Chapter 2

Accounting Information, Regression Analysis, and Financial Management

2.1. Introduction

Accounting information, market information, and basic aggregated economic data are the basic inputs needed for financial analysis and planning; statistical methods, regression analysis, operation research programming techniques, and computer programming knowledge are important tools for achieving financial planning and forecasting. In performing financial analysis and planning, it is important to know how to use the appropriate tools in analyzing the relevant data.

The main purposes of this chapter are (i) to show how algebraic and statistical methods are used in cost–volume–profit (CVP) analysis and (ii) to demonstrate how modern econometric methods can be used to analyze the dynamic adjustment process of financial ratios and obtain new insights into the use of financial ratios in the financial analysis, planning, and forecasting. Recall that for financial management, the three major policies of the firm are investment, financing, and dividend policy. The basic concept of CVP analysis can be used in the areas of investment and financing, specifically for capital budget decision-making and leverage analysis. Similarly, ratio analysis can be used to determine a firm's liquidity position, leverage position, the effectiveness of asset utilization, and profitability performance.

This chapter is organized as follows. Section 2.2 reviews four important financial statements: the balance sheet, the income statement, the retained earnings statement, and the statement of changes in financial position. Section 2.3 discusses possible weaknesses of accounting information, and proposes possible methods to minimize these weaknesses. In Section 2.4, static ratio analysis is reviewed and dynamic financial ratio analysis is presented. Both single-equation and simultaneous-equation approaches to dynamic financial analysis are explored. In Section 2.5, cost–volume–profit (CVP) analysis is extended from deterministic analysis to stochastic analysis. The concepts of statistical distributions are used to improve the robustness of CVP analysis. The relationship between accounting income and economic income is explored in Section 2.6. Finally, Section 2.7 summarizes the key concepts of the chapter. In addition, there are two appendices to this chapter reviewing basic econometric methods. Appendix 2.A reviews basic concepts and methods of simple regression and multiple regressions, and Appendix 2.B discusses the basic concepts and methods of instrumental variables and two-stage least-squares regression.

2.2. Financial Statements: A Brief Review

Corporate annual and quarterly reports generally contain four basic financial statements: balance sheet, income statement, statement of retained earnings, and statement of changes in financial position. Using Johnson & Johnson (JNJ) annual consolidated financial statements as examples, we discuss in turn the usefulness of, and problems associated with the use of, each of these statements in financial analysis and planning. Finally, the use of annual vs quarterly financial data are addressed.

2.2.1. *Balance Sheet*

The balance sheet describes a firm's financial position at one specific point in time. It is a static representation, as if a snapshot had been taken, of the firm's financial composition of assets and liabilities at one point in time. The balance sheet of Johnson & Johnson, shown in Table 2.1, is broken down into two basic areas of classification — total assets (debit) and total liabilities and shareholders' equity (credit).

On the debit side, accounts are divided into six groups: current assets, marketable securities — non-current, property, plant and equipment, intangible assets, deferred taxes on income, and other assets. Current assets represent those accounts that are of a short-term nature such as cash and cash equivalent, marketable securities and accounts receivable, inventories, deferred tax on income and prepaid expense. It should be noted that deferred tax on income in this group is a current deferred tax and will be converted into income tax within 1 year. Property encompasses all fixed or capital assets such as real estate, plant and equipment, and special tools

Table 2.1. Consolidated balance sheets of Johnson & Johnson Corporation and consolidated subsidiaries (2000–2005) (dollars in millions).

Assets	2000	2001	2002	2003	2004	2005
Current assets						
Cash and cash equivalent	$4278	$3758	$2894	$5377	$9203	$16,055
Marketable securities	2479	4214	4581	4146	3681	83
Account receivable	4601	4630	5399	6574	6831	7010
Inventory	2905	2992	3303	3588	3744	3959
Deferred taxes on income	1174	1192	1419	1526	1737	1845
Prepaid expenses and other receivable	1254	1687	1670	1784	2124	2442
Total current assets	**16,691**	**18,473**	**19,266**	**22,995**	**27,320**	**31,394**
Marketable securities — Noncurrent	657	969	121	84	46	20
Property, plant and equipment, net	7409	7719	8710	9846	10,436	10,830
Intangible assets, net	7535	9077	9246	11,539	11,842	6185
Deferred taxes on income	240	288	236	692	551	385
Other assets	1713	1962	2977	3107	3122	3221
Total assets	**$34,245**	**$38,488**	**$40,556**	**$48,263**	**$53,317**	**$58,025**

Liabilities and shareholder's equity

Current liabilities						
Loans and notes payable	$1489	$565	$2117	$1139	$280	$668
Account payable	2122	2838	3621	4966	5227	4315
Accrued liabilities	2793	3135	3820	2639	3523	3529
Accrued rebates, returns and promotion						
Accrued salaries, wages and commissions	529	969	1181	1452	1094	1166
Taxes on income	322	537	710	944	1506	940
Total current liabilities	**7255**	**8044**	**11,449**	**13,448**	**13,927**	**12,635**
Long-term debt	3120	2217	2022	2955	2565	2017
Deferred tax liability	255	493	643	780	403	211
Employee related obligations	1804	1870	1967	2262	2631	3065
Other liabilities	1373	1631	1778	1949	1978	2226

(*Continued*)

Table 2.1. (*Continued*)

Assets	2000	2001	2002	2003	2004	2005
Shareowners' equity						
Preferred stock-without par value	—	—	—	—	—	—
Common stock-par value $1.00	3120	3120	3120	3120	3120	3120
Net receivable from employee stock plan	−35	−30	−25	−18	−11	—
Accumulated other comprehensive income	−461	−530	−842	−590	−515	−755
Retained earnings	18,113	23,066	26,571	30,503	35,223	41,471
Less: Common stock held in treasury	342	1393	6127	6146	6004	5965
Total shareowners' equity	**20,395**	**24,233**	**22,697**	**26,869**	**31,813**	**37,871**
Total liabilities and shareholders' equity	**$34,245**	**$38,488**	**$44,556**	**$48,263**	**$53,317**	**$58,025**

and the allowance for depreciation and amortization. Intangible assets refer to the assets of research and development (R&D).

The credit side of the balance sheet in Table 2.1 is divided into current liabilities, long-term liabilities, and shareowners' equity. Under current liabilities, the following accounts are included: accounts, loans, and notes payable; accrued liabilities; accrued salaries and taxes on income. Long-term liabilities include various forms of long-term debt, deferred tax liability, employee-related obligations, and other liabilities. The stockholder's equity section of the balance sheet represents the net worth of the firm to its investors. For example, as of December 31, 2000, Johnson & Johnson had $0 million preferred stock outstanding, $3,120 million in common stock outstanding, and $18,113 million retained earnings. The total shareholder equity for this year is $20,395. Sometimes, there are preferred stock and hybrid securities (e.g. convertible bond and convertible preferred stock) on the credit side of the balance sheet.

The balance sheet is useful because it depicts the firm's financing and investment policies. The use of comparative balance sheets, those that present several years' data, can be used to detect trends and possible future problems. Johnson & Johnson has presented on its balance sheet, information for six periods: December 31, 2000; December 31, 2001; December 31, 2002; December 31, 2003; December 31, 2004; and December 31, 2005. The balance sheet, however, is static and therefore should be analyzed with caution in financial analysis and planning.

2.2.2. *Statement of Earnings (Income Statement)*

Johnson & Johnson's income statements are presented in Table 2.2 and describe the results of operations for a 12-month period, ending December 31. The usual income-statement periods are annual, quarterly, and monthly. Johnson has chosen the annual approach. Both the annual and quarterly reports are used for external as well as internal reporting. The monthly statement is used primarily for internal purposes such as the estimation of sales and profit targets, judgment of controls on expenses,

Table 2.2. Consolidated statements of earnings of Johnson & Johnson Corporation and subsidiaries (2000–2005) (dollars in millions).

(Dollars in millions except per share figures)	2000	2001	2002	2003	2004	2005
Sales to customers	$29,846	$32,317	$36,298	$41,862	$47,348	$50,514
Cost of products sold	8908	9581	10,447	12,176	13,422	13,954
Gross profit	20,938	22,736	25,851	29,686	33,926	36,560
Selling, marketing, and administrative expenses	11,218	11,260	12,216	14,131	15,860	16,877
Research expense	3105	3591	3957	4684	5203	6312
Purchased in-process research and development	66	105	189	918	18	362
Interest income	−429	−456	−256	−177	−195	−487
Interest expense, net of portion capitalized	204	153	160	207	187	54
Other (income) expense, net	−94	185	294	−385	15	−214
	14,070	14,838	16,560	19,378	21,088	22,904
Earnings before provision for taxes on income	6868	7898	9291	10,308	12,838	13,656
Provision for taxes on income	1915	2230	2694	3111	4329	3245
Net earnings	4953	5668	6597	7197	8509	10,411
Basic net earnings per share	$1.65	$1.87	$2.20	$2.42	$2.87	$3.50
Diluted net earnings per share	$1.61	$1.84	$2.16	$2.40	$2.84	$3.46

and monitoring progress toward long-term targets. The income statement is more dynamic than the balance sheet because it reflects changes for the period. It provides an analyst with an overview of a firm's operations and profitability of the firm on a gross, and operating, and a net income basis. Johnson & Johnson's income includes sales, interest income, and other net income/expenses. Costs and expenses for Johnson & Johnson's include the cost of goods sold; selling, marketing, and administrative expenses; and depreciation, depletion, and amortization. The difference between the income and cost and expenses results in the company's Net Earnings. A comparative income statement is very useful in financial analysis and planning because it allows insight into the firm's operations, profitability, and financing decisions over time. Net earnings of Johnson & Johnson in 2000 was $4,953. In addition, the rule earnings per share and the diluted net earnings per share in 2000 were $1.65 and $1.63 respectively.

2.2.3. *Statement of Equity*

Johnson & Johnson's equity statements are shown in Table 2.3. This statement presents the changes of the shareowners equity items in the balance sheet. Retained earnings is the most important item in the statement of equity. These are the earnings that a firm retains for reinvestment rather than paying them out to shareholders in the form of dividends. The equity statement is easily understood if it is viewed as a bridge between the balance sheet and the income statement. The equity statement presents a summary of those categories that have an impact on the level of retained earnings: the net earnings and the dividends declared for preferred and common stock. It also represents a summary of the firm's dividend policy and shows how net income is allocated to dividends and reinvestment. Johnson & Johnson's equity is one source of funds for investment, and this internal source of funds is very important to the firm. The retained earnings of Johnson & Johnson in 2000 was $18,113.

2.2.4. *Statement of Cash Flows*

Another extremely important part of the annual and quarterly report is the statement of cash flows. This statement is very helpful in evaluating a firm's use of its funds and in determining how these funds were raised. Statements of cash flow for Johnson & Johnson are shown in Table 2.4. These statements of cash flow are composed of three sections: cash flows from operating activities, cash flows from investing activities, and cash flows from financing

Table 2.3. Consolidated statements of equity of Johnson & Johnson Corporation and subsidiaries (2000–2005) (dollars in millions).

(Dollars in millions)	Total	Comprehensive income	Retained earnings	Note receivable from employee stock ownership plan (ESOP)	Accumulated other comprehensive income	Common stock issued amount	Treasury stock amount
Balance, January 2, 2000	$16,995		14,768	(41)	(399)	3,120	(453)
Net earnings	4953	4953	4953				
Cash dividends paid	(1724)		(1724)				
Employee stock compensation and stock option plans	619		(456)				1075
Conversion of subordinated debentures	504		504				
Repurchase of common stock	(973)						(973)
Business combinations	77		68				9
Other comprehensive income, net of tax:							
Currency translation adjustment	(45)	(45)			(45)		
Unrealized gains/(losses) on securities	(2)	(2)			(2)		
Pension liability adjustment	(15)	(15)			(15)		
Reclassification adjustment		(52)					
Total comprehensive income		4839					
Note receivable from ESOP	6			6			

(*Continued*)

Table 2.3. (*Continued*)

(Dollars in millions)	Total	Comprehensive income	Retained earnings	Note receivable from employee stock ownership plan (ESOP)	Accumulated other comprehensive income	Common stock issued amount	Treasury stock amount
Balance, December 31, 2000	$20,395		18,113	(35)	(461)	3,120	(342)
Net earnings	5668	5668	5668				
Cash dividends paid	(2047)		(2047)				
Employee stock compensation and stock option plans	842		(602)				
Conversion of subordinated debentures	815		632				
Repurchase of common stock	(2742)						
Business combinations	1366		1302				
Other comprehensive income, net of tax:							
Currency translation adjustment	(175)	(175)			(175)		
Unrealized gains/(losses) on securities	8	8			8		
Gains/(losses) on derivatives & hedges	98	98			98		
Reclassification adjustment		(14)					
Total comprehensive income		5585					
Note receivable from ESOP	5			5			

(*Continued*)

Table 2.3. (*Continued*)

(Dollars in millions)	Total	Comprehensive income	Retained earnings	Note receivable from employee stock ownership plan (ESOP)	Accumulated other comprehensive income	Common stock issued amount	Treasury stock amount
Balance, December 30, 2001	$24,233		23,066	(30)	(530)	3120	(1393)
Net earnings	6597	6597	6597				
Cash dividends paid	(2381)		(2381)				
Employee stock compensation and stock option plans	806		(489)				1,295
Conversion of subordinated debentures	131		(222)				353
Repurchase of common stock	(6382)						(6382)
Other comprehensive income, net of tax:							
Currency- translation adjustment	(10)	(10)			(10)		
Unrealized gains/(losses) on securities	(86)	(86)			(86)		
Pension liability adjustment	(18)	(18)			(18)		
Gains/(losses) on derivates & hedges	(198)	(198)			(198)		
Reclassification adjustment		(26)					
Total comprehensive income		6259					
Note receivable from ESOP	5			5			

(*Continued*)

Table 2.3. (*Continued*)

(Dollars in millions)	Total	Comprehensive income	Retained earnings	Note receivable from employee stock ownership plan (ESOP)	Accumulated other comprehensive income	Common stock issued amount	Treasury stock amount
Balance, December 29, 2002	**$22,697**		**26,571**	**(25)**	**(842)**	**3120**	**(6127)**
Net earnings	7197	7197	7197				
Cash dividends paid	(2746)		(2746)				
Employee stock compensation and stock option plans	534		(626)				1160
Conversion of subordinated debentures	2		(2)				4
Repurchase of common stock	(1183)						(1183)
Business combinations	109		109				
Other comprehensive income, net of tax:							
Currency translation adjustment	334	334			334		
Unrealized gains on securities	29	29			29		
Pension liability adjustment	(31)	(31)			(31)		
Losses on derivatives & hedges	(80)	(80)			(80)		
Reclassification adjustment		(2)					
Total comprehensive income		7447					
Note receivable from ESOP	7			7			

(*Continued*)

Table 2.3. (*Continued*)

(Dollars in millions)	Total	Comprehensive income	Retained earnings	Note receivable from employee stock ownership plan (ESOP)	Accumulated other comprehensive income	Common stock issued amount	Treasury stock amount
Balance, December 28, 2003	**$26,869**		**30,503**	**(18)**	**(590)**	**3120**	**(6146)**
Net earnings	8509	8509	8509				
Cash dividends paid	(3251)		(3251)				
Employee stock compensation and stock option plans	883		(520)				1403
Conversion of subordinated debentures	105		(18)				123
Repurchase of common stock	(1384)						(1384)
Other comprehensive income, net of tax:							
Currency translation adjustment	268	268			268		
Unrealized gains on securities	(59)	(59)			(59)		
Pension liability adjustment	(282)	(282)			(282)		
Losses on derivatives & hedges	30	30			30		
Reclassification adjustment		(10)					
Total comprehensive income		8574					
Note receivable from ESOP	7			7			

(*Continued*)

Table 2.3. (*Continued*)

(Dollars in millions)	Total	Comprehensive income	Retained earnings	Note receivable from employee stock ownership plan (ESOP)	Accumulated other comprehensive income	Common stock issued amount	Treasury stock amount
Balance, January 2, 2005	**$31,813**		**35,223**	**(11)**	**(515)**	**3120**	**(6004)**
Net earnings	10,411	10,411	10,411				
Cash dividends paid	(3793)		(3793)				
Employee stock compensation and stock option plans	1017		(441)				1458
Conversion of subordinated debentures	369		(132)				501
Repurchase of common stock	(1717)		203				(1920)
Other comprehensive income, net of tax:							
Currency translation adjustment	(415)	(415)			(415)		
Unrealized gains on securities	(16)	(16)			(16)		
Pension liability adjustment	26	26			26		
Losses on derivatives & hedges	165	165			165		
Reclassification adjustment		(15)					
Total comprehensive income		10,156					
Note receivable from ESOP	11			11			
Balance, January 1, 2006	**$37,871**		**41,471**	—	**(755)**	**3120**	**(5965)**

Table 2.4. Consolidated statements of cash flow of Johnson & Johnson Corporation and subsidiaries (dollars in millions).

(Dollars in Millions)	2000	2001	2002	2003	2004	2005
Cash flows from operating activities						
Net earnings	$4953	$5668	$6597	$7197	$8509	$10,411
Adjustments to reconcile net earnings to cash flows:						
Depreciation and amortization of property and intangibles	1,592	1,605	1,662	1,869	2,124	2,093
Purchased in-process research and development	66	105	189	918	18	362
Deferred tax provision	−128	−106	−74	−720	−498	−46
Accounts receivable allowances	41	99	−6	6	3	−31
Changes in assets and liabilities, net of effects from acquisitions:						
Increase in accounts receivable	−468	−258	−510	−691	−111	−568
(Increase)/decrease in inventories	128	−167	−109	39	11	−396
(Decrease)/increase in accounts payable and accrued liabilities	41	1401	1420	2192	607	−911
Decrease/(increase) in other current and non-current assets	124	−270	−1429	−746	−395	620
Increase in other current and non-current liabilities	554	787	436	531	863	343
Net cash flows from operating activities	6903	8864	8176	10,595	11,131	11,877
Cash flows from investing activities						
Additions to property, plant and equipment	−1689	−1731	−2099	−2262	−2175	−2632
Proceeds from the disposal of assets	166	163	156	335	237	154
Acquisitions, net of cash acquired	−151	−225	−478	−2812	−580	−987
Purchases of investments	−5676	−8188	−6923	−7590	−11,617	−5660
Sales of investments	4827	5967	7353	8062	12,061	9187
Other (primarily intangibles)	−142	−79	−206	−259	−273	−341
Net cash used by investing activities	−2665	−4093	−2197	−4526	−2347	−279

(*Continued*)

Table 2.4. (*Continued*)

(Dollars in Millions)	2000	2001	2002	2003	2004	2005
Cash flows from financing activities						
Dividends to shareholders	−1724	−2047	−2381	−2746	−3251	−3793
Repurchase of common stock	−973	−2570	−6538	−1183	−1384	−1717
Proceeds from short-term debt	814	338	2359	3062	514	1215
Retirement of short-term debt	−1485	−1109	−560	−4134	−1291	−732
Proceeds from long-term debt	591	14	22	1,023	17	6
Retirement of long-term debt	−35	−391	−245	−196	−395	−196
Proceeds from the exercise of stock options	387	514	390	311	642	696
Net cash used by financing activities	−2425	−5251	−6953	−3863	−5148	−4521
Effect of exchange rate changes on cash and cash equivalents	−47	−40	110	277	190	−225
Increase in cash and cash equivalents	1766	−520	−864	2483	3826	6852
Cash and cash equivalents, beginning of year	2512	4278	3758	2894	5377	9203
Cash and cash equivalents, end of year	$4278	$3758	$2894	$5377	$9203	$16,055
Supplemental cash flow data						
Cash paid during the year for:						
Interest	$215	$185	$141	$206	$222	$151
Income taxes	1651	2090	2006	3146	3880	3429
Supplemental schedule of noncash investing and financing activities						
Treasury stock issued for employee compensation and stock option plans, net of cash proceeds	$754	$971	$946	$905	$802	$818
Conversion of debt	504	815	131	2	105	369
Acquisitions						
Fair value of assets acquired	$241	$1925	$550	$3135	$595	$1128
Fair value of liabilities assumed	−5	−434	−72	−323	−15	−141
Net cash paid for acquisitions	$236	$1491	$478	$2812	$580	$987
Treasury stock issued at fair value	−85	−1266	—	—	—	—
Net cash paid for acquisitions	$151	$225	$478	$2812	$580	$987

activities. The statement of cash flows, whether developed on a cash or working capital basis, summarizes long-term transaction that affect the firm's cash position. For Johnson & Johnson, the sources of cash are essentially provided by operations. Application of these funds includes dividends paid to stockholders and expenditures for property, plant, equipment, etc. The last item of statement of cash flow is cash and cash equivalents which is the first item in the balance sheet. Therefore, this statement reveals some important aspects of the firm's investment, financing, and dividend policies, making it an important tool for financial planning and analysis.

The cash flow statement shows how the net increase or decrease in cash has been reflected in the changing composition of current assets and current liabilities. It highlights changes in short-term financial policies. It helps answer question such as: Has the firm been building up its liquidity assets or is it becoming less liquid?

The statement of cash flow can be used to help resolve differences between finance and accounting theory. There is value for the analyst in viewing the statement of cash flow over time, especially in detecting trends that could lead to technical or legal bankruptcy in the future. Collectively, these four statements present a fairly clear picture of the firm's historical and current position.

2.2.5. *Annual vs Quarterly Financial Data*

Both annual and quarterly financial data are important to financial analysts; which one is more important depends on the time horizon of the analysis. Depending upon the patterns of fluctuation in the historical data, either annual or quarterly data could prove more useful. As Gentry and Lee (1983) discuss, understanding the implications of using quarterly data vs annual data is important for proper financial analysis and planning.[1]

Quarterly data has three components: trend-cycle, seasonal, and irregular or random components. It contains important information about seasonal fluctuations that "reflects an intra-year pattern of variation which is repeated constantly or in evolving fashion from year to year."[2] Quarterly data have the disadvantage of having a large irregular, or random, component that introduces noise into analysis.

Annual data is composed of two components, rather than the three of quarterly data, the trend-cycle, and the irregular component, but no seasonal component. The irregular component is much smaller in annual data than in quarterly data. While it may seem that annual data would be most useful for long-term financial planning and analysis, seasonal data

[1] Lee, CF and JA Gentry (1983). *Measuring and Interpreting Time, Firm, and Ledger Effects.*
[2] *Ibid.*

reveal important permanent patterns that underlie the short-term series in financial analysis and planning. In other words, quarterly data can be used for intermediate-term financial planning to improve financial management.

Use of either quarterly or annual data has a consistent impact on the mean-square error of regression forecasting (see Appendix 2.A), which is composed of variance and bias. Changing from annual to quarterly data will generally reduce variance while increasing bias. Any difference in regression results, because of the use of different data, must be analyzed in light of the historical patterns of fluctuation in the original time-series data.

2.3. Critique of Accounting Information

2.3.1. *Criticism*

At first glance, accounting information seems to be heavily audited and regulated, automatically determining what numbers are presented. However, careful analysis makes it apparent that accountants work with a fairly broad framework of rules that increase the distance between accounting and financial valuation. This leeway in accounting rules also tends to make accounting information more random. In addition, Hong (1977) shows that the selection of LIFO or FIFO methods for tax and depreciation based upon historic cost generally introduces a bias in a firm's market-value determination. This combination of discrepancy, bias, and randomness means that accounting information does not represent the "true" information. As a result, both time-series and cross-sectional comparisons of accounting information are difficult to analyze.

A major problem with the use of accounting information rises from errors made in classifying transactions into individual accounts. There are several types of classification errors.

One classification error occurs when a bookkeeper enters an item in the wrong account. This is dealt with by modern auditing through the use of sampling techniques where the auditor certifies that the probability of a material error, that is, an error that would alter a manager's or investor's decision, is within an acceptable limit.

The difference between accountancy and finance theory is another case of classification error. An accountant defines income as the change in shareholder's wealth due to operations of the firm. This includes the use of accruals in wealth determination. The finance discipline defines a firm's income as cash income, or the difference between cash revenues and cash expenses (those payments made to generate current revenue).[3] Due to the accruals used in accounting, accounting income is numerically different from cash income because of a difference in timing.

Another problem with accounting information relates to depreciation costs. There are various accepted ways to spread the cost of an asset over its useful life.[4] The choice of a depreciation method can cause a wide variation in net income.[5] A straight-line method will reduce income less than an accelerated method in the first years of depreciation. In the later years, accelerated depreciation will reduce income less than a straight-line method.

The use of historical costs for pricing an asset acquisition also causes problems in using accounting information. Such reliance on historical cost is particularly troublesome in times of high inflation because historical cost values are no longer representative of the underlying values of the assets and liabilities of the firm. The accounting profession is attempting to deal with this problem through the use of supplementary disclosure of selected financial statement items, as required by Financial Accounting Standard Board 33, for large, publicly traded firms.[6] Accountants are also developing replacement costs and other inflation-adjusted accounting procedures.

2.3.2. *Method for Improvement*

Three possible methods for improving the representativeness or accuracy of accounting information in financial analysis and planning are the use of alternative information, of statistical tools, and of finance and economic theories.

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[3]Haley and Schall (1979). *The Theory of Financial Decisions*. McGraw Hill, p. 8.

[4]Depreciation is a procedure that allocates the acquisition costs of the asset to subsequent periods of time on a systematic and rational basis. There are several widely used methods of allocating the acquisition costs: straight-line, declining balance, and sum-of-the-years digits.

[5]There is a limit on the ability of the firm to manipulate its financial statements by repeatedly changing accounting methods, for depreciation, inventory valuation, or any other of the numerous decisions permitted by generally accepted accounting principles (GAAP). The limitation on constant changes in accounting methods is provided by several sources. Accounting Principle Board 20 requires that any changes must be justified on the basis of fair presentation and that the change and the justification be disclosed.

The American Institute of Certified Public Accountants, through the Auditing Standards Board, requires that the auditor certify that accounting principles have been consistently observed in the current period in relation to the preceding periods (AU 150.02).

[6]Financial Accounting Standards Board Statement #33, Stamford CT, June 1974.

2.3.2.1. *Use of Alternative Information*

Of the many types of alternative information that could be used to improve the accounting data, the most practical and consistent type is market information. Stock prices and replacement costs can be used to adjust reported accounting earnings. According to the theory of efficient capital markets, the market price of a security represents the market's estimate of the value of that security. Furthermore, the market value (or the "intrinsic" value) of a common stock represents the firm's "true" earning potential perceived by investors. An example of the use of market information to complement accounting information is the use of the option-pricing model in capital budgeting under uncertainty in Chapter 10.

2.3.2.2. *Statistical Adjustments*

Another method of improving accounting information is the use of statistical tools. By using a time-series decomposition technique suggested by Gentry and Lee (1983), quarterly earnings can be divided into three components: trend-cyclical, seasonal, and irregular. This decomposition procedure can be used to remove some undesirable noise associated with accounting numbers. Therefore, this statistically adjusted accounting earnings data can be used to improve its usefulness in determining a firm's intrinsic value.

For long-term financial planning and analysis, the trend-cyclical component is the major source of information. The seasonal and irregular components introduce noise that clouds the analysis, and this noise can be removed. For short-term (or intermediate-term) planning and analysis, the seasonal component also produces valuable information. Thus, both trend-cycle and seasonal components should be used in working capital management. Note that the source(s) of noise can also be eliminated by moving average or other statistical methods.

2.3.2.3. *Application of Finance and Economic Theories*

The third method of improving accounting information is the use of finance and economic theories. For example, there are the Modigliani and Miller valuation theory, the capital-asset pricing theory, and option pricing theory, which will be discussed in Chapters 6 and 7. By applying these theories, one can adjust accounting income to obtain a better picture of income measurement, i.e. finance income (cash flow). Also, the use of finance theory combined with market and other information gives an analyst another estimate of income measurement. In addition, various earnings estimates can shed additional light on the firm's value determination. To do these kinds of empirical tests, Lee and Zumwalt (1981) use a multiple regression model to investigate the association between six alternative accounting profitability measures and security rate-of-return determination. Their empirical results suggest that accounting profitability information is an important extra-market component information of asset pricing. In other words, it is shown that different accounting profitability measures should be used by security analysts and investors to determine the equity rates of return for different industries.

2.4. Static-Ratio Analysis and Its Extension

In order to make use of financial statements, an analyst needs some form of measure for analysis. Frequently, ratios are used to relate one piece of financial data to another. The ratio puts the two pieces of data on an equivalent base, which increases the usefulness of the data. For example, net income as an absolute number is meaningless to compare across firms of different sizes. If one creates a net profitability ratio (NI/Sales), however, comparisons are made easier. Analysis of a series of ratios will give us a clear picture of a firm's financial condition and performance.

Analysis of ratios can take one of two forms. First, the analyst can compare the ratios of one firm with those of similar firms or with industry averages at a specific point in time. This is one type of cross-sectional analysis technique that may indicate the relative financial condition and performance of a firm. One must be careful, however, to analyze the ratios while keeping in mind the inherent differences between firms' production functions and operations. Also, the analyst should avoid using "rules of thumb" across industries because the composition of industries and individual firms varies considerably. Furthermore, inconsistency in a firm's accounting procedures can cause accounting data to show substantial differences between firms, which can hinder comparability through the use of ratios. This variation in accounting procedures can also lead to problems in determining the "target ratio" (to be discussed later).

The second method of ratio comparison involves the comparison of a present ratio with that same firm's past and expected ratios. This form of time-series analysis will indicate whether the firm's financial condition has improved or deteriorated. Both types of ratio analyses can take one of the two following forms: static determination and analysis, or dynamic adjustment and its analysis.

2.4.1. *Static Determination of Financial Ratios*

The static determination of financial ratios involves the calculation and analysis of ratios over a number of periods for one company, or the analysis of differences in ratios among individual firms in one industry. An analyst must be careful of extreme values in either direction because of the interrelationships between ratios. For instance, a very high liquidity ratio is costly to maintain, causing profitability ratios to be lower than they need to be. Furthermore, ratios must be interpreted in relation to the raw data from which they are calculated, particularly for ratios that sum accounts in order to arrive at the necessary data for the calculation. Even though this analysis must be performed with extreme caution, it can yield important conclusions in the analysis for a particular company. Table 2.5 presents ratio data for the domestic pharmaceutical industry.

2.4.2. *Liquidity Ratios*

Liquidity ratios are calculated from the information on the balance sheet; they measure the relative strength of a firm's financial position. Crudely interpreted, these are coverage ratios that indicate the firm's ability to meet short-term obligations. The current ratio (ratio (1) in Table 2.5) is the most popular of the liquidity ratios because it is easy to calculate and it has intuitive appeal. It is also the most broadly defined liquidity ratio, as it does not take into account the differences in relative liquidity among the individual components of current assets. A more specifically defined liquidity ratio is the quick or acid-test ratio (ratio (2)), which excludes the least liquid portion of current assets, inventories.

2.4.3. *Leverage Ratios*

If an analyst wishes to measure the extent of a firm's debt financing, a leverage ratio is the appropriate tool to use. This group of ratios reflects the financial risk posture of the firm. The two sources of data from which these ratios can be calculated are the balance sheet and the income statement.

The balance-sheet leverage ratio measures the proportion of debt incorporated into the capital structure. The debt–equity ratio measures the

Table 2.5. Company ratios period 2003–2004.

Ratio classification		Formula	J&J 2003	J&J 2004	Industry 2003	Industry 2004
Liquidity ratio						
(1)	Current ratio	$\frac{\text{Current asset}}{\text{Current liabilities}}$	1.71	1.96	1.59	1.7
(2)	Quick ratio	$\frac{\text{CA}-\text{inventory}-\text{other CA}}{\text{Current liabilities}}$	1.21	1.47	1.048	1.174
Leverage ratio						
(3)	Debt-to-asset	$\frac{\text{Total debt}}{\text{Total asset}}$	0.44	0.40	0.36	0.35
(4)	Debt-to-equity	$\frac{\text{Total debt}}{\text{Total equity}}$	0.80	0.58	1.30	1.45
(5)	Equity multiplier	$\frac{\text{Total asset}}{\text{Total equity}}$	1.80	1.68	2.31	2.47
(6)	Times interest paid	$\frac{\text{EBIT}}{\text{Interest exp enses}}$	12.6	14.6	23.8	27.3
Activity ratios						
(7)	Average collection period	$\frac{\text{Account receivable}}{\text{Sales/365}}$	57.32	52.66	58.3	56.6
(8)	Accounts receivable turnover	$\frac{\text{Sales}}{\text{Acounts receivable}}$	6.37	6.93	6.26	6.45
(9)	Inventory turnover	$\frac{\text{Cost of good sold}}{\text{Inventory}}$	3.39	3.58	3.28	3.42
(10)	Fixed asset turnover	$\frac{\text{Sales}}{\text{Fixed assets}}$	4.25	4.54	4.5	4.7
(11)	Total asset turnover	$\frac{\text{Sales}}{\text{Total assets}}$	0.87	0.89	0.79	0.78
Profitability ratios						
(12)	Profit margin	$\frac{\text{Net income}}{\text{Sales}}$	17.19%	17.97%	17.19%	17.97%
(13)	Return on assets	$\frac{\text{Net income}}{\text{Total assets}}$	14.91%	15.96%	7.34%	7.06%
(14)	Return on equity	$\frac{\text{Net income}}{\text{Total equity}}$	26.79%	26.75%	14.00%	12.44%
Market value						
(15)	Price/earnings	$\frac{\text{Market price per share}}{\text{Earning per share}}$	30.15	24.2	21.35	22.1
(16)	Price-to-book-value	$\frac{\text{Market price per share}}{\text{Book value per share}}$	5.52	4.68	5.71	5.92

proportion of debt that is matched by equity; thus, this ratio reflects the composition of the capital structure. The debt–asset ratio (ratio (3)), on the other hand, measures the proportion of debt-financed assets currently being used by the firm. Other commonly used leverage ratios include equity multiplier, ratio (4) and time interest paid, ratio (6).

The income-statement leverage ratio measures the firm's ability to meet fixed obligations of one form or another. The time interest paid, which is earnings before interest and taxes over interest expense, measures the firm's ability to service the interest expense on its outstanding debt. A more broadly defined ratio of this type is the fixed-charge coverage ratio, which includes not only the interest expense but also all other expenses that the firm is obligated by contract to pay. (This ratio is not included in Table 2.5, because there is not enough information on fixed charges for these firms to calculate this ratio.)

2.4.4. *Activity Ratios*

This group of ratios measures how efficiently the firm is utilizing its assets. With activity ratios one must be particularly careful about the interpretation of extreme results in either direction; very high values may indicate possible problems in the long term, and very low values may indicate a current problem of not generating enough sales or of not taking a loss for assets that are obsolete. The reason that high activity may not be good in the long term is that the firm may not be able to adjust to an even higher level of activity and therefore may miss out on a market opportunity. Better analysis and planning can help a firm get around this problem.

The days-in-accounts-receivable or average collection-period ratio (7) indicates the firm's effectiveness in collecting its credit sales. The other activity ratios measure the firm's efficiency in generating sales with its current level of assets, appropriately termed turnover ratios. While there are many number of turnover ratios that can be calculated, there are three basic ones: inventory turnover (9), fixed assets turnover (10), and total assets turnover (11). Each of these ratios measures a quite different aspect of the firm's efficiency in managing its assets.

2.4.5. *Profitability Ratios*

This group of ratios indicates the profitability of the firm's operations. It is important to note here that these measures are based on past performance. Profitability ratios generally are the most volatile, because many of the variables affecting them are beyond the firm's control. There are three groups of profitability ratios: those measuring margins and those measuring returns, and those measuring the relationship of market values to book or accounting values.

Profit-margin ratios show the percentage of sales dollars that the firm was able to convert into profits. There are many such ratios that can be calculated to yield insightful results, namely, profit margin (12), return on asset (13), and return on equity (14).

Return ratios are generally calculated as a return on assets or equity. The return on assets ratio (13) measures the profitability of the firm's asset utilization. The return on equity (14) indicates the rate of return earned on the book value of owner's equity. Market-value analyses include (i) market-value/book-value ratio and (ii) price per share/earnings per share (P/E) ratio. These ratios and their applications will be discussed in Chapter 6.

Overall, all five different types of ratios (as indicated in Table 2.5) have different characteristics stemming from the firm itself and the industry as a whole. For example, the collection-period ratio (which is Accounts Receivable times 365 over net sales) is clearly the function of the billings, payment, and collection policies of the pharmaceutical industry. In addition, the fixed-asset turnover ratios for those firms are different. This might imply that different firms have different capacity utilization.

2.4.6. *Estimation of the Target of a Ratio*

An issue that must be addressed at this point is determination of an appropriate proxy for the target of a ratio. For an analyst, this can be an insurmountable problem if the firm is extremely diversified, and if it does not have one or two major product lines in industries where industry averages are available. One possible solution is to determine the relative industry share of each division or major product line, then apply these percentages to the related industry averages, and then derive one target ratio for the firm as a whole with which its ratio can be compared. One must be very careful in any such analysis because the proxy may be extremely over- or underestimated. The analyst can also use SIC codes to properly define the industry of diversified firms. He can then use three- or four-digit codes and compute his own weighted industry average.

Often an industry average is used as a proxy for the target ratio. This can lead to another problem, the appropriate calculation of an industry average, even though the industry and companies are fairly well defined. The issue here is the appropriate weighting scheme for combining the individual company ratios in order to arrive at one industry average. Individual ratios can be weighted according to equal weights, asset weights, or sales weights. The analyst must determine the extent to which firm size, as measured by asset base or market share, affects the relative level of a firm's ratios and the tendency for other firms in the industry to adjust toward the target level of this ratio. One way this can be done is by calculating the coefficients of variation for a number of ratios under each of the weighting schemes and to compare them to see which scheme most consistently has the lowest coefficient variation. This would appear to be the most appropriate weighting scheme. Of course, one could also use a different weighting scheme for each ratio, but this would be very tedious if many ratios were to be analyzed. Note that the median, rather than the average or mean, can be used, to avoid needless complications with respect to extreme values that might distort the computation of averages. In the dynamic analysis that follows, the equal-weighted average is used throughout.

2.4.7. *Dynamic Analysis of Financial Ratios*

In basic finance and accounting courses, industry norms are generally used to determine whether the magnitude of a firm's financial ratios is acceptable. Taken separately, ratios are mere numbers. This can lead to some problems in making comparisons among and drawing conclusions from them. In addition, by making only static, one-ratio-to-another comparisons, we are not taking advantage of all the information they can provide. A more dynamic analysis can improve our ability to compare companies with one another and to forecast future ratios. Regressing current ratios against past ratios helps one analyze the dynamic nature and the adjustment process of a firm's financial ratio.

2.4.7.1. *Single-Equation Dynamic Adjustment Process*

1. Basic Model. Lev (1969) uses the concept of the partial-adjustment model to define a dynamic financial-ratio adjustment process as

$$Y_{j,t} = Y_{j,t-1} + \delta_j (Y^*_{j,t} - Y_{j,t-1}), \tag{2.1}$$

where $0 \leq \delta_j \leq 1$, and

δ_j = A partial adjustment coefficient;
$Y_{j,t}$ = Firm's jth financial ratio period t;
$Y_{j,t-1}$ = Firm's jth financial ratio period $t-1$; and
$Y^*_{j,i}$ = Firm's jth financial ratio target in period t.

This model is used in a wide variety of empirical applications of the dynamic properties of financial analysis and forecasting, such as the investment, financing, and dividend decisions, and forecasting. The relationship postulates that at any time, t, only a fixed fraction of the desired adjustment is achieved in that period. Thus, the coefficient of adjustment, δ_j, reflects the fact that there are limitations to the periodic adjustment of ratios.

Lev (1969) suggests that differences across ratios in their speed of adjustment coefficient, δ_j, are a function of two conflicting types of costs: (1) the cost of adjustment, and (2) the cost of being out of equilibrium. These two costs must be balanced for each ratio. Equation (2.1) implies that a firm's current financial ratio is equal to the last period's financial ratio plus adjustment term. The adjustment factor depends upon two elements: the partial adjustment coefficient, δ_i, and the difference between $Y^*_{j,t}$ and $Y_{j,t-1}$. However, $Y^*_{j,t}$ is not an observable variable; so we must find some alternative proxy.

To resolve the problem associated with determining the target ratio ($Y^*_{j,t}$), Lev assumes that (1) $Y^*_{j,t}$ is exactly equal to the industry average of the jth financial ratio in the previous period, denoted as $X_{j,t-1}$ and (2) $Y^*_{j,t}$ is proportional to $X_{j,t-1}$, that is, $CX_{j,t-1}$, where C is the related proportional constant. A generalized proxy of $Y^*_{j,t}$ can be defined as

$$Y^*_{j,t} = CX_{j,t-1} + \tau_{j,t}, \tag{2.2}$$

where $0 \leq C \leq 1$ and $\tau_{j,t}$ represent the proxy error. Proxy error is the error arising from the fact that the substitute, or proxy, ratio only partially approximates the desired target ratio. If $C = 1$ and $\tau_{j,t} = 0$, then $X_{j,t-1}$ is the perfect proxy for $Y^*_{j,t}$. Then we can substitute $X_{j,t-1}$ for $Y^*_{j,t}$ in Eq. (2.1) and obtain

$$Y_{j,t} - Y_{j,t-1} = \delta_j[X_{j,t-1} - Y_{j,t-1}]. \tag{2.3}$$

In order to estimate the partial adjustment coefficient, δ_j, a simple time-series regression can be run and used in the empirical study. The linear form of this regression is defined as

$$Z_{j,t} = A_j + B_j W_{j,t-1} + \varepsilon_{j,t}, \tag{2.4}$$

where

$$\begin{aligned} Z_{j,t} &= Y_{j,t} - Y_{j,t-1}; \\ W_{j,t-1} &= X_{j,t-1} - Y_{j,t-1}; \\ A_j \text{ and } B_j &= \text{regression parameters,} \\ \text{and } \varepsilon_{j,t} &= \text{the error term.} \end{aligned}$$

2. Extensions of this model. Lev also suggests a log-linear form of this model in order to study the dynamic ratio-adjustment process:

$$Z'_{j,t} = A'_j + B'_j W'_{j,t-1} + \varepsilon'_{j,t}, \tag{2.5}$$

where

$Z'_{j,t} = \log(Y_{j,t}) - \log(Y_{j,t-1});$
$W'_{j,t-1} = \log(X_{j,t-1}) - \log(Y_{j,i-1});$
and $\varepsilon'_{j,t} =$ the error term.

One of the possible advantages of the log-linear form of this model over the linear form is that the estimated B'_j represents the elasticity of change, while the estimated B_j does not. The argument is based upon the fact that

$$\begin{aligned} B'_j &= \frac{\partial \log(Y_{j,t}/Y_{j,t-1})}{\partial \log(X_{j,t-1}/Y_{j,t-1})} \\ &= \frac{\%\text{ change in}[Y_{j,t}/Y_{j,t-1}]}{\%\text{ change in}[X_{j,t-1}/Y_{j,t-1}]}. \end{aligned} \tag{2.6}$$

This model can be generalized by assuming that the optimal ratio level attained by the firm is last period's industry ratio average times an adjustment factor, as follows:

$$Y^*_{j,t} = CX_{j,t-1}. \tag{2.7}$$

The adjustment coefficient, C, indicates that firms tend to maintain a fixed deviation from the industry mean in their adjustment process. Furthermore, the analysis of the coefficient and the partial adjustment coefficient (δ_j) should be very helpful in demonstrating the dynamic nature of a firm's financial structure, its financial ratios and their adjustment toward the industry mean.

As for predicting future ratios, Lev finds that the model's predictive powers can be enhanced substantially through the following extension to multiple regression:

$$Y_{j,t} = \hat{A} + \hat{B}_1 X_{j,t-1} + \hat{B}_2 Y_{j,t-1} + \varepsilon_{j,t}. \tag{2.8}$$

This model is found to be substantially more accurate in prediction of future ratios, while the model detailed in Eq. (2.4) is better at estimating the

Table 2.6. Dynamic adjustment ratio regression results.

Variable	Current ratio	Leverage ratio
Mean Z	0.0075	−0.03083
Mean W	−0.14583	0.361666667
Var(Z)	0.013039	0.006099
Cov(Z, W)	0.074	0.009
B'_j	0.810[a]	0.259
t-statistics	[3.53]	[1.06]
A'_j	0.032	−0.042

[a]Partial adjustment coefficient significant at 95% level

partial adjustment coefficient, B_j. With this model, analysts can forecast future possibilities. Furthermore, once the future ratios are estimated, one can work backward and determine the estimated levels of individual accounts; this procedure facilitates planning ahead to meet unpleasant future economic situations.

3. Empirical Data. Annual financial ratio data for Johnson & Johnson and the industry as a whole will be used to show how Eqs. (2.4) and (2.5) perform in empirical financial ratio analysis. The sample period from 1992 to 2004 for Johnson & Johnson in terms of Eq. (2.5) has been empirically estimated. The estimated B'_j and A'_j, and the information needed to estimate these two regression parameters are listed in Table 2.6. Based upon the procedure discussed in Appendix 2.A, the estimated mean Z, mean W, Var (W), and Cov (Z, W) can be used to estimate B'_j, and A'_j estimates of Table 2.6 indicate that the partial adjustment coefficients associated with both current ratio and leverage ratio for Johnson & Johnson.

The accounting general ledger items used in calculating ratios are interrelated. A ratio is merely calculated by using at least two such items. Hence, important financial ratios of a firm may be interrelated. The correlation coefficient matrix among current ratio (CR), asset turnover (AT), gross profit margin (GPM), and leverage ratio (LR) for Johnson & Johnson is presented in Table 2.7 to show the interrelationship. Fisher's z-statistics imply that the sample correlation coefficients between CR and GPM, CR and LR, AT and LR, and GPM and LR are statistically significant at the 95% level. Based upon approximations of Fisher's z-statistics, as discussed by Snedecor (1965), the sample correlation coefficients (as indicated in Table 2.7) can be statistically tested.[7]

[7]z-statistics $= 1/2 \log[(1+\rho)/(1-\rho)]$. where ρ is the simple correlation coefficient.

Table 2.7. Ratio correlation coefficient matrix.

	CR	AT	GPM	LR
CR	1.0			
AT	−0.443841	1.0		
GPM	0.363273	0.381393	1.0	
LR	−0.51175	0.21961	−0.05028	1.0

As shown in Table 2.7, the leverage ratio (LR) is fairly negatively correlated with current ratio (CR, −0.51175) and gross profit margin (GPM, −0.05028), but positively correlated with the activity ratio (AT, 0.21961). Also, gross profit margin is somewhat positively correlated with the current ratio (0.363273). It can thus show that these ratios are interrelated. This tells us that we must use a system of ratios in simple analysis, or use simultaneous equations in a statistical analysis.

2.4.7.2. *Simultaneous Determination of Financial Ratios*

The high correlation between some ratios implies that the financial ratio adjustment process may well be determined by a combination of financial circumstances. To test this hypothesis, a two-equation for current ratio and leverage ratio can be specified as

$$Z_{1,t} = A_0 + A_1 Z_{2,t} + A_2 W_1 + \varepsilon_{1,t}, \tag{2.9a}$$

$$Z_{2,t} = B_0 + B_1 Z_{1,t} + B_2 W_2 + \varepsilon_{2,t}, \tag{2.9b}$$

where $A_i, B_i (i = 0, 1, 2)$ are coefficients, ε_1 and ε_2 are error terms, and

$Z_{1,t}$ = Individual firm's current ratio in period t
− individual firm's current ratio in period $t - 1$;
$Z_{2,t}$ = Individual firm's leverage ratio in period t
− individual firm's leverage ratio in period $t - 1$;
$W_{1,t}$ = Industry average current ratio in period $t - 1$
− individual firm's current ratio in period $t - 1$;
$W_{2,t}$ = Industry average leverage ratio in period $t - 1$
− individual firm's leverage ratio in period $t - 1$.

The equation system above includes two endogenous (Z_1, Z_2) and two exogenous variables (W_1, W_2). The exogenous variable in Eq. (2.9a) is

Table 2.8. Johnson & Johnson empirical results for the simultaneous equation system.

	$A_0(B_0)$	$A_1(B_1)$	$A_2(B_2)$
(2.9a)	−0.071	−0.378	0.080
	[−1.80]	[−5.52]	[1.20]
(2.9b)	−0.0577	−0.842	0.074
	[−1.59]	[−6.07]	[0.91]

different from the one in Eq. (2.9b). Therefore, this equation system is a just-identified equation system (see Appendix 2.B for the exact definition of endogenous and exogenous variables and the procedure for identifying an equation system).

There are random errors (sampling errors) in both Z_1 and Z_2, the independent variables in Eqs. (2.9a) and (2.9b), respectively, which bias the estimated coefficients, A_1 and B_1. (See Appendix 2.B for a discussion on bias.) In order to obtain unbiased estimates for both the coefficients, A_1 and B_1, we use the instrumental-variable technique (discussed in Appendix 2.B) to estimate the parameter of Eqs. (2.9a) and (2.9b). The empirical results for this simultaneous equation system for the current and leverage ratios of Johnson & Johnson are shown in Table 2.8. The results indicate that the estimated coefficients associated with endogenous variables, A_1 and B_1, are statistically different from zero at the 95% significance level, implying that the current and leverage ratio adjustment processes are jointly determined for. Hence, single-equation ratio analysis and forecasting might be subject to simultaneous-equation bias (see Appendix 2.B). This is why we use the system of ratios (for example, the DuPont System) in elementary financial management. In addition, results of Table 2.8 indicate that exogenous variables, W_1 and W_2, are not statistically important in explaining the fluctuations of Johnson & Johnson's current ratio and leverage ratio over time.

2.4.8. *Statistical Distribution of Financial Ratios*

Normal and lognormal distributions are two of the most popular statistical distributions used in accounting and financial analysis. The density function of a normal distribution is

$$F[X] = \frac{1}{\sigma\sqrt{2\pi}} e^{-(X-\mu)^2/2\sigma^2} \quad (-\infty < X < +\infty), \tag{2.10}$$

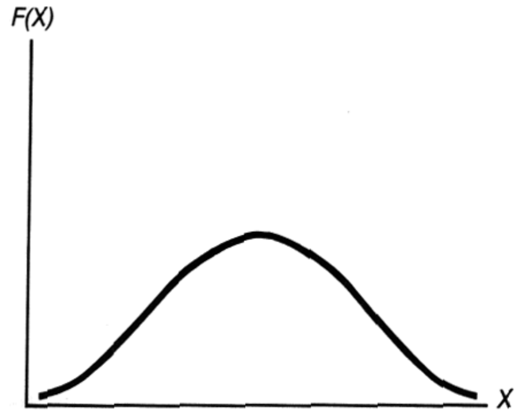

Fig. 2.1. Normal distribution with large variance.

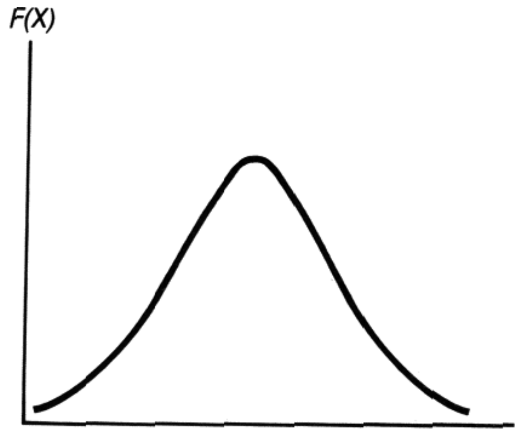

Fig. 2.2. Normal distribution with small variance.

where μ and σ^2 are the population mean and variance, respectively, and e and π are given constants, that is, $\pi = 3.14159$ and $e = 2.71828$.

Normal distributions with different means and variances are graphed in Figs. 2.1 and 2.2. In these two figures, $F(X)$ represents the frequency of the variable X. The variance of Fig. 2.1 is larger than the variance of Fig. 2.2.

If a variable is normally distributed, the information that fully describes the distribution is the mean and the variance. The relative skewness of normal distribution is 0, and the kurtosis of a normal distribution is equal to 3.

There is a direct relationship between the normal distribution and the lognormal distribution. If Y is lognormally distributed, then $X = \log\ Y$ is normally distributed. Following this definition, the mean and the variance of Y can be defined as

$$\mu_Y = \exp\left(\mu_x + \frac{1}{2}\sigma_x^2\right), \tag{2.11a}$$

$$\sigma_Y^2 = \exp(2\mu_x + \sigma_x^2)(\exp(\sigma_x^2) - 1), \tag{2.11b}$$

where exp represents an exponential with base e.

Deakin (1976) finds that the cross-sectional distribution of financial ratios is lognormally instead of normally distributed. Upon analyzing the raw data, he finds that, within the pharmaceutical industry, only the debt–asset ratio is normally distributed; this occurs in 15 of the 19 years of his dataset. All other ratios are lognormally distributed. However, after taking the log transformation, the current ratio becomes normally distributed in 12 of the 19 years, while the normality of the debt–asset ratio drops from 15 to only 6 of the 19 years.

Generally, it seems that financial ratios are not normally distributed and that log transformation does help normalize the data in some, but not in all cases. The reason why we need a normal distribution for analyzing ratios is for testing the significance of a difference, for example, between the behavior of firm and industry figures for the same ratio. Therefore, it is necessary for the analyst to look at data with and without transformations, in order to determine which set of data fits the normal distribution more closely.

2.5. Cost-Volume-Profit Analysis and Its Applications

Cost–volume–profit (CVP) analysis is a synthesized analysis of the income statement. Volume, price per unit, variable cost per unit, and the total fixed cost are the key variables for doing this kind of analysis. The basic type of CVP analysis is the break-even analysis, which can be extended to operating and financial leverage analysis. All of these analyses are important tools of financial analysis and control. Technically, ratio-variable inputs are required for performing these analyses. Conceptually, CVP and its derived relationships are designed to analyze the income statement in terms of an aggregated ratio indicator. Hence, CVP analysis can be regarded as one kind of financial ratio analysis.

2.5.1. *Deterministic Analysis*

Deterministic break-even analysis is an important concept in basic micro-economics, accounting, finance, and marketing courses. Mathematically, the operating (earnings before interest and tax (EBIT)) can be defined as

$$\text{Operating Profit} = \text{EBIT} = Q(P - V) - F, \tag{2.12}$$

where

Q = Quantity of goods sold;
P = Price per unit sold;
V = Variable cost per unit sold;
F = Total amount of fixed costs; and
$P - V$ = Contribution margin.

If operating profit is equal to zero, Eq. (2.12) implies that $Q(P-V)-F=0$ or that $Q(P-V)=F$, that is,

$$Q^* = \frac{F}{(P-V)}. \tag{2.13}$$

Equation (2.13) represents the break-even quantity, or that quantity of sales at which fixed costs are just covered. There are two kinds of break-even analysis, linear and nonlinear. The two forms are shown graphically in Figs. 2.3 and 2.4.

There are very important economic interpretations of these alternative break-even analyses. Linear representation of the total revenue curve implies that the firm operates within a perfect output or product market; the linear total cost curve implies that the input market is linear or perfect and the return (economies) to scale is constant. If these conditions do not hold, linear break-even analysis becomes either unrealistic or only an approximation of the real situation facing the firm.

In the real world, returns (economies) to scale can either be constant, increasing, or decreasing. A nonlinear representation of the variable cost

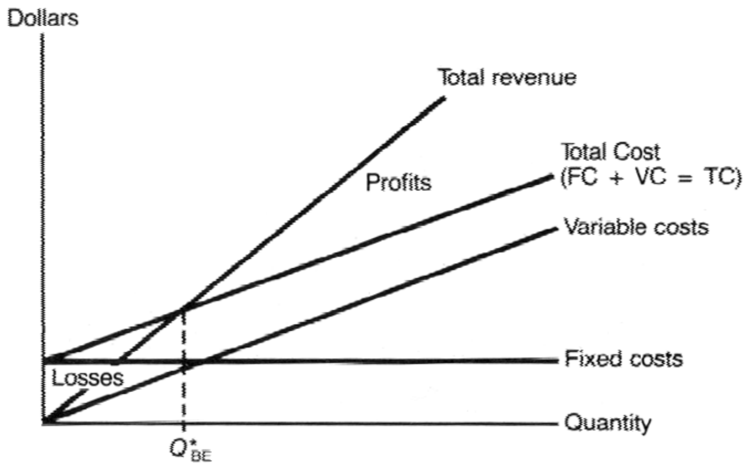

Fig. 2.3. Linear break-even analysis.

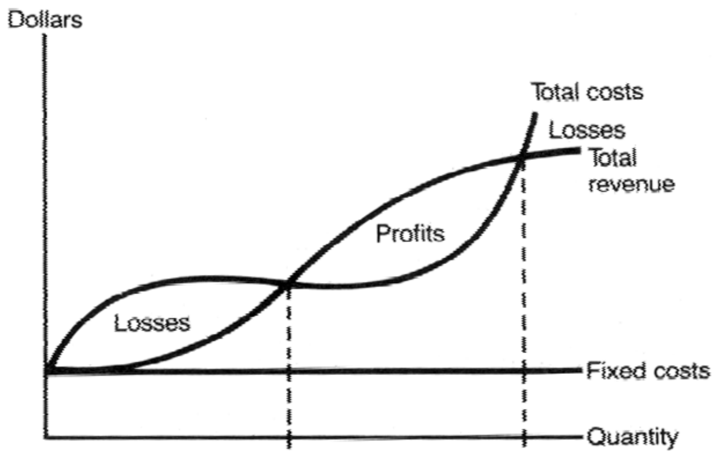

Fig. 2.4. Nonlinear break-even analysis.

and total revenue curves is a more accurate representation of the real one break-even level of sales using this form of analysis.

Break-even analysis can be used in three separate but related ways in financial management, that is (i) to analyze a program of modernization and automation, (ii) to study the effects of a general expansion in the level of operations, and (iii) in new-product decision. These operating leverage decisions can be defined more precisely in terms of the way a given change in volume affects profits. For this purpose we use the definition of degree of operating leverage (DOL) defined in Eq. (2.14):

$$\begin{aligned} DOL &= \frac{\%\text{ Change in profits}}{\%\text{ Change in sales}} \\ &= \frac{Q(P-V)}{Q(P-V)-F} = 1 + \frac{\text{Fixed costs}}{\text{Profits}}. \end{aligned} \tag{2.14}$$

The first equality in Eq. (2.14) is the basic definition of DOL; the second equality is obtained by substituting the definition of profits and sales from Eq. (2.12) (see Appendix 2.B of Chapter 6 for derivation). The third equality implies that the degree of operating leverage increases with a firm's exposure to fixed costs (see Appendix 2.B of Chapter 6 for derivation). Based upon the definition of linear break-even quantity defined in Eq. (2.13), the degree of operating leverage can be rewritten as

$$DOL = \frac{1}{[1-(Q^*/Q)]}. \tag{2.15}$$

There are two important implications of this formulation: (1) if $Q > Q^*$, then $DOL > 0$, and the change in profits is in the same direction as the change in sales; and (2) if $Q < Q^*$, then $DOL < 0$ and the change in losses is in the opposite direction from the change in sales (i.e. if sales increase, losses will decrease). Both equations (2.14) and (2.15) can be used to calculate DOL at any level of output, Q. If company XYZ's break-even quantity Q^* is 50,000 units, then DOL at 100,000 production units is 2. This implies that 1% of XYZ's sales will generate 2% of its profit.

2.5.2. *Stochastic Analysis*

In reality, net profit is a random variable because the quantity used in the analysis should be the quantity sold, which is unknown and random, rather than the quantity produced, which is internally determined. This is the simplest form of stochastic CVP analysis, for there is only one stochastic variable and one need not be concerned about independence among the variables. The distribution of sales is shown graphically in Fig. 2.5.

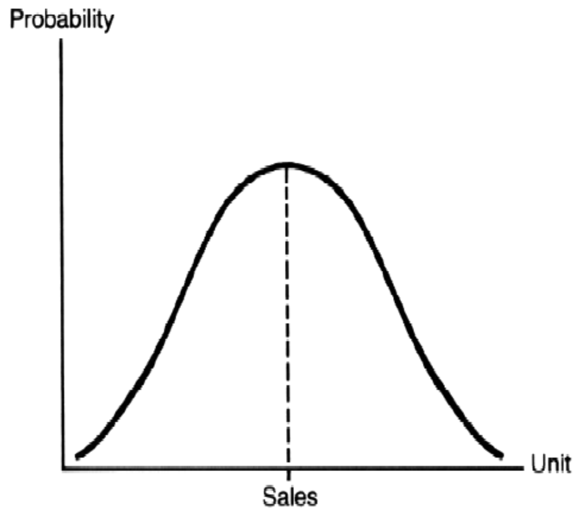

Fig. 2.5. Distribution of sales.

A slightly more complicated form of stochastic CVP analysis is obtained when it is assumed that both the quantity of goods sold (Q) and the contribution margin ($P - V$) are stochastic variables and are independently distributed. The independence assumption is reasonable because the second stochastic variable is defined as the contribution margin, rather than the three separate random variables Q, P, and V. In this situation, quantity and price are probably not independent, because both distributions are determined by imperfections in the product market. Furthermore, these three variables are generally highly negatively correlated, while the normality of their distributions is questionable (and needs further empirical testing). Under the contribution margin approach, one variable that is subtracted from prices, variable costs, has a distribution that is determined by imperfections in the input market. This drastically reduces the degree of correlation with the quantity sold.

While the assumption of independence seems to be fairly accurate in some cases, there is need for more research in this area. Hilliard and Leitch (1975) addressed this problem through the use of a lognormal approach to CVP analysis under uncertainty. They have developed an easily implemented model that can handle dependence among input variables, and that should prove to be helpful to the practitioner.

This formulation for CVP analysis under uncertainty is very important for the decision-maker. Because it is becoming increasingly important to move from point (certainty) to interval (uncertainty) estimates, particularly in today's dynamic business environment, the stochastic nature of this CVP formulation allows one to calculate the point estimate and also the related interval estimate based on the combined probability distributions. This application of probabilistic models greatly enhances the degree of realism. Uncertainty break-even analysis has been generalized by Wei (1979) and Yunker and Yunker (1982) to take into account the crucial elements of random demand and the level of production in the determination of actual sales and resulting profits.

Besides the applications discussed in this section, both CVP and break-even analysis can be integrated with the net present value method of capital budgeting decisions to do financial analysis. Reinhardt (1973) uses this approach to do break-even analysis for Lockheed's Tri Star Program. The major difference between the NPV type of break analysis and the "naive" break-even analysis does not take account of the cost of capital; this will be further explored in Chapter 12, capital budgeting under certainty.

2.6. Accounting Income vs Economic Income[8]

There are three ways of describing income: accounting earnings, finance income, and economic income. Accounting earnings are based upon recording transactions according to generally accepted accounting principles (GAAP) using accruals and deferrals, rather than cash flows. Accountants measure the change in stockholders' wealth due to the operations of the firm. Economic earnings are more abstract than accounting earnings. The historic definition of economic income, as given by Hicks (1965), is the maximum value at which an individual can consume during a period and still be as only the change in wealth due to realized gains and obvious losses (those that are realized as well as those that are inevitable). Economic income measures the change in wealth based upon both realized and unrealized gains and losses.

Finance income is based on cash flow changes in wealth. Cash income is cash revenues less cash expenses. Finance income defines change in wealth

[8]This section is based, in part, on Haley and Schall (1979, pp. 8–10).

as net cash flow, or net cash income less cash investment outlays. Technically economic income rather than accounting earnings should be used to determine the value of a firm, but theoretical economic income is not directly observable; so accounting earnings are generally used as proxy for them. Conceptually, the relationship between accounting earnings and economic income can be defined as

$$E_t = A_t + P_t, \tag{2.16}$$

where

E_t = Economic income,
A_t = Accounting earnings,
P_t = Proxy errors.

In estimating the cost of capital for the utility industry, Miller and Modigliani (1966) take accounting earnings as a proxy for economic income, using instrumental-variable technique, to remove the proxy errors (as discussed in Appendix 2.B). Finance income (cash flows instead of accounting income) will be used to evaluate alternative capital budgeting decisions, which will be used to evaluate alternative capital budgeting decisions and are discussed in Chapters 9 and 10. The main difference between accounting income and cash flows (finance income) is that the former does not focus on cash flows when they occur, while the latter does. The cash flows, for example, correctly deduct the entire expenditure for investment in plant and equipment at the time the cash outflows occur.

2.7. Summary

In this chapter, the usefulness of accounting information in financial analysis is conceptually and analytically evaluated. Both statistical methods and regression analysis techniques are used to show how accounting information can be used to perform active financial analysis for the pharmaceutical industry.

In these analyses, static ratio analysis is generalized to dynamic ratio analysis. The necessity of using simultaneous-equation technique in conducting dynamic financial ratio analysis is also demonstrated in detail. In addition, both deterministic and stochastic CVP analyses are examined. The potential applications of CVP analysis in financial analysis and planning are discussed in some detail. Overall, this chapter gives readers a good understanding of basic accounting information and econometric methods, which are needed for financial analysis and planning.

Problem Set

1. What is the value of accounting information in the process of financial analysis and planning? What are the components to annual and quarterly accounting information and their respective advantages and disadvantages for financial analysis and planning?
2. Define the following terms:
   (a) Real versus financial market
   (b) M_1 and M_2
   (c) Leading economic indicators
   (d) NYSE, AMEX, and OTC
   (e) Primary versus secondary stock market
   (f) Bond market
   (g) Options and futures markets
3. What are limits related to the use of accounting information? What are differences between accounting information and that of economics and finance that can result? How can these limits be overcome and differences reconciled?
4. Discuss the major difference between the linear and nonlinear break-even analysis?
5. What can ratio analysis contribute to financial planning and analysis? What are the determinants of the dynamic adjustment process? How are target ratios derived?
6. What is the relationship between CVP and ratio analysis? How can it be used in financial analysis and planning?
7. Briefly discuss the issue related to net income (EAIT) in financial analysis and planning.
8. A market model is defined as

$$R_{jt} = A_j + B_j R_{mt} + \in_j,$$

   where R_{jt} and R_{mt} are rate of return for jth security and market rates of return, respectively; A_j is the intercept, and B_j is the slope. Use the OLS theory and method discussed in Appendix 2.A of this chapter to show how A_j and B_j can be estimated.

9. Parts of financial records for Company XYZ are:

   Anticipated sales = \$400,000
   Degree of financial leverage = 4/3
   Variable cost = \$200,000
   Combined leverage effect = 2
   Quantity sold = \$100,000 units
   Profit margin = 5%
   Total debt = \$200,000
   Leverage ratio = 1/2
   Common stock outstanding = 10,000 shares
   Current price per share = \$40
   Retention rate = 1/2
   IRR = 8%.

   Calculate the following:

   (a) The total interest expense.
   (b) The total fixed cost.
   (c) The degree of operating leverage.
   (d) The break-even quantity.
   (e) The EAIT.
   (f) Total corporation income tax expense.
   (g) The return on net worth.
   (h) The return on total asset.
   (i) The EPS.
   (j) The P/E ratio for common stock.
   (k) The pay-out ratio for dividend.
   (l) The growth rate for the common stock.
   (m) The required rate of return.
   (n) Total asset turnover.
   (o) Analyze the financial situation of Company XYZ.
   (p) If the probabilistic concepts are applied to break-even analysis, how should the analyses in (o) be revised?

10. Use the ratio information listed in Table 2.6 of the text to estimate the partial ratio adjustment model for GM and interpret the related results.
11. ABC Company's financial records are as follows:
    Quantity of goods sold = 10,000
    Price per unit sold = \$20
    Variable cost per unit sold = \$10

Total amount of fixed cost = \$50,000
Corporate tax rate = 50%

(a) Calculate EAIT.
(b) What is the break-even quantity?
(c) What is the DOL?
(d) Should the ABC Company produce more for greater profits?

12. ABC Company's predictions for next year are as follows:

	Probability	Quantity	Price	Variable Cost/Unit	Corporate Tax Rate
State 1	0.3	1,000	\$10	\$5	0.5
State 2	0.4	2,000	\$20	\$10	0.5
State 3	0.3	3,000	\$30	\$15	0.5

In addition, we also know that the fixed cost is \$15,000. What is the next year's expected EAIT?

13. Use an example to discuss four alternative depreciation methods.
14. XYX, Inc. currently produces one product that sells for \$330 per unit. The company's fixed costs are \$80,000 per year; variable costs are \$210 per unit. A salesman has offered to sell the company a new price of equipment which will increase fixed costs to \$100,000. The salesman claims that the company's break-even number of units sold will not be altered if the company purchases the equipment and raises its price (assuming variable costs remain the same).

(a) Find the company's current break-even level of units sold.
(b) Find the company's new price if the equipment is purchased and prove that the break-even level has not changed.

15. Consider the following financial data of a corporation:
Sales = \$500,000
Quantity = 25,000
Variable cost = \$300,000
Fixed cost = \$50,000

(a) Calculate the DOL at the above quantity of output.
(b) Find the break-even quantity and sales levels.

16. On the basis of the following firm and industry norm ratios, identify the problem that exists for the firm:

Ratio	Firm	Industry
Total asset utilization	2.0	3.5
Average collection period	45 days	46 days
Inventory turnover	6 times	6 times
Fixed asset utilization	4.5	7.0

17. The financial ratios for Wallace, Inc., a manufacturer of consumer household products, are given below along with the industry norm:

	Firm			
Ratio	1986	1987	1988	Industry
Current ratio	1.44	1.31	1.47	1.2
Quick ratio	0.66	0.62	0.65	0.63
Average collection period	33 days	37 days	32 days	34 days
Inventory turnover	7.86	7.62	7.72	7.6
Fixed asset turnover	2.60	2.44	2.56	2.8
Total asset turnover	1.24	1.18	2.8	1.20
Debt to total equity	1.24	1.14	0.84	1.00
Debt to total assets	0.56	0.54	0.46	0.50
Times interest earned	2.75	5.57	7.08	5.00
Return on total assets	0.02	0.06	0.07	0.06
Return on equity	0.06	0.12	0.12	0.13
Net profits margin	0.02	0.05	0.05	0.05

Analyze Wallace's ratios over the three-year period for each of the following categories:

(a) Liquidity
(b) Asset utilization
(c) Financial leverage
(d) Profitability

18. Below are the Balance Sheet and the Income Statement for Nelson Manufacturing:

Balance Sheet for Nelson on 12/31/88

Assets	
Cash and marketable securities	$ 125,000
Accounts receivable	239,000
Inventories	225,000
Prepaid expenses	11,000
Total Current Assets	$ 600,000
Fixed assets (net)	400,000
Total Assets	$ 1,000,000
Liabilities and Stockholder's Equity	
Account payable	$ 62,000
Accruals	188,000
Long-term debt maturing in 1 year	8,000
	$ 258,000
Long-term debt	221,000
Total Liabilities	$ 479,000
Stockholder's Equity	
Preferred stock	5,000
Common stock (at par)	175,000
Retained earnings	341,000
Total Stockholder's Equity	$ 521,000
Total Liabilities and Stockholder's Equity	$ 1,000,000

Income Statement for Nelson for Year Ending 12/31/88

Net sales	$ 800,000
Less: Cost of goods sold	381,600
Selling, general, and administrative expense	216,800
Interest expense	20,000
Earnings before taxes	$ 181,200
Less: Tax expense (40 percent)	72,480
Net income	$ 108,720

(a) Calculate the following ratios for Nelson:

Nelson	Industry
(1) Current ratio	3.40
(2) Quick ratio	2.43
(3) Average collection period	88.65
(4) Inventory turnover	6.46
(5) Fixed asset turnover	4.41
(6) Total asset utilization	1.12
(7) Debt to total equity	0.34
(8) Debt to total assets	5.25
(9) Times interest earned	12.00
(10) Return on total assets	0.12
(11) Return on equity	0.18
(12) Net profit margin	0.12

(b) Identify Nelson's strengths and weaknesses relative to the industry norm.

19. The debt equity ratio for American Express (AXP), Johnson & Johnson (JNJ) and Exxon Mobile (XOM) and their industry average are presented in the following table.

Year	AXP	Finance Industry	XOM	Gas and Oil Industry	JNJ	Pharma Industry
2000	12.17	15.30	19	59.43	0.72	0.32
2001	11.51	18.19	14.76	60.54	0.59	0.51
2002	10.34	14.28	14.41	61.5	0.79	0.5
2003	10.42	13.38	10.62	46.43	0.80	0.39
2004	11.02	14.84	8.15	34.93	0.68	0.39
2005	9.80	16.33	7.19	29.59	0.53	0.41
2006	11.16	15.47	7.33	23.44	0.79	0.44

(a) Please draw the time charts to compare the debt equity ratios for (i) AXP and its industry average, (ii) XOM and its industry average, and (iii) JNJ and its industry average.

(b) Please calculate mean, standard deviation, and coefficient of variation for all debt equity ratios presented in the table and perform some analysis.

20. The return on equity for American Express (AXP), Johnson & Johnson (JNJ) and Exxon Mobile (XOM) and their industry average are presented in the following table.

Year	AXP (%)	Finance Industry (%)	XOM (%)	Gas and Oil Industry (%)	JNJ (%)	Pharma Industry (%)
2000	24.05	27.34	22.60	27.39	25.52	31.70
2001	10.89	23.34	20.65	18.33	23.39	31.75
2002	19.27	21.23	14.76	14.73	29.07	33.55
2003	19.58	25.94	23.31	24.67	26.79	18.51
2004	21.95	26.42	24.89	25.22	26.75	18.89
2005	30.53	28.12	32.50	28.97	27.49	19.28
2006	35.48	30.71	34.70	29.60	28.11	20.12

(a) Please draw the time charts to compare the return on equity ratios for (i) AXP and its industry average, (ii) XOM and its industry average, and (iii) JNJ and its industry average.
(b) Please calculate mean, standard deviation, and coefficient of variation for all return on equity ratios presented in the table and perform some analysis.

Appendix 2.A: Simple Regression and Multiple Regression

2.A.1. *Introduction*

Algebra, basic calculus, and linear regression topics are usually required for both undergraduate and graduate business students. This appendix reviews simple regression and multiple regressions. (Appendix 2.B will (i) review basic algebraic simultaneity, and (ii) integrate the algebraic simultaneous equation concept with multiple regression, in order to introduce the concepts of instrumental variable and econometric simultaneous equation.) This appendix enables the reader to use the standard multiple regression and simultaneous equation statistic packages that are available (i.e. North Carolina State University's S.A.S. and University of Illinois SOUPAC) to estimate and interpret the empirical results of financial analysis and planning.

2.A.2. *Simple Regression*

If we want to explain the variation of the current ratio for Johnson & Johnson Company in period $t[Y_t]$, given the auto industry's current ratio in period $t-1[X_{t-1}]$, we can choose either a linear or log-linear model, as defined below.

$$Y_t = a + bX_{t-1} + \varepsilon_t, \tag{2.A.1a}$$

$$\log Y_t = a' + b' \log X_{t-1} + \varepsilon_t', \tag{2.A.1b}$$

where ε_t and ε_t' are error terms representing the difference between actual current ratios and the predicted current ratios. The choice between Eqs. (2.A.1a) and (2.A.1b) depends on whether the related variables, Y_t and X_{t-1}, are normally or log-normally distributed.

The virtue of a linear relationship is that it is simple, yet quite robust. If the natural phenomenon is not linearly related, then the linear relationship can be regarded as an approximation of the nonlinear relationship. Graphically, the relationship between Y_t and X_{t-1} in terms of Johnson & Johnson's and industry's current ratio data (1952–1979) as listed in Table 2.7 can be presented in a scatter diagram as indicated in Fig. 2.A.1.

In order to obtain the best linear model to predict Y_t, given X_{t-1}, we want to find the equation that minimizes the squared error terms. The error terms ($\hat{\varepsilon}_t$) represent the difference between the actual and current ratio (Y_t) and the current ratio predicted by the estimated linear model ($\hat{Y}_t$). The estimated current ratio can be defined as $Y = \hat{a} + \hat{b}X_{t-1}$. The theory and method of estimating a and b are one of the main issues of this appendix.

In Eq. (2.A.1a), if the unconditional probability distribution of Y_t is normally distributed with mean $\bar{Y}$ and variance σ_Y^2, the conditional probability distribution of $Y_t, \tilde{Y}_t \big| X_{t-1}$ will be a normal distribution with mean $(a + b\bar{X}_{t-1})$ and variance σ_ε^2.

Applying the variance operator to both sides of Eq. (2.A.1a) we have

$$\begin{aligned}\text{Var}[Y_t] &= \text{Var}[a + bX_{t-1} + \varepsilon_t] \\ &= \text{Var}[a] + \text{Var}[bX_{t-1}] + \text{Var}[\varepsilon_t] + 2\ \text{Cov}[a, bX_{t-1}] \\ &\quad + 2\text{cov}[a, \varepsilon_t] + 2\text{cov}[bX_{t-1}, \varepsilon_t],\end{aligned} \tag{2.A.2a}$$

$$\text{Var}[Y_t] = b^2\text{Var}[X_{t-1}] + \text{Var}[\varepsilon_t]. \tag{2.A.2b}$$

The conditions for obtaining Eq. (2.A.2b) are

(i) Both a and b must be constants. Equation (2.A.1) is a fixed coefficient model instead of a random coefficient model.
(ii) X_{t-1} must be uncorrelated with ε_t. This implies that there is no errors-in-variables problem inherent in the raw data associated with the independent variable. (The errors-in-variables problem is discussed in the instrumental variables and two-stage least-squares analysis in Appendix 2.B.)

Equation (2.A.2b) implies that the total variance Y_t, $\text{Var}[Y_t]$, can be decomposed into two components: (1) explained variance, $b^2\text{Var}[X_{t-1}]$ and (2) unexplained variance, $\text{Var}[\varepsilon_t]$]. If X_{t-1} has any explanatory power, then $\text{Var}[Y_t]$ will be larger than $\text{Var}[\varepsilon_t]$. The degree of explanatory power X_{t-1} can be defined as

$$\begin{aligned} R^2 &= \frac{\text{Variation explained by the explanatory variable}}{\text{Total variation in the dependent variable}} \\ &= \frac{b^2\ \text{Var}[X_{t-1}]}{\text{Var}[Y_t]}. \end{aligned} \tag{2.A.3}$$

To obtain the best estimates of a and b, we want to find the equation that minimizes the error sum of squares (ESS) as defined below:

$$ESS = \sum_{t=1}^{n} [Y_t - \hat{Y}_t]^2 = \sum_{t=1}^{n} [Y_t - \hat{a} - \hat{b}X_{t-1}]^2. \tag{2.A.4}$$

ESS evaluates the predicted relationship by summing the squares of the differences between actual and predicted values of the dependent variable, Y_t. In order to minimize the value of ESS, we must take the derivative of ESS with respect to $\hat{a}$ and $\hat{b}$, and set the results equal to zero, as shown in Eqs. (2.A.5a) and (2.A.5b):

$$\frac{\partial(ESS)}{\partial a} = -2\sum_{t=1}^{n} (Y_t - \hat{a} - \hat{b}X_{t-1}) = 0, \tag{2.A.5a}$$

$$\frac{\partial(ESS)}{\partial b} = -2\sum_{t=1}^{n} X_{t-1}(Y_t - \hat{a} - \hat{b}X_{t-1}) = 0. \tag{2.A.5b}$$

In order to jointly solve for estimates of the parameters a and b, Eqs. (2.A.5a) and (2.A.5b) are used to formulate a two-equation simultaneous system as follows:

$$\hat{a}n + \hat{b}\sum_{t=1}^{n} X_{t-1} = \sum_{t=1}^{n} Y_t, \tag{2.A.6a}$$

$$\hat{a}\sum_{t=1}^{n} X_{t-1} + \hat{b}\sum_{t=1}^{n} X_{t-1}^2 = \sum_{t=1}^{n} X_{t-1}Y_t. \tag{2.A.6b}$$

In these normal equations, two parameters are to be solved for from the given information: $\sum_{t=1}^{n} X_{t-1}; \sum_{t=1}^{n} Y_t; \sum_{t=1}^{n} X_{t-1}^2$; and $\sum_{t=1}^{n} X_{t-1}Y_t$. By Cramer's rule (see also Chapter 3), we have:

$$\hat{b} = \frac{\begin{vmatrix} n & \sum_{t=1}^{n} Y_t \\ \sum_{t=1}^{n} X_{t-1} & \sum_{t=1}^{n} X_{t-1}Y_t \end{vmatrix}}{\begin{vmatrix} n & \sum_{t=1}^{n} X_{t-1} \\ \sum_{t=1}^{n} X_{t-1} & \sum_{t=1}^{n} X_{t-1}^2 \end{vmatrix}}$$

$$= \frac{n\left(\sum_{t=1}^{n} X_{t-1}Y_t\right) - \left(\sum_{t=1}^{n} X_{t-1}\sum_{t=1}^{n} Y_t\right)}{n\sum_{t=1}^{n} X_{t-1}^2 - \left(\sum_{t=1}^{n} X_{t-1}\right)^2}, \tag{2.A.7}$$

$$\hat{b} = \frac{\mathrm{Cov}[X_{t-1}, Y_t]}{\mathrm{Var}[X_{t-1}]}, \tag{2.A.7a}$$

$$\hat{a} = \frac{\begin{vmatrix} \sum Y & \sum X_{t-1} \\ \sum X_{t-1}Y_t & \sum X_{t-1}^2 \end{vmatrix}}{\begin{vmatrix} n & \sum X_{t-1} \\ \sum X_{t-1} & \sum X_{t-1}^2 \end{vmatrix}}$$

$$= \frac{\left(\sum_{t=1}^{n} Y_t\right)\left(\sum_{t=1}^{n} X_{t-1}^2\right) - \left(\sum_{t=1}^{n} X_{t-1}\right)\left(\sum_{t=1}^{n} X_{t-1}Y_t\right)}{n\sum_{t=1}^{n} X_{t-1}^2 - \left(\sum_{t=1}^{n} X_{t-1}\right)^2}$$

$$= \frac{\begin{array}{c}\left(\sum_{t=1}^{n} Y_t/n\right)\left[n\left(\sum_{t=1}^{n} X_{t-1}^2\right) - \left(\sum_{t=1}^{n} X_{t-1}\right)^2\right] \\ -\left(\sum_{t=1}^{n} X_{t-1}/n\right)\left[n\left(\sum_{t=1}^{n} X_{t-1}Y_t\right) - \left(\sum_{t=1}^{n} X_{t-1}\right)\left(\sum_{t=1}^{n} X_{t-1}\right)\right]\end{array}}{n\sum_{t=1}^{n} X_{t-1}^2 - \left(\sum_{t=1}^{n} X_{t-1}\right)^2}, \tag{2.A.8}$$

$$\hat{a} = \bar{Y} - \bar{X}\hat{b}. \tag{2.A.8a}$$

Equations (2.A.7a) and (2.A.8a) can be used to estimate the parameters of Eq. (2.A.1a). For Johnson & Johnson's current ratio and the related industry average data, we have:

$$\bar{X} = 1.730 \quad \mathrm{Var}[X_{t-1}] = 0.0481$$
$$\bar{Y} = 1.587 \quad \mathrm{Var}[Y_{t-1}] = 0.0967$$
$$\mathrm{Cov}[Y_t, X_{t-1}] = 0.0402$$
$$\hat{b} = 0.8358 \quad \hat{a} = 0.1411.$$

Before the estimated $\hat{a}$ and $\hat{b}$ are used, they should be tested to determine whether they are statistically different from zero or not. To perform the null hypothesis test, the variance of $\hat{b}$ and $\hat{a}$ should be derived.

2.A.3. *Variance of* $\hat{b}$

Equation (2.A.7a) implies that

$$\hat{b} = \sum_{t=1}^{n} \frac{(x_{t-1}y_t)}{\sum_{t=1}^{n} x_{t-1}^2} = \sum_{t=1}^{n} W_{t-1}y_t, \tag{2.A.7b}$$

where

$$x_{t-1} = X_{t-1} - \bar{X},$$
$$y_t = Y_t - \bar{Y},$$
$$W_{t-1} = \frac{x_{t-1}}{\sum_{t=1}^{n} x_{t-1}^2}.$$

Substituting $y_t = bx_{t-1} + \varepsilon_t$ into Eq. (2.A.7a), we have

$$\hat{b} = \sum_{t=1}^{n} W_{t-1}bx_{t-1} + \sum_{t=1}^{n} W_{t-1}\varepsilon_t. \tag{2.A.7c}$$

Through the application of the variance operator on Eq. (2.A.7c), we have

$$\begin{aligned}
\mathrm{Var}(\hat{b}) &= E(\hat{b} - b)^2 \\
&= E\left(\sum_{t=1}^{n} W_{t-1}bX_{t-1} + \sum_{t=1}^{n} W_{t-1}\varepsilon_t - b\right)^2 \\
&= E\left[\left(\sum_{t=1}^{n} W_{t-1}x_{t-1} - 1\right) b + \sum_{t=1}^{n} W_{t-1}\varepsilon_t\right]^2 \\
&= E\left(\sum_{t=1}^{n} W_{t-1}\varepsilon_t\right)^2, \qquad \text{since } \sum_{t=1}^{n} W_{t-1}x_{t-1} = 1.
\end{aligned}$$

Therefore,

$$\mathrm{Var}(\hat{b}) = E[(W_0\varepsilon_1)^2 + 2(W_0W_1\varepsilon_1\varepsilon_2) + (W_1\varepsilon_2)^2 + \cdots]. \tag{2.A.9}$$

If ε_t is serially uncorrelated, that is, $E[\varepsilon_t, \varepsilon_{t-1}] = 0$, then Eq. (2.A.9) implies that

$$\begin{aligned}\mathrm{Var}(\hat{b}) &= E(W_0\varepsilon_1)^2 + E(W_1\varepsilon_2)^2 + \cdots \\ &= W_0^2E(\varepsilon_1^2) + W_1^2E(\varepsilon_2^2) + \cdots .\end{aligned}$$

In generalized form,

$$\begin{aligned}\mathrm{Var}(\hat{b}) &= \sum_{t=1}^{n} W_{t-1}^2 E(\varepsilon_t^2) \\ &= \sigma_\varepsilon^2 \sum_{t=1}^{n} W_{t-1}^2.\end{aligned}$$

But

$$\sum_{t=1}^{n} W_{t-1}^2 = \frac{\sum_{t=1}^{n} x_{t-1}^2}{(\sum_{t=1}^{n} x_{t-1}^2)^2} = \frac{1}{\sum_{t=1}^{n} x_{t-1}^2}.$$

Therefore,

$$\mathrm{Var}(\hat{b}) = \frac{\sigma_\varepsilon^2}{\sum_{t=1}^{n} x_{t-1}^2}. \tag{2.A.10}$$

Using a similar derivation, we can derive $\mathrm{Var}(\hat{a})$ and $\mathrm{Cov}(\hat{a}, \hat{b})$:

$$\mathrm{Var}(\hat{a}) = \sigma_\varepsilon^2 \frac{\sum_{t=1}^{n} x_{t-1}^2}{n\sum_{t=1}^{n} x_{t-1}^2}, \tag{2.A.11}$$

$$\mathrm{Cov}(\hat{a}, \hat{b}) = -\sigma_\varepsilon^2 \frac{\bar{X}}{\sum_{t=1}^{n} x_{t-1}^2}. \tag{2.A.12}$$

2.A.4. *Multiple Regression*

If the current ratio for Johnson & Johnson in period $t[Y_t]$ is a function of the pharmaceutical industry's current ratio in period $t-1$ $[X_{1,t-1}]$ and the pharmaceutical industry's leverage ratio in period $t-1[X_{2,t-1}]$, the linear relationship can be defined as

$$Y_t = a + bX_{1,t-1} + cX_{2,t-1} + \varepsilon_t. \tag{2.A.13}$$

The error sum of squares can be defined as

$$ESS = \sum \hat{\varepsilon}_t^2 = \sum (Y_t - \hat{Y}_t)^2,$$

where

$$\hat{Y}_t = \hat{a}_t + \hat{b}X_{1,t-1} + \hat{c}X_{2,t-1}.$$

To obtain the least-squares estimates of the parameters a, b, and c, we can minimize *ESS* by calculating its partial derivatives with respect to these three unknown parameters, equating each to zero, and solving

$$\frac{\partial ESS}{\partial a} = 0$$

or

$$\sum Y_t = na + b\sum X_{1,t-1} + c\sum X_{2,t-1}, \qquad (2.A.14a)$$

$$\frac{\partial ESS}{\partial b} = 0$$

or

$$\sum X_{1,t-1}Y_t = a\sum X_{1,t-1} + b\sum X_{1,t-1}^2 + c\sum X_{1,t-1}X_{2,t-1}, \qquad (2.A.14b)$$

$$\frac{\partial ESS}{\partial c} = 0$$

or

$$\sum X_{2,t-1}Y_t = a\sum X_{2,t-1} + b\sum X_{1,t-1}X_{2,t-1} + c\sum X_{2,t-1}^2. \qquad (2.A.14c)$$

Substituting $y_t = Y_t - \hat{Y}$, $x_{1,t-1} = X_{1,t-1} - \hat{X}$, and $x_{2,t-1} = X_{2,t-1} - \hat{X}$ for Y_t, $X_{1,t-1}$, and $X_{2,t-1}$, Eqs. (2.A.14a), (2.A.14b), and (2.A.14c), respectively, can be rewritten as

$$0 = na + b(0) + c(0), \qquad (2.A.15a)$$

$$\sum x_{1,t-1}y_t = a(0) + b\sum x_{1,t-1}^2 + c\sum x_{1,t-1}x_{2,t-1}, \qquad (2.A.15b)$$

$$\sum x_{2,t-1}x_t = a(0) + b\sum x_{1,t-1}x_{2,t-1} + c\sum x_{2,t-1}^2. \qquad (2.A.15c)$$

The important conditions used to obtain Eq. (2.A.15) are

(i) $\sum y_t = 0$,

(ii) $\sum x_{1,t-1} = 0$,

(iii) $\sum x_{2,t-1} = 0$.

Equation (2.A.15a) implies that $a = 0$. Therefore, we can use Eqs. (2.A.15b) and (2.A.15c) to solve $\hat{b}$ and $\hat{c}$. Based upon Cramer's rule, we have

$$\hat{b} = \frac{\sum x_{1,t-1}y_t\left(\sum x_{2,t-1}^2\right) - \sum x_{2,t-1}y_t \sum x_{1,t-1}x_{2,t-1}}{\left(\sum x_{1,t-1}^2\right)\left(\sum x_{2,t-1}^2\right) - \left(\sum x_{1,t-1}x_{2,t-1}\right)^2}, \quad (2.A.16a)$$

$$\hat{c} = \frac{\sum x_{2,t-1}y_t\left(\sum x_{1,t-1}^2\right) - \sum x_{1,t-1}y_t \sum x_{1,t-1}x_{2,t-1}}{\left(\sum x_{1,t-1}^2\right)\left(\sum x_{2,t-1}^2\right) - \left(\sum x_{1,t-1}x_{2,t-1}\right)^2}. \quad (2.A.16b)$$

Substituting Eqs. (2.A.16a) and (2.A.16b) into Eq. (2.A.14a), and dividing both sides of Eq. (2.A.14a) by n, we have

$$\hat{a} = \hat{Y} - \hat{b}\bar{X}_1 - \hat{c}\bar{X}_2. \quad (2.A.17)$$

Using the concept of estimating standard errors of regression parameters as discussed earlier, standard errors of $\hat{a}$, $\hat{b}$, and $\hat{c}$ (S_a, S_b, and S_c, respectively), can be estimated. The empirical results for Johnson & Johnson's ratio are listed in Eq. (2.A.13b).

The multiple regression result associated with Johnson & Johnson's dynamic current ratio adjustment process is

$$\begin{aligned} Y_t = {} & -0.2837 + 0.7564X_{1,t-1} + 0.2990X_{2,t-1}. \\ & (0.4323) \quad (0.3288) \qquad\quad (0.2240) \end{aligned} \quad (2.A.13b)$$

Figures the regression coefficients are standard errors of estimated regression coefficients.

Substituting related estimates into (2.A.17), we obtain

$$\begin{aligned} \hat{a} &= 1.7071(0.7564)(1.8448)(0.2990)(1.6904) \\ &= 0.2837. \end{aligned}$$

There exists a similar coefficient of determination (R^2) for the multiple regression.

The difference between Y_t and its mean $\bar{Y}_t$, can be broken down as

$$(Y_t - \bar{Y}_t) = (Y_t - \hat{Y}_t) + (\hat{Y}_t - \bar{Y}_t), \tag{2.A.18}$$

where

$$\hat{Y}_t = \hat{a} + \hat{b}X_{1,t-1} + \hat{c}X_{2,t-1}. \tag{2.A.19}$$

Note that $\hat{Y}$ is the estimated dependent variable and Y_t is the actual dependent variable; $Y_t - \hat{Y}$is the residual term for the tth period, and $(\hat{Y}_t - \bar{Y})$ represents the difference between the overall mean and the estimated dependent variable in period t (conditional mean). Squaring both sides of Eq. (2.A.18) and summing over all observations (1 to n), we obtain

$$\underset{TSS}{\sum(Y_t - \bar{Y}_t)^2} = \underset{ESS}{\sum(Y_t - \hat{Y}_t)^2} + \underset{RSS}{\sum(\hat{Y}_t - \bar{Y}_t)^2}, \tag{2.A.20}$$

where

TSS = Total sum of squares;
ESS = Residual sum of squares; and
RSS = Regression sum of squares.

R^2 can now be defined as

$$R^2 = \frac{\text{RSS}}{\text{TSS}} = \frac{\sum(\hat{Y}_t - \bar{Y}_t)^2}{\sum(Y_t - \bar{Y}_t)^2} = 1 - \frac{\sum \hat{\varepsilon}_t^2}{\sum(Y_t - \bar{Y}_t)^2}. \tag{2.A.21}$$

Here R^2 measures the portion of variation in Y that is explained by the multiple regression. The term R^2 is often informally interpreted as a measure of "goodness of fit" and used as a statistic for comparison of the validity of the regression results under alternative specifications of the independent variables of the model.

The difficulty with R^2 as a measure of "goodness of fit" is that R^2 pertains to the explained and unexplained variation in Y and therefore does not account for the number of degrees of freedom in the problem. Originally there are n degrees of freedom in a sample of n observations, but one degree of freedom is used up in calculating $\bar{Y}$ leaving only $n-1$ degrees of freedom for residuals $(Y - \bar{Y})$ to calculate $\text{Var}(Y_t)$. Similarly, k degrees of freedom are used up in calculating k regressors, leaving only $n - k$ degrees of freedom for calculating $\text{Var}(\hat{\varepsilon}_t)$. To correct this problem, the corrected R^2 $(\bar{R}^2)$ is defined as

$$R^2 = 1 - \frac{\sum \hat{\varepsilon}_t^2}{\text{Var}(Y_t)}, \tag{2.A.22}$$

where

$\mathrm{Var}(\hat{\varepsilon}_t) = \sigma_\varepsilon^2 = \frac{\sum \hat{\varepsilon}_t^2}{n-k}$,

$\mathrm{Var}(Y_t) = \frac{\sum (Y_t - \bar{Y})^2}{n-1}$,

and $k =$ the number of independent variables.

Even though the error sum of squares will decrease (or remain the same) as new explanatory variables are added, the residual variance need not decrease. From Eqs. (2.A.21) and (2.A.22), the relationship between R^2 and $\bar{R}^2$ can be defined as

$$\bar{R}^2 = 1 - (1 - R^2)\frac{n-1}{n-k}. \tag{2.A.23}$$

Some implications of Eq. (2.A.23) are

(a) if $k = 1$, then $R^2 > \bar{R}^2$;
(b) if $k > 1$, then $R^2 > \bar{R}^2$;
(c) $\bar{R}^2$ can be negative.

The R^2 and $\bar{R}^2$ associated with Eq. (2.A.13b) are 0.4901 and 0.4350, respectively. If the error, $\hat{\varepsilon}_t$, is normally distributed, t-tests can be applied to test the regression coefficient because $(\hat{a} - a)/S_a$,$(\hat{b} - b)/S_b$, and $(\hat{c} - c)/S_c$ are all t-distributions with $n - k$ degrees of freedom. The t-statistics associated with $\hat{a}$, $\hat{b}$, and $\hat{c}$ are -0.6565, 2.3005, and 1.3345, respectively. The estimated regression coefficients, the standard errors and t-statistics, $\bar{R}^2$ are printed out by most regression programs.

In addition to the t-statistics, the regression program also prints F-statistics, R^2, and $\bar{R}^2$. The relationship between the F-statistic and R^2 can be defined as

$$F(k-1, n-k) = \frac{R^2}{1-R^2}\frac{n-k}{k-1},$$

where $F(k-1, n-k)$ represents F-statistic with $k-1$ and $n-k$ degrees of freedom.

Strictly speaking, the $F(k-1, n-k)$-statistic allows us to test the hypothesis that none of the explanatory variables helps to explain the variation of Y about its mean. In other words, the F-statistics is used to test the joint hypothesis, $H(0)$: $a = b = c = 0$. The F-statistic for Johnson & Johnson's current ratio is $F(2, 24) = 11.7689$. This statistic is significantly different from zero at the 95% confidence level. The multiple regression explored here will be used in the chapters on cost of capital and dividend policy.

Appendix 2.B. Instrumental Variables and Two-Stage Least Squares

In Appendix 2.A, we assumed that each of the independent variables in the linear regression model was uncorrelated with the true error term. If this assumption does not hold, then the estimated slope will not necessarily be unbiased. If the sample slope estimator is equal to the population slope estimator, then this sample slope estimate is an unbiased estimator. There are three instances when independent variables may be correlated with the associated error term:

1. One or more of the independent variables is measured with error.
2. One or more of the independent variables is determined in part (through one or more separate equations) by the dependent variable.
3. One or more of the independent variables is a lagged dependent in a model with which the error term is serially correlated.

All three of these cases appear in empirical finance research.

There exist error-in-variable problems in the estimation of systematic risk (to be discussed in Chapter 7) and in the estimation of the relative effect of dividends and retained earnings on the price of common stocks (to be discussed in Chapter 13). There are simultaneous equation problems in estimating the joint determination of financial ratios (as discussed in Chapter 2) and in estimating the cost of capital (to be discussed in Chapter 8). There exist serial correlation problems in estimating the dynamic ratio-adjustment process, as indicated in Chapter 2, and in estimating partial adjustment coefficients in the dividend decision model (to be shown in Chapter 13). All these problems can be resolved by the instrumental variable, two-stage least squares, or modified instrumental variable technique of estimation.

2.B.1. *Errors-in-Variable Problem*

In Chapter 7, we will use the market model to estimate systematic risk. The market model is defined as

$$R_{j,t} = A_j + B_j R_{m,t} + \varepsilon_t, \tag{2.B.1}$$

where $R_{j,t}$ and $R_{m,t}$ are the rates of return for the jth security in period t and the market rate of return in period t, respectively. As true market rate of return, $R_{m,t}$ is not directly observable, the equity market rate of return,

$R^*_{m,t}$ is used as a proxy. Hence, there are proxy errors that result from the use of $R^*_{m,t}$ to replace $R_{m,l}$. The relationship between $R_{m,t}$ and $R_{m,t}$ can be defined as

$$R^*_{m,t} = R_{m,t} + V_t, \tag{2.B.2}$$

where V_t is the proxy error (or measurement error), and

$$\text{Var}(R^*_{m,t}) = \text{Var}(R_{m,t} + V_t) = \sigma^2_m + \sigma^2_V. \tag{2.B.3}$$

Substituting Eq. (2.B.2) into Eq. (2.B.1) yields the actual empirical regression model shown in Eq. (2.B.4)

$$R_{j,t} = A_j + B_j R^*_{m,t} + \varepsilon^*_t, \tag{2.B.4}$$

where $\varepsilon^* = \varepsilon - B_j V_j$.

In Eq. (2.B.4), $\text{Cov}[R^*_{m,t}, \varepsilon^*_t] = -B_j\sigma^2_V$, that is, the independent variable $R^*_{m,t}$ is correlated with the error terms. Therefore, the least-squares estimates of regression parameters will be biased. In addition, this implies that the standard least-squares slope estimates are not reliable systematic risk measures for investment analysis and financial management.

Based upon the OLS estimate for $\hat{B}_j$ derived in Appendix 2.A, we have

$$\begin{aligned}
\hat{B}_j &= \frac{\text{Cov}(R^*_{m,t}, R_{jt})}{\text{Var}(R^*_{m,t})} \\
&= \frac{\text{Cov}(R_{m,t} + V_t, \alpha_j + B_j R_{m,t} + \varepsilon_t)}{\text{Var}(R_{m,t}) + \text{Var}(V_t)} \\
&= \frac{B_j \text{Cov}(R_{m,t}, R_{m,t}) + \text{Cov}(V_t, \varepsilon_t)}{\text{Var}(R_{m,t}) + \text{Var}(V_t)} \\
&= \frac{B_j}{1 + \sigma^2_V/\sigma^2_M} \quad \text{if } \text{Cov}(V_{t1}, \varepsilon_t) = 0.
\end{aligned} \tag{2.B.5}$$

Equation (2.B.5) shows that even if measurement errors are assumed to be independent of $R_{m,t}$ and ε_t, the estimated slope, b, will be biased downward; σ^2_V/σ^2_M is generally used to measure the quality of the data. There are two generally accepted techniques for overcoming the problems of errors in variables: (1) grouping and (2) instrumental variables. Black *et al.* (1972) and Lee (1976) use the grouping method to estimate beta coefficients. The grouping method can reduce measurement errors because the errors of individual observations tend to be canceled out by their mutual independence. Hence, there is less measurement error in a group average than there would be if sample data were not grouped. In addition, Lee also suggests an instrumental variable method to estimate the beta coefficients.

2.B.2. *Instrumental Variables*

Instrumental variables can be defined from both the error-in-variable and the two-stage, least-squares estimation viewpoints. In classical error-in-variable problems, an instrumental variable is one that is highly correlated with the independent variable, but independent of the measurement error associated with independent variable, V_t, and the true regression error, ε_t. If Z_t is the instrumental variable to be used to reduce the measurement error associated with $R^*_{m,t}$ in estimated beta, as discussed in Section 2.B.1, then Z_t should be independent of both Z_t and ε_t. Lee (1976) uses the rank order (i.e. with values $1, 2, 3, \ldots, N$) as the variable Z for estimating Beta coefficients. Taking the covariance of Z with respect to all variables in Eq. (2.B.1) yields

$$\mathrm{Cov}(R_j, Z) = B_j \mathrm{Cov}(R_m, Z) + \mathrm{Cov}(Z, \varepsilon) \tag{2.B.6}$$

If $\mathrm{Cov}[Z, V] = \mathrm{Cov}[Z, \varepsilon]$,

$$\text{then } \hat{B}_j = \frac{\mathrm{Cov}(R_j, Z)}{\mathrm{Cov}(R^*_m, Z)} = \frac{\mathrm{Cov}(R_j, Z)}{\mathrm{Cov}(R_m, Z)}. \tag{2.B.7}$$

Here $\hat{B}_j$ is a consistent estimator of B_j. Note that this method is sometimes called the "covariance" method of estimating beta.

In estimating the parameters of simultaneous equation system, a two-stage, least-squares estimator is generally an instrumental variable estimably more than a single equation regression can capture. Specifically, seldom is a variable determined by a single relationship (equation). Normally, a variable is determined simultaneously with many other variables in a whole system of simultaneous equations. For example, the current ratio is determined simultaneously with the leverage ratio, the activity ratio, and the profitability ratio, as discussed earlier.

Using a two-equation system to serve as an example to discuss identification problems, we have

$$Y_1 = A_0 + A_1 Y_2 + E_1, \tag{2.B.8a}$$

$$Y_2 = B_0 + B_1 Y_1 + B_2 Z_1 + E_2; \tag{2.B.8b}$$

$$Y_1 = A_0 + A_1 Y_2 + A_2 Z_2 + E_1, \tag{2.B.9a}$$

$$Y_2 = B_0 + B_1 Y_1 + B_2 Z_1 + E_2; \tag{2.B.9b}$$

$$Y_1 = A_0 + A_1 Y_2 + A_2 Z_2 + A_3 Z_3 + E_1 Y, \tag{2.B.10a}$$

$$Y_2 = B_0 + B_1 Y_1 + B_2 Z_1 + E_2. \tag{2.B.10b}$$

Equations (2.B.8)–(2.B.10) are three different simultaneous equation systems. Y_1 and Y_2 are endogenous variables determined within the system of equations, while Z_1Z_2, and Z_3 are exogenous variables and E_1 and E_2 are residual terms. There are two methods to distinguish between the endogenous and exogenous variables. Conceptually, the exogenous variables, Z_1Z_2, and Z_3, are determined outside this system of equations. They can also be referred to as predetermined variables. The essential point is that their values are determined elsewhere and are not influenced by Y_1, Y_2, E_1, or E_2. On the other hand, Y_1 and Y_2 are jointly dependent, or endogenous, variables: their values are determined within the model, and thus they are influenced by Z_1Z_2, Z_3, E_1, and E_2. Statistically, Y_2 and E_1 and Y_1 and E_2 are dependent. Therefore, they face the error-in-variable problem (or simultaneous equation bias) when the ordinary least-squares (OLS) method is used to estimate the parameters of the model. The exogenous variables, Z_1Z_2, and Z_3, and the error terms, E_1 and E_2, are statistically independent.

A requirement for identifying an equation is that the number of exogenous variables that are excluded from the equation (K) must be at least equal to the number of endogenous variables that are included on the right-hand side of that equation (H). The equations above are defined as follows:

1. In Eqs. (2.B.8a), (2.B.9a), (2.B.9b), and (2.B.10a), $K = H$. These are "exactly identified" equations.
2. In Eq. (2.B.8b), $K < H$. Equation (2.B.8b) is an "under-identified" equation.
3. In Eq. (2.B.10b), $K > H$. Equation (2.B.10b) is an "over-identified" equation.

In an under-identified equation, the related regression parameters cannot be statistically estimated. If an equation is either exactly identified or over-identified, the instrumental variable and the two-stage, least-squares (2SLS) technique can be used to statistically estimate the related regression parameters. Johnston and Dinardo (1996) have shown that 2SLS and instrumental-variable techniques are equivalent procedures, on the condition that the first-stage system and on the condition that the instrument used in the instrumental-variable procedure is the fitted value of the first-stage regression.

2.B.3. *Two-Stage, Least-Square*

Equations (2.B.10a) and (2.B.10b) will serve as examples in the discussion of the 2SLS estimation procedure.

Stage 1: Use OLS to estimate the following two reduced-form equations

$$Y_1 = C_0 + C_1 Z_1 + C_2 Z_2 + C_3 Z_3 + E_1 \quad \text{(2.B.11a)}$$

$$Y_2 = D_0 + D_1 Z_1 + D_2 Z_2 + D_3 Z_3 + E_2. \quad \text{(2.B.11b)}$$

Stage 2: Use OLS to estimate the following structural equations

$$Y_1 = A_0 + A_1 \hat{Y}_2 + A_2 Z_2 + A_3 Z_3 + E_1, \quad \text{(2.B.10a')}$$

$$Y_2 = B_0 + B_1 \hat{Y}_1 + B_2 Z_1 + E_2, \quad \text{(2.B.10b')}$$

where $\hat{Y}_1$ and $\hat{Y}_2$ are the estimates of Y_1 and Y_2.

The stochastic components associated with the error terms $E_1$and E_2 have been purged in Stage 1. The estimated parameters, $\hat{C}_0, \hat{C}_1, \hat{C}_2, \hat{C}_3$, $\hat{D}_0, \hat{D}_1, \hat{D}_2$, and $\hat{D}_3$, are reduced-form parameters, while the estimated parameters, $\hat{A}_0, \hat{A}_1, \hat{A}_2, \hat{A}_3$, $\hat{B}_0, \hat{B}_1$, and $\hat{B}_2$ are structural parameters. Johnston and Dinardo (1996) have used the relationship between the structural parameters and reduced-form parameters to discuss the identification problem. An equation is unidentified if there is no way of estimating all the structural parameters from the reduced-form parameters. Furthermore, an equation is exactly identified if a unique value is obtainable for some parameters.

The 2SLS estimating method is used by Modigliani and Miller (1966) to reduce the measurement errors of accounting earnings, in estimating the cost of capital for the electric utility industry. The simultaneous current ratio and leverage ratio determination process was defined in Eq. (2.9) of this chapter, and was estimated by using Johnson & Johnson's ratio data. The first-stage regression results associated with Eqs. (2.B.11a) and (2.B.11b), in terms of Johnson & Johnson's current ratio and leverage ratio, are

$$\begin{array}{l} Y_1 = -0.2399 + 0.8198 Z_1 - 1.9004 Z_1,\ R^2 = 0.3449, \\ \qquad (0.1012) \qquad (0.2802) \qquad (1.245) \end{array} \quad \text{(2.B.10a'a)}$$

$$\begin{array}{l} Y_2 = 0.0746 - 0.1133 Z_1 + 0.7849 Z_2,\ R^2 = 0.4240, \\ \qquad (0.0195) \qquad (0.0541) \qquad (0.2405) \end{array} \quad \text{(2.B.10a'b)}$$

where the digits below the regression coefficients are standard errors of estimates, and Z_1 and Z_2 represent the firm's current-ratio and leverage-ratio deviations from the related industry average in the previous period.

Based upon Eqs. (2.B.10a′a) and (2.B.10a′b), the estimated current ratio and leverage ratio for Johnson & Johnson Corporation can be estimated. These estimated endogenous variables are then used in the structural equations, as indicated in Eqs. (2.B.10a′) and (2.B.10a′) to obtain the results of second-stage regressions. The second-stage regression results associated with Johnson & Johnson's current and leverage ratios are listed in Table 2.10.

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