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Collusion and Financial Leverage: An Analysis of the Integrated Mill Steel Industry

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We show that firms can design their capital structure to provide a publicly observable indication of compliance with a collusive agreement. We develop two empirically testable hypotheses based on this argument and test these propositions on data for seven integrated mill steel firms. Our study period covers years when prices were overtly coordinated under the basing point pricing system and after the demise of the system. Empirical tests confirm the hypotheses that leverage is positively related to both price elasticity of demand and the level of convertibles outstanding during the years after the collapse of the basing point pricing system.

Since the Modigliani and Miller (1958) study, one of the central issues in financial economics is why and how firms choose specific capital structures. Ravid (1988) reviews a number of studies that focus on product market conditions and financial decisions, yet Harris and Raviv (1991) indicate a serious lack of research relating financial leverage to the nature of the firm's product market.

Maksimovic (1988) suggests that leverage can be used to effectively maintain collusion. First, he defines the general conditions and motivations that make it possible and desirable for oligopolists that have only equity in their capital structure to engage in collusion. He then shows that when a firm is partially financed with nonconvertible debt, there is a discernable ceiling on leverage that is a positive function of a firm's price elasticity of demand. This ceiling provides a publicly observable gauge that the colluding firms can use to judge compliance with a collusive agreement. The firms that do not exceed the threshold indicate their intention to abide by the compact. Firms that exceed the ceiling send the opposite message, thus jeopardizing the continuing existence of the cartel. Brander and Lewis (1986, 1988) and Stenbacka (1994) outline similar approaches to Maksimovic.

We extend Maksimovic's model to show that the use of convertible securities in place of nonconvertible debt permits a firm to exceed the industry's debt ceiling and still demonstrate compliance with the agreement. This is possible because the conversion options attached to the debt allow bondholders to share in gains the stockholders would realize by deviating from the collusive arrangement. The extent to which debt can be increased above the ceiling is a positive function of the number of shares of common stock obtained after exchange of the convertible securities.

If we assume that firms use capital structure to indicate compliance with a collusive arrangement, the theoretical arguments imply two empirically testable hypotheses. The first is that leverage should vary positively in response to changes in the price elasticity of demand. The second is that leverage should be a positive function of the number of new equity shares created if bondholders were to exercise all their convertible security options.

We test both of these hypotheses using data that measure financial leverage, price elasticity of demand, and convertible security usage for seven domestic integrated mill steel firms. Our

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sample period is 1947 through 1980. These firms comprise a relatively concentrated sector of the American steel industry and are considered to have maintained some type of collusive arrangement throughout this entire period. We find the steel industry especially interesting since there is continuing uncertainty about how it was able to maintain collusion after 1959, when the US Steel Corporation's overtly collusive formal price leadership, the basing point pricing system, collapsed. This sample provides an opportunity to examine firm behavior towards collusion before and after the breakdown of this system. We anticipate that prior to the demise of basing point pricing, subtle forms of collusion would not have been necessary, given the strong position held by US Steel. However, in the following years, we anticipate that firms operating in the industry used and maintained some form of tacit collusion.

We also incorporate control variables for changes in tax rates, inflation rates, profitability, market-to-book ratios, the volatility of equity value, and market interest rates in our model since previous studies suggest that these factors affect a firm's financial leverage decision. Researchers also believe that many of these same variables influence the number of convertible securities outstanding.

Our regression results provide empirical evidence that is consistent with expectations before and after the collapse of basing pointing pricing. We find significant evidence that the sample firms altered financial leverage positively with changes in both price elasticity of demand and convertible security usage in the years following the collapse of the basing point pricing system. There is no evidence of similar behavior while this system was in place.

The paper proceeds as follows. Section I presents our hypotheses on the relation between financial leverage, price elasticity of demand, and convertible securities. Sections II and III briefly describe the American steel industry and our sample firms. In Section IV, we describe the method used to estimate the steel demand function and the annual price elasticities. In Section V, we develop our model and describe the empirical results in Section VI. We conclude and summarize the paper in Section VII.

I. Theoretical Development

In this section, we first illustrate the motivation for collusion among firms that use only equity financing. We then demonstrate that it is possible to enforce a cartel agreement through the addition of nonconvertible debt. Finally, we show how convertible debt affects the enforcement of collusion among the oligopolists.

A. Collusion Among Equity Financed Firms

To demonstrate that cartel members can use financial leverage to enforce collusion, we first introduce Maksimovic's (1988) equity-only model. Assume an oligopolistic industry with N equal-sized firms that use only equity financing. The firms face a repeating game where annual profits can be at one of three discrete states depending on the collective or individual actions of the participants. Let π_i^c represent the profit earned by firms from collusion, π_i^d the one-period profit of a single firm that cheats on the collusive arrangement, and π_i^{nc} the profit earned by firms at the non-colluding Nash equilibrium, where we assume that $\pi_i^d > \pi_i^c > \pi_i^{nc}$. We also assume that all participants know each of these profit states with perfect certainty. If the firms in the industry can develop a successful strategy to establish and enforce collusive behavior, they will earn a perpetual stream of π_i^c and the value of equity, V_i^c, will be:

$$V_i^c = \pi_i^c (1 + \frac{1}{r}) \tag{1}$$

where r represents the discount rate.

If the collusive arrangement collapses, or if it cannot be established in the first place, firms will earn a perpetual stream of π_i^{nc}. In this case, equity value, V_i^{nc}, will be:

$$V_i^{nc} = \pi_i^{nc} (1 + \frac{1}{r}) \tag{2}$$

Since $V_i^c > V_i^{nc}$, the incentive for collusion clearly exists. However, if firms are to establish a cartel, they must consider the circumstances that would motivate one of the members to cheat. If we assume that deviating from the agreement by any firm will cause the cartel to collapse, thus leading all firms to earn π_i^{nc} in subsequent periods, then the equity value for the cheating firm, V_i^d, will be:

$$V_i^d = \pi_i^d + (\frac{\pi_i^{nc}}{r}) \tag{3}$$

If $V_i^d > V_i^c$, it would benefit any cartel member to deviate once the industry has established and implemented the collusive strategy. Therefore, the creation, and subsequent continuation, of a collusive arrangement is possible only when $V_i^d < V_i^c$.

B. Nonconvertible Debt Financing

We again refer to Maksimovic (1988) to illustrate how introducing debt into a firm's capital structure can alter the fundamental conditions that make collusion desirable. We also show how firms can use financial leverage to help maintain a cartel by providing a publicly observable sign of the firm's intention to abide by agreements.

We assume firms are corporations with limited liability and wish to add the greatest feasible amount of nonconvertible debt into their capital structures. We presume that firms choose the maximum level of debt due to tax savings associated with debt relative to equity financing (Miller and Modigliani, 1961, and Stenbacka, 1994). We define the perpetual annual interest obligations incurred by the i^{th} firm as I_i. When the level of debt is set so that $I_i > \pi_i^{nc}$, bankruptcy occurs if profits drop to π_i^{nc}. The threat of bankruptcy provides a powerful incentive to maintain collusion that is mutually self-enforcing.[1]

After the debt is issued, the value of equity for the previous three profit states becomes:

$$\overline{V}_i^c = (\pi_i^c - I_i)(1 + \frac{1}{r}), \tag{4}$$

$$\overline{V}_i^{nc} = 0, \text{ and} \tag{5}$$

$$\overline{V}_i^d = (\pi_i^d - I_i). \tag{6}$$

The addition of debt to the firms' capital structures creates the potential for $\overline{V}_i^d > \overline{V}_i^c$ even though $V_i^c > V_i^d$. This possibility occurs and threatens cartel stability when the annual interest obligation of a firm rises to the point where $I_i > \pi_i^c - r(\pi_i^d - \pi_i^c)$. However, the tax

[1]The case where $I_i < \pi_i^{nc}$ is of little interest since collusion would be feasible under all of the same circumstances as for all equity financing. Also, this capital structure contributes nothing to the enforcement of the cartel since the stockholders are no longer threatened with bankruptcy.

benefits of debt in capital structure should create the incentive for firms to raise I_i near to $\pi_i^c - r(\pi_i^d - \pi_i^c)$. When a firm promises annual interest payments near, but not exceeding this ceiling, it provides evidence to other firms that it will not violate the agreement.

Further, since we can show that the profit states of π_i^c and π_i^d are positively related to a firm's price elasticity of demand, it follows that the debt ceiling also depends on the price elasticity of demand. (For details on this relation, see Maksimovic, 1988.) The combination of the threat of bankruptcy and desire to exploit the tax benefits of debt financing indicates that colluding firms should modify their capital structures positively with fluctuations in the price elasticity of demand. Although it is unlikely that cartel members will have all the necessary information to set and precisely assess the threshold level of debt, it does seem probable that the participants would know enough to establish a reasonable level of debt and to judge if changes in leverage are justified or if they should be viewed with suspicion.

This argument leads to our first hypothesis on how firms can arrange their capital structure to show compliance with a collusive arrangement. We design a test to search for a positive link between leverage and price elasticity of demand. The first hypothesis is formally stated as:

$H1_o$: Among members of a cartel, financial leverage is not positively related to a firm's price elasticity of demand.

$H1_a$: Among members of a cartel, financial leverage is positively related to a firm's price elasticity of demand.

(Note that this is just one possible solution to the problem of effectively enforcing collusive behavior. Failure to reject the null hypothesis does not imply that collusion is not taking place, only that capital structure is not supported as the enforcement mechanism.)

Some empirical evidence already exists to suggest that firms might use capital structure as a means to enforce collusive behavior. Chevalier (1995a,b) and Phillips (1995) conduct event studies of local markets in which at least one of the firms increased leverage through a leveraged buyout (LBO). They find that in markets where all firms have reasonably high debt levels, there is a tendency for an LBO to be followed by increased prices. However, when rivals are not highly leveraged, the LBO is often followed by a price decrease. This decrease suggests that the other firms might be trying to exploit the LBO firm's weakness.

Our analysis differs substantially from these previous event studies that concentrate on an isolated alteration of leverage by one firm in an industry. Using a group of firms widely perceived to have engaged in such practices, we test for long-term evidence of the mechanism used to enforce collusive behavior.

C. Convertible Debt Financing

Maksimovic (1988) also suggests that conversion features attached to bonds allow colluding firms to use more leverage than the amount allowed when all debt is nonconvertible. We develop an extension of the previous model that includes only nonconvertible debt to show how this is possible.

First, we assume that each limited liability corporation issues a single class of debt securities that can be either convertible or nonconvertible, and that once again, the firms choose the level of debt so that the annual interest obligations, I_i, exceed π_i^{nc}. If a firm issues convertible bonds, we assume they all have identical conversion ratios. Next, we assume that all holders of these convertible securities behave uniformly. This is the critical simplifying assumption that leads to a less ambiguous result than that of Maksimovic. He assumes the holders of convertible bonds will not all exercise their options at the same time. His approach forces several critical assumptions about the timing of the realization of revenues and operating expenses that further complicate the model. Finally, we assume that all participants have perfect knowledge about the potential outcomes and the motivations of others.

The stakeholders now follow a three-step process to determine each firm's capital structure. First, the stockholders select the type and level of debt that establishes the annual interest payments (I_i) and, for convertible debt, the conversion ratio that determines the percentage of new shares of common stock created upon conversion (λ_i). For instance, if $\lambda_i = 1$ and all bondholders convert, one new share of stock will be created for each existing share of stock, thus doubling the number of shares. The issuance of nonconvertible debt implies $\lambda_i = 0$. In the second step, the stockholders of each firm decide whether to adhere to the collusive agreement or to cheat. The last step requires the convertible debt holders to decide whether to maintain debt ownership or to convert to common stock. We assume that all debt holders receive their annual interest payment prior to making the decision to convert their securities into common equity and sharing in the distributions to the stockholders. This assumption could be altered slightly, thus changing the exact nature of the relation, but it would not alter its substance.

To protect and preserve the established collusive agreement, the stockholders of each firm must design the convertible debt contracts so that if cheating occurs, the debt holders will convert and capture a substantial portion of the cheating firm's one-time profit. The possibility of conversion by debt holders is, in effect, a self-imposed "tax" on deviating behavior that is publicly observable by other members of the cartel. When all abide by the agreement and the debt holders do not convert, the value of firm equity will again be $\overline{V}_i^c = (\pi_i^c - I_i)(1 + \frac{1}{r})$. However, if a firm cheats and the debt holders exercise their conversion privilege, the value of equity, $\ddot{V}_i^d$, for the original shareholders will be:

$$\ddot{V}_i^d = [(\pi_i^d - I_i) + \frac{\pi_i^{nc}}{r}]\,[\frac{1}{1+\lambda_i}] \tag{7}$$

When the conversion privilege is exercised, the original stockholders retain only $1/(1+\lambda_i)$ of the cash flows generated while the new stockholders (the former debt holders) receive the remaining $\lambda_i/(1+\lambda_i)$ of the cash flow. To establish the conditions where $\overline{V}_i^c > \ddot{V}_i^d$, which preserves the incentive to remain in the cartel, requires that:

$$I_i < \frac{\pi_i^c (1+r)(1+\lambda_i) - r\,\pi_i^d - \pi_i^{nc}}{1 + [\lambda_i (1+r)]} \tag{8}$$

In Equation (8), I_i is a positive function of λ_i since the derivative,

$$\frac{\partial I_i}{\partial \lambda_i} = \frac{[\pi_i^{nc} + r(\pi_i^d - \pi_i^c)](1+r)}{(1 + [\lambda_i (1+r)])^2} \tag{9}$$

is positive under normal conditions where, π_i^d, π_i^c, π_i^{nc}, and r are nonnegative, and $\pi_i^d > \pi_i^c > \pi_i^{nc}$. Equation (8) implies that it is possible to use convertible debt at levels where $I_i > \pi_i^c - r(\pi_i^d - \pi_i^c)$ and still remain a compliant member of the cartel.

As a matter of fact, it is theoretically possible to raise I_i all the way to π_i^c if λ_i is raised to infinity. Obviously, in a world without perfect certainty it is unlikely that any firm would attempt to do this, but it does show that the introduction of convertible bonds increases the maximum level of debt financing above the ceiling that is possible with nonconvertible debt alone.

This derivation suggests that colluding firms can use more leverage in their capital structure when convertible debt is added to the mix of debt securities outstanding. It also leads to the second hypothesis on the capital structure decisions made by firms. A firm's leverage should be positively correlated with the number of new shares of common stock created when convertible securities are exercised. This second hypothesis is formally stated as:

$H2_0$: Among members of a cartel, financial leverage is not positively related to the proportion of new to existing shares that will be created upon conversion of all convertible securities.

$H2_a$: Among members of a cartel, financial leverage is positively related to the proportion of new to existing shares that will be created upon conversion of all convertible securities.

II. The American Steel Industry (1947-1980)

After the government eliminated formal price controls on steel products at the end of World War II, steel prices remained effectively fixed under the basing point pricing system. Under this system, US Steel published a base price for steel products in Pittsburgh and the American Iron & Steel Institute provided a schedule of railway freight rates from Pittsburgh to various locations throughout the country. Integrated mill steel firms would then set local prices according to this schedule.

This overt system of collusion was maintained throughout most of the 1950s. However, near the end of the decade, three significant events occurred that transformed the industry. First, in 1959, the years of uneasy peace between labor and management were shattered by a major strike. Second, new domestic electric furnace "mini mills" that recast scrap metal began to capture the markets for round products such as wire rods, bars, pipes, and structural shapes. Finally, extremely efficient Japanese and European rivals began to flood the market for traditional heavy steel products.[2]

Mancke (1968) and Rippe (1970) found that by 1960, the basing point pricing system had been effectively abandoned by the integrated mills. However, a Federal Trade Commission Report by Duke, Johnson, Mueller, Quails, Rosh, and Tar (1977) argued that collusion continued for heavy steel products even after the end of this long established pricing system.

We examine the question of how collusion continued after the collapse of the overt pricing system by using the hypotheses developed in this paper. We reason that the existence of the basing point pricing system and the strong price leadership position held by US Steel before 1959 rendered tacit collusion irrelevant. However, given that some sort of price setting might have still been in place after the system's demise, the question of how such cooperation could have been maintained remains unanswered.

The unique set of circumstances surrounding the steel industry offers the opportunity to test Hypotheses (1) and (2) for a period when basing point pricing was in effect and also for

[2]For more details see, Adams (1977), Adams and Mueller (1986), Barnett and Crandall (1986), Barnett and Schorsch (1983), Crandall (1981), Hogan (1971, 1987), and Tiffany (1988).

a period after its collapse. We anticipate no evidence of a significant relation between financial leverage and either price elasticity of demand, or convertible security usage before the end of the pricing system. However, after the system's demise, given the need for some mechanism to enforce collusion, we look for significant positive relations among these variables that are consistent with our hypotheses.

III. Sample Firms

We collect data, from 1947 through 1980, for a sample of seven publicly traded integrated mill steel firms: ARMCO[3], Bethlehem Steel, Universal Cyclops, Inland Steel, Interlake Iron, Republic Steel, and US Steel. We truncated the starting date of our study due to a lack of price data on individual steel products necessary to calculate the price elasticity of demand. We chose the ending date because of inconsistencies in the data on financial leverage caused by mergers among integrated mill steel firms in the early 1980s. These firms, which mostly produced large, heavy, flat steel products, represent a segment of the industry that was sufficiently concentrated during the study years to provide the conditions necessary for collusive behavior. Further, these seven firms present an interesting opportunity to test the hypothesis on convertible securities, since they used a variety of debt securities in their capital structures during these years.

IV. Price Elasticity of Demand

To test the first hypothesis requires us to measure the sample firms' price elasticity of demand. Unfortunately, the information necessary to estimate the elasticity for each of the individual steel mills is not available. The fact that each of the sample firms produces and sells a number of different steel products provides an additional complication.

As a proxy, we estimate the price elasticity of demand for the product market segment dominated by the firms included in the sample. First, we create a Hicksian (1939) composite commodity that comprises the primary products dominated by the integrated steel mills throughout the sample period. These products are plates, hot rolled sheets, cold rolled sheets, galvanized sheets, and tin plates.[4] We measure the output for the sector as the sum of the tons of steel products shipped annually. As a proxy of the price for the product group, we use the weighted average of the prices of the steel products included in the composite commodity. The weights are based on the percentage that each item represents in the composite. Fortunately, these weights varied little over the years studied. This weighting scheme follows a procedure similar to that used by Nelson (1994). We obtain the prices and shipments of each steel product from various issues of the *Annual Statistical Report* of the American Iron and Steel Institute and *Metal Statistics*.

Using the data for the Hicksian composite commodity, we model demand as:

$$QSTEEL_t = \beta_{0t} + \beta_{1t}RSP_t + \beta_{2t}IP_t + \beta_{3t}CBOND_t + \beta_{4t}IER_t + \beta_{5t}TREND_t + \mu_t \quad (10)$$

[3]Known as American Rolling Mills in the early years of the study.

[4]See Barnett and Crandall (1986) and Hogan (1987) for a discussion of evolution of the product markets controlled by various types of steel firms. In the later years of the study, mini mills effectively stripped away the markets for hot rolled bars, cold finished bars, structural shapes, billots, and wire rods.

where $QSTEEL_t$ is total shipments (in tons) of steel products. RSP_t is the real weighted price of the products. We adjust these prices for price level changes using the metals price index calculated by the Bureau of Labor Statistics (1982=100). IP_t is the US industrial production index. $CBOND_t$ is the annual average of monthly yields on *Moody's Seasoned Aaa Corporate Bonds.* IER_t is the ratio of steel imports to exports. $TREND_t$ is a time variable starting at one in 1947. Finally, μ_t is an additive transitory disturbance term.

We assume, *a priori*, that RSP_t, $CBOND_t$, and IER_t should negatively affect $QSTEEL_t$ and that IP_t should have a positive influence. We include US industrial production to capture changes in the use of steel caused by economic conditions in the economy. The Aaa corporate bond rate is intended to capture the impact of interest rates changes on the demand for steel. To control for the impact of foreign competition on the demand for domestic steel products, we include the ratio of steel imports to steel exports. We use the trend variable ($TREND_t$) to capture general trends in steel usage over the years that could be positive or negative.

Empirical studies typically assume that the structure of behavioral relationships is stable over time and that any variations are transitory in nature. Unfortunately, this restrictive assumption may not be true in many situations, especially when a study covers a lengthy period. The demand functions faced by the integrated steel mills are likely to have undergone structural changes over the years. Permanent changes in these demand relationships could have been caused by any number of factors including the post-war recovery and increased competition of foreign steel producers, the closer oversight of this industry by the Justice Department due to its history of anticompetitive practices, the rise of mini mills that chipped away at the markets formerly dominated by large integrated steel mills, and variations in the relative importance of steel products used in construction and manufacturing.

There are many ways to incorporate structural changes into empirical analysis. One of the more flexible is the Adaptive Regression Model introduced by Cooley and Prescott (1973, 1976).[5] The major advantage of this model is that it requires little prior knowledge about how structures may have changed over time. This variable (random walk) model allows the parameters to vary through time, based on a nonstationary probabilistic scheme with no inherent tendency for them to return to a mean value. The model assumes that the estimated equation parameters are subject to stochastic variation that depends on the sum of both permanent and transitory effects. The permanent effects cause persistent movement in parameter values through time, but the transitory effects are felt only in the current period. This is shown as:

$$y_t = x_t' \beta_t \qquad t = 1, 2, \ldots, T \tag{11}$$

where y_t is a vector of T observations of the dependent variable, x_t is a k component vector of explanatory variables, and β_t is a k component vector of parameters subject to sequential variation. The two sources of variation are incorporated as:

$$\beta_t = \beta_t^p + \nu_t \tag{12}$$

and

$$\beta_t^p = \beta_{t-1}^p + \upsilon_t \tag{13}$$

[5]For examples of the use of the adaptive regression model, see McIntosh and Shideed (1989), Parrott and McIntosh (1996), and Rausser and Laumas (1976).

where we denote the permanent component of the parameters with the superscript p.

We assume that the stochastic variates ν_t and υ_t are normal, identically, and independently distributed with mean vectors zero and covariance matrices:

$$\operatorname{cov}(\nu_t) = (1-\gamma)\,\sigma^2\,\Sigma_\nu \tag{14}$$

and

$$\operatorname{cov}(\upsilon_t) = (\gamma)\,\sigma^2\,\Sigma_\upsilon \tag{15}$$

where $\gamma \in [0,1]$. The parameter γ is the rate at which the β's adapt to structural change, meaning that as γ approaches one, the effects of the permanent changes increase relative to the transitory ones. The matrices Σ_ν and Σ_υ provide information concerning the relative variability of the parameters that are assumed to be known up to a scale factor. In addition, we normalize them so that the element corresponding to the intercept is unity. This means that the first explanatory variable is the intercept and its transitory component is captured in the model by the usual additive error term.

Because the process generating the parameters is nonstationary, we cannot specify the likelihood function necessary for parameter estimation. However, Cooley and Prescott (1976) show that a well-defined likelihood function can be constructed by considering specific realizations of the parameter process at a particular point in time. They focus on the value of the parameter process one period (T+1) beyond the sample period. By repeated substitution we see that:

$$\begin{aligned}\beta^p_{T+1} &= \beta^p_t + \upsilon_{T+1} \\ &= \beta^p_t + \sum_{j=t+1}^{T+1} \upsilon_j\end{aligned} \tag{16}$$

and by insertion into Equation (12) leads to:

$$\beta_t = \beta^p_{T+1} - \sum_{j=t+1}^{T+1} \upsilon_j + \nu_t \tag{17}$$

Substituting β_t from Equation (17) for β_t in Equation (11) results in:

$$y_t = x_t'\beta + \mu_t \tag{18}$$

where $\beta = \beta^p_{T+1}$, and $\mu_t = x_t'\nu_t - x_t' \sum_{j=t+1}^{T+1} \upsilon_j$.

The random disturbance vector μ is normally distributed with mean vector zero and a covariance matrix defined as:

$$\operatorname{cov}(\mu) = \sigma^2\,[(1-\gamma)R + \gamma Q] = \sigma^2\,\Omega_{(\gamma)} \tag{19}$$

where R is a diagonal matrix with elements $r_{ii} = x_i'\Sigma_\nu x_i$ and Q a $T \times T$ matrix with elements $q_{ij} = \min\{|t-i|, |t-j|\}\, x_i'\Sigma_\upsilon x_j$ when both i and j are greater than or less than t, otherwise $q_{ij} = 0$. We can now write the full model and the distribution of Y as:

$$Y = X\beta + \mu \tag{20}$$

where $Y \sim N[X\beta, \sigma^2 \Omega_{(\gamma)}]$, X is a $\mathbf{T} \times k$ matrix and β is a k component vector.

If γ is known, we can apply generalized least squares to obtain the parameter estimates, since all the other factors are observed exogenous variables. However, since γ will not be known in most instances, we can write the log likelihood function of the observations specified at a particular realization as:

$$L(Y; b, \sigma^2, \gamma, X) = -\frac{T}{2}\ln 2\pi - \frac{T}{2}\ln\sigma^2 - \frac{1}{2}|\Omega_{(\gamma)}| - \frac{1}{2\sigma^2}(y - X\beta)'\,\Omega_{(\gamma)}^{-1}(y - X\beta) \tag{21}$$

Maximizing Equation (21) with respect to β and σ^2 yields estimators conditional on γ as:

$$\hat{\beta}_{(\gamma)} = [X'\Omega_{(\gamma)}^{-1}X]^{-1}X'\Omega_{(\gamma)}^{-1}y \tag{22}$$

and

$$\hat{\sigma}^2_{(\gamma)} = \frac{1}{T}[y - X\hat{\beta}_{(\gamma)}]'\,\Omega_{(\gamma)}^{-1}[y - X\hat{\beta}_{(\gamma)}]\cdot \tag{23}$$

Substituting these estimators into Equation (21) yields the concentrated log likelihood function:

$$L_c(Y;\gamma) = -\frac{T}{2}(\ln\ 2\pi + 1) - \frac{T}{2}\ln\hat{\sigma}^2_{(\gamma)} - \frac{1}{2}\ln\left|\Omega_{(\gamma)}\right| \tag{24}$$

Maximizing the concentrated likelihood function for $\gamma \in [0,1]$ is equivalent to maximizing the log likelihood equation. We can then insert the value of γ that maximizes the conditional log likelihood function (say γ^*) into Equations (22) and (23) to obtain estimates of β and σ^2 that are asymptotically efficient (Cooley and Prescott, 1973, 1976).

Without prior knowledge that some other specification is superior, Cooley and Prescott (1973) suggest that it is appropriate to set the relative importance of the permanent and transitory changes equal to each other for all random parameters. This assumption suggests that Σ_v and Σ_υ are equal. Further, if we have no reason to suspect that the random parameters are correlated with each other over time, we can assume the matrices to be diagonal. Given these assumptions, the only requisite is the specification of the relative variability of the different parameters. Cooley and Prescott (1976) indicate that the loss in estimation efficiency is comparatively small even for sizeable errors in specifying the diagonal elements. In this study, we use the standard errors of the parameters that we obtain by using a maximum likelihood estimator that assumes constant parameters. We use these standard errors as the diagonal elements of Σ_v and Σ_υ to serve as a proxy for the relative variability of the parameters. In addition, we scale the diagonal elements so that the first element is equal to one.

We calculate the estimated price elasticities by using each annual β_{1t}, the coefficient on real steel prices (RSP_t), and the corresponding price and quantity data over the entire dataset. We show this as:

$$\varepsilon_t = \frac{\partial QSTEEL_t}{\partial RSP_t} \times \frac{RSP_t}{QSTEEL_t} \tag{25}$$

where $\hat{\beta}_{1t}$ from Equation (10) is $\partial(QSTEEL_t)/\partial(RSP_t)$. Panel A of Table I shows the annual estimates of the parameters in Equation (10), γ (the permanent components of β), and the asymptotic standard errors of β. Panel B contains the annual estimates of the price elasticity of demand. To gain a visual sense of how elasticity fluctuated throughout the study period, Figure I shows graphically the annual estimates of the price elasticity of demand.

V. The Model

We specify the following model to test the hypotheses that suggest that among cartel members, financial leverage is positively related to both price elasticity of demand and the number of new shares created if the bondholders were to exercise all outstanding convertible securities.

$$\begin{aligned} LEV_{t,i} = {} & \alpha + \psi_1 LEVBMAN_t + \psi_2 SIGMA_{t,i} + \psi_3 MB_{t,i} + \psi_4 CBOND_t + \psi_5 PROFIT_{t,i} \\ & + \theta_1 PED_t + \theta_2 LAMBDA_{t,i} + \phi_1 SIGLAM_{t,i} + \phi_2 MBLAM_{t,i} + \phi_3 CBONDLAM_{t,i} \\ & + \eta_1 PED59_t + \eta_2 LAMBDA59_{t,i} + \tau_1 SIGLAM59_{t,i} + \tau_2 MBLAM59_{t,i} \\ & + \tau_3 CBONDLAM59_{t,i} + \Sigma\Phi_i D_i + \mu_{t,i} \end{aligned} \tag{26}$$

We estimate the equation using panel data that includes observations from 1947 to 1980 for seven domestic integrated mill steel firms. We define all the variables below and provide justification for the control factors that we add to more adequately specify the model. Table II contains summary statistics for the principle variables included in the model.

The dependent variable, $LEV_{t,i}$, is the proxy for financial leverage. In calculating this ratio for the i^{th} firm in year t, the numerator is the book value of long-term debt and the denominator is the sum of the book values of long-term debt and preferred stock and the market value of common equity. We obtain the book values and number of outstanding shares from various issues of the *Moody's Industrial Manual* and end-of-year stock prices from the CRSP tape.

The first five explanatory variables represent general controls that we include in the model to capture the effects of additional factors that potentially influence the financial leverage used by firms. The first, $LEVBMAN_t$, measures the average ratio of the book values of long-term debt to the book values of long-term liabilities and equity for US manufacturing firms in the t^{th} year. We obtain the data from Taggart (1985) who provides information from the IRS publication *Statistics of Income*. We include this term to control for systemic changes in financial leverage that are caused by fluctuations in macroeconomic conditions, such as changes in tax and inflation rates, that affect all manufacturing firms in a similar fashion. It should be positively related to financial leverage. The second variable, $SIGMA_{t,i}$, is our proxy for firm risk. We measure it as the annual standard deviation of monthly stock returns for the i^{th} firm in year t using CRSP data.[6] The impact of risk on leverage is difficult to specify *a priori*. According to Modigliani and Miller (1958), the risk of equity should increase when financial leverage rises. However, other researchers argue that debt can be negatively correlated with operational risk. Either relation can hold since our sample contains time-series and cross-sectional elements. The empirical evidence on the relation between risks, measured by the volatility of either earnings or stock returns, and financial leverage has

[6]We also tried beta from the Capital Asset Pricing Model (CAPM) as an estimate of systematic risk, but the results were not statistically significant.

Table I. Demand Equation Parameter and Elasticity Estimates

In panel A, we show the parameter estimates obtained for Equation (10), and in panel B, we show the price elasticity of demand estimates (ε_t) obtained using Equation (25). The two equations, respectively, are:

$$QSTEEL_t = \beta_{0t} + \beta_{1t}RSP_t + \beta_{2t}IP_t + \beta_{3t}CBOND_t + \beta_{4t}IER_t + \beta_{5t}TREND_t + \mu_t \text{ and}$$

$$\varepsilon_t = \frac{\partial QSTEEL_t}{\partial RSP_t} \times \frac{RSP_t}{QSTEEL_t}$$

We define the variables of Equation (10) as follows. $QSTEEL_t$ is the proxy for output of the sample integrated mill steel firms. We specify $QSTEEL_t$ as a Hicksian composite commodity composed of the total shipments of steel products (measured in tons) that consist of plates, hot rolled sheets, cold rolled sheets, galvanized sheets, and tin plates. RSP_t is the weighted real price of the steel products included in the composite commodity. IP_t is the annual industrial production index. $CBOND_t$ is the annual average of monthly yields on Moody's Seasoned Aaa Corporate Bonds. IER_t is the ratio of U.S. steel imports to U.S. exports. $TREND_t$ is a time variable starting at one in 1947. We use data from 1947-1985 to estimate the demand function. The results shown in both panels are truncated in 1980 to be consistent with other data available for the integrated mill steel firms. Gamma represents the rate that the β's adapt to structural change in the adaptive regression model. Maximum likelihood estimation is used given $0 \le \hat{\gamma}_t < 1$ in increments of 0.02. When gamma equals one, the variance-covariance matrix is singularwhich prevents parameter estimation. Parameter estimates and standard errors are unchanged when $\gamma_t = 0$. This happened in 1947-58, 1970-72, and 1974-80, hence only the estimates for 1947 are shown to save space. Asymptotic standard errors are reported in parentheses. We calculate the price elasticity of demand estimates (ε_t) using Equation (25) where $\partial QSTEEL_t / \partial RSP_t$ is β_{1t} from Equation (10) and RSP_t and $QSTEEL_t$ are the actual annual observations of these two variables in the t[th] year.

Panel A. Equation (10) Parameter Estimates

Year	Gamma ($\hat{\gamma}_t$)	Intercept$_t$ (β_{0t})	RSP_t (β_{1t})	IP_t (β_{2t})	$CBOND_t$ (β_{3t})	IER_t (β_{4t})	$TREND_t$ (β_{5t})
1947	0.00	46,963.93	-95.06	520.00	-3,781.21	-862.67	718.86
		(11,251)***	(33.97)***	(120.7)***	(375.9)***	(243.8)***	(312.3)**
1959	0.12	48,482.23	-112.45	682.10	-3,106.23	-780.63	286.09
		(13,266)***	(39.96)***	(124.8)***	(475.0)***	(260.7)***	(334.3)
1960	0.22	44,014.20	-101.74	761.35	-2,770.16	-779.16	-5.11
		(13,073)***	(39.13)**	(127.8)***	(519.0)***	(254.2)***	(355.0)
1961	0.10	43,396.78	-95.39	701.96	-3,028.46	-875.77	153.38
		(12,126)***	(36.24)**	(127.1)***	(469.9)***	(240.6)***	(350.6)
1962	0.10	39,334.08	-81.01	716.53	-3,004.70	-916.60	68.93
		(11,460)***	(33.93)**	(127.6)***	(475.9)***	(235.9)***	(361.2)
1963	0.08	39,271.42	-77.79	706.76	-2,996.53	-909.05	52.85
		(11,104)***	(32.76)**	(127.4)***	(477.5)***	(236.7)***	(368.6)
1964	0.12	37,939.28	-70.48	707.31	-2,707.69	-858.43	-69.09
		(10,761)***	(31.57)**	(126.7)***	(508.2)***	(241.3)***	(381.6)
1965	0.12	33,846.39	-56.11	727.34	-2,712.15	-847.84	-171.03
		(10,933)***	(32.34)*	(128.2)***	(514.9)***	(245.9)***	(395.4)
1966	0.20	29,344.07	-44.07	783.77	-2,484.58	-807.11	-440.76
		(11,205)**	(33.48)	(132.1)***	(531.2)***	(255.8)***	(424.4)
1967	0.16	34,115.11	-56.86	720.92	-2,554.01	-700.02	-300.91
		(12,129)***	(37.15)	(136.0)***	(532.2)***	(275.9)***	(448.5)
1968	0.30	41,134.52	-77.12	719.34	-2,339.77	-440.87	-449.64
		(12,665)***	(39.85)*	(136.8)***	(543.5)***	(283.5)	(483.6)
1969	0.64	38,253.84	-66.74	830.65	-1,766.74	-323.97	-1,063.27
		(10,829)***	(34.14)*	(114.8)***	(528.9)***	(225.9)	(457.2)**
1973	0.72	55,760.95	-123.02	874.63	-3,028.15	-624.07	-655.77
		(9,650)***	(36.86)***	(119.4)***	(409.4)***	(161.5)***	(437.3)

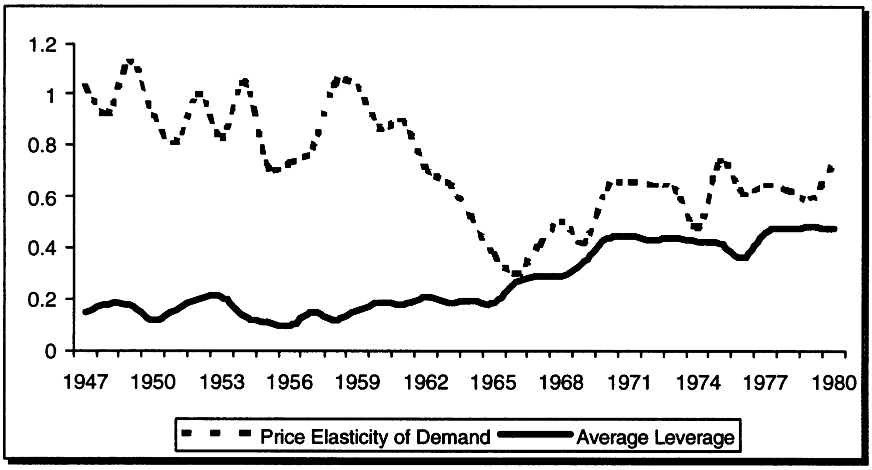
Table I. Demand Equation Parameter and Elasticity Estimates (*Continued*)

Panel B. Price Elasticity of Demand Estimates							
Year	**Elasticity (e_t)**	**Year**	**Elasticity (e_t)**	**Year**	**Elasticity (e_t)**	**Year**	**Elasticity (e_t)**
1947	1.028	1956	0.730	1965	0.370	1974	0.477
1948	0.921	1957	0.791	1966	0.298	1975	0.738
1949	1.132	1958	1.044	1967	0.414	1976	0.611
1950	0.911	1959	1.028	1968	0.499	1977	0.645
1951	0.810	1960	0.866	1969	0.419	1978	0.625
1952	1.001	1961	0.893	1970	0.632	1979	0.592
1953	0.826	1962	0.708	1971	0.656	1980	0.731
1954	1.047	1963	0.650	1972	0.646		
1955	0.718	1964	0.521	1973	0.629		

***Significant at the 0.01 level.
**Significant at the 0.05 level.
*Significant at the 0.10 level.

Figure I. Leverage and Price Elasticity of Demand

Yearly movements of the proxy for price elasticity of demand and average leverage for the sample integrated mill steel firms.



been mixed and provides little guidance.[7] Hence we have no *a priori* expectation concerning the impact of risk on leverage.

Our third control variable, $MB_{t,i}$, measures the market-to-book ratio for the i^{th} firm in year t. We take the data necessary to compute this ratio from various issues of the *Moody's Industrial Manual* and the CRSP tape. This ratio is the proxy for the extent to which firm value is based on options on future opportunities rather than assets in place. Since it is difficult for bondholders receiving fixed payments to rely on such options, many studies (e.g., Titman

[7]Carleton and Silberman (1977), Castanias (1983), and Bradley, Jarrell, and Kim (1984) all find a negative relation. Toy, Stonehill, Remmers, and Beekhuisen (1974), Long and Malitz (1985) and Kim and Sorensen (1986) find positive relations. Ferri and Jones (1979), Flath and Knoeber (1980) and Titman and Wessels (1988) find no significant relations. Kale, Noe, and Ramirez (1991) find evidence of a non-linear relation among these variables. Note that in most of the studies, the direction of the relation tends to vary by industry.

Table II. Summary Statistics of the Principle Equation Variables

This table shows the means and standard deviations of the principle variables included in Equation (26). We define the variables shown below as follows. LEV is the proxy for financial leverage measured as the ratio of the book value of long-term debt to the sum of the book values of long-term debt and preferred stock and the market value of common equity. LEVBMAN is the average financial leverage of all US manufacturing firms. SIGMA is the standard deviation of annual average monthly stock returns. MB is the market-to-book ratio of equity. CBOND is the annual average of monthly yields on *Moody's Seasoned Aaa Corporate Bonds*. PROFIT is the proxy for firm profits measured as the ratio of gross profits (sales minus cost-of-goods-sold) to sales revenue. PED is the proxy for price elasticity of demand for the integrated mill steel firms. LAMBDA is the ratio of convertible security options against current shares outstanding.

	Variable	Mean	Standard Dev.
1947-1980: (Observations: 238)	LEV	0.267	0.158
	LEVBMAN	0.200	0.058
	SIGMA	0.069	0.022
	MB	0.804	0.378
	CBOND	5.454	2.469
	PROFIT	0.149	0.064
	PED	0.724	0.211
	LAMBDA	0.031	0.064
1947-1958: (Observations: 84)	LEV	0.148	0.114
	LEVBMAN	0.141	0.021
	SIGMA	0.066	0.019
	MB	0.937	0.396
	CBOND	3.061	0.413
	PROFIT	0.181	0.050
	PED	0.913	0.132
	LAMBDA	0.028	0.063
1959-1980: (Observations: 154)	LEV	0.332	0.141
	LEVBMAN	0.232	0.044
	SIGMA	0.070	0.024
	MB	0.732	0.349
	CBOND	6.759	2.118
	PROFIT	0.131	0.064
	PED	0.620	0.170
	LAMBDA	0.032	0.064

and Wessels, 1988) document a significant negative relation between financial leverage and the market-to-book ratio.

The fourth variable, $CBOND_t$, is the annual average of monthly yields on *Moody's Seasoned Aaa Corporate Bonds*. Because the control variable $LEVBMAN_t$ is a financial leverage measure based on the book value of equity, it might not fully control for the effects of changing market interest rates since $LEV_{t,i}$ is calculated using the market value of equity. To account for this possibility we include $CBOND_t$ as a proxy for market interest rates in the model. The effect of this variable on a market-based measure of financial leverage is also difficult to predict. On the one hand, an increase in rates might decrease the value of equity, thus increasing $LEV_{t,i}$. On the other hand, many studies suggest that when rates are high, firms tend to shy away from long-term debt financing in favor of raising marginal capital in the form of equity.

The last general control variable is, $PROFIT_{t,i}$, a proxy for firm profitability. We include it because Titman and Wessels (1988) show that there is a significant negative relation between leverage and profitability. We measure this variable as the ratio of gross profits (sales minus cost-of-goods-sold) to sales revenue of the i^{th} firm in the t^{th} year. Again, we collect the necessary data from *Moody's Industrial Manuals.*

The next two explanatory variables, PED_t and $LAMBDA_{t,i}$, test the two hypotheses developed in this paper. The first, PED_t, measures the price elasticity of demand of the industry sector dominated by the integrated steel mills in the t^{th} year. Panel B of Table I, shown in the previous section, contains the annual price elasticity estimates. We hypothesize that price elasticity of demand should be positively related to financial leverage.

The second variable, $LAMBDA_{t,i}$, measures the number of new shares created if all outstanding convertible securities of the i^{th} firm are exercised at time t. The securities we use in the estimation of $LAMBDA_{t,i}$ ($\lambda_{t,i}$) are convertible bonds and preferred stocks. We do not include warrants outstanding, since Maksimovic (1988) argues that their effect on collusive behavior is subtly different relative to convertible bonds and preferred stocks. However, inclusion of the rare warrant issues in $\lambda_{t,i}$ had no appreciable impact on any of the regression results.[8] We obtain the number of outstanding shares and convertibility options from the *Moody's Industrial Manuals*. We hypothesize that the number of convertibility options is positively related to financial leverage.

The next three variables, $SIGLAM_{t,i}$, $MBLAM_{t,i}$, and $CBONDLAM_{t,i}$, are cross-product terms that we use to control for the fact that the decision to issue convertible securities can also be influenced by several exogenous factors. To date, there have been several theoretical propositions advanced for the issuance of convertibles. Two traditionally popular rationale for the issue of these securities are that they serve as a "sweetener" to lower borrowing costs, particularly when rates are high, and that they can serve as delayed equity financing when stock value is low (Billingsley and Smith, 1996.) Two more recent theoretical arguments focus on how convertibles can reduce agency costs of debt financing by diminishing stockholders incentives to invest in overly risky projects (Jensen and Meckling, 1976; Brennan and Schwartz, 1977; Green, 1984; Barnea, Haugen, and Senbet, 1985; and Mayers, 1998), and how they can help relay to markets positive, asymmetrical information possessed by managers (Stein, 1992). These arguments ultimately center on four factors that might induce firms to issue convertible securities. They are high interest rates, undervalued firm equity, volatility of firm returns, and the presence of asymmetrical information possessed by the manager concerning future firm performance. These factors must be controlled for in the model in order to examine if convertible securities allow firms to use more debt in their capital structure than would be allowed within the collusive arrangement with straight debt alone.

The control variables $SIGMA_{t,i}$ and $CBOND_{t,i}$ provide readily available proxies for firm risk and the level of interest rates, respectively. In addition, previous studies have used the market-to-book ratio, $MB_{t,i}$, as a proxy for both under-valuation of equity and the existence of high levels of asymmetrical information. Therefore, we incorporate the interaction of these factors with the levels of convertible debt outstanding by introducing the cross-product terms $SIGLAM_{t,i}$, $MBLAM_{t,i}$, and $CBONDLAM_{t,i}$, which are the products of $LAMBDA_{t,i}$ with $SIGMA_{t,i}$, $MB_{t,i}$, and $CBOND_t$, respectively. The coefficients on these variables describe the impact of the interaction of these factors on financial leverage. We

[8]The inclusion of $LAMBDA_{t,i}$ in Equation 26 also introduces the potential for simultaneity bias when we estimate the parameters. This bias arises because the decision to issue new debt with options attached simultaneously affects the dependent variable $LEV_{t,i}$ and the independent variable $LAMBDA_{t,i}$. However, since the overwhelming majority of debt in this sample is nonconvertible, we believe that the bias is inconsequential.

have no *a priori* expectation on how these interaction terms will affect leverage.

We contend that the existence of the overt basing point pricing system may have rendered subtle covert collusion unnecessary. Thus, it is possible that the behavior of the industry differs markedly before and after 1959 in relation to the theories developed in this paper. We include the next five independent variables to control for this possibility. We create a dummy variable that is set to zero before 1959 and one thereafter. We then create interaction terms as the products of this dummy variable with PED_t, $LAMBDA_{t,i}$, $SIGLAM_{t,i}$, $MBLAM_{t,i}$, and $CBONDLAM_{t,i}$. These are shown in the model as $PED59_t$, $LAMBDA59_{t,i}$, $SIGLAM59_{t,i}$, $MBLAM59_{t,i}$, and $CBONDLAM59_{t,i}$. Including these terms in the model defines the parameters θ_i and ϕ_j as the marginal impact of the associated variables on leverage before 1959, and the η_i and τ_j parameter estimates show changes to θ_i and ϕ_j in the years following 1958.

Given that we estimate Equation 26 using panel data, firm dummy variables (D_i) are added to the model to capture any firm specific information that affects base level differences in capital structure across firms. We examine the structure of the error terms and find they are first-order autoregressive with contemporaneous correlation between the cross-sections. This error structure is represented as:

$$\mu_{t,i} = \rho_i \mu_{t-1,i} + \varepsilon_{i,t} \tag{27}$$

and

$$E[\mu_{t,i}, \mu_{t,j}] = \sigma_{i,j} \tag{28}$$

We use the Parks (1967) method to estimate the parameters since it is based on this particular error structure.

VI. Results

Table III shows our parameter estimates for Equation 26. All five of the general control variables are statistically significant. Those for which we developed *a priori* expectations behave as anticipated. The coefficient on $LEVBMAN_t$ (ψ_1) is not only positive and significant, but an F-test indicates that the estimate is not significantly different from one. This result suggests that the integrated mill steel firms alter their financial leverage in a manner similar to other manufacturing firms in response to changes in overall macroeconomic conditions. Consistent with earlier empirical results, such as Titman and Wessels (1988), the variables $MB_{t,i}$, and $PROFIT_{t,i}$, (parameters ψ_3 and ψ_5, respectively) are negative and significantly correlated with leverage. Parameter estimates for the two control variables for which we had no *a priori* expectation are also statistically significant. The parameter estimate ψ_2 on $SIGMA_{t,i}$ indicates that risk is negatively correlated with leverage. The parameter estimate (ψ_4) on $CBOND_t$ indicates a significant positive impact of market interest rates on leverage decisions among these firms.

The parameters θ_1, θ_2, η_1, and η_2 represent the coefficients on the variables that we use to test our hypotheses. θ_1 and θ_2 measure the impact of the price elasticity of demand (PED_t) and the portion of new shares created if bondholders were to exercise all convertibility options ($LAMBDA_{t,i}$), respectively, on leverage before 1959. Neither parameter is statistically significant. This evidence supports our expectation that the overtly collusive basing point pricing system rendered subtle enforcement mechanisms, such as those we describe in this

Table III. Empirical Regression Results of Equation 26

This table shows the parameter and standard error estimates associated with the variables included in Equation (26).

$$LEV_{t,i} = \alpha + \psi_1 LEVBMAN_t + \psi_2 SIGMA_{t,i} + \psi_3 MB_{t,i} + \psi_4 CBOND_t + \psi_5 PROFIT_{t,i} + \theta_1 PED_t + \theta_2 LAMBDA_{t,i} + \phi_1 SIGLAM_{t,i} + \phi_2 MBLAM_{t,i} + \phi_3 CBONDLAM_{t,i} + \eta_1 PED59_t + \eta_2 LAMBDA59_{t,i} + \tau_1 SIGLAM59_{t,i} + \tau_2 MBLAM59_{t,i} + \tau_3 CBONDLAM59_{t,i} + \Sigma\Phi_i D_i + \mu_{t,i}$$

We define the variables as follows. $LEV_{t,i}$ is the proxy for financial leverage measured as the ratio of the book value of long-term debt to the sum of the book values of long-term debt and preferred stock and the market value of common equity. LEVBMAN is the average financial leverage of all US manufacturing firms. SIGMA is the standard deviation of annual average monthly stock returns. MB is the market-to-book ratio of equity. CBOND is the annual average of monthly yields on *Moody's Seasoned Aaa Corporate Bonds*. PROFIT is the proxy for firm profits measured as the ratio of gross profits (sales minus cost-of-goods-sold) to sales revenue. PED is the proxy for price elasticity of demand for integrated mill steel firms. LAMBDA is the ratio of convertible security options against current shares outstanding. SIGLAM is an interaction term that is the product of SIGMA and LAMBDA. MBLAM is an interaction term that is the product of MB and LAMBDA. CBONDLAM is an interaction term that is the product of CBOND and LAMBDA. PED59 and LAMBDA59 are interaction terms of PED and LAMBDA with a dummy variable set to one in the years after 1958. SIGLAM59, MBLAM59, and CBONDLAM59 are interaction terms with the variables SIGLAM, MBLAM, and CBONDLAM with a dummy variable set to one in the years after 1958. We include dummy variables to capture base level differences in capital structure across firms. To conserve space, we do not show these cross-sectional intercept-shifting parameter estimates, but they are available from the authors on request. An F-test confirms the joint hypothesis of significant differences in base level capital structures across the sample firms. An F-test confirms that the parameter estimate of LEVBMAN is not significantly different from one. Standard errors are shown in parentheses.

Parameter	Variable	Parameter Estimates
ψ_1	LEVBMAN	0 .978 (0.238)***
ψ_2	SIGMA	-0.390 (0.131)***
ψ_3	MB	-0.141 (0.012)***
ψ_4	CBOND	0.016 (0.006)***
ψ_5	PROFIT	-0.218 (0.077)***
θ_1	PED	0.014 (0.020)
θ_2	LAMBDA	-1.192 (1.262)
ϕ_1	SIGLAM	2.092 (4.212)
ϕ_2	MBLAM	-0.331 (0.229)
ϕ_3	CBONDLAM	0.639 (0.367)
η_1	PED59	0.052 (0.014)***
η_2	LAMBDA59	3.811 (1.405)***
τ_1	SIGLAM59	-0.854 (4.381)
τ_2	MBLAM59	-2.113 (0.451)***
τ_3	CBONDLAM59	-0.809 (0.375)**

***Significant at the 0.01 level. $R^2 = 0.780$
**Significant at the 0.05 level. N = 238

study unnecessary. However, the positive and significant estimates of η_1 and η_2 support our two fundamental hypotheses. These parameters measure changes to θ_1 and θ_2, respectively, after the collapse of the basing point pricing system.[9]

The positive and significant sign on η_1 supports the expectation that after 1958, the seven firms altered financial leverage positively in response to changes in price elasticity of demand. This result indicates that changes in product market conditions led the firms to alter their financial leverage. This outcome also supports our conjecture that collusion was maintained among these firms, at least to some extent, through information provided through their capital structure choices. Figure I shows the yearly joint movements of average leverage for these firms with price elasticity of demand. This graph provides visual support for the lack of a meaningful correlation before 1959 and a relatively solid positive relation in the later period, particularly after 1965.

We estimate the economic significance of the impact of a change in price elasticity demand on financial leverage by using average values of the relevant variables. The mean level of price elasticity demand in the period after 1958 was 0.62 with a standard deviation of 0.17 (see Table II). The empirical estimate of the partial derivative of leverage on the price elasticity of demand, which is the sum of θ_1 and η_1, is 0.066. This result suggests that if price elasticity of demand increases from its mean by one standard deviation, the leverage ratio would increase from its sample mean of 33.20% to 34.32% (0.066 x 0.17). If we assume that the value of equity remains unchanged, this increase implies a 5.14% rise in the total value of debt from \$438.92 million to \$461.47 million, an increase of about \$22.54 million for the average firm.

The parameter η_2 is also positive and significant. This result suggests that by introducing convertibles into the mix of debt securities, a firm is able to use more financial leverage than would normally be permissible within the collusive arrangement without jeopardizing the cartel's stability.

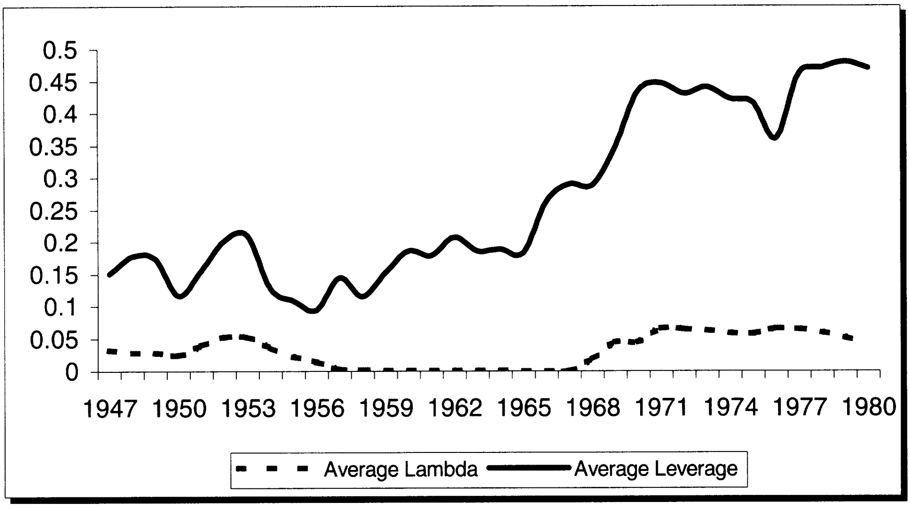
Figure II shows the relations between the average leverage for the seven firms and the average number of convertibility options outstanding. Again, as implied by the regression results, the visual evidence supports the significant relation between the number of convertibility options outstanding and leverage after the basing point pricing period, particularly following 1965. Before 1959, the use of convertible securities apparently did not result in significantly higher usage of debt, suggesting that their issue merely replaced non-convertible obligations. However, in later years, the results suggest that the firms sold convertible securities to raise needed marginal capital in amounts that might have upset the collusive arrangement if it had been issued as non-convertible debt.

The interaction terms in Equation (26) included to control for the influence of exogenous factors on the issuance of convertible securities also show contrast before and after the collapse of the basing point pricing system. Before 1959, none of the parameter estimates (ϕ_1, ϕ_2, and ϕ_3) on the cross-product terms $SIGLAM_{t,i}$, $MBLAM_{t,i}$, and $CBONDLAM_{t,i}$, nor the coefficient on $LAMBDA_{t,i}$ (θ_2), are statistically significant. These results suggest that before 1959, the firms that issued convertibles did so for some reason other than to increase overall leverage. On the other hand, two of the three parameters on the cross-product terms, τ_2 on $MBLAM59_{t,i}$ and τ_3 on $CBONDLAM59_{t,i}$, are statistically significant. These findings indicate that after 1959 financial leverage was also significantly influenced by the interactions of the decision to issue convertible securities with the market-to-book ratios and interest rates.

[9]Since the impact on leverage of product market changes and convertibles could conceivably be delayed, we substitute one-period lags of price elasticity of demand and convertible security options outstanding into Equation (26) to test for this possibility. The estimated results show that neither of the lagged variables is statistically significant.

Figure II. Leverage and Convertible Securities

Yearly movements of the average number of convertibility options outstanding (lambda) and the average leverage for the sample integrated mill steel firms.



VII. Summary and Conclusion

We test propositions that firms can arrange their capital structure in such a way as to publicly demonstrate compliance with a collusive agreement. We show that when a group of firms employ financial leverage as the mechanism to enforce collusion, there is a ceiling on the amount of nonconvertible debt that each firm can issue. Further, we show that under these conditions this debt ceiling varies positively with changes in price elasticity of demand. We also demonstrate that it is possible for an individual firm to increase its debt level above the ceiling by issuing convertible bonds.

We use data from seven American integrated steel mill firms to test these propositions. This sector of the steel industry was highly concentrated during our study, thus providing conditions necessary for collusion to exist.

We collect time-series data on financial leverage and convertible securities for the seven firms during the period from 1947 to 1980. We use an adaptive regression technique to calculate the corresponding price elasticities of demand for the steel products dominated by these firms. To control for other general factors that have been shown to influence leverage decisions, we include variables for the average leverage for domestic manufacturing firms, firm risk, the market-to-book ratio, market interest rate conditions, and firm profitability. We include cross-product variables to capture how convertible options outstanding interact with the other factors that might affect the decision to issue convertibles (risk, the market-to-book ratio, and market interest rates).

We find that substantive changes occurred in the integrated steel industry following the collapse of the overtly collusive basing point pricing system around 1959. Before 1959 subtle forms of tacit collusion were most likely unnecessary. However, after 1958 the situation is very different. Since these firms still may have engaged in some form of price setting, there are still questions about how they were able to maintain collusive pricing without formal price leadership. Because of the structural differences before and after the collapse of basing point pricing system, we design our model to isolate the capital structure decisions of these firms under the two different regimes.

The regression results support our hypothesis that the integrated mill steel firms positively altered leverage in response to changes in the price elasticity of demand in the period after 1958. Further, empirical evidence shows that during these same years the firms significantly increased their use of leverage when they included convertible securities in their mix of debt obligations. As we expected, we found no evidence of a positive relation of leverage with either price elasticity of demand or the number of convertible options outstanding before the collapse of the basing point pricing system.

The results of our study indicate that it is possible for firms to support a collusive arrangement through the design of their capital structure. Indeed, these findings provide important insights into how the firms in the integrated mill sector of the American steel industry might have maintained oligopolistic collusion after the collapse of basing point pricing.■

References

Adams, W., 1977, "The Steel Industry," in W. Adams, Ed., *The Structure of American Industry*, 5th ed., New York, NY, Macmillian, 86-129.

Adams, W. and H. Mueller, 1986, "The Steel Industry," in W. Adams, Ed, *The Structure of American Industry*, 7th ed., New York, NY, Macmillian, 74-125.

Annual Statistical Report, various issues, Washington, American Iron and Steel Institute.

Barnea, A., R.A. Haugen, and L.W. Senbet, 1985, *Agency Problems and Financial Contracting*, Englewood Cliffs, NJ, Prentice-Hall.

Barnett, D.F. and R.W. Crandall, 1986, *Up From the Ashes: The Rise of the Steel Minimill in the United States*, Washington D.C., Brookings Institution.

Barnett, D.F. and L. Schorsch, 1983, *Steel: Upheaval in a Basic Industry*, Cambridge, Bollinger.

Billingsley, R.S. and D.M. Smith, 1996, "Why Do Firms Issue Convertible Debt?," *Financial Management* 25, 93-99.

Bradley, M., G. Jarrell, and E.H. Kim, 1984, "On the Existence of an Optimal Capital Structure: Theory and Evidence," *Journal of Finance* 39, 857-878.

Brander, J.A. and T.R. Lewis, 1986, "Oligopoly and Financial Structure: The Limited Liability Effect," *American Economic Review* 76, 956-970.

Brander, J.A. and T.R. Lewis, 1988, "Bankruptcy Costs and the Theory of Oligopoly," *Canadian Journal of Economics* 21, 221-243.

Brennan, M.J. and E. Schwartz, 1977, "Convertible Bonds: Valuation and Optimal Strategies for Call and Conversion," *Journal of Finance* 32, 1699-1715.

Carleton, W.T. and I.H. Silberman, 1977, "Joint Determination of Rate of Return and Capital Structure: An Econometric Analysis," *Journal of Finance* 32, 811-821.

Castanias, R.P., 1983, "Bankruptcy Risk and Optimal Capital Structure," *Journal of Finance* 38, 1617-1635.

Chevalier, J.A., 1995,"Capital Structure and Product-Market Competition: Empirical Evidence from the Supermarket Industry, *American Economic Review* 85, 415-436.

Chevalier, J.A., 1995,"Do LBO Supermarkets Charge More? An Empirical Analysis of the Effects of LBO's on Supermarket Pricing," *Journal of Finance* 50, 1095-1112.

Cooley, T.F. and E.C. Prescott, 1973, "An Adaptive Regression Model," *International Economic Review* 14, 364-371.

Cooley, T.F. and E.C. Prescott, 1976,"Estimation in the Presence of Stochastic Parameter Variation," *Econometrica* 44, 167-184.

Crandall, R.W., 1981, *The US Steel Industry in Recurrent Crisis: Policy Options in a Competitive World*, Washington DC, Brookings Institution.

Duke, R.M., R.L. Johnson, H. Mueller, P. D. Quails, C.T. Rosh, and D.G. Tar, 1977, *The United States Steel Industry and Its International Rivals: Trends and Factors Determining International Competitiveness*, Washington D.C., Federal Trade Commission.

Ferri, M.G. and W.H. Jones, 1979, "Determinants of Financial Structure: A New Methodological Approach," *Journal of Finance* 34, 631-644.

Flath, D. and C.R. Knoeber, 1980, "Taxes, Failure Costs, and Optimal Industrial Capital Structure: An Empirical Test," *Journal of Finance* 35, 99-117.

Green, R.C., 1984, "Investment Incentives, Debt, and Warrants," *Journal of Financial Economics* 13, 115-136.

Harris, M. and A. Raviv, 1991, "The Theory of Capital Structure," *Journal of Finance* 46, 297-355.

Hicks, J.R., *Value and Capital*, 1939, Oxford, Oxford University Press.

Hogan, W.T., 1971, *Economic History of the Iron and Steel Industry in the United States*, Vol. 4 and 5, Washington, D.C., Lexington Books.

Hogan, W.T., 1987, *Mini mills and Integrated Mills: A Comparison of Steel making in the_United States*, Washington, D.C., Lexington Books.

Jensen, M.C. and W.H. Meckling, 1976, "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure," *Journal of Financial Economics* 3, 305-360.

Kale, J.R., T.H. Noe, and G.G. Ramirez, 1991, "The Effect of Business Risk on Corporate Capital Structure: Theory and Evidence," *Journal of Finance* 46, 1693-1715.

Kim, W.S. and E.H. Sorensen, 1986, "Evidence on the Impact of the Agency Costs of Debt on Corporate Debt Policy, " *Journal of Financial and Quantitative Analysis* 21, 131-144.

Long, M.S. and I.B. Malitz, 1985,"Investment Patterns and Corporate Leverage," in B.M. Friedman, Ed., *Corporate Capital Structure in the United States*, Chicago, National Bureau of Economic Research, 325-351.

Maksimovic, V., 1988, "Capital Structure in Repeated Oligopolies," *Rand Journal of Economics* 19, 389-407.

Mancke, R., 1968, "The Determinants of Steel Prices in the US: 1947-1965," *Journal of Industrial Economics* 16, 147-160.

Mayers, D., 1998, "Why Firms Issue Convertible Bonds: The Matching of Financial and Real Investment Options," *Journal of Financial Economics* 47, 83-102.

McIntosh, C.S. and K.H. Shideed, 1989, "The Effect of Government Programs on Acreage Response Over Time: The Case of Corn Production in Iowa," *Western Journal of Agricultural Economics* 14, 38-44.

Metal Statistics: The Purchasing Guide of the Metal Industry, various issues, New York, NY, Fairchild Publications.

Miller, M. and F. Modigliani, 1961,"Dividend Policy, Growth, and the Valuation of Shares," *Journal of Business* 34, 411-432.

Modigliani, F. and M. Miller, 1958, "The Cost of Capital, Corporate Finance and the Theory of Investment," *American Economic Review* 48, 261-297.

Moody's Industrial Manual, various issues, NY, Moody's Investors Service.

Moody's Seasoned Aaa Corporate Bond Yield, Moody's Investors Service. Available at: http://www.stls.frb.org/fred/data/irates/aaa.

Nelson, J.A., 1994, "Estimation of Food Demand Elasticities Using Hicksian Composite Commodity Assumptions," *Quarterly Journal of Business and Economics* 33, 51-68.

Parks, R.W., 1967, "Efficient Estimation of a System of Regression Equations when Disturbances are Both Serially and Contemporaneously Correlated," *Journal of the American Statistical Association* 62, 500-509.

Parrott, S.D. and C.S. McIntosh, 1996,"Nonconstant Price Expectations and Acreage Response: The Case of Cotton Production in Georgia," *Journal of Agricultural and Applied Economics* 28, 203-210.

Phillips, G.M., 1995,"Increased Debt and Industry Product Markets: An Empirical Analysis," *Journal of Financial Economics* 37, 189-238.

Rausser, G.C. and P.S. Laumas, 1976,"The Stability of the Demand for Money in Canada," *Journal of Monetary Economics* 2, 367-380.

Ravid, S.A., 1988, "On Interactions of Product and Financial Decisions," *Financial Management* 17, 87-99.

Rippe, Richard D., 1970, "Wages, Prices, and Imports in the American Steel Industry," *Review of Economics and Statistics* 52, 34-46.

Stein, J.C., 1992, "Convertible Bonds as Backdoor Equity Financing," *Journal of Financial Economics* 32, 3-21.

Stenbacka, R., 1994, "Financial Structure and Tacit Collusion with Repeated Oligopoly Competition," *Journal of Economic Behavior and Organization* 25, 281-292.

Taggart, R.A., 1985,"Secular Patterns in the Financing of US Corporations," in B.M. Friedman, Ed., *Corporate Capital Structure in the United States*, Chicago, National Bureau of Economic Research, 13-80.

Tiffany, P.A., 1988, *The Decline of American Steel: How Management, Labor and Government Went Wrong*, New York, NY, Oxford University Press.

Titman, S. and R. Wessels, 1988,"The Determinants of Capital Structure Choices," *Journal of Finance* 43, 1-19.

Toy, N., A. Stonehill, L. Remmers, and T. Beekhuisen, 1974, "A Comparative International Study of Growth, Profitability, and Risk as Determinants of Corporate Debt Ratios in the Manufacturing Sector," *Journal of Financial and Quantitative Analysis* 9, 875-886.