-1.77)	(2.32)	(1.60)				
DST =	NSU	ΔCA-ΔCL	GM	CI3	DSTL				
	1.32	0.012	0.004	27.7	0.20				0.77
	(5.38)	(2.08)	(0.40)	(3.14)	(2.59)				
ADM =	TA	GM	OP	CPE	CI5	ADML			
	0.002	0.13	-0.12	0.09	540.	0.06			0.81
	(2.11)	(7.34)	(-5.20)	(3.00)	(2.36)	(0.81)			
CPE =	OP/TAL	ΔLA	ΔSTI	ΔIE	CI4	USIL	CPEL		
	39396.	0.04	-268.	-439.	59.3	-3.30	0.11		0.66
	(1.66)	(2.14)	(-1.42)	(-2.12)	(2.09)	(-2.97)	(1.09)		
DPR =	PPEL+.5·CPE		OP	PF	DPRL				
	0.01		-0.02	748.	0.32				0.96
	(9.01)		(-1.46)	(15.4)	(4.96)				
CMS =	NS-REC	CL-AR-INV	OP	STI	CMSL				
	-0.63	0.15	0.31	515.	0.67				0.81
	(-3.94)	(2.89)	(1.09)	(1.69)	(11.2)				
OA =	GM	USP	USIL	LTI	OAL				
	-0.10	1.63	-1.91	722.	0.92				0.97
	(-1.26)	(1.45)	(-0.78)	(1.93)	(25.1)				
CL =	OP	CA	TA	STI	CLL				
	-0.36	0.17	0.14	-494.	0.57				0.95
	(-1.51)	(2.53)	(4.03)	(-1.64)	(6.77)				

[a]The parameter estimates, derived using the two-stage least squares technique, are shown along the their respective *t*-statistics in parentheses. The R^2 metrics are from the reduced form regressions. A "Δ" is used to designate the current period change in a variable (relative to the prior period).

to profit. This latter result is consistent with "income smoothing" behavior by management. Each of these sales-generating relations are partially determined by the cost of their related functions. Third, the company's capital expenditures are linked to the funds available and cost indexes, while the level of assets (CMS and OA) and liabilities (CL) are determined by the available funds and external indexes. Finally, the administrative and depreciation relations are linked with company profits, the available resources, and cost levels.

While this article is not directed at the potential applications or uses of financial models, its usefulness in management decision making is well documented (Shim and McGlade, 1984; Pappas and Remer, 1984; Khan and Morrison, 1985; Sutcliffe, 1986). The financial model can yield evidence on the determinants of key financial variables, and provides numerical measures to complement management's analysis of company operations. Specifically, parameter estimates, while indicative of past performance and relations, yield useful information for evaluation of past actions and in formulating future

Table 3

Measurement Bias in the Ordinary Least Squares Estimates of The Financial Model[a]

Financial Measure	Measurement Bias in Ordinary Least Squares Estimates								Average (Absolute) Measurement Bias
NSU =	MKT	ADV	DST	PI	IF	NSUL			
	0.21	-0.02	-0.29	-0.41	0.25	0.03			-0.04 (0.20)
PRC =	COG/NSU	ADV	MKT	CPE	COM	PRCL			
	-0.14	0.21	-0.07	0.18	0.48	-1.20			-0.09 (0.38)
PRD =	NS	ADV	PRC/COM	INVL	PRDL				
	-0.04	-1.21	-1.23	0.10	0.02				-0.47 (0.52)
COG =	NSU	RM1	RM2	CI6	COGL				
	-0.03	-0.02	-0.01	0.03	-0.12				-0.03 (0.04)
REC =	NS	ΔSTI	RECL						
	-0.03	0.04	0.07						0.03 (0.05)
ADV =	GM	GML	OP	PRC/COM	CI1	CI2	USIL	ADVL	
	-0.19	-0.11	-0.27	0.05	0.43	-0.01	-0.03	-0.07	-0.02 (0.15)
MKT =	NSU	GM	OP	DST	INVL				
	0.93	-0.56	-0.61	-0.51	0.00				-0.15 (0.52)
DST =	NSU	ΔCA-ΔCL	GM	CI3	DSTL				
	-0.03	0.58	-1.23	-0.06	0.11				-0.13 (0.40)
ADM =	TA	GM	OP	CPE	CI5	ADML			
	0.12	0.01	0.08	-0.46	-0.20	-0.29			-0.12 (0.19)
CPE =	OP/TAL	ΔLA	ΔSTI	ΔIE	CI4	USIL	CPEL		
	-0.31	-0.36	-0.16	0.00	-0.02	-0.08	-0.07		-0.14 (0.14)
DPR =	PPEL+.5·CPE	OP	PF	DPRL					
	-0.01	-0.31	-0.01	0.04					-0.07 (0.09)
CMS =	NS-REC	CL-AR-INV	OP	STI	CMSL				
	-0.20	0.69	0.74	0.06	-0.09				0.24 (0.35)
OA =	GM	USP	USIL	LTI	OAL				
	-0.39	-0.06	0.12	-0.01	0.00				-0.07 (0.12)
CL =	OP	CA	TA	STI	CLL				
	-0.78	0.45	0.31	0.57	-0.19				0.07 (0.46)

[a]Measurement bias is computed as the ordinary least squares estimate less the two-stage least squares estimate, and this quantity scaled by the latter estimate. A "Δ" is used to designate the current period change in a variable (relative to the prior period).

strategy. The financial model offers several other insights into company operations. For example, an analysis of impact multipliers along with the model's (company's) "dynamic" characteristics can assist managers in understanding and predicting the effects of alternative strategies. Similarly, sensitivity tests of alterations in underlying variables ("what-if" analyses) can assist in evaluation of strategic alternatives.

4.2 Parameter Measurement Bias

This section investigates differences between the two-stage least squares and the ordinary least squares parameter estimates. For this purpose, the ordinary least squares estimates are computed for each of the parameters of the financial model.[5] The measurement bias in the ordinary least squares parameters is provided in table 3. The two right-most columns of table 3 give the average and absolute values of the measurement bias for the entire set of explanatory variables for each relation. The overall average parameter measurement bias is negative and approximates 7.4 percent. While every ordinary least squares parameter is not downward biased, the probability of obtaining this proportion of

Table 4

Decomposition Analysis of the Ordinary Least Squares Measurement Bias[a]

Panel A: Analysis by the number of endogenous variables in the relation

Row	Number of Endogenous Variables in the Relation[b]	n	Percent of Bias Mean	Percent of Bias Std. Dev.	Percent of Bias Sig.[c]	Percent of Absolute Bias Mean	Percent of Absolute Bias Std. Dev.	Percent of Absolute Bias Sig.[c]
(1)	One	13	-3.1%	12.3%	0.37	7.3%	10.2%	0.02
(2)	Two	11	-11.8	14.7	0.02	12.6	13.9	0.01
(3)	Three	34	-5.4	48.5	0.52	32.5	35.9	0.01
(4)	Four	17	-11.8	48.1	0.33	35.6	33.5	0.01
(5)	One and Two	24	-7.1	13.8	0.02	9.7	12.1	0.01
(6)	Three and Four	51	-7.6	48.0	0.27	33.5	34.8	0.01

Attained significance levels from paired *t*-tests on the measurement bias across rows[d]

Bias Metric	(1) & (2)	(2) & (3)	(3) & (4)	(5) & (6)
Average Percent Bias	0.14	0.51	0.66	0.95
Absolute Percent Bias	0.31	0.01	0.77	0.01

Panel B: Analysis by the variable type and source of the performance measures

Row	Variable Type and Source[e]	n	Percent of Bias Mean	Percent of Bias Std. Dev.	Percent of Bias Sig.[c]	Percent of Absolute Bias Mean	Percent of Absolute Bias Std. Dev.	Percent of Absolute Bias Sig.[c]
(7)	All Types and All Sources	75	-7.4%	40.2%	0.11	25.9%	31.5%	0.01
(8)	Endogenous Types & All Sources	37	-12.7	50.1	0.13	37.3	35.3	0.01
(9)	Exogenous Types & All Sources	38	-2.3	27.1	0.61	14.8	22.7	0.01
(10)	All Types & Earnings Source	53	-10.9	41.5	0.06	26.0	34.0	0.01
(11)	Endogenous & Earnings Source	28	-17.3	48.9	0.07	34.2	38.5	0.01
(12)	Exogenous & Earnings Source	25	-3.7	30.8	0.55	16.8	25.9	0.01
(13)	All Types & Financial Position	22	1.0	36.3	0.90	25.7	25.0	0.01
(14)	Endogenous & Financial Position	9	1.7	54.1	0.93	47.0	21.2	0.01
(15)	Exogenous & Financial Position	13	0.5	18.9	0.93	11.0	15.0	0.02

[a]Measurement bias is computed as the least squares estimate less the two-stage least squares estimate, and this quantity scaled by the latter estimate. Absolute bias is the absolute value of the measurement bias for individual parameters.

[b]Relations of the financial model are sorted on the number of endogenous explanatory variables.

[c]The reported significance (sig.) level is from a *t*-test of the null hypothesis that the "measurement bias is zero."

[d]Significance levels are reported from paired *t*-tests of the null hypothesis that the "measurement bias of the parameters of row *i* is equal to that of row *j*", where *i* and *j* refer to rows (1) through (6) of panel A.

[e]The variables are classified as either endogenous or exogenous, and the equations of the financial model are categorized by source. The source of the relations is either "earnings" based or descriptive of "financial position"; these correspond to the dependent variable performance measure (financial position variables are CMS, OA, CPE and CL).

downward biased parameters (i.e., forty-five of the seventy-five parameters) under the null hypothesis of "unbiased parameters" is less than 5 percent (based on a binomial test). The overall average absolute measurement bias exceeds 25 percent.

Further scrutiny of table 3 reveals at least two potential sources of measurement bias. First, the magnitude of the bias, for individual relations, appears related to the number of endogenous explanatory variables. Second, measurement bias, both its direction and magnitude, seems linked to the type of financial activity. To systematically investigate these propositions, a decomposition of measurement bias is performed. Panel A of table 4 provides a breakdown of measurement bias by the number of endogenous variables within a relation. This analysis demonstrates that categorization of the relations by the number of endogenous variables yields substantially different degrees of measurement bias. Specifically, the absolute measurement bias monotonically increases with the number of endogenous variables in a relation. The absolute bias is 7.3, 12.6, 32.5 and

35.6 percent for relations with one, two, three and four endogenous variables, respectively. Statistical tests show that the absolute bias is significantly (at the 0.02 level) greater than zero. However, the average directional bias is not linked with the number of endogenous variables; e.g., the average bias is -3.1, -11.8, -5.4 and -11.8 percent for relations with one, two, three and four endogenous variables, respectively.

Further analysis shows that a substantial increase in measurement bias occurs when three or more endogenous variables appear in the financial relation -- see rows (5) and (6) of panel A. For example, the absolute bias increases from 9.7 percent for relations with one or two endogenous factors to 33.5 percent for those with three or four endogenous factors. Evidence from a pairwise comparison of the relations categorized by the number of endogenous variables is presented in the lower half of panel A. The level of the absolute bias is significantly (at the 0.01 level) greater for relations with three or more endogenous variables as compared to those with fewer endogenous factors -- see pairwise absolute bias tests between rows (5) and (6).

The evidence in table 3 also hints at a relation between measurement bias and the type of financial activity. This phenomenon is more apparent in a decomposition of the results by (1) variables categorized into endogenous and exogenous, and (2) relations categorized by earnings-based or financial position type activities. The evidence in rows (8) and (9) in panel B of table 4 indicates that while absolute measurement bias persists for both endogenous and exogenous variables, the directional underestimation bias is limited to the endogenous variables. Measurement bias is -12.7 percent (significant at the 0.13 level), whereas no such measurement bias exists for the exogenous variables (attained significance level greater than 0.60).

The results in table 4 also show that measurement bias is linked to the type of financial activity in that both the magnitude and direction of measurement bias is related to whether the performance measure reflects earnings or financial position; see rows (10) through (15) of panel B. The negative measurement bias (-7.4 percent) is significantly (at the 0.06 level) tied to the earnings relations (-10.9 percent) and <u>not</u> to financial position relations (1.0 percent). Moreover, the downward bias in the earnings relations is primarily due (significant at the 0.07 level) to the endogenous factors (-17.3 percent) and not the exogenous variables (-3.7 percent). Yet it must be recognized that while the directional nature of the measurement bias is linked to certain characteristics of the financial model, the absolute bias is significant (at better than the 0.02 level) in all cases.

5. Summary and Conclusion

5.1 Major Results

This article provides empirical evidence on the effect of using an advanced parameter measurement technique in relation to a parsimonious procedure for a financial model of the firm. The motivation for this analysis stems from the increasing importance of, and reliance placed on, financial models in managerial decisions, and from prior surveys which report the prevalent use of simple measurement procedures in practice. Accordingly, while the more advanced measurement techniques are theoretically superior, their benefits may or may not be realized in practical applications.

To investigate this question, a field study of a financial model is conducted. Two common parameter measurement techniques are investigated for comparison purposes: (1) two-stage least squares, and (2) ordinary least squares. The performance of these measurement techniques is assessed by both the magnitude and direction of bias. Moreover, measurement bias is decomposed in an attempt to relate it to characteristics of the firm and the financial model.

The evidence indicates the existence of substantial differences in parameter measurements, attributed to the estimation technique, for the financial model. Evidence of these significant differences jeopardizes managerial decisions which depend on accurate measurement of the financial model. The evidence emphasizes the relevance of the parameter measurement technique in practice, and encourages managers to seriously scrutinize the results from their financial models. The evidence also suggests that the direction and magnitude of the measurement bias are related to both model and firm characteristics. Specifically, financial relations which are determined by factors endogenous to the firm are shown to be particularly prone to measurement bias. Nevertheless, the absolute level of bias is high regardless of the presence of endogenous determinants. A decomposition of the measurement bias shows that the direction of bias (downward) is determined by (1) the endogenous nature of the variable, and (2) the type of financial activity it represents. It is shown that nearly all of the underestimation bias is attributed to earnings relations in comparison to those reflecting the firm's financial position, and that the measurement bias in earnings relations is primarily linked with the endogenous determinants.

In summary, the evidence in this article indicates that application of a simultaneously-determined financial model of the firm must not ignore potentially significant differences in managerial inferences due to the parameter measurement technique selected. Specifically, the evidence suggests that use of parsimonious parameter measurement techniques can seriously compromise managerial decisions which rely on the output of financial models. This article identifies characteristics of both the model and firm which increase the likelihood of measurement bias, and which might be usefully utilized by practitioners in isolating potential measurement error. The consequences of erroneous managerial decisions, and strategic actions, from reliance on improperly measured financial models emphasize the importance of field study evidence on model measurement of the type reported here.

5.2 Suggestions for Future Research

Empirical evidence on the measurement of financial models, and its role in managerial decision making, is limited. While this article demonstrates the importance of the parameter measurement technique for strategic analyses which rely on a financial model, much about the measurement of these models, and their application, is unknown. One extension of this article is to explore alternative, or new, measurement techniques which are adaptive to changes in both environmental conditions and the firm. Such research must recognize the existence of both nonstationary behavior in variables and diversity of financial operations. The research in this area must also consider the feasibility and flexibility of the measurement techniques. Another extension is to explore the inclusion of expectations into financial models. There exist numerous sources for predictions of firm performance (e.g., *Value Line Investment Survey*, *Zacks Investment Research*), yet little research exists on the potential opportunities for their use in financial models. Finally, financial models rely on accounting data, yet there is little appreciation for the accounting recognition and measurement concepts which determine their values. An examination of the influence of accounting methods, managerial income strategies, and environmental determinants on the stochastic properties of accounting data is needed. In sum, to the extent that we can better model the financial operations of a firm, managerial decision making will be enhanced.

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*****Footnotes*****

1. Based on the three-tier strategic framework descriptive of company operations (the corporate, business, and functional area level), the focus of this article is at the functional level since it entails the company's financial operations involving claims to resources (financial position) and changes in those resources (earnings) -- see Schendel and Patton (1978), Vancil and Lorange (1975).
2. This conclusion is drawn in spite of only thirty-five observations for parameter measurement purposes; obviously, the usual asymptotic properties associated with the more advanced measurement techniques might not be realized in such limited information environments.
3. Like the limited information set of Saltzman's (1967) model, neither the Elliott and Uphoff (1972) nor Elliott (1972) models relied on more than 24 observations for parameter measurement.
4. Although not reported, a constant term is included in all equations of the financial model. Furthermore, the Koyck (1954) approach of accounting for distributed lags in the endogenous variables is utilized in each equation. Each equation of the model is "over-identified" in an econometric sense, based on examination of the order and rank conditions; consequently, consistent and asymptotically efficient parameter estimates are obtainable. Since nonlinearities exist in the MKT, ADV, DPR, and ADM relations, due to the presence of OP, these endogenous variables are solved in terms of the predetermined and other endogenous variables prior to estimation.
5. While not shown, the least squares estimates can be derived from information in tables 2 and 3.

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