Chapter 2
A Business Simulation Model of Conventional Firms

Abstract This chapter discusses an accounting approach for the derivation of our business model *FIRM* from the concepts of profit rate and profit margin. Equations for fundamental business variables are presented, including sales, assets, total costs, total profit, profit rate, and profit margin. A system equations approach is discussed for estimating these equations by means of regression methods for the purposes of business analyses and simulations.

Keywords Regression equations • System equation approach • Sales equation • Profit rate equation • Capital stocks equation • Profit margin equation

As discussed in Chap. 1, our profit system model of the firm consists of a set of equations for sales, costs, assets, profits, profit rate, and profit margin that together capture the dynamic relationships among these fundamental business variables. The estimated system of equations is to be used for finding the probable paths of these variables in the future expected to result from today's managerial decisions. This chapter presents a business analysis model of the firm. The first part presents the model and their equations, and the second part reviews the derivation of the model. Our model is based on previous work published in Chap. 2 of Anari and Kolari's *The Power of Profit* (2009). Here, we utilize this model as an analytical tool for conventional firms to conduct simulations of the impact of managerial decisions on sales, costs, assets, profits, profit rate, and profit margin.

2.1 Business Model

FIRM is a program designed to be used for conventional, unregulated-profit firms. Table 2.1 shows model *FIRM* consisting of three equations to be estimated using logarithms (log) of sales (s), capital stocks (k), and profit rate (r). One lag of these variables (i.e., the value of the variable in the previous period) is used in the

A. Anari and J.W. Kolari, *Excel-Based Business Analysis: Forecasting Key Business Trends*, SpringerBriefs in Business 8, DOI 10.1007/978-1-4614-2050-7_2,

Table 2.1 Business analysis model *FIRM* for simulation

	Initial conditions	s_t, r_t, m_t, k_t
(2.1.1)	Sales model	$s_{t+1} = \beta_0 + \beta_1 r_t + \beta_2 m_t + \beta_3 k_t$
(2.1.2)	Capital stocks model	$k_{t+1} = \alpha_0 + \alpha_1 s_t + \alpha_2 r_t + \alpha_3 m_t$
(2.1.3)	Profit rate model	$r_{t+1} = \theta_0 + \theta_1 s_t + \theta_2 m_t + \theta_3 k_t$
(2.1.4)	Profit margin model	$m_{t+1} = r_{t+1} + k_{t+1} - s_{t+1}$ $S_t = antilog(s_t)$, K_t= antilog (k_t), R_t= antilog (r_t), and M_t= antilog (m_t)
(2.1.5)	Total profit model	$Z_{t+1} = S_{t+1} \times M_{t+1}$
(2.1.6)	Total cost model	$C_{t+1} = S_{t+1} - Z_{t+1}$

Bold numbered equations are empirically estimated by regression analyses, and other equations are derived from their forecasts. All equations are solved simultaneously or recursively in forecasting and simulation analyses

The variables are defined as follows: $S(s)$ = sales in current dollars (log), $K(s)$ = capital stocks in current dollars (log), $R(r)$ = profit rate (log), $M(m)$ = profit margin (log), Z = profit in current dollars, and C = total costs in current dollars

equations for projections of the variables. Projections of log profit margin (m), total profits (Z), and total costs (C) are then estimated using forecasts of sales, capital stocks, and profit rate generated from the estimated three equations. Equation (2.1.1) uses values of capital stocks (k_t), profit rate (r_t), and profit margin (m_t) in period t for forecasting log of sales (s_{t+1}) in period t+1. In (2.1.2), logs of sales (s_t), profit rate (r_t) and profit margin (m_t) in period t are used for forecasting log of capital stocks (k_{t+1}) in period t+1. Equation (2.1.3) employs logs of capital stocks (k_t), sales (s_t), and profit margin (m_t) in period t for forecasting profit rate (r_{t+1}) in period t+1. In (2.1.4), the forecast of log of profit margin (m_{t+1}) in period t+1 is obtained using forecasts of logs of sales (s_{t+1}), capital stocks (k_{t+1}), and profit rate (r_{t+1}) in period t+1. Taking antilogs of the logs of sales (s_{t+1}), capital stocks (k_{t+1}), profit rate (r_{t+1}), and profit margin (m_{t+1}) gives the values of these variables, or S_{t+1}, K_{t+1}, R_{t+1}, and M_{t+1}, respectively. Equation (2.1.5) forecasts total profits (Z_{t+1}) in period t+1 as the product of profit margin (M_{t+1}) and sales (S_{t+1}) in period t+1. And, (2.1.6) forecasts total costs (C_{t+1}) in period t+1 as the difference between sales (S_{t+1}) and total profits (Z_{t+1}) in period t+1.

As will be shown in the next chapter, the program *FIRM* has an Excel worksheet for simulation of the impact of changes in total costs, total sales, and total assets on the expected future values of these variables in addition to the future values of total profit, profit rate, and profit margin.

2.2 Derivation of the Model

The business analysis model *FIRM* presented in Sect. 2.1 is derived from a model of the firm proposed in Chap. 2 of Anari and Kolari's *The Power of Profit* (2009). These authors used two approaches, mathematical economics and accounting definitions, for deriving the model. This section presents (1) the foundations of the model based on accounting definitions and (2) its system equations approach. Chap. 3 provides step-by-step applications of the models.

2.2.1 Foundations of the Model FIRM

The average profit rate R_t in period t commonly calculated by firms is defined as the dollar value of nominal profit or earnings Z_t in period t generated from capital stocks divided by the total market value of the capital stocks K_t, or

$$R_t = \frac{Z_t}{K_t}. \tag{2.1}$$

Profit margin in period t is defined as nominal profit Z_t divided by the dollar value of nominal output in either sales or value-added terms:

$$M_t = \frac{Z_t}{S_t}. \tag{2.2}$$

Solving for Z_t in (2.1) and (2.2), we alternatively obtain

$$Z_t = R_t K_t = M_t S_t. \tag{2.3}$$

No matter how profit is defined (before or after charging interest costs, taxes, depreciation, etc.), the identities (2.1) and (2.2) result in (2.3) as long as the same figure for profit is used for computing R_t and M_t. Solving for K_t, S_t, R_t, and M_t results in the following equations:

Capital stocks equation:

$$K_t = \frac{S_t M_t}{R_t}, \tag{2.4}$$

Sales or output equation:

$$S_t = \frac{R_t K_t}{M_t}, \tag{2.5}$$

Profit rate equation:

$$R_t = \frac{S_t M_t}{K_t}, \tag{2.6}$$

Profit margin equation:

$$M_t = \frac{R_t K_t}{S_t}. \tag{2.7}$$

Equation (2.4) is a valuation model of capital stocks. In this equation the value of the stock of capital is the discounted value or capitalized value of profit, in which the numerator shows profit as the product of sales and the profit margin, and the denominator is the discount rate equal to the average profit rate.

Equation (2.5) can be viewed as a sales or production behavior model of managers in the business sector. Consider a firm that has capital stocks K. The firm's capital stocks comprise the bundle of investment goods selected by the firm in the past based on expected hurdle profit rates. The firm's management is expected to attain the profit rate R used for selecting investment projects, which means that R is the target profit rate. Multiplying the expected target profit rate by the amount of capital stocks gives the expected target total profit, or $Z_t = R_t K_t$. In order to attain the expected target profit, the firm must achieve a target level of sales or output derived by multiplying the expected target profit ($Z_t = R_t K_t$) and expected sales to profit ratio $\left(\frac{1}{M_t} = \frac{Y_t}{Z_t}\right)$ to get $S_t = \frac{R_t K_t}{M_t}$, viz., (2.5). While ex-post realized profit rates and profit margins can be negative on a firm basis or even on an industry basis, *expected* target profit rates and profit margins are positive, due to the fact that firms do not embark on production activities unless they anticipate positive profits in the future.

Equation (2.6) shows that profit rate (R_t) can be computed using K_t, S_t and M_t, and (2.7) shows that profit margin (M_t) can be computed using K_t, S_t, and R_t.

Note that (2.3)–(2.7) are all in terms of profit measures. Equations (2.3), (2.6), and (2.7) are total profit, profit rate, and profit margin, respectively. In the capital stocks equation (2.4), the numerator is total profit, and the denominator is profit rate. In the production equation (2.5), the numerator is total profit, and the denominator is profit margin.

2.2.2 A System Equation Approach

Market participants know the concepts of profit rate and profit margin and intuitively understand the relationships among the values of sales, capital stocks, total profit, profit rate, and profit margin as shown in (2.1)–(2.7). Interconnections between these business variables are informally used by firms and market participants for forecasting, capital budgeting, profit planning, investment analysis, etc. In Anari and Kolari (2009), these relationships are formally developed as a model of the firm to be estimated and used for the same purposes. Here we present a simpler version of the model of the firm presented there.

The dependency of the fundamental business variables on one another shown above means that in the real world the magnitudes of these variables are determined simultaneously. For this reason, systems of dynamic equations containing five equations for the five variables (i.e., sales, capital stocks, total profit, profit rate, and profit margin) are the most appropriate and potentially useful empirical representation of the model.

As an initial step to developing the model for a firm, we take the logarithms of both sides of capital stocks equation (2.4), sales equation (2.5), profit rate equation (2.6), and profit margin equation (2.7) resulting in the following simple contemporaneous relationships (i.e., relationships in the same period) between the logarithms of S_t, K_t, R_t, and M_t:

$$k_t = s_t + m_t - r_t, \tag{2.8}$$

$$s_t = r_t + k_t - m_t, \tag{2.9}$$

$$r_t = s_t + m_t - k_t, \tag{2.10}$$

$$m_t = r_t + k_t - s_t, \tag{2.11}$$

where the coefficients of the principle variables in the model (s_t, r_t, m_t, and k_t) are either plus or minus one as posited by theory, and there is no residual error.

Next, it is reasonable to assume that firms and market participants use lagged values of the profit rate, profit margin, capital stocks, and sales to form conditional expectations or forecasts of their current and future values. The simplest approach to modeling expectations when forecasting each variable in period $t+1$ is to use the values of other variables in the previous period t as follows:

$$k_{t+1} = \alpha_0 + \alpha_1 s_t + \alpha_2 r_t + \alpha_3 m_t, \tag{2.12}$$

$$s_{t+1} = \beta_0 + \beta_1 r_t + \beta_2 m_t + \beta_3 k_t, \tag{2.13}$$

$$r_{t+1} = \theta_0 + \theta_1 s_t + \theta_2 m_t + \theta_3 k_t, \tag{2.14}$$

$$m_{t+1} = \eta_0 + \eta_1 r_t + \eta_2 k_t + \eta_3 s_t, \tag{2.15}$$

where the left-hand-side variables are expected values or forecasts of capital stocks, sales, profit rate, and profit margin, respectively, for period $t+1$ using the values of the other variables in the previous period t. A constant term is added to each equation for econometric estimation of the equations. Note that when lags of the variables are used for forming expectations, the coefficients on the lagged variables are no longer equal to plus or minus unity and residual error exists. To minimize residual errors in these equations, other variables can be included in the set of variables used for forecasting the fundamental business variables.

Equations (2.12)–(2.15) can provide estimates of expectations or forecasts of capital stocks, sales, profit rate, and profit margin. Different econometric methods can be applied for their estimation. When using a system approach for estimating all the equations, we can reduce the number of equations (and hence coefficients) to be estimated by using the forecasts of the variables generated in the model. For instance, (2.15) can be derived from estimates of (2.12)–(2.14). Table 2.1 provides a model of a conventional firm dubbed *FIRM* comprised of dynamic relationships among sales, capital stocks, profit rate, profit margin, and total profit represented by equations for these variables. This model can be extended to include more lags of the variables in equations for sales, capital stocks, and profit rate as discussed in Chap. 2 of Anari and Kolari (2009). There the extended model with several lags was augmented to include other variables such as the Federal funds rate and growth rate of debt outstanding, as these variables were found to have significant impacts on the fundamental business variables (sales, capital stocks, profit, profit rate, and profit margin). Due to limitations of Excel for handling large models (i.e., models with many lags and variables), we specified only one lag of the variables in the model.

http://www.springer.com/978-1-4614-2049-1

Excel-Based Business Analysis
Forecasting Key Business Trends
Anari, A.; Kolari, J.W.
2012, XV, 44 p. 43 illus., 32 illus. in color., Softcover
ISBN: 978-1-4614-2049-1