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The Reduced Form as an Empirical Tool: A Cautionary Tale from the Financial Veil

by Ben Craig and Christopher A. Richardson

Ben Craig is an economist at the Federal Reserve Bank of Cleveland, and Christopher A. Richardson is a graduate student of economics at Indiana University. The authors have benefited from the generous help and advice of Charles Carlstrom.

Introduction

Economic data usually influence policy through a reduced-form analysis. Using such an analysis, the researcher generally poses an empirical relationship between an outcome variable, such as a firm's total investment, and a policy variable, such as the design of a particular tax. This relationship serves as a point of departure in the analysis. Explicit assumptions about behavior that underlie the relationship are not emphasized; rather, the researcher asserts that the "data do the talking." Policy implications, where they exist, are directly observed in the pattern estimated in the data. Most empirical analyses of policy questions follow a reduced-form strategy.[1]

It is easy to understand why a reduced-form approach might, at first glance, appear to be the best way to analyze policy. It is a simple methodology, and thus can more easily keep track of what is happening during the complicated process of analyzing data. One does not need to specify a sophisticated and consistent model of behavior to use this approach. Further, the answers embodied in the model estimates may accord with a wide variety of behaviors that could be true of the firm.

A different approach to estimating the effect of taxes would be to specify a model of optimizing behavior on the part of the firm and to model the tax policy as a set of constraints on this optimizing behavior. A simplistic reason for preferring the reduced-form approach is that economists are interested only in the overall effect of a proposed tax policy on investment. Why should we care about the intermediate steps by which a tax will affect the firm?

How successful is the reduced-form approach at testing a behavior or measuring a policy effect? Given that we are never shown the truth behind the mystery, this paper will examine the history of an economic question that has been subjected to 35 years of intense scrutiny: Does corporate financial structure affect real investment? The empirical answer to this question, which lies at the heart of corporate financial economics, has heavily influenced every tax reform bill since the 1960s.

■ **1** *Reduced form* has a different meaning here than in simultaneous equations estimation, where a reduced form is estimated by regressing an endogenous variable on all of the exogenous variables in a system of equations. We use the term in a wider context, where the pattern in the data—not an assumed behavioral structure—forms the point of departure for estimation.

The initial econometric strategy was to follow a pure reduced-form approach. How well have the results of this research program held up to further scrutiny?

Modigliani and Miller (1958) provide the first theoretical model showing the influence of corporate debt structure on investment. In the world they portray, perfect capital markets, coupled with symmetric information about the investment prospects of the firm, the investors, and the lenders, mean that the firm's debt level is irrelevant to the amount of investment it undertakes.

One reduced-form approach would be to directly examine the empirical relevance of the Modigliani–Miller (hereafter "MM") hypothesis that with perfect capital markets, no taxes, and a given investment policy, capital structure is irrelevant to firm value. As a consequence, neither capital structure nor dividends should affect investment behavior. The MM propositions provide the following broad empirical prediction: In a properly specified regression of investment on the debt/equity ratio, dividends, and other covariates, the coefficients of debt/equity and dividends should equal zero. A reduced-form estimating strategy uses this prediction as the point of departure.

The following two sections discuss the history of tests of this hypothesis from both a cross-section and a time-series perspective. Next, we step back and explore the reasons for the pattern in the early reduced-form estimates through a simple structural model. We then look at what we have learned about whether a tax policy can affect investment through its influence on a company's financial structure. We conclude with the object lessons that accompany 35 years of intensive research on this topic—lessons that could be applied to other situations where the reduced form is used to help shape policy. What did we first believe the data were telling us, and how did these beliefs change under close scrutiny? After all this time spent researching a single hypothesis, what limitations in our knowledge may be embedded in the reduced-form approach?

I. Cross-Section Regression Tests of the MM Hypothesis

The clear and simple MM hypothesis that there is no relationship between financing and real capital investment seems to lend itself easily to cross-section regressions. The early reduced-form models assume away the importance of differential corporate and personal income taxes, which are a clear violation of the original MM statement. Thus, they jointly test the MM model and the hypothesis that the income tax structure is irrelevant to the effect of financial structure on real investment. We will treat the two tests separately later in this paper. The test of the joint hypothesis measures the statistical significance of financial variables in an investment equation where the dependent variable is capital investment and the independent variables are measures of a firm's financial position, which may include its debt/equity ratio, cash flow, and dividends. The hypothesis of no relationship between financing and investment is rejected if the coefficients of the debt/equity ratio and dividends are statistically close to zero. A simple regression is not adequate here because both dividend payments and the firm's debt are endogenous. Thus, absence of a correlation between the debt/equity ratio and investment is not necessarily evidence that the MM hypothesis holds.

To alleviate this problem, early cross-section studies specified instruments in a system that estimated investment (I), dividends (D), and new debt (ND) equations of the general form

$$I_{it} = \alpha_0 + \alpha_1 D_{it} + \alpha_2 ND_{it} + \alpha_3 X_{it} + \varepsilon_I$$

$$D_{it} = \beta_0 + \beta_1 I_{it} + \beta_2 ND_{it} + \beta_3 Y_{it} + \varepsilon_D$$

$$ND_{it} = \gamma_0 + \gamma_1 I_{it} + \gamma_2 D_{it} + \gamma_3 Z_{it} + \varepsilon_{ND},$$

where i and t are firm and time subscripts, the ε's are statistical error terms, and X, Y, and Z are vectors of exogenous explanatory variables. For the investment equation to be identified (so that we are estimating a separate equation for investment, not a hodgepodge of all three equations), the vectors Y and Z must contain variables that are not included in X. It is this process of identification that proved so problematic in the early reduced-form studies. What exogenous variable affects dividends and debt levels but does not influence investment behavior?

It is important to note here that the MM hypothesis is not a theory of investment, but of why a firm's financial structure does not influence investment. The estimating system of equations that test the MM hypothesis must include a theory of investment (even if it is implicit) to control for its endogeneity. Thus, the reduced form is a joint test of both the MM hypothesis and an underlying theory of investment. For example, if the researcher holds investment opportunities constant through using a measure of Tobin's q, then the test of the MM

hypothesis also tests whether Tobin's q is an empirically useful model of investment behavior.[2] Hence, the test is only as good as the theory of investment.

The early studies used identifying instruments[3] that included profits, proxies for firm size and taxes, and firm and industry dummy variables to allow for fixed firm and industry effects.[4] (See, for example, Dhrymes and Kurz [1967], McDonald, Jacquillat, and Nussenbaum [1975], and McCabe [1979].) These studies, like so many modern consulting reports, argue by assertion—for example, the profit level should affect dividends but not investment. Unfortunately, a researcher's assertion that a variable is an instrument does not necessarily make it so. A reduced form offers few checks as to whether the assertion reflects reality.

Empirical tests of the MM irrelevance hypothesis during the 1970s and early 1980s, though more advanced econometrically, still came up short in modeling differences in the financial environment firms face. Although the studies varied in their conclusions, all suffered from the lack of a convincing instrument that would control for a firm's investment opportunities. Again, the studies could not adequately address the fact that firms with better investment opportunities might choose higher levels of debt. McDonald, Jacquillat, and Nussenbaum estimate cross-section models using ordinary least squares (OLS) and two-stage least squares (2SLS), as does McCabe, but their conclusions differ. McDonald et al. find support for the MM propositions, while McCabe does not. Because investment opportunities surely vary across firms and certainly affect investment independently of financial structure, these early studies were never conclusive tests of the MM irrelevance hypothesis.

Another reason for conflicting conclusions among the early empirical studies seems to lie in the differences in equation specification. McDonald et al., like many other researchers before McCabe, estimate investment as a function of contemporaneous variables only. Because it is likely that the decision to invest today will depend in part on financial decisions made previously, excluding lagged financing and dividend variables from an investment equation results in a misspecification.

How was one to choose between these early studies? If they had been structural, a researcher could affirm that a particular study was the most convincing if it had more believable parameter estimates (for example, if it generated rate-of-return estimates of the same general magnitude as the interest rate). A classic indication that a system is identified improperly (that is, by false assumptions) is that estimates of the individual equations yield parameters that make little sense economically. One reason the earliest tests of the MM hypothesis seemed, on balance, to support the theory was that the estimates which rejected MM had the "wrong" expected sign for the dividend equation. This seemed to indicate that the studies which did not reject the hypothesis used more convincing instruments. One pitfall of a simple reduced-form strategy is that it yields so few checks of whether an estimated parameter makes economic sense.

Subsequent cross-section studies made significant improvements over previous work. For example, Peterson and Benesh (1983) estimate a system of three equations similar to that used in earlier studies (adding a lagged profit variable to the investment equation and a lagged dividend variable to the dividend equation), but in addition to estimating the standard OLS, 2SLS, and 3SLS models, they also conduct MM hypothesis tests on the reduced-form equations by estimating a seemingly unrelated regressions (SUR) model. Their SUR results corroborate the 2SLS and 3SLS findings, which reject the null hypothesis that financing and investment decisions are independent. The lagged profit variable serves as a proxy (albeit an imperfect one) for investment opportunities, which makes the rejection of the MM irrelevance hypothesis somewhat more convincing.

The use of lagged profits suffers from a problem common to all studies that rely on lagged variables for identifying instruments. Although it is true that lagged profits are approximate measures of investment opportunities, they may also affect both dividends and debt in the same ways that these variables were correlated with the original contemporaneous error term. It is not clear that simply including the lagged profit term will correct the original statistical bias.

Most recent reduced-form cross-section models reject the MM hypothesis. (See, for example, Gilchrist and Himmelberg [1995].) However,

■ **2** Tobin's q is defined as the ratio of the market value of capital to the replacement cost of capital.

■ **3** An *instrument* is a variable that is correlated with a variable on the right-hand side of the equation (in this case, corporate debt or dividends) without being correlated with the statistical error term. An *identifying instrument* in this case is one that is correlated with the right-hand variables without being included as a right-hand variable. Thus, it may be included in the equation where dividends or debt are left-side variables, but it must be excluded from the original investment equation.

■ **4** In some cases, X, Y, and Z contain the same variables.

these models often suffer a distressing lack of robustness to econometric specification. This makes precise determination of the estimated reduced-form parameters problematic. Further, the reduced-form approach does not present us with an easy point of departure for determining the correct econometric specification through convincing tests. We also lack a consensus on parameter estimates that are specific and precise enough to be more useful in a policy context than are cross-section reduced-form models. Can we glean additional evidence on the empirical validity of the MM irrelevance hypothesis from time-series patterns in the data?

II. Granger Causality Tests

Given the difficulty of pinning down a convincing set of instruments to tease out that part of the correlation of debt and investment stemming from debt's possible impact on investment, some researchers have tried to determine the causality by studying the timing of debt and investment. Thus, if investment precedes debt, the correlation may be spurious because the firm, seizing its more potent investment opportunities, creates more debt, whereas the less fortunate firms do not have as much debt. This would be the case when the higher debt level was due to more investment opportunities for the high-debt firm. The test of a causal relationship between the variables proposed by Granger (1969) says that if a variable or event X (a change in a financial variable) causes another variable or event Y (a change in investment), then X should precede Y. The test involves measuring the power of lagged values of X in predicting Y. A test of whether debt affects investment is connected to whether corporate debt "Granger causes" investment.

Smirlock and Marshall (1983) perform Granger causality tests on a sample of 194 firms from 1958 to 1977. Using annual data on dividends and investment, they fail to reject the null hypothesis of no Granger causality for the aggregate sample of firms. Causality tests on each of the 194 firms' series do not reject the null any more often than would be expected by chance, leading the authors to conclude that their results support the MM irrelevance hypothesis.

True to the pattern of cross-section tests of the MM hypothesis, the early test did not hold up to later scrutiny. It is imperative that enough variables be included in a Granger causality study so that nearly identical firms are being compared. For example, Smirlock and Marshall omit a financing variable, so that the analysis compares noncomparable firms that differ in *precisely* that dimension which the causality test requires to be the same. Mougoue and Mukherjee (1994) address this issue by including a long-term debt-financing variable in their causality tests. They find that dividend and investment growth rates Granger cause each other negatively, long-term debt and investment growth rates Granger cause each other positively, and debt and dividends Granger cause each other positively, thus rejecting the MM irrelevance principle.[5] If the reduced-form test is to be appropriate, some sort of implicit structure must underlie it. In this case, the researchers had to have an idea about which financing variables were important so that the Granger causality could test comparable firms.

Although Mougoue and Mukherjee's Granger causality tests can detect significant interactions among investment, debt, and dividend variables, they do not tell us much else. That dividends and investment Granger cause each other simply means that a motion in one precedes a motion in the other. Which comes first, the investment chicken or the dividend egg?

Moreover, it is somewhat ironic that Mougoue and Mukherjee's causality tests may also suffer from a misspecification bias due to the omission of a proxy for investment opportunities, such as cash flow. If internal funds are omitted from the system of equations, the observed negative causality from dividends to investment may actually stem from a negative causality from dividends to retained earnings and a negative causality from retained earnings to investment. The MM irrelevance hypothesis would still be rejected, but for different reasons. Although more properly specified equation systems may be useful in illustrating the existence of causal relationships, it appears that Granger causality tests have only limited utility in distinguishing among the different hypotheses of how, why, and to what degree financing and real investment decisions interact.

In addition, Granger causality tests suffer from a difficulty related to the forming of expectations. If debt Granger causes investment, the interpretation is that the corporate structure effects a change in investment behavior. However, expectations about investment

■ **5** It is assumed here that firms use borrowed funds to finance future investment or to increase dividend payments. Because the variables are expressed as changes in logarithms (growth rates), positive bidirectional causality between debt and investment does not support or refute the presence of financing constraints, as it might if debt and investment were expressed in levels.

opportunities could just as well influence both investment and corporate debt levels, but affect debt sooner because debt levels adjust more quickly. Tests that center on the timing of debt and investment thus provide weak evidence on the relevance of the MM hypothesis.

Interestingly, the pattern of evidence in the Granger causality tests is the same as the pattern in the cross-section regression results. Initially, the evidence seemed to support the MM hypothesis. However, closer scrutiny and clearer identifying assumptions tend to reject the hypothesis. Even current studies are unable to provide more information than a crude rejection of the hypothesis. Precise parameter estimates needed for policy prediction seem to require a different estimation strategy. Why do we observe this pattern in the reduced-form estimates? It is not clear which part of the joint hypothesis—perfect capital markets or the empirical irrelevance of the personal and corporate income tax structure—is being rejected by the above tests. To further define the two hypotheses, a simple heuristic model is needed.

III. A MM Structural Model

In this section, we explore a model in which the underlying behavior of firms generates the data. A simple statement of the model will clarify the measurement problems inherent in testing the MM hypothesis with cross-section or time-series data. A MM firm chooses the levels of investment, I_0, in a project that will pay $F(I_0)$ dollars for each period in the future, $F'(I_0) > 0$, $F''(I_0) < 0$, so that the firm receives

$$(1) \quad \sum_{t=1}^{\infty} \frac{F(I_0)}{(1+\rho)^t} = \frac{F(I_0)}{\rho}$$

from the investment, where ρ represents the interest rate.[6] The firm starts with a predetermined amount of cash, C, and must decide how much of this cash to pay out in dividends, C_d, and how much to reinvest, C_I ($C = C_d + C_I$). The firm can also issue debt, D, to finance the investment. A tax rate is imposed on a corporation at rate τ_c and on individuals at rate τ_p.

MM's first observation is that the market value of the shares, S, is just a tax-adjusted value of the investment payoffs (including the corporate cash paid out today, C_d) minus the value of debt, or

$$(2) \quad S = (1-\tau_p)C_d + (1-\tau_c)\left[\frac{F(I_0)}{\rho} - D\right].$$

The firm maximizes S with respect to the amount of investment subject to the financing constraints $I_0 = C_I + D$ and $C = C_d + C_I$. A simple substitution gives

$$(3) \quad S = (1-\tau_p)(C - C_I) + (1-\tau_c)\left[\frac{F(C_I + D)}{\rho} - D\right],$$

with first-order conditions

$$(4) \quad F' = \rho$$

and

$$(5) \quad F' = \rho\,\frac{(1-\tau_p)}{(1-\tau_c)},$$

corresponding to investment financed out of debt and cash, respectively.

If the personal tax rate is equal to the corporate tax rate (or $\tau_p = \tau_c$, which nests the special case of MM's no-tax scenario), the first-order conditions make it apparent that the expense of an additional dollar of investment is the same however it is financed, and that the firm finances from either debt or retained earnings until the marginal benefit from investment is equal to the outside rate of return (or $F'[I_0] = \rho$).

It is important to note that the first-order condition in this case simultaneously says two things about the firm's behavior. First, a firm's decision to finance a given level of investment out of debt or retained earnings is irrelevant: The firm is indifferent between the two. Second, the investment level is determined by the rule that the firm invests until the marginal benefit of investment is equal to the interest rate.[7] The level of debt says nothing about the value of the firm except that it has traded debt for dividends at a rate of one for one. Investors who are paying for a share of the company and who might prefer a higher level of debt in their portfolio can continue holding shares of this firm, but elect to borrow more on the outside market to increase the debt level within their own portfolios. This and other similar possible arbitrages force the share value to treat debt and retained earnings symmetrically.

In a world where the corporate tax rate is higher than the personal tax rate, $\tau_c > \tau_p$, the firm's rule is to finance until the return on

■ **6** The MM results do not depend on risk neutrality, a constant stream of benefits, or a constant discount rate. These are assumed here for expositional convenience.

■ **7** In the MM exposition, the firm invests until the marginal benefit equals the rate of return for the firm's risk class. The theory also shows that investment financed out of new equity issues is equivalent to investment financed out of retained earnings or debt.

investment is equal to ρ. The investment is financed entirely out of debt and all of the cash appears as a dividend. Financing out of debt rather than retained earnings costs less because debt payments are fully deductible. MM (1963) makes the point that the tax advantages of debt financing (interest payments are deductible as a cost in calculating corporate taxes) imply that investment should never be financed out of retained earnings in a pure example of their model. Indeed, because of the tax advantages, the firm prefers to borrow more than its investment amount to finance a larger dividend. Clearly, a more complicated model is needed to explain why a corporation chooses one method of financing over another. However, the simpler model may still be adequate to explain the level of investment if the data show no relationship between that level and corporate financial structure.

If the corporate tax rate is less than the personal tax rate, then cash is the relatively less expensive investment source. The firm will use only cash to finance investment unless the marginal return on investment after all of the cash is used (and the dividend is zero) exceeds the cost of financing additional investment out of debt (or $F'[C] > \rho$). At this point, debt becomes the marginal investment source, with the first-order condition given by equation (4). If $F'(C) < \rho$, then debt will equal zero, and only cash will be used to finance investment, until equation (5) is satisfied.

The top federal individual tax rate and the top federal corporate tax rate are currently about the same (39.6 percent versus 38 percent). However, in many states, the top corporate rate is higher than the top individual rate (in Ohio, the respective figures are 8.1 percent and 4.1 percent). Based on the above analysis, one would expect to find corporations financing investment entirely out of debt and never using retained earnings for this purpose. Clearly, this is not the case, as firms use both debt and equity financing. One reason companies do not rely solely on debt is that outside credit constraints (or the costs of bankruptcy) may make the marginal cost of debt rise as the total level of debt increases. In other words, the market value of debt may decrease the firm's value faster at higher debt levels because high debt may alert the capital markets that the firm is less likely to survive, or because lenders become less willing to lend to firms that could be hit with bankruptcy costs. In this world, the value of the shares might be written as

$$(6) \quad S = (1-\tau_p)(C-C_I) + (1-\tau_c)\left[\frac{F(I_0)}{\rho} - [D+\delta(D)]\right].$$

The parameter δ is the increasing cost of debt not captured in the interest rate, where $\delta(0) = 0$, $\delta' > 0$, and $\delta'' > 0$. The new rule for debt-financed investment is

$$(7) \quad F'(I_0) = \rho\,[1 + \delta'(D)].$$

The first-order condition for investment financed out of equity is the same as in equation (5). The rule for investment explicitly makes the amount of investment a decreasing function of the firm's debt level if the firm finances out of debt. Similar to the MM model, the first-order conditions can generate corner solutions in which the firm finances investment either completely out of debt or completely out of cash. For example, if $\tau_c \leq \tau_p$, the firm will finance up to its total cash holdings out of equity, then finance out of debt only if the marginal return on investment at that point is greater than or equal to ρ. If the corporate tax rate is greater than the personal tax rate (as it is for most U.S. corporations), then the investment rule is more complicated. The firm will finance out of debt only if $[1 + \delta'(D)] < (1-\tau_p)/(1-\tau_c)$; that is, if the marginal cost of increasing the firm's debt burden is small enough. If this is not the case, firms will use both debt and cash to finance their investment projects. First-order conditions for investment financed out of cash remain the same (equation [5]), so that the equation determining the debt level, if both debt and cash are used to finance investment, is

$$(8) \quad [1 + \delta'(D)] = \frac{(1-\tau_p)}{(1-\tau_c)}.$$

It is important for policymakers to know whether a world represented by MM or an environment of substantially increasing marginal cost of debt, crudely represented by equation (6), best reflects investment behavior. One easy reduced-form test of the MM assumptions in the earlier cross-section studies was to examine whether investment was negatively correlated with debt. If the study detected no negative relationship, then the conclusion might be that equation (6) did not make empirical sense. However, as the following example illustrates, lack of correlation between debt and equity might occur in a world that is very non-MM.

Suppose our sample consists of two types of firms that differ only in their set of investment opportunities. Each type faces an investment

payoff of $a_iF(I)$, where $a_1 > a_2$. The empirical researcher observes only the debt and investment outcomes of the two firms. The firms face a very non-MM world, one in which increasing debt discourages investment, represented by equation (6). We further assume that both debt and equity are used to finance investment, so that equation (8) holds. First-order conditions for the two firms are $F'(I_0) = \frac{\rho}{a_i}[1 + \delta'(D)] = \rho(1-\tau_p)/a_i(1-\tau_c)$. The behavior rule gives the following outcome: $I_1 > I_2$ and, if both firms finance investment out of some of their retained earnings, $D_1 = D_2$.[8] A simple regression of investment on the firm's debt level would lend support to the MM hypothesis of the irrelevance of debt for the level of investment, even though the data are generated by a behavior where the debt level, ceteris paribus, discourages investment. Clearly, lack of a simple correlation between debt and investment is not enough to test the appropriateness of the theory. If the potential cash available to the individual firms, C, is unobserved by the empirical researcher (as is likely), then the dividend amount may also be uncorrelated with the investment level. The problem is that the corporate financial instruments are behavior variables chosen by the agents, not experimental variables applied by the researcher.

Any estimation must take into account that both investment and corporate financial structure are caused by the environment facing the firm, and that the available data contain very little of the information needed to reconstruct the decision process for each firm's investment and corporate financial structure, even if all of the correct variables are included. The key to the earlier studies lay in finding sufficient instruments to control for the different investment opportunities represented by a_i and for the fact that debt was a behavioral variable chosen by the firm. Poor instrument choice was bound to lead to poor estimates. In this estimating context, the underlying structure of behavior and a clear notion of what is generating differences across observations are needed to formulate a useful reduced form.

The problems with reduced-form analysis are clear from this example, yet researchers do not necessarily have the data to conduct a full-blown structural estimation. Despite these limitations, we can profit from structural models by using them to devise a test that can help uncover some of the important factors driving firms' investment decisions.

IV. Tax Effects and the Investment/ Financing Relationship

Early reduced-form empirical work on the tax effects of the investment/financing relationship, such as Long and Malitz (1985), Titman and Wessels (1988), and Fischer, Heinkel, and Zechner (1989), failed to find economically or statistically significant effects, just as early reduced-form studies failed to find a link between corporate financial structure and investment. These early nonstructural studies had an important influence on the policy debate, particularly when federal tax reform was discussed. For example, when the Economic Recovery Tax Act of 1981 (ERTA) was being debated, it was theoretically understood that in a credit-constrained world, the investment tax credit might yield a strong substitution effect as firms changed their investment funding from debt financing to retained earnings. This was not considered important because the early reduced-form estimates indicated that the effect of taxes on corporate financial structure was negligible.[9]

Subsequent, more careful work has generally found evidence of a significant tax effect. For example, MacKie-Mason (1990) states that earlier studies suffered from a failure to fully consider the impact of a firm's tax shields (tax deductions or investment tax credits) on its effective marginal tax rate. He notes that if a firm has no taxable income, any additional tax shields it receives will have no impact on its marginal tax rate. The marginal rate will be affected only if tax shields lower taxable income to zero. By taking this point into account and investigating incremental financing decisions using discrete-choice models instead of debt/equity ratios, MacKie-Mason finds evidence that firms with high tax-loss carryforwards are less likely to rely on debt. This is certainly consistent with both the theoretical models of MM and the debt-constraint model, which predict that as the corporate tax rate decreases, debt should shrink.

This more recent finding of a significant tax effect forces the reduced-form research to be more careful in defining its hypotheses. How do taxes influence investment? They could

■ **8** This follows directly from the relation $\frac{(1-\tau_p)}{(1-\tau_c)} = 1 + \delta'(D)$.

■ **9** See Trezevant (1994), which discusses the contemporary debate surrounding ERTA. The author finds a significant substitution effect in taxes.

affect it directly through a change in the post-tax price of real investment, or indirectly through a change in corporate financial structure, as demonstrated in the previous section. The indirect influence is the one of interest to corporate finance. Separation of the indirect financial effect from the direct real-price effect requires a clarity that makes reduced-form estimation look more like structural estimation.

This clarity is seen in more recent research that concentrates on the impact of taxes on corporate financial structure. Givoly et al. (1992) and Cummins, Hassett, and Hubbard (1994) find evidence of a relationship between debt and taxes. The Givoly study empirically examines the response of business firms to the Tax Reform Act of 1986 (TRA). The authors find evidence of a substitution effect between debt and nondebt tax shields, as hypothesized by DeAngelo and Masulis (1980). In addition, both corporate and personal tax rates appear to affect leverage decisions.

Givoly et al. provide a good example of how forming an implicit structure about the effect of taxes provides a precise hypothesis for testing with a reduced-form estimation strategy. Consider how they use their structure and their knowledge of TRA specifics to develop simple statistical hypotheses. For example, they use only 1987 data to describe TRA's effect, because they assert that the Act was surrounded by uncertainty until its actual passage by the Senate. Their test year was 1987, and their control years were 1984 and 1985, before any tax reform legislation was introduced. Although firms might have behaved in anticipation of a new tax structure, it is unlikely that this Lucas effect would be of overriding importance in the statistical results.

Givoly et al. test their hypotheses involving tax code changes by estimating standard cross-section OLS regressions of the change in leverage on the firm's effective tax rate, nondebt tax shields, dividend yield, Tobin's *q*, firm size, business risk, and changes in depreciation and investment tax credits.[10] The authors are able to reach definitive conclusions about the effect of the TRA using cross-section analysis because they state their hypotheses carefully. For example, the TRA greatly reduced the statutory corporate tax rates, so that firms faced more similar rates. Thus, their Hypothesis 1 states that in response to the decline in the statutory corporate tax rate, firms with a high marginal effective rate will decrease their leverage more than will firms with a low marginal effective rate. In other words, the decline in the effective corporate tax rate will have a greater impact on firms with high marginal tax burdens. Low effective tax rates imply a low tax advantage of debt and result in a smaller decrease in leverage stemming from a cut in the statutory tax rate. Hence, the relationship between the effective tax rate and changes in leverage should be inverse.

Notice how the hypothesis embodies a solid underlying structure of how the firm reacts to a tax change. This structure gives the hypothesis a clarity and specificity that provide the necessary power for a reduced-form test. The hypothesis also illustrates a clear understanding of the workings of the tax code. Although tax laws specify the marginal statutory corporate tax rate, corporate decisions are based on the marginal effective tax rate, which is the present value of future tax payments resulting from an additional dollar of taxable income. The statutory rate is the same for all firms, but the effective rate differs from firm to firm above a certain dollar amount. Tax shields such as investment tax credits, tax-loss carryforwards, depreciation allowances, and interest expenses lower the effective tax rate.

The Givoly results support all of their hypotheses: Each of the relevant coefficients is statistically significant and has the proper sign for 1987, the first year the TRA was in effect. The hypotheses appear to be of moderate economic significance. For example, a firm with an effective tax rate 10 percent above that of another firm would have lowered its debt/equity ratio 1.15 percent more in response to the TRA.

Givoly and others provide only part of the answer regarding the effect of financial structure on real input decisions. By showing that taxes influence financial structure, the studies have shown that capital markets are imperfect, thus providing an important clue as to why the MM propositions are not supported by the data. However, they have not clearly shown how these financial decisions impact real input decisions. Furthermore, the magnitude of the effect is far from certain. Thus, the latest findings point out one link of the chain of indirect tax effects through capital structure by showing how taxes influence corporate finance. However, the complete change still suffers from lack of information on the magnitude of the effect of corporate financial structure on real investment decisions.

■ **10** In Givoly et al., Tobin's *q* proxies for bankruptcy costs and the collateral value of the firm when bankrupt. Business risk is proxied by the coefficient of variation in operating income (minus depreciation) over the firm's last 10 years.

Although earlier empirical work found no significant tax effects, more recent studies have addressed the inherent empirical problems and have produced evidence that supports the importance of taxes on financing decisions. Hence, one link between policy and real investment behavior has been established, but only after very clear statements about the firm's underlying structural behavior were used to define relevant variables and identifying assumptions. These are formulations that require a careful, informed analysis. Even so, only a fully structural model can provide policymakers with an accurate measure of how changes in tax policy influence real investment. Without parameter estimates from such a model, the short- and long-term effects of tax policy changes on real investment remain uncertain.

V. Conclusion

What have we learned from examining 35 years of research? In each case—the direct test of the MM hypothesis through cross-section regressions, the test of the timing of investment through Granger causality, and the test of whether taxes should matter to corporate financial structure—the findings exhibit the same pattern. Early research often failed to reveal statistical significance in the relationship between corporate real investment and the explanatory variable, be it financial structure or taxes. This seemed to provide prima facie support for the empirical relevance of MM's assertions.

Our present knowledge of corporate financial structure through reduced-form estimation is typical of what a more careful reduced-form strategy can do. The weight of the current evidence seems to reject the MM neutrality hypothesis. Financial structure does matter to a firm's investment decisions, and taxes do influence these decisions through their effect on financial structure. These are important statements to bear in mind both when deciding on policy and when formulating new theory with which to guide policy.

Our cautionary tale does not say that the reduced form is an unwise estimation strategy. Rather, it notes what conditions are necessary if a reduced form is to yield accurate results. In all cases, an underlying structure of behavior (even when not used explicitly in a structural estimation model) guided the research through the crucial steps of data definition and formulating the correct econometric test. It is also important to note that a reduced-form analysis is a critical step in any empirical study of a policy question. Simply estimating a structural model without first determining and reporting general directions in the data is a recipe for disaster.

However, the reduced-form strategy, when used without accompanying structural estimates, is distinguished by what it has *not* done. We do not have precise estimates of the magnitude of the effects. Because the estimating equations are formulated without an explicit structure, the resulting parameters are subject to fewer "reality checks" to determine whether they make economic sense. In addition, fewer comparisons can be made to related empirical literatures to determine the appropriateness of the estimating equations' specifications. Is this or that estimated parameter comparable to a risk-aversion parameter estimated in the portfolio-balance literature? We cannot tell from a reduced-form estimate because the reduced form resists a structural interpretation that will allow comparison.

References

Cummins, J.G., K.A. Hassett, and R.G. Hubbard. "A Reconsideration of Investment Behavior Using Tax Reforms as Natural Experiments," *Brookings Papers on Economic Activity,* vol. 2 (1994), pp. 1–59.

DeAngelo, H., and R. Masulis. "Optimal Capital Structure under Corporate and Personal Taxation," *Journal of Financial Economics,* vol. 8, no. 1 (March 1980), pp. 3–29.

Dhrymes, P., and M. Kurz. "Investment, Dividend, and External Finance Behavior of Firms," in *Determinants of Investment Behavior.* New York: National Bureau of Economic Research, 1967.

Fischer, E., R. Heinkel, and J. Zechner. "Dynamic Capital Structure Choice: Theory and Tests," *Journal of Finance,* vol. 44, no. 1 (March 1989), pp. 19–40.

Gilchrist, S. and C.P. Himmelberg. "Evidence on the Role of Cash Flow for Investment," New York University, Stein School of Business, Working Paper, 1995.

Givoly, D., C. Hayn, A. Ofer, and O. Sarig. "Taxes and Capital Structure: Evidence from Firms' Response to the Tax Reform Act of 1986," *Review of Financial Studies,* vol. 5, no. 2 (1992), pp. 331–55.

Granger, C. "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," Econometrica, vol. 37, no. 3 (July 1969), pp. 424–38.

Long, M.S., and I.B. Malitz. "Investment Patterns and Financial Leverage," in B.M. Friedman, ed., *Corporate Capital Structures in the United States*. Chicago: University of Chicago Press, 1985, pp. 325–48.

MacKie-Mason, J. "Do Taxes Affect Corporate Financing Decisions?" *Journal of Finance,* vol. 45, no. 5 (December 1990), pp. 1471–93.

McCabe, G.M. "The Empirical Relationship between Investment and Financing: A New Look," *Journal of Financial and Quantitative Analysis,* vol. 14, no. 1 (March 1979), pp. 119–35.

McDonald, J.G., Jacquillat, B., and M. Nussenbaum. "Dividend, Investment, and Financing Decisions: Empirical Evidence on French Firms," *Journal of Financial and Quantitative Analysis,* vol. 10, no. 5 (December 1975), pp. 741–55.

Modigliani, F., and M. Miller. "The Cost of Capital, Corporate Finance, and the Theory of Investment," *American Economic Review,* vol. 48, no. 3 (June 1958), pp. 261–97.

_____ and _____. "Corporate Income Taxes and the Cost of Capital: A Correction," American Economic Review, vol. 53, no. 3 (June 1963), pp. 433–43.

Mougoue, M., and T.K. Mukherjee. "An Investigation into the Causality among Firms' Dividend, Investment, and Financing Decisions," *Journal of Financial Research,* vol. 17, no. 4 (Winter 1994), pp. 517–30.

Peterson, P.P., and G.A. Benesh. "A Reexamination of the Empirical Relationship between Investment and Financing Decisions," *Journal of Financial and Quantitative Analysis,* vol. 18, no. 4 (December 1983), pp. 439–53.

Smirlock, M., and W. Marshall. "An Examination of the Empirical Relationship between the Dividend and Investment Decisions: A Note," Journal of Finance, vol. 38, no. 5 (December 1983), pp. 1659–67.

Titman, S., and R. Wessels. "The Determinants of Capital Structure Choice," *Journal of Finance,* vol. 43, no. 1 (March 1988), pp. 1–19.

Trezevant, R. "How Did Firms Adjust Their Tax-Deductible Activities in Response to the Economic Recovery Tax Act of 1981?" *National Tax Journal,* vol. 47, no. 2 (June 1994), pp. 253–71.