Financial Structure, Production and Productivity Growth in U.S. Food Manufacturing Industry

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Abstract

This paper examines how financing decision by firms affect production, input demands, profitability, and productivity. A model that integrates production technology with financing decision is applied to the U.S. food manufacturing industry. Empirical results shows that output supply, variable input demands, profitability and productivity are affected by agency costs of debt and signaling benefits of dividend payments. A one percent increase in dividend payment leads to a 0.11 percent increase in post-tax variable profit, while a one percent increase in outstanding debt causes the variable profit to decline by 0.04 percent. Every $1.00 raised through bond issue is associated with $.076 in debt adjustment cost. Average annual total factor productivity growth was 0.8 percent in U.S. food manufacturing industry. Signaling benefit contributed for about 3.75 percent of the growth in productivity, while agency cost accounted for about 11.25 percent reduction in growth. Thus, positive signaling benefits of dividend payment was more than offset by the agency cost of debt in the productivity growth in the U.S. food manufacturing industry.

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Major changes in the structure and performance of manufacturing industries over the recent decades have generated considerable interest among researchers to understand the implications of these changes. Although the increased interest in changes in market structure, technology, and globalization have led many researchers to explore the issue in various contexts, U.S. food manufacturing sector has received far less attention than either the more high-tech manufacturing sectors or the agricultural sector. The food-manufacturing sector is clearly important in terms of its size and welfare implications relative to many sectors that have received far more attention. Food and fiber industries account for about 20 percent of the U.S. manufacturing output of which about 85 percent comes from the food industry. The U.S. food-manufacturing sector is nearly as large as the farm sector, and is greater than the 12 percent share of the food industry in U.K. and 3 percent share in Canada (Paul 1999a).

Although generally perceived as less technology oriented than other manufacturing sectors, the average capital intensity of the food manufacturing industry is about as high as that for the remaining non-durable manufacturing sector, and is close to that of transportation equipment and fabricated metals industries (Paul 1999a). The average high-tech component in capital in the food industry increased considerably over the years, from 1.5 percent in 1961 to 10 percent in 1991. Further, the ratio of high-tech capital to "other capital" increased from 3 percent in 1958 to 25 percent in 1991. The increase in the average high-tech capital in the food industry between 1976 and 1991 (from 4 percent to 10 percent) is close to that for the overall non-durable industry. (Paul 1999a, and Berndt and Morrison 1995).

The U.S. food-manufacturing industry has been affected by several factors including consolidation and concentration. Major structural changes took place in the industry via mergers and acquisition, especially during 1965-70 and 1979-89. The average four-firm concentration ratio increased from about 59 percent in 1987 to about 65 percent in 1992. At 4-digit SIC level, during the 1972-92 period, this concentration ratio increased at least 25 percent in 14 food industries while it increased more than 100 percent in case of soft drinks, meat packing, macaroni and spaghetti, and poultry slaughtering and processing industries.

Another development in the U.S. food manufacturing industry relates to changing financial structure of the sector. Over the years the industry has significantly increased its dependence on debt financing as is evident from Figure 1, which shows the debt/asset ratio of the industry (SIC 20) for the 1960-98 period. The rising debt/asset ratio in Figure 1 imply that the industry has significantly increased its debt use over the years, from about 25 percent in 1960 to 26 percent in 1964, and reaching to 39 percent in 1974. After falling to 34 percent by 1976 and remaining stable, the ratio increased from 35 percent in 1984 to 56 percent in 1990. The ratio remained above 50 percent during the entire 1990s. Also note that the sharp increases in the debt/asset ratio during 1964-74 and 1984-90 periods almost mirrors the periods when this industry experienced increased pace of consolidation and concentration.

Despite these developments and the importance of the industry, few studies have focused on the performance of the food industries. Previous research on the performance of the food and fiber industries includes Heien (1983), Huang (1991), Goodwin and Brester (1995), Morrison (1997), Morrison and Seigel (1998) and Paul (1999a, 1999b). Heien (1983) computes the Törnqvist-Theil multifactor productivity index for the aggregate and selected disaggregated industries. However, his study suffers from some major drawbacks for not

including capital and problems with input definitions. Morrison (1997) analyzes the impacts of capital investment and asset fixity on cost structure and productivity of the food industry while Paul (1999a) focuses on scale economy, mark-up behavior, trade, investment and cost structure in the aggregate food and fiber industry. Morrison and Siegel (1998) explore the existence and extent of scale economies arising from "knowledge capital", high-tech capital, and human capital. Paul (1999b) explores the impacts of technical change and trade on costs, scale economies, pricing behavior and input demand, but focuses only on the meat sector.

None of the studies mentioned above addresses the interlinkages between financial decisions and production, input demand and dynamic efficiency. This follows the past tradition of analyzing production and performance where decisions on *real* economic variables are kept separate from financial decisions. However, recent research has shown that *real* and financial decisions of firms may be interconnected due to the existence of asymmetric information, information costs and the consequent frictions in capital markets[1].

Incentive conflicts due to information asymmetry generate agency costs of bond financing and signaling benefits of dividend payments, and thereby affect production and investment decisions. Debt levels are determined through a trade-off between agency costs and tax benefits of debt financing, while dividend payments are decided based on the trade-off between tax disadvantages and signaling benefits. The recognition of the potential effects of financial variables on many aspects of *real* economic decisions needs to be incorporated in the empirical analyses of production, technological change and productivity growth.

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[1] See Hubbard (1998) for comprehensive surveys on the issue.

Despite the recognition of the effects of financial decisions on *real* economic variables, empirical evidence on the effects of financial variables, especially of agency costs of debt and signaling benefits of dividends, on production, profitability, technological change and productivity growth is still limited. Few studies in the area include Kim and Maksimovic (1990) and Greenwald, Kohn and Stiglitz (1990) and Bernstein and Nadiri (1993). Kim and Maksimovic (1990) analyze the effects of agency costs on the productivity of U.S. airline industry. Greenwald, Kohn and Stiglitz (1990) study investigates the effect of agency costs on the productivity of the overall U.S. manufacturing sector while Bernstein and Nadiri (1993) examine the effects of both agency costs of debt and signaling benefits of dividend payments on production, technological change and total factor productivity (TFP) growth for the U.S. manufacturing sector. They decompose the TFP growth that allows quantitative estimation of the contribution of debt and dividend payments on TFP growth. However, these issues have not been addressed in the context of U.S. food manufacturing industry.

The objective of this study is to provide empirical evidence on the impacts of agency costs of debt and signaling benefits of dividend payments on output supply, input demands, profitability, technological progress, and the dynamic efficiency, measured by total factor productivity (TFP) growth in the U.S. food manufacturing industry. The paper is organized as follows: Section 2 describes the conceptual framework and empirical model used in the study. Section 3 describes the variables used, data sources, and estimation method utilized in the analysis. Section 4 presents the empirical results, followed by the Conclusions section.

Conceptual Framework and Empirical Model

The conceptual framework that underlies the empirical analysis integrates production technology with agency costs of debt and signaling benefits of dividend payments, where production and financial decisions are simultaneously modeled. In this setting, tax costs of dividends and agency costs of debt affect output supply, while output and input prices affect dividend payments. The model incorporates adjustment costs to long-run equilibrium due to capital installation costs as well as costs associated with new debt issue. The decomposition of TFP in this framework allows evaluation of the impacts of agency costs of debt and signaling benefits of dividend on the dynamic efficiency of the food manufacturing industry.

The production process is described by the following function

$$y_t = F\left(\mathbf{x}_t, x_t^m, K_{t-1}, \Delta K_t, t\right), \tag{1}$$

where, F is the production function, y denotes output, **x** is an n-dimensional vector of variable inputs, x_t^m is the managerial input, K denotes capital, ΔK denotes change in capital, and t is a technology indicator captured by time trend. Subscript t refers to time period.

The managerial input represents the services of planning, organizing, and monitoring input use to ensure technologically efficient production[2]. There are capital adjustment costs in the production process in the form of foregone output due to resource allocation for capital installation, which are represented in the production function by changes in capital input.

The monitoring of managerial decisions by shareholders and creditors cannot be done without costs. The asymmetric information between managers and shareholders and creditors

[2] See Brander and Spencer (1989) for discussions on managerial inputs and financial structure.

may lead to incentive divergence between the agents. Dividend payments and new shares issues by firms serve as signaling devices (Leland and Pyle 1977, Ross 1977, Myers and Majluf 1984, and Bernheim 1991). Management's decision to pay dividends signals that the firm is in good financial position with adequate net flow of funds. However, the signaling benefits of dividends have a trade-off in the form of higher tax obligations associated with dividend payments (King 1977, Auerbach 1979, and Poterba and Summers 1985).

Asymmetric information between managers and creditors is a source of agency costs. Jensen and Meckling (1976), Stiglitz and Weiss (1981), and Greenwald, Kohn and Stiglitz (1990) show that, in the presence of asymmetric information, firms can undertake relatively risky investments that increase the risk exposure of the creditors. Myers (1977) suggests that debt financing involves costs to firms because they may have to forego profitable investment opportunities. Part of the benefit of debt-financed investments accrue to creditors while shareholder bear the costs. The agency cost of debt is traded off against tax reductions associated with interest payments on debt.

The signaling benefits of dividend and agency costs of debt are incorporated into the model by defining the following managerial cost function,

$$c_t^m = mG\left(D_t, B_{t-1}, \Delta B_t\right), \tag{2}$$

where c_t^m is managerial cost, μ is the price of managerial input, D is dividend payment, B is the value of outstanding bonds and ΔB is the value of new bonds issue. The function G may be interpreted as the firm's financing ability function, which is decreasing in debt and increasing in dividends. The agency costs are associated with both outstanding debt and new bond issues, the latter defines the debt adjustment cost. The managerial cost function is

connected with the G function in the sense that an increase (decrease) in financing ability increases (decreases) the demand for managerial services, and the managerial input cost rises (falls). A formal link between managerial input demand and the G-function can be obtained by applying the Shephard's Lemma on (2) to obtain $x_t^m = \frac{dc_t^m}{dm} = G(D_t, B_{t-1}, \Delta B_t)$. Thus, the G-function represents the managerial input demand. Substituting $\mathbf{x}_t^m$ into the production function (1) yields an augmented production function that includes financial variables,

$$y_t = \Im\left(x_t, D_t, B_{t-1}, K_{t-1}, \Delta K_t, \Delta B_t, t\right) \tag{3}$$

The production cum managerial, equation (3), shows that debt and dividend levels affect output supply and input use. An increase (decrease) in outstanding debt lowers (increases) managerial input demand, which in turn decreases (increases) output with given non-managerial inputs. Thus, changes in outstanding debt affect both capital and non-capital inputs. Similarly, changes in new debt issue and dividends generate output and input effects.

Capital is a quasi-fixed input whose stock follows the process

$$K_t = I_t + \left(1 - d\right) K_{t-1} \tag{4}$$

where $0 < \delta < 1$ is the fixed depreciation rate, and I_t is the investment in time t. The flow of funds relating the production and financing decision can be described as

$$P_{1,t} y_t - \mathbf{P}_t^T \mathbf{x}_t - Q_t I_t - R_t B_{t-1} + \Delta B_t + \Delta S_{n,t} - D_t = 0\,, \tag{5}$$

where, $P_{1,t}$ is the post-tax price of output, $\mathbf{P}_t^T$ is a vector of post-tax variable input prices, Q_t represents the post-tax purchase price of capital, R_t is the post-tax interest rate on debt, and $\Delta S_{n,t}$ is the value of share issue in time t.

Production and financing decisions are made to maximize the expected discounted value of equity. The optimization problem is

$$\max_{\{y_t, x_t, I_t, D_t, \Delta S_{n,t}, \Delta B_t\}} \quad E_t \sum_{t=1}^{\infty} a_{t,t} \left(D_t (1-u_{p,t})/(1-u_{g,t}) - \Delta S_{n,t} \right) \tag{6}$$

subject to equations (3) - (5), given initial capital stock and debt level. In the above equation, the discount factor is $a_{t,t} = 1,\ a_{t,t+1} = [(1 + r_{t+1}(1-u_{p,t+1})/(1-u_{g,t+1}))]^{-1}$ where ρ is the discount rate, u_p is the personal income tax rate, and u_g is the capital gains tax rate with $0 < u_g < u_p < 1$. Shareholders are subject to dividend tax at the same rate as personal income tax rate.

In this setting, the intertemporal production and financing problem can be solved in two stages. The first stage determines the short-run equilibrium, which is obtained from

$$\max_{\{y_t, x_t, D_t\}} \quad P_{1,t} y_t - P_{2,t} D_t - \mathbf{P}_t^T \mathbf{x}_t \tag{7}$$

subject to equations (3) and (5), conditional on the capital stock and debt levels. In equation (7) above, $P_{2,t} = (u_p - u_g)/(1-u_g) > 0$ can be considered as the price of dividend, which is the additional tax shareholders have to pay per dollar of dividends relative to receiving a dollar of capital gains. In the short-run the firm chooses output, variable inputs, and dividend to maximize the post-tax variable profit net of dividends. In the short-run equilibrium the tax cost associated with dividends is offset at the margin by the signaling benefits through higher managerial ability to finance production. Conditional on capital stock and debt, dividend payments are determined simultaneously with output supply and variable factor demands.

Thus, under this framework, output supply and variable input demands are affected by changes in dividend price while dividend payments are affected by output and variable input prices. Debt level affects output and input decisions through the marginal productivity

of managerial input and the rate of substitution between managerial input and variable inputs. Further, changes in debt level affect dividend payments through the effects of agency costs on signaling ability. In the short-run, capital accumulation and technological change affect the relative marginal product of the managerial input, and thereby the dividend payments.

The solution to the optimization problem in equation (6) generates a post-tax variable profit function (net of dividend payments) given by

$$\Phi_t^v = \Phi\left(P_{1,t}, P_{2,t}, P_t^T, K_{t-1}, B_{t-1}, \Delta K_t, \Delta B_t, t\right) \tag{8}$$

In order to empirically implement the model, a translog functional form is assumed. Thus the variable profit (net of dividend payments) function is given by[3]

$$\begin{aligned}\ln\left(\Phi^v / P_{n+2}\right) = {} & b_0 + \sum_{i=1}^{n+1} b_i \ln\left(P_i/P_{n+2}\right) + \sum_{k=K}^{B} b_k \ln K_k + b_t t \\ & + 0.5\left(\sum_{i=1}^{n+1}\sum_{j=1}^{n+1} b_{ij} \ln\left(P_i/P_{n+2}\right)\ln\left(P_j/P_{n+2}\right) + \sum_{k=K}^{B}\sum_{s=K}^{B} b_{ks} \ln K_k \ln K_s + b_{tt} t^2\right) \\ & + \sum_{i=1}^{n+1}\sum_{k=K}^{B} b_{ik} \ln\left(P_i/P_{n+2}\right)\ln K_k + \sum_{i=1}^{n+1} b_{it} \ln\left(P_i/P_{n+2}\right) t + \sum_{k=K}^{B} b_{kt} \ln K_k t\end{aligned} \tag{9}$$

where, P_1 is post-tax price of output, P_2 is the post-tax price of dividend, P_i denotes post-tax price of variable inputs for i (i = 3, …n+2), K_k = capital input, and K_B = Debt level. In equation (9) the symmetry condition is imposed by assuming $\beta_{ij} = \beta_{ji}$, and $\beta_{ks} = \beta_{sk}$. Further, marginal capital and debt adjustment costs are assumed to be zero when net investment and new bond issues are zero. This assumption allows separation of adjustment costs from other components of net variable profit. The adjustment cost is given by

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[3] The homogeneity of degree one of the variable profit function in prices is imposed by normalizing Φ^v and prices by a variable input price. Henceforth, time subscript is omitted to simplify notation.

$$c^a = 0.5\sum_{k=K}^{B}\sum_{s=K}^{B} a_{ks}\Delta K_k \Delta K_s \,,\; a_{ks} = a_{sk} \,. \tag{10}$$

Both new debt and capital expansion affect the marginal adjustment costs of both capital and debt, and this interaction reflects that often new debt are issued to finance capital expansion.

Using the net variable profit function (9), the short-run equilibrium conditions are obtained by applying the Hotelling's Lemma to obtain

$$s_i = b_i + \sum_{j=1}^{n+1} b_{ij} \ln\left(P_j / P_{n+2}\right) + \sum_{k=K}^{B} b_{ik} \ln K_k + b_{it} t, \qquad \text{i = 1, 2,…, n+1} \tag{11}$$

where $s_1 = P_1 y / \Phi^v$ is output's share in (net) variable profit, $s_2 = -P_2 D/\Phi^v$ is dividend share in Φ^v, and $s_i = -P_i x_i/\Phi^v$ is variable input i's share in Φ^v (i = 3, …,n+1). Equation (11) above shows that in the short-run equilibrium output, dividends and variable factor components of Φ^v are functions of relative output and input prices, capital stock, debt level, and technology.

The intertemporal productions and financing decisions are solved in the second stage. In this stage firms choose the optimal debt and share issue. Substituting equations (4) and (8) into equation (6), the intertemporal production and financing problem can be expressed as

$$\max_{\{K_t, B_t\}} \quad E_t \sum_{t=1}^{\infty} a_{t,t} [\Phi^v - R_t B_{t-1} + B_t - B_{t-1} - Q_t (K_t - (1-d) K_{t-1})] \tag{12}$$

where Q and R denote the post-tax purchase price of investment and interest rate on debt.

Solution to the optimization problem in equation (12) results in the determination of optimal capital and debt level for the firm. Once the new (optimal) levels of capital and debt are determined, the investment and new debt issues are determined which in turn allows the determination of the share issue. Substituting the solutions for capital and debt from equation (12) into equation (11) allows the determination of output supply, dividend payments and

variable factor demands. New share issues are then determined by plugging-in the solutions for output, inputs, dividend payments, new investment, and debt into equation (5).

Substituting the post-tax net variable profit function defined in equation (9) and the adjustment cost function defined in equation (10) into equation (12), and solving the intertemporal optimization problem leads to the following two Euler equations

$$\begin{aligned}&-a_{KK}\Delta K_t - a_{KB}\Delta B_t - Q_t + E_t a_{t,t+1}([b_K + b_{KK}\ln K_t + b_{KB}\ln B_t + \sum_{i=1}^{n+1} b_{iK}\ln\left(P_{i,t+1}/P_{n+2,t+1}\right)\\&+b_{kt}(t+1)](\Phi^v_{t+1}P_{n+2,t+1})/K_t + a_{KK}\Delta K_{t+1} + a_{KB}\Delta B_{t+1} - Q_{t+1}(1-d)) = 0\end{aligned} \tag{13}$$

$$\begin{aligned}&-a_{BB}\Delta B_t - a_{KB}\Delta K_t + 1 + E_t a_{t,t+1}([b_B + b_{BB}\ln B_t + b_{KB}\ln K_t + \sum_{i=1}^{n+1} b_{iB}\ln\left(P_{i,t+1}/P_{n+2,t+1}\right)\\&+b_{Bt}(t+1)](\Phi^v_{t+1}P_{n+2,t+1})/B_t + a_{BB}\Delta B_{t+1} + a_{KB}\Delta K_{t+1} - R_{t+1} - 1) = 0\end{aligned} \tag{14}$$

Equation (13) shows that at optimal capital level the expected marginal post-tax profit of capital in period t+1 inclusive of expected adjustment cost and post-tax purchase price savings from previous period's undepreciated capital stock is offset against the post-tax contemporary purchase of capital inclusive adjustment cost. Equation (14) implies that at equilibrium the expected marginal reduction in post-tax profit in period t+1 due to the agency costs of debt inclusive of interest payments net of expected debt adjustment cost savings from previous period's debt issue is offset against the current additional funds from a dollar of debt net of marginal debt adjustment costs. These two equations reveal that capital expansion and debt increases have opposite effects on variable profit. The benefit of capital is the profit it generates, while that of debt is the extra fund that flows to the firm while profit is reduced due to agency costs.

Data and Estimation

Data used in the study relates to the food manufacturing industry (SIC 20) and cover the 1960-96 period. Data on quantities and implicit price indices of outputs and inputs are from NBER Manufacturing Productivity Database. The input and output quantities and price data in the NBER database (at 4-digit SIC level) are first converted to real values at 1987 prices and then aggregated to 2-digit SIC level. Real output and input quantities are obtained by simply adding up across industries. Aggregate price indices are obtained as weighted averages of the price indices with revenue/cost share of each of the 4-digit industry used as weights.

Output is measured by the real value of shipments. There are two variable factors, labor and material (including energy), and a quasi-fixed input, capital. Quantity of labor input is defined in millions of hours and includes only the production workers. Nominal wage rate per hour is obtained by dividing total production wage bill by the total hours worked. Real wage rate is obtained by deflating the nominal wage rate with the GDP deflator.

The dollar value of *Cash Dividends Charged to Retained Earnings* (for SIC 20) obtained from Quarterly Financial Report (QFR) is used as total dividend payment. The real values of the dividend payments are obtained by deflating the nominal dividend payments by the GDP deflator, obtained from the Bureau of Labor Statistics. The price of dividend is defined as $P_2 = \left(u_p - u_g\right) P_p / \left(1 - u_p\right)$ where u_p is the effective personal tax rate on dividend income, u_g is the effective tax rate on capital gains and P_p is the GDP deflator. Data on tax rates on dividend income and capital gains for 1960-84 are from Feldstein and Jun (1987), which was updated for other years using information obtained from the Statistics of Income.

Real value of capital, in 1987 dollars, and implicit deflator for new investment are from the NBER database, which includes both equipment capital, and structures and building. Using the investment deflator the post-tax purchase price of investment is calculated as: $Q_t = P_I (1 - \omega_k - u_c z)$ where P_I is investment deflator, ω_k is investment tax credit, u_c is corporate income tax rate, and z is present value of capital consumption allowance. Investment tax credit was first instituted in 1962 so that the value of ω_k for 1960 and 1961 are set equal to zero. Data on the investment tax credit for the years 1962 to 1981 are from Jorgenson and Sullivan (1981). For other years, we follow Bernstein and Nadiri (1993) and use 8% rate for 1981 and 7.5% for the remaining years. Corporate income tax rate for 1960- 85 are from Pechman (1987), which was updated using information obtained from the office of tax analysts at the U.S. department of treasury. The present value of capital consumption allowances is calculated as $z = \lambda(1 - \eta\omega_k)(r + \lambda)$ where λ is the ratio of capital consumption allowance to capital stock less treasury stock (both obtained from QFR) at cost, η is 0.5 for 1962 and 1963 and zero elsewhere, and r is the yield on 10-year U.S. T-bonds.

The stock of debt is defined as the sum of installments due in more than one year on long-term loans from banks, and other long-term debt. Both are end of the period values for the fourth quarter and are obtained from the QFR. Interest rate on debt is measured by the yield on 10-year Treasury bonds. Discount rate is given by $\rho(1 - u_p)/(1 - u_g)$, where ρ is the annual rate of return on equity in the food industry (SIC 20) obtained from QFR.

The empirical model consists of equations (9), (11), (13) and (14). The adjustment cost function (equation (10) is not estimated because the parameters are contained in the capital and debt equations. The endogenous variables in the model are post-tax net variable

profit, output, labor, dividend variable profit components, capital and debt. For empirical estimation of the system of equations, error terms with zero expected value are added to equations (9) and (11). Error terms are introduced in equations (13) and (14) by removing the conditional expectations operator and substituting realized values of the variables. It is assumed that the error structure forms a positive definite symmetric covariance matrix.

Since the empirical model contains expected future values of the variables, the equations are estimated using Hansen and Singleton's (1982) GMM estimator. Equivalent to non-linear 3SLS estimator, it is consistent and efficient for the set of instruments used (Pindyck and Rotemberg 1983). Lagged values of relative prices, interest rate, post-tax purchase price of capital, post-tax variable profit, capital and debt are used as instruments.

Empirical Results

The estimated model coefficients and the associated standard errors are presented in Table 1. The model coefficients are well determined and most coefficients are statistically significant. The J-statistics for testing the validity of the overidentifying restrictions of the model yield an estimated value of 53.26. For our empirical model, the J-statistic is distributed as χ^2 with degrees of freedom equal to 47. The 95% critical value of $\div^2_{47}$ is 64.00, which is greater than the computed value of the statistic. Thus we conclude that the null hypothesis that the model is correctly specified cannot be rejected.

Financial Consideration, Production and Profitability

First, we present the results relating to the effects of financing strategy on allocation decisions relating to output supply, input demands, and profitability of aggregate U.S. food industry. The effects of financing decisions on output, inputs and profitability work through

two channels. One channel relates to the effects on production and profitability when price of dividend is altered via changes in tax code, while the other relates to the effects of changes in outstanding debt that has been determined by the financing decision in the previous period.

First we consider the effects of changes in prices of output and variable inputs as well as dividend. In the empirical model output and input prices affect dividend payments, which in turn affect output supply and input demand. The short-run price elasticities are given by

$$e_{ij} = \left(b_{ij} + s_i s_j - d_{ij} s_i\right) / s_i \quad \text{i, j = output, dividend, labor,}$$

where e_{ij} = elasticity of the ith quantity with respect to the jth price, $\delta_{ij} = 1$ if i = j, and $\delta_{ij} = 0$ if $i \neq j$. Recall that $s_i > 0$ for output and $s_i < 0$ for dividend and variable inputs. Price elasticities associated with material input are calculated by obtaining the relevant coefficients form the homogeneity restriction. Share of material input is obtained as $s_4 = 1 - s_1 - s_2 - s_3$.

The estimated price elasticities and associated standard errors are presented in Table 2 which shows that increases in output prices increase output supply, dividend payments and demand for both variable inputs. Increase in dividend price has negative effects on output, dividend payments and variable input demands. Further, increases in both variable input prices have negative impacts on output (as expected), dividend payment and demand for both inputs. Estimated elasticities suggest that dividend is relatively more responsive to changes in output and input prices than its own price. Changes in dividend price generate only inelastic responses from output supply and input demands while changes in other prices bring elastic responses. A one percent increase in dividend price leads to reductions in output supply and input demands, with magnitudes ranging from 0.013 to 0.352.

Changes in dividend price also affect variable profit via its effects on output supply and input demands. Since post-tax variable profit (before dividend payments) is given by $p^{v} = \Phi^{v}(1-s_2)$ where $s_2 = - P_2D/\Phi^{v}$, the elasticity of π^{v} with respect to dividend price is

$$e_{p2} = [s_2(1-s_2) - b_{22}]/(1-s_2)$$

The estimated value for $e_{\pi 2}$ is -0.018 (with a S.E. = 0.004) implying that a one percent increase in dividend price causes only about 0.02 percent decrease in π^{v}. The signaling benefit of dividend (in higher profitability) is the percentage change in π^{v} relative to percentage change in dividends resulting from a one percent increase in dividend price. In terms of the model parameters, this is given by $e_{pD} = e_{p2}/e_{22}$, where $e_{\pi 2}$ and e_{22} are as defined earlier. The estimated $e_{\pi D}$ is 0.11 implying that a one percent increase in dividend causes about 0.11 percent increase in the variable profit of U.S. food manufacturing industry.

The level of debt also affects output supply and variable input demands. Based on model coefficients, we estimate the effects of outstanding debt on production, dividend payments, and profitability. Also, we compare these results with the effects of increases in capital stock and technological change. The effects of technological change, capital, and debt on output supply, variable input demands, and dividend payments can be computed as

$$e_{ij} = b_{ij}/s_i + e_{fj} \qquad \text{i = output, dividend, labor and materials, j = K, B, t}$$

where $e_{\phi j}$ is the effect of j on post-tax variable profit.

The estimated values of the elasticities and their associated standard errors are presented in Table 3, which clearly shows that increases in debt have negative impacts on output, input demands, and profitability. Point estimates of the elasticities with respect to debt suggest that a one-percent increase in debt leads to about 0.04 percent decline in output,

dividend payments, and variable input demands. The agency cost associated with outstanding debt can be defined in terms of foregone profitability. Expressed in elasticity form, the effect of debt on post-tax variable profit is given by $e_{pB} = \left[e_{fB}(1-s_2) - b_{2B} \right] / (1-s_2)$, the point estimate of which is –0.040 with S.E. of 0.004. The finding that profitability falls with higher debt levels is consistent with the notion that higher debt levels cause agency costs to rise. These elasticities are comparable to those obtained by Kim and Maksimovic (1990) for U.S. airline industry, and Bernstein and Nadiri (1993) for U.S. manufacturing sector as a whole.

Effects of capital expansion and technological change on output, input demands, and dividend payments are also given in Table 3. Capital expansion and technological change have positive effects on production, dividends and profitability, and therefore works to mitigate the negative effects on these variables. Estimated elasticities suggest that capital is the driving factor affecting output, input demands, dividend payments and variable profits.

Adjustment Costs

The adjustment costs in our model are reflected in the costs associated with capital expansion and debt issue. The estimated adjustment cost parameters, α_{KK}, α_{KB} and α_{BB} in equations (13) and (14), reported in Table 1, show that own adjustment costs coefficients are positive (as expected) while the interaction term α_{KB} is negative. The signs α_{KK} and α_{BB} imply that net capital expansion via investment increases marginal installation cost while additional debt issue increases the marginal agency costs. Negative α_{KB} implies that capital investment and debt issues are adjustment complements in the sense that increases in net capital stock lower the marginal agency cost. That is, agency costs are reduced when capital

expansion is financed through debt. Estimated coefficients yield ($\alpha_{KK}\alpha_{BB}$ - a_{KB}^2)> 0 implying convexity of adjustment costs in net capital investment and new debt issue.

The agency costs of debt affect the adjustment towards long run equilibrium and create a wedge between the contemporaneous and long run effects of debt on profitability. In long-run equilibrium the marginal debt adjustment cost is zero and the reduction in variable profit due to agency costs is the difference between post-tax rate of return to shareholders and the post-tax interest rate on debt, which is given by $W_{B,t} = r_t(1-u_{p,t})/(1-u_{g,t}) - r_t(1-u_{c,t})$, where $r_t(1-u_{c,t}) = R_t$, r_t is the interest rate on debt in period t and $u_{c,t}$ is corporate income tax rate in period t. In the long run, the ratio between the marginal agency cost and the net opportunity cost of funds (W_B) has to equal to unity. Therefore, the relative importance of marginal adjustment costs of debt (the system deviates from long-run equilibrium) can be obtained as the ratio of marginal adjustment cost (i.e., adjustment cost per dollar of new debt) to the rate of return to shareholders. This is given by $[(a_{BB}\Delta B_t + a_{KB}\Delta K_t)/\Delta B_t]/W_{B,t}$. The computed marginal adjustment costs of capital increase and new debt are reported in Table 4. The average marginal debt adjustment cost was found to be about 0.076 for the 1961-96 period implying that for $1.00 cost of debt there is an additional adjustment cost of about $0.076. This adjustment cost was highest in the 1980s and lowest during 1991-96 period.

Similarly in long-run equilibrium when marginal adjustment cost is zero, marginal profit associated with capital expansion equals the after-tax rental rate (or the opportunity cost of capital serves) of capital given by $W_{K,t} = Q_t[r_t(1-u_{p,t})/(1-u_{g,t}) + d]$. Therefore, the marginal adjustment cost of capital is $[(a_{BB}\Delta K_t + a_{KB}\Delta B_t)/\Delta K_t]/W_{K,t}$. Estimated marginal adjustment cost of capital (reported in Table 4) yield an average adjustment cost of 0.112 for

1961-96 period, implying that that for $1.00 rental of capital services, there is an additional adjustment cost of $0.118 of which $0.112 is the capital installation cost and $0.076 is debt adjustment cost. These findings are similar to those of Berndt and Morrison (1981), Pindyck and Rotemberg (1983), Mohnem, Nadiri and Prucha (1986), Bernstein and Nadiri (1993).

Returns to Scale, Technological Change and Productivity Growth

Returns to scale in production, given by the proportional change in output in response to changes in variable inputs and quasi-fixed factor (capital), and the rate of technological change are also affected by debt and dividend price. It is assumed that managerial inputs and technology do not change. Under this assumption, the post-tax variable profit function can be used to obtain a measure of the degree of returns to scale as

$$RRS = -\sum_{i=3}^{n+2} s_i / s_1 + (\partial \ln \Phi^v / \partial \ln K) / s_1 \tag{15}$$

where i = 3 represents labor and i = n+2 = 4 represents material input. The rate of technological change can also be obtained from the variable profit function as

$$RTC = (\partial \ln \Phi^v / \partial t) / s_1 \tag{16}$$

Table 4 contains the results relating to returns to scale (RRS) and the rate of technical change (RTC) for the U.S. food manufacturing industry. These results suggest that the U.S. food manufacturing industry is essentially a constant returns to scale industry. The estimated rate of technical change in this industry fluctuated between 0.70 and 078 percent for most of the years except the 1991-96 period when this rate was found to be 0.65 percent. The estimated average rate of RTC was 0.72 percent for the 1961-96 period. Thus, the U.S. food industry experienced a slower rate of technical progress relative to the overall manufacturing sector. For instance, both Bernstein and Nadiri (1993) and Gullickson (1995) estimated a 1.3

percent annual rate of technological change for the aggregate manufacturing industry. A noticeable aspect of our result is that the RTC in the food manufacturing industry was slower in the first half of 1990s when U.S. economy experienced widespread technological progress.

The dynamic efficiency of the food industry is investigated by analyzing the total TFP growth over the 1961-96 period. Traditional sources of TFP growth are technological change and scale effects. Recent extensions in the literature have included factors such as efficiency, market power, asset fixity, etc. as additional sources of TFP change. We do not focus on market power or efficiency, but obtain an expanded TFPG decomposition to include the effects of agency costs of debt and signaling benefits of dividend payments. Total factor productivity growth is defined by

$$TFPG = d\ln y - \sum_{i=L}^{M}(P_i x_i / C) - (W_k K / C) d\ln K \tag{17}$$

where L = labor input, and M is the material input $C = \sum_{i=L}^{M} P_i x_i + W_K K$ is the total cost. Taking a total differential of equation (8) and $\Phi^v = P_1 y - \sum_{i=L}^{M} P_i x_i - P_2 D$, the Hotelling's Lemma yields

$$\begin{aligned} s_1 d\ln y + \sum_{i=L}^{M} s_i d\ln x_i + s_2 d\ln D = & \left(\partial \ln \Phi^v \big/ \partial \ln K\right) d\ln K \\ & + \left(\partial \ln \Phi^v \big/ \partial \ln B\right) d\ln B + \partial \ln \Phi^v / \partial t \end{aligned} \tag{18}$$

where $s_1 = P_1 y/\Phi^v > 0$, $s_2 = - P_2 D/\Phi^v$, and $s_i = - P_i x_i/\Phi^v < 0$ (i = L, M) are output, dividend, and variable input components in net variable profit. Multiplying both sides of (18) by (Φ^v/C) and adding (17) to both sides of (18) gives

$$\begin{aligned} TFPG = & \left(1 - (\Phi^v / C) s_1\right) d\ln y + (\Phi^v / C)\, \partial \ln \Phi^v / \partial t + (\Phi^v / C)(\partial \ln \Phi^v / \partial \ln K \\ & - (W_k K / C) d\ln K) + (\Phi^v / C) s_2 d\ln D + (\Phi^v / C)(\partial \ln \Phi^v / \partial \ln B) d\ln B \end{aligned} \tag{19}$$

The TFP decomposition in equation (19) shows that there are five components of TFP growth. The first term is the scale effect, the second term reflects technological change, the third term denotes the capital adjustment effect, the fourth term reflects the signaling benefits of dividends, and the fifth term is the effect of agency costs of debt financing. Thus, TFP growth in the food industry, in addition to being affected by the traditional factors, is also impacted by financing decision of firms.

In this decomposition of TFP growth, increases in dividend payments make positive contribution while increases in debt make negative contribution TFP growth. Results of TFP decomposition are presented in Table 5. Table 5 shows that in the U.S. food manufacturing industry, TFP experienced an average annual growth rate of 0.8 percent during the 1961-96 period. The signaling benefits of dividend payments contributed to the average annual rate of TFP growth by 0.0003 or 3.75 percent, compared to a 4.2% contribution calculated by Bernstein and Nadiri (1993) for the overall U.S. manufacturing industry. Agency cost of debt made a negative contribution to the TFP growth in the food manufacturing industry. For the 1961-96 period, agency cost associated with debt reduced TFP growth by 0.0009 or by 11.25 percent. This is about three and a half times the negative contribution of debt to TFP growth in the overall manufacturing sector computed by Bernstein and Nadiri (1993) and about 4 times that computed by Kim and Maksimovic (1990) for U.S. airline industry. Thus, for the U.S. food manufacturing industry, we find that the dynamic efficiency effects associated with agency costs of debt are much higher than the signaling benefits associated with dividend payments. Adjustment of capital to long-run equilibrium made had positive effects on TFP growth, implying that the positive effects of capital outweighed the installation costs and adjustment costs associated with bond financing of capital. Growth in TFP came mainly from

technological progress and capital expansion, while scale effects and agency costs of debt were a drag on the TFP growth in the U.S. food manufacturing industry.

Conclusion

In this study, we examine how financing decision by firms affect production, input demands, profitability, and productivity. In particular, we estimate the impacts of agency costs of associated with debt financing and signaling benefits of dividend payments on output supply, input demands, profitability, and productivity growth in U.S. food manufacturing industry. We find that a one percent increase in dividend payment leads to a 0.11 percent increase in post-tax variable profit, while a one percent increase in outstanding debt causes the variable profit to decline by 0.04 percent. The average adjustment cost in the U.S. food industry was about $0.118 of which $0.112 was capital installation cost and $.076 was attributable to the agency cost from bond issue.

Output supply and variable input demand are affected by dividend payments and outstanding debt. Dividend payments have positive effects on output supply and variable input demands through positive signaling benefits, while outstanding debt level have negative via agency costs. Agency costs and signaling benefits also affected the TFP growth in U.S. food manufacturing industry. Overall, annual total factor productivity growth was 0.8 percent in U.S. food manufacturing industry. Signaling benefit contributed for about 3.75 percent of the growth in productivity, while agency cost accounted for about 11.25 percent reduction in growth. Thus, positive signaling benefits of dividend payment was more than offset by the agency cost of debt in the productivity growth in the U.S. food manufacturing industry.

Table 1. Estimated Model Coefficients, Standard Errors and t-ratios

Parameter	Estimate	Standard Error	t-ratio
β_0	34.19470	12.0560	2.84
β_1	3.29686	1.2997	2.54
β_2	-0.41023	0.1559	-2.63
β_3	-0.93213	0.3358	-2.78
β_K	-3.17025	1.5740	-2.01
β_B	-0.12521	0.0629	-1.99
β_t	0.10707	0.0362	2.96
β_{11}	1.88583	0.8381	2.25
β_{22}	-0.01470	0.0028	-5.23
β_{33}	0.10913	0.0174	6.26
β_{KK}	0.35012	0.1913	1.99
β_{BB}	0.00257	0.0008	3.06
β_{tt}	-0.00043	0.0004	-1.84
β_{12}	-0.06753	0.0192	-3.51
β_{13}	-0.31738	0.0760	-4.18
β_{23}	0.09471	0.0150	6.31
β_{KB}	0.00505	0.0015	3.29
β_{1K}	0.13562	0.1157	1.17
β_{2K}	-0.00508	0.002	2.47
β_{3K}	0.04430	0.0301	1.47
β_{1B}	0.00508	0.0034	1.28
β_{2B}	-0.00043	0.0009	-0.49
β_{3B}	0.00286	0.0013	2.25
β_{1t}	-0.04977	0.0045	-11.14
β_{2t}	-0.00098	0.0003	-3.11
β_{3t}	0.00573	0.0007	8.10
β_{Kt}	-0.00586	0.0023	-2.54
β_{Bt}	-0.00033	0.0001	-4.05
α_{KK}	0.00899	0.0045	1.98
α_{KB}	-0.00069	0.0004	-1.90
α_{BB}	0.00461	0.0019	2.48

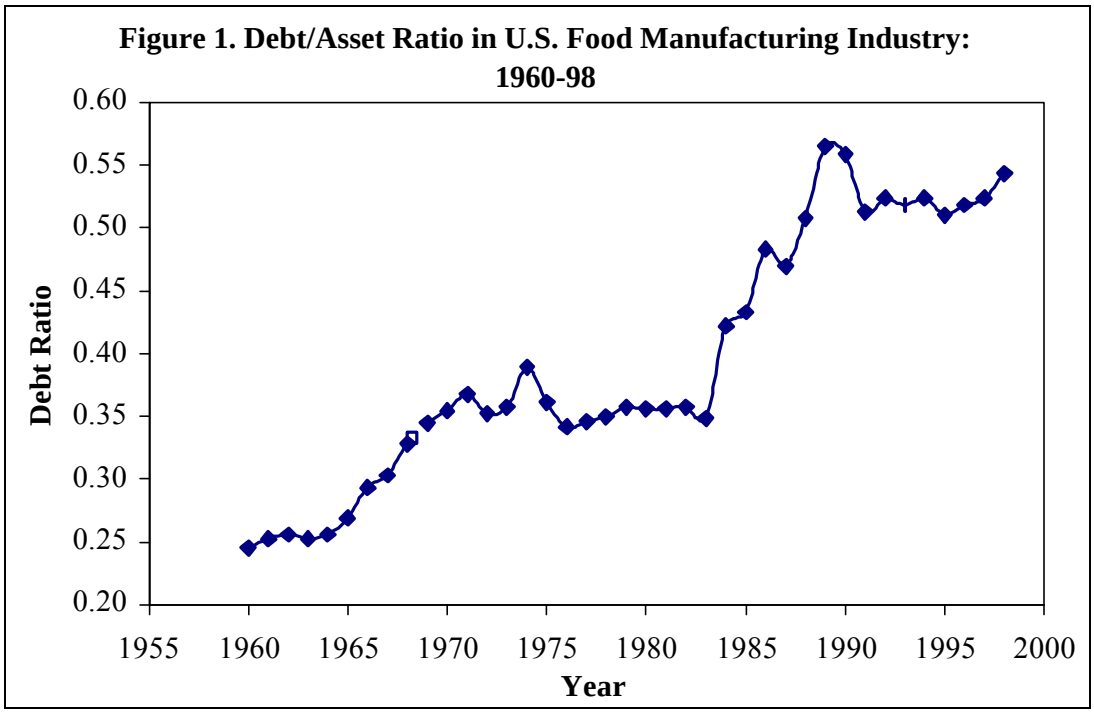

Table 2. Short-run Price Elasticities

Quantity	Price			
	Output	**Dividends**	**Labor**	**Materials**
Output	3.404	-0.034	-0.364	-3.05
	(0.214)	(0.008)	(0.041)	(0.194)
Dividends	7.847	-0.163	-5.786	-1.898
	(1.117)	(0.016)	(0.591)	(0.983)
Labor	5.043	-0.352	-1.669	-3.023
	(0.268)	(0.027)	(0.234)	(0.242)
Materials	4.496	-0.013	-0.327	-4.156
	(0.359)	(0.008)	(0.061)	(0.473)

Note: Elasticities are computed at mean values, and standard errors are in parentheses.

Table 3. Elasticities with Respect to Capital, Debt and Technological Change

	Capital	Bond	Technology
Output	0.936	-0.039	0.023
	(0.150)	(0.003)	(0.036)
Dividends	0.900	-0.041	0.035
	(0.605)	(0.004)	(0.035)
Labor	0.913	-0.040	0.036
	(0.141)	(0.007)	(0.036)
Materials	0.857	-0.043	0.047
	(0.113)	(0.015)	(0.036)
Variable Profit	0.906	-0.040	0.036
	(0.007)	(0.004)	(0.036)

Table 4. Adjustment Cost, Returns to Scale and Rate of Technological Change

	Marginal Adjustment Cost		Returns to Scale	Rate of Tech. Change
	Capital	**Debt**		
1961 - 1970	0.209	.077	0.948	0.0070
1971 - 1980	0.109	.077	0.950	0.0072
1981 - 1990	0.053	.089	0.941	0.0078
1991 - 1996	0.051	.051	0.938	0.0065
1961 - 1996	0.112	.076	0.945	0.0072

Table 5. Total Factor Productivity Growth and Decomposition

	Scale	Technological Change	Capital Adjustment	Dividends	Debt	TFPG
1962 - 70	-0.0082	0.0098	0.0072	0.0001	-0.0011	0.0078
1971 - 80	-0.0070	0.0097	0.0063	0.0002	-0.0002	0.0090
1981 - 90	-0.0054	0.0106	0.0035	0.0003	-0.0023	0.0067
1991 - 96	-0.0067	0.0087	0.0057	0.0011	0.0004	0.0091
1962 - 96	-0.0069	0.0098	0.0057	0.0003	-0.0009	0.0080

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