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FINANCIAL BEHAVIOR

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**AN ASSESSMENT OF TAX POLICIES IN MODELS WITH ENDOGENOUS
FINANCIAL BEHAVIOR**

By

John Charles Navin

A DISSERTATION

**Submitted to
Michigan State University
in partial fulfillment of the requirements
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ABSTRACT

AN ASSESSMENT OF TAX POLICIES IN MODELS WITH ENDOGENOUS FINANCIAL BEHAVIOR

By

John Charles Navin

The purpose of my dissertation is to study the effects of corporate tax policies on the financial and investment decisions of firms in the U.S. economy. In the first section, I construct a model of firm investment and financial behavior which can be used to study the effects of various tax policies in a computational general equilibrium (CGE) model.

In the second section, I use a panel data set of 781 firms to examine the impact of changes in statutory tax rates on firms' debt/capital ratios. Data on firms' debt/capital ratios were taken from the COMPUSTAT data tape, covering the years 1969-1988. A fixed-effects model was used to measure the impact of tax rate changes on firm's debt/capital ratios. The results of the empirical estimation indicate that the response of firms to changes in the tax rates was very small. The elasticity estimates, after correcting for autocorrelation, ranged between -0.11 and -0.73 for the debt/capital ratios with respect to changes in the personal income tax rate.

In the final section, I use a nine-sector CGE model to examine the effects of three different tax policy proposals: full corporate tax integration, a reduction in the corporate

income tax rate, and a dividend exclusion from the personal income tax. The model consists of nine production sectors, a single consumer, and also a government sector. The model incorporates the empirical elasticities of firm financial behavior, in order to allow firms to adjust their debt/capital ratios in response to changes in tax policy.

The tax policy simulations resulted in welfare gains under each policy proposal. The welfare gains ranged between \$463 billion, under full corporate tax integration, and \$340 billion, for the reduction in the corporate income tax rate.

This dissertation is dedicated to my brother, Jim.

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Chapter 1

INTRODUCTION

1.1. Introduction

The corporate income tax may have long-term effects on savings, investment, and firm financial decisions. The purpose of my dissertation is to study the effects of corporate tax policies on the financial and investment decisions of firms in the U.S. economy. I begin with a brief survey of earlier work. I then construct a model which can be used to study the effects of various tax policies in a computational general equilibrium (CGE) model. The model yields implications for corporate debt/capital ratios that may be tested econometrically. In Chapter 3, I report on my investigation into the effects of changes in the personal and corporate tax rates on firms' financial decisions, using a panel data set of annual data from 1969 through 1988. Then in Chapter 4, I describe the CGE model and in Chapter 5, report on the results of the policy simulations.

1.2. Overview of Some Corporate Income Tax Distortions

The corporate income tax is an important (although relatively declining) source of revenue for the federal government, ranking third behind the payroll tax and the

personal income tax.¹ It has been criticized on the grounds that it distorts individual and firm behavior.² The following are some decisions which are believed to be distorted by the corporate income tax:

(1) The firm's decision on whether to finance new capital with new issues of equity or new issues of debt. Under the current tax code, interest payments on debt are deductible from the corporate tax base, while disbursements to equity holders are not. This asymmetry in the tax code heavily favors debt finance. See, for example, Stiglitz (1973) or Gordon and Malkiel (1981).

(2) The firm's decision on whether to undertake new investment. A key factor in determining whether to undertake new investment is the after-tax rate of return received by the firm. As the corporate income tax rate changes, the rate of return required on investments will fluctuate. This distortion has been discussed by Auerbach and Hassett (1989),

¹ According to Pechman (1987) the corporate income tax accounted for approximately 8 percent of federal revenues compared with 45 percent from the personal income tax and 37 percent from payroll taxes in 1986. Pechman points out that the percentage of total federal tax revenue raised by the corporate income tax has been declining steadily over the past 30 years, falling from 27.3% in 1955, to 8% in 1986.

² Although the percentage of total federal tax revenue received from the corporate income tax is declining, this does not necessarily imply that the size of the welfare losses incurred due to the existence of the corporate income tax are declining. In fact, it may imply that the size of the distortions caused per dollar of tax revenue raised may be increasing.

Feldstein and Frisch (1977), Fullerton and Henderson (1989), and Hall and Jorgenson (1967).

(3) The allocation of capital between the corporate and noncorporate sectors. Different tax rates between sectors will cause capital to move out of the higher-tax sector into the lower-tax sector. The seminal work on this distortion was done by Harberger (1962, 1966), using a two-sector model.

Harberger's most famous result is that a tax on capital in the corporate sector is borne by all owners of capital, even if their capital is not incorporated. Harberger also estimated the efficiency loss from the taxation of capital. He estimated that the deadweight loss from the taxation of capital between 1953 and 1959 was between 2.4 and 7.0 percent of corporate income tax revenue.

The development of CGE techniques has allowed the construction of multiple-sector models. See, for example, Shoven and Whalley (1972), Shoven (1976), and Fullerton, King, Shoven, and Whalley (1981).³ Gravelle and Kotlikoff (1989) have explored the misallocation of capital between corporate and noncorporate establishments which produce in the same sector. Their results indicate that, if one takes into account the presence of corporate and noncorporate capital in

³ Shoven (1976) has twelve production sectors in his model. In addition to disaggregation, Shoven also corrects a mathematical error by Harberger. Harberger understates the true amount of capital income in his model by almost four million dollars. Both the higher level of disaggregation and the correction of Harberger's error lead to welfare gains which were, on average, 40 percent larger than Harberger's results.

the same sector, the distortion is much larger than previously believed. They examine this distortion at a high level of industry aggregation. It may be the case that, if one were to take a more disaggregated view of the economy, this distortion may be much smaller than their results indicate. Another criticism is the accuracy of their model in capturing the decision on whether to incorporate. Their model provides a high elasticity of incorporation with respect to tax parameter changes within the model. Gordon and MacKie-Mason (1990) find that, empirically, there appears to be little elasticity in the decision to incorporate with respect to changes in the tax system. In any event, I choose to focus on the more traditional question of the misallocation of capital between the corporate and noncorporate sector.

(4) The individual savings decision. If one accepts Harberger's result that the burden of the corporate tax is shifted to all owners of capital, then the corporate income tax lowers the after-tax rate of return for all savers. This biases their savings decision in favor of current consumption instead of future consumption. The effect of taxation on intertemporal decisions has been explored by a number of authors, including Atkinson (1971, 1980), Auerbach and Kotlikoff (1987), Ballard (1990), Feldstein (1978), Feldstein and Frisch (1977), and Periera (1988).

(5) The dividend payout policy of firms. Under the current tax structure, dividends are taxed twice, once as corporate income, and once as personal income. This increases

the cost to shareholders of receiving dividends, and biases the firm toward a low payout ratio. The effect of the tax system on corporate dividend policy is explored by Poterba and Summers (1985) and Feldstein and Green (1983).

The simplest method for removing these distortions would be the elimination of the corporate income tax. The outright elimination of the corporate tax is unlikely for two major reasons. The first is that, despite its relative decline, the corporate income tax is a major source of federal revenue, raising approximately \$83.9 billion in 1987.⁴ Secondly, the elimination of the corporate income tax also may lead to some distortions of its own. One such distortion would be the incentive for individuals to shelter income in corporations in order to avoid paying personal income taxes.

Short of simple elimination of the corporate income tax, some economists have suggested the integration of the corporate and personal income taxes. One of the most thorough discussions of corporate tax integration is found in McLure (1979). He discusses the administrative implications of tax integration as well as various other proposals. The possible proposals for integration range from complete integration to partial dividend relief. Under the partnership method of full corporate integration, the corporate tax is eliminated and all corporate income is attributed to equity holders of the

⁴ U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, Washington, D.C., January 1990, P. 274.

corporation, based on the number of shares held, and is taxed as personal income.

Another proposal is to allow a deduction for dividends within the corporate tax. If firms choose to pay out all earnings as dividends, a 100% dividend deduction would have the same effect as full integration. However, even with a 100% deduction, this would probably not have as great an effect as full integration, because firms may have other reasons for retaining earnings.

Dividend relief, within the personal income tax, reduces or eliminates the double taxation of dividends. One method would be to issue a credit to taxpayers for the corporate income tax paid on income disbursed to shareholders as dividends. Besides full dividend relief, it is also possible to give individuals a partial dividend credit. Although this would not eliminate the double taxation of dividends, it would lessen the distortion.

1.3. Review of the Literature

1.3.1. Corporate Tax Integration and CGE models

This section briefly reviews earlier work on tax integration, and CGE modeling. Readers familiar with this literature may want to proceed to section [1.3.2.]

A number of studies have examined the effect of various corporate tax integration plans. Using tax return data from

the U.S. Department of Treasury's Tax File of 1973, Feldstein and Frisch (1977) examine the distributional and revenue implications of full corporate integration and a revenue-neutral partial integration plan. They report that full corporate integration may result in annual welfare gains as large as \$7 billion (approximately 19.25% of federal corporate income tax revenue in 1973) by reducing the distortion on the individual savings decision alone.

Ballentine and McLure (1981) examine the effects of full integration of the personal and corporate tax systems, while taking into account the financial behavior of firms. They modify a two-sector Harberger general equilibrium model to incorporate a model of firm financial decision making. They find that, with the incorporation of the corporate financial structure, the implementation of corporate tax integration will lead to greater welfare gains to the economy, than in an otherwise identical two-sector model which abstracts from firm behavior. This is due to a reduction in the difference between the rate of return on corporate and noncorporate capital, and a reduction in the risk premiums required on corporate securities. The reduction in the risk premiums will lead to relatively larger increases in the income of investors in the noncorporate sector, because previously the corporate income tax burden was shifted onto owners of noncorporate

capital. This will also result in an increase in the progressivity of the income tax.⁵

These studies by Feldstein and Frisch and by Ballentine and McLure made important contributions to the examination of integration. However, these studies are lacking in that they are not able to model more completely the complexity of the tax laws and the ability of individuals to change their behavior in response to changes in these laws. Advances in computer technology have allowed researchers to use CGE models to simulate the effects of changes in tax policy, using large-scale models of the United States economy. Computational models allow the modeling of multiple production sectors as well as many different types of consumers. These models also allow for a complex modeling of the current tax system. These models have also been used to study the effects of corporate tax integration. Fullerton, Shoven, King, and Whalley [FKSW (1981)] use a CGE model to examine the welfare effects of four corporate tax integration plans, ranging from full integration to partial dividend relief. Their model consists of 19 producing sectors which produce 16 different consumer goods. The model also includes 12 differing consumer classes, which are separated based on income levels. Their model's data set consists of information based on the 1973 tax rates, capital stocks, and income distribution of the United States.

⁵ This result is based on the fact that the ownership of corporate capital tends to be more highly concentrated in the upper-income classes than the ownership of noncorporate capital.

However, FKS_W do not explicitly model the effects of changes in the tax system on corporate financial behavior.

The authors run simulations under revenue-neutral conditions, adjusting personal tax rates so that there is no loss in total tax revenue. The static gains from total integration are very large (on the order of \$6 billion per year, approximately 16.5% of total federal corporate income tax revenue, in 1973 dollars). The plans for dividend relief resulted in efficiency gains of about half as much as the total integration plan. FKS_W also look at dynamic gains, i.e., gains which accrue in the future due to increases in the accumulation of capital. These changes are very large, with a present value of at least \$100 billion in every case.

Fullerton (1983) examines the effects of full corporate tax integration in a model with partially mobile industry-specific capital. Fullerton uses the nineteen-sector FKS_W model, but restricts the flow of capital out of some sectors to the amount of depreciation that occurs in that sector's capital stock. In his model, a large portion of the economy's capital stock is freely mobile. A portion of the capital stock is, however, restricted to be sector-specific. The sector-specific capital is assumed to remain in the original production sector. The sector-specific capital will depreciate away over the course of simulations, and after ten years, all capital is assumed to be perfectly mobile. In his most restrictive case, Fullerton assumes that five production sectors consist of sector-specific capital. Full integration

simulations, under his most restrictive case, result in dynamic welfare gains that are \$5 billion dollars lower than those found by FSKW.

Fullerton and Gordon (1983) also use a CGE model to examine the effects of changes in tax policy on the United States economy. They modify the FKS model to incorporate the effects of changes in the tax system on the selection of corporate debt/capital ratios. The authors rely on the bankruptcy theory of corporate finance, which is discussed in Gordon and Malkiel (1981). Under this theory, firms trade off the benefits of financing new investment with debt against the increased costs of bankruptcy associated with a greater amount of leverage. The theories of financial leverage will be discussed in greater detail in section [1.3.2].

Fullerton and Gordon examine the effects of full integration via the partnership method. Under full integration, there is no longer any tax advantage to using debt, so firms have an optimal debt/capital ratio of zero. In every revenue-neutral simulation in which personal tax rates were increased to compensate for lost revenue, full integration resulted in welfare losses. There were welfare gains when the loss in tax revenue was replaced by a lump-sum tax, but they were very small in comparison to those found by FKS (1981). The changes in the FKS model resulted in a dramatic change in the effects of corporate tax integration.

Although the Fullerton-Gordon paper would seem to indicate that there are few benefits to corporate tax

integration, one must be cautious in evaluating their results. The reason for this caution is the type of risk that they incorporate into their model. In their model, Fullerton and Gordon focus on the income risk of firm ownership. The total return on a capital asset is composed of two parts. These are the current return on the asset and changes in the value of that asset. Income risk is associated with changes in the current return to the asset. Fullerton and Gordon assume that the government assumes full income risk sharing.

Bulow and Summers (1986) point out that fluctuations in the value of the asset, referred to as capital risk, are much larger than assumed by Fullerton and Gordon. Variations in stock prices are generally much larger than fluctuations in current income. The findings of Bulow and Summers call into question the assumption of a large amount of income-risk sharing by the government. The fact that Fullerton and Gordon incorporate endogenous financial behavior into their model is clearly an important step forward in the modeling of the U.S. economy. However, although the financial decisions of the firms are endogenized, the investment decisions of the firm are not. If changes in the financial decisions of the firm affect the cost of investment to the firm, the welfare effects of corporate tax integration could be very different from those found by FKSU or Fullerton and Gordon.

Slemrod (1983) uses a CGE model to examine the effect of indexing the federal tax system for inflation. One of the major features of his model is the modeling of financial

behavior of the corporate sector. In modeling the choice of a firm's debt/equity ratio, Slemrod also relies on the bankruptcy tradeoff theory. As the tax parameters of the model change, the optimal debt/equity levels will change. Slemrod relies on econometric estimates, his own and those of King (1978), of the elasticity of firm's debt levels and dividend payout ratios with respect to changes in the personal and corporate tax rates. Slemrod finds that indexation of the federal income tax system will result in a "significant" reallocation of financial resources. He also finds that indexation results in large welfare gains for upper-income individuals. Although this paper is a major contribution toward CGE modeling, it is lacking in that it groups all corporations into one sector and does not allow for intersectoral variation.

Galper, Lucke, and Toder (1988) also use a CGE model to examine the effects of changes in the tax system on a model which incorporates the debt/equity decision of the firm. Their general equilibrium model is used to examine the effects of the 1986 Tax Reform Act. Their modeling of the corporate debt/equity choice differs from Slemrod (1983). Galper, Lucke, and Toder use theoretical considerations to derive explicit demand functions for debt, instead of relying on econometric estimates of firm responses to changes in the tax system. Firms in their model select an optimal debt/equity ratio to minimize the cost of capital, given the interest rate, the corporate tax parameters, and the parameters of

individual demand functions for equity. Galper, Lucke, and Toder find that the Tax Reform Act of 1986 resulted in large welfare gains to the upper-income households, because upper-income households tend to hold a disproportionate amount of capital assets. They also find there should be a slight decline in corporate debt/equity ratios. This is the result of two offsetting effects: a reduction in the corporate income tax, and an increase in the tax rate on capital gains.

Although this model proves very useful, it suffers from the same criticisms as Slemrod (1983): the aggregation of the corporate sector and the lack of dynamics in the model. Galper, Lucke, and Toder make an important contribution, however, by using an explicit model of firm debt behavior.

Jorgenson and Yun (1986) use an econometrically-estimated general equilibrium model to examine the efficiency of capital allocation among corporate and noncorporate assets. Their model uses empirically estimated production and consumption parameters based on time series data from 1955-1980. A business sector and a household sector are included in their model. The business sector produces consumption and investment goods from labor and corporate and noncorporate capital services. The capital services in the business sector are divided among short-lived and long-lived assets. The household sector, in their model, is an aggregate of consumption goods in the economy as well as household capital services, and leisure time. A government sector is also

included in their model. Jorgenson and Yun examine the impact of the ERTA of 1981.

They find that the ERTA of 1981 had potential welfare gains of \$542 billion, if a lump-sum tax was used to replace the revenue loss. Using an increase in the tax rate on labor income to recoup the revenue shortfall would result in potential welfare gains of \$328 billion, while a sales tax replacement could result in potential welfare gains of \$295 billion dollars.

The Jorgenson and Yun paper is important, because unlike many other CGE models, it relies on actual empirical estimates of consumer and producer behavior. But, it does not include endogenous financial behavior.

The papers reviewed up to this point have dealt with two major issues, corporate tax integration and CGE models. Although the modeling of corporate tax integration has improved greatly over the past twenty years, there is still a great amount of work to be done. Table 1 presents a listing of the major features of the CGE models which are discussed here.

1.3.2. Theories of Corporate Financial Leverage

This section will give a brief examination of the theories of corporate financial leverage. The corporate leverage decision plays a major role in the development of my model in Chapter 2.

The seminal research on corporate financial policy was done by Modigliani and Miller (1958). Their major result was that corporate financial policy is irrelevant in determining the value of the firm, i.e., *ceteris paribus*, investors will be indifferent to the debt/equity policy or the dividend payout ratio of the firm. Modigliani and Miller's findings are reached under some very restrictive assumptions. They assume: (1) There are perfect capital markets. (2) All bonds are riskless assets. (3) There are no bankruptcy or leverage costs. (4) There are no taxes. The Modigliani-Miller Theorem relies on the ability of investors to borrow and lend to offset any changes in firms' borrowing or dividend policy.

Table 1
Summary of Features of Computational General Equilibrium Models

<u>Authors</u>	<u>Number of Sectors</u>	<u>Endogenous D/E Ratio</u>	<u>Endogenous Dividends</u>	<u>Dynamics</u>
Fullerton, King, Shoven & Whalley (1981)	19	No	No	Yes
Fullerton (1983)	19	No	No	Yes
Fullerton & Gordon (1983)	19	Yes	No	Yes
Slemrod (1983)	5	Yes	Yes	No
Galper, Lucke, and Toder (1988)	5	Yes	No	No
Jorgenson & Yun (1986)	1	No	No	Yes

When corporate and personal taxation are introduced, the Modigliani-Miller Theorem no longer holds. Under the current tax system, interest payments to bondholders are deductible

from corporate income, while dividend payments of a firm are not. This makes it cheaper for a firm to use debt than equity. Because debt is the cheaper means of financing an investment, a profit-maximizing firm would finance all of its investments out of debt.

Casual observation of the corporate sector shows that this is not the case in the United States. Firms only finance a portion of their capital stock with debt. There are a number of theories on why firms do not finance all of their capital with debt. The existence of agency costs, clientele effects, and bankruptcy costs will be discussed here.

The use of large amounts of debt finance may lead to agency costs in the form of distorted investment incentives for firms. One way to reduce these agency costs is to force managers of firms to finance a portion of their new investment with equity, to preserve some future investment opportunities. The theory of agency costs of this type is discussed by Meyers (1977).

Although the current corporate tax law favors the use of debt finance, the existence of personal income taxation may work to reduce the benefits of using debt. The existence of clientele effects, the interaction of personal and corporate tax rates, and the relative costs of debt and equity may also effect corporate debt/equity positions. The effects of personal taxation on corporate financial decisions have been explored by Stiglitz (1973), Miller (1977), and Auerbach and King (1983).

Stiglitz (1973) and Miller (1977) focus on the relative costs of borrowing based on the relationship between the corporate income tax rate and personal income tax rate. They point out that certain features of the personal income tax system work to minimize the benefits of using leverage. When a firm uses debt finance, a lower portion of the investment will be taxed as capital gains. Until the Tax Reform Act of 1986, realized capital gains were taxed at a lower rate than interest or dividend income. In addition, capital gains are taxed only on a realization basis instead of an accrual basis. This lowers the effective tax rate on equity even further. The existence of a progressive income tax system leads to differing advantages of debt and equity finance for individuals. Because individuals have differing tax rates on bond and equity income, they will want to invest in firms with differing degrees of leverage. This will lead to a market equilibrium with some firms which are very leveraged and some firms that are not very leveraged.

Auerbach and King (1983) explore the interaction of personal and corporate taxation in a general equilibrium model. Investors in this model select themselves into one of two categories based on their income tax bracket and their personal level of risk aversion. Investors prefer all-debt finance or all-equity finance. Depending on an individual's income class, income from debt may be taxed at a lower rate

than equity, or vice versa.⁶ Another major factor in the selection of the debt/capital ratio is that some investors may be risk averse. If risk aversion is taken into account, investors may put themselves in an all-equity position, even when debt is the tax-preferred form of financing. The existence of differing tax brackets and levels of risk aversion in the economy will lead, in the aggregate, to some capital being financed with debt and some capital being financed with equity. It is important to note, however, that investors end up in either of two extremes, all-debt or all-equity. This model does not provide for mixed portfolios.

The clientele models do not provide for individual firm interior debt/equity positions. This is a major drawback. In the real world, firms do not seek an all-debt or an all-equity position. In these models, the advantages and disadvantages of using debt stem only from the interaction of the personal and corporate tax systems, and varying levels of risk aversion. The introduction of real costs in the use of debt will lead firms to select an optimal interior debt/capital ratio. The possibility of bankruptcy imposes leverage costs on the firm for using debt. Firms will trade off the tax advantages of using debt against the increase in the

⁶ Auerbach and King assume that the tax rate on equity is an effective tax rate which combines the lower tax rate on capital gains with a slightly higher rate on dividend income. The tax rate on personal interest income is assumed to be greater than the effective tax rate on equity. However, it is the interaction of the personal and corporate tax rates which leads to a consumer preferring all debt or all equity.

probability of bankruptcy (which is assumed to impose real costs on the firm). As mentioned earlier, this theory is explored in Gordon and Malkiel (1981), and adapted to a CGE model in Fullerton and Gordon (1983). The addition of bankruptcy costs may have varying effects across sectors and firms. This will lead to differing leverage positions of firms. I believe that this is an important advantage of the bankruptcy model. Consequently, bankruptcy costs are used in this paper to model firms' leverage decisions.

The bankruptcy theory takes into account the asymmetry of the corporate tax code with respect to its treatment of the use of debt and equity by corporations. It also takes into account the effects of the personal income tax system on reducing the tax advantages to investors of firms relying on debt finance, as explored in Stiglitz (1973), Miller (1977), and Auerbach and King (1983). The following is a brief description of a standard version of the bankruptcy theory.

Interest income received by bondholders is taxed at their marginal tax rate, θ . The returns to equity holders are taxed in two ways. The portion of the return that is received in the form of dividends, α , is taxed at the marginal tax rate θ . The remaining portion, $(1-\alpha)$, is taxed at the capital gains rate c . Dividend payments are taxed at the corporate level, as corporate income, at the corporate tax rate τ . Interest payments on bonds are deductible from the corporate income tax base, so they are not taxed at the corporate level. The after-tax return on a corporate bond is $(1-\theta)r$, where r

represents the interest payment on the bond. The after-tax return on equity is $\{\alpha(1-\theta)+(1-\alpha)(1-c)\}(1-\tau)r$. Note that this model does not take into account any risk, and that the parameter α is assumed to be fixed.

Following Fullerton and Gordon (1983), if a firm issues a dollar of debt and then uses that dollar of debt to repurchase a dollar of equity, the gain to investors is $(1-\theta)r$, the new interest payments on the debt, minus $\{\alpha(1-\theta)+(1-\alpha)(1-c)\}(1-\tau)r$, the reduction in the return to equity. This expression reduces to

$$r\{(1-\theta) - (1-\tau)[\alpha(1-\theta) + (1-\alpha)(1-c)]\}. \quad (1)$$

As long as expression (1) is positive, the investors in the firm will gain because the use of debt saves them money. Gordon and Malkiel (1981) explore the conditions under which expression (1) would be positive, or equal zero. As noted in Fullerton-Gordon (1983), they find that, for reasonable values of the tax rates, expression (1) will be positive.

If there were no leverage costs and expression (1) were positive, one would reach the all-debt-finance conclusion. However, with leverage costs, the managers of the firm will realize that they can reduce the cost of acquiring capital by using debt finance, but that this increase in leverage results in real costs to the firm. The bankruptcy costs can be summarized by a function $\psi(\omega)$, where ω represents the firm's debt/capital ratio. It is assumed that $\psi' > 0$ and $\psi'' > 0$.

Setting the costs and benefits of debt equal to each other yields the equilibrium condition

$$\psi'(\omega) = r\{(1-\theta) - (1-\tau) [\alpha(1-\theta) + (1-\alpha)(1-c)]\}. \quad (2)$$

Expression (1) implies that changes in the personal and corporate tax rates will affect the incentive for firms to use debt. The derivative of expression (1) with respect to the corporate tax rate yields⁷

$$\frac{\partial(\text{expression 1})}{\partial \tau} = r\{\alpha(1-\theta) + (1-\alpha)(1-c)\}, \quad (3)$$

which indicates that an increase in the corporate tax rate will increase the benefits of using debt. It increases the value of the interest deduction on debt, and should lead to an increase in the use of leverage.

A change in the personal tax rate (θ) will change the taxes that must be paid on interest income and change the taxes that must be paid on dividend income.

$$\frac{\partial(\text{expression 1})}{\partial \theta} = r\{(-1) + (1-c)(\alpha)\} \quad (4)$$

The derivative is clearly negative, indicating that the overall impact of an increase in the personal tax rate is a

⁷ Note these are partial equilibrium derivatives. In a general equilibrium setting, it will generally not be possible to alter one tax rate without also altering the other tax rates to achieve revenue neutrality.

decrease in the benefits of relying on debt finance. This will cause firms to reduce their leverage position. This is because the increase affects the total return to debt, while affecting only a portion of the return on equity.

Finally, an increase in the capital gains tax rate should result in an increase in the use of debt because it lowers the after-tax rate of return on equity, but has no effect on the after-tax rate of return on debt. This is shown by equation (5), which is positive, indicating an increase in the benefits of using leverage.

$$\frac{\partial(1)}{\partial c} = r(1-\tau)(1-\alpha) \quad (5)$$

Because equation (5) is positive, it indicates that an increase in leverage should result from an increase in the capital gains tax rate. Interest income received by bondholders is taxed at their marginal tax rate. The bankruptcy theory yields empirically testable results with respect to the effect of the personal and corporate tax rates. These results will be tested in Chapter 3.

The purpose of this essay is to take the modeling of CGE models and corporate tax policies one step further, by presenting a model of firm behavior which can be used in a CGE model. This model will then be used to examine corporate tax policies in a setting where the effects of policies on the financial decisions of the firm, as well as the effects on the

investment decisions, are taken into account.⁸ It will also allow for examination of the dynamic effects of tax integration proposals. The model of firm behavior is presented next. Econometric estimates of the impact of changes in the personal and corporate tax rates on a firm's debt/capital ratio will be obtained from a panel data set of U.S. non-financial corporations covering the period from 1969 until 1988 in Chapter 3.

⁸ My model does not attempt to explain the dividend behavior of firms, but instead focuses on firms' choices of debt-to-capital ratios. However, the effects of changes in the dividend behavior of the firm may be explored in subsequent work.

Chapter 2

MODEL OF FIRM BEHAVIOR

This section presents a more complex model of firm behavior. The model encompasses the debt/capital choice of the firm as well as its investment decision. It relies heavily on earlier work by Goulder and Summers (1989), which in turn, is based on Summers (1981). The behavior of firms is based on the premise that managers of firms seek to maximize the value of the firm for its shareholders.

I begin by specifying the fundamental asset market equilibrium condition which requires that the after-tax rate of return from ownership in a firm (risk adjusted) must be equal to the rate of return that could be achieved by holding a riskless asset, such as a municipal bond. The equilibrium is characterized by

$$(1-c) [\dot{V} - S^N] + (1-\theta)[Div] - \eta V = i(1-\theta)V, \quad (6)$$

where c is the capital gains tax rate, $\dot{V}$ is the change in the value of the firm over time, S^N is book-value of new share issues, θ is the personal tax rate on dividend and interest income, Div are dividends paid by the firm, η is the equity risk premium, which is assumed to be exogenous, V is the value of the firm, and i is the nominal interest rate. Equation (6) indicates that the after-tax return on capital gains plus the

after-tax dividend income from the firm (which equals the total net return on the firm), risk adjusted, must equal the after-tax return on the safe asset. Equation (6) can be rearranged to yield the differential equation

$$\dot{V} - \frac{r}{(1-c)} V = S^N - \frac{(1-\theta)}{(1-c)} Div, \quad (7)$$

where $r = i(1-\theta) + \eta$. If one imposes the transversality condition

$$\lim_{s \rightarrow \infty} V_s \left[\exp \int_t^s \frac{-r}{(1-c)} du \right] = 0 \quad (8)$$

to rule out explosive growth in the value of the firm, equation (7) can be solved to yield

$$V_t = \int_t^{\infty} \left[\frac{(1-\theta)}{(1-c)} Div_s - S_s^N \right] \left[\exp \int_t^s \frac{-r_u}{(1-c)} du \right] ds. \quad (9)$$

This expression implies that the value of the firm in time t is equal to the present discounted value of the perpetual stream of after-tax dividends less new share issues. Managers will seek to maximize (9) each period.

Firms in this model are assumed to maintain a 100 percent dividend-payout ratio. All current after-tax earnings are returned to shareholders in the form of dividend payments. Investment expenditures of the firm are entirely financed out of new debt and new share issues. There are no retained

earnings in this model.⁹ The assumptions of a 100 percent dividend-payout ratio and only new-debt and new-share investment finance place two constraints on the firm:

$$Div = EARN \quad (10)$$

and

$$IEXP = B^N + S^N. \quad (11)$$

EARN represents the firm's after-tax earnings, B^N represents new bond issues and IEXP represents new investment expenditures.

The after-tax earnings of the firm are

$$(PF(K, L, M) - WL - P_M M - iD) (1 - \tau) + \tau Dep, \quad (12)$$

where: P = the price of output, F = the production function of the firm, K = capital inputs, L = labor inputs, M = the vector of intermediate inputs, W = the wage rate, P_M = vector of intermediate input prices, D = nominal debt, τ = corporate tax rate, Dep = the value of current depreciation allowances.

Investment expenditures are specified as

⁹The assumption of no retained earnings in this model is important. By not allowing firms to use retained earnings, often thought of the least expensive form of investment finance, one may prevent the firm from undertaking some investment. This may introduce some distortion into the firm's investment decision.

$$IEXP = (1-ITC) P_K I + (1-\tau) P \phi\left(\frac{I}{K}\right) I, \quad (13)$$

where ITC is the investment tax credit and $\phi(I/K)$ measures the investment costs per unit of investment. It is assumed that the adjustment costs are homogeneous of degree one in I and K. Following Goulder and Summers, I model adjustment costs as being internal to the firm. This implies that, holding constant the amount of investment, an increase in adjustment costs results in a reduction in output. This is due to more inputs being diverted from production to the installation of new capital. I also assume, as do Goulder and Summers, that output, Y, is separable between inputs and adjustment costs, i.e.,

$$Y = F(K, L, M) - \phi\left(\frac{I}{K}\right) I. \quad (14)$$

I deviate from Goulder and Summers in that I allow the firm to select its level of debt as well as the issue of new shares. The use of more debt will impose real costs on the firm in the form of an increased probability of bankruptcy.¹⁰ I posit the following bankruptcy function

¹⁰ The Wall Street Journal, October 23, 1990, reports that the number of corporate bankruptcies has risen substantially over the past five years. The number of bankruptcies rose to nearly 680,000, which they report is almost double the number of bankruptcies filed in 1985. This coincides with the increased use of debt finance in leveraged buyouts during the 1980's.

$$\Psi = \Psi\left(\frac{D}{D+S}\right), \quad (15)$$

where S represents the book-value of outstanding shares. Note that I assume $\Psi' > 0$ and $\Psi'' > 0$. This function will cause the firm to incur real costs as it increases the share of debt relative to the total value of its capital stock. The bankruptcy costs are modeled as a continuous function of the debt/capital ratio. There is no minimum level of leverage that must be reached before there is a positive probability of bankruptcy. Any positive leverage will result in real costs to the firm.¹¹

Introducing explicit bankruptcy costs also plays an important role in determining how investment is financed. In a similar model, Goulder and Summers indicate that, due to the tax disadvantages of equity, firms would never issue new shares. This is not the case in this model. Although new shares are disadvantageous from a tax standpoint, they work to reduce the probability of bankruptcy to the firm. In this model, it is feasible for the reduction in bankruptcy costs, and hence an increase in the value of the firm, to offset the tax disadvantages of issuing new shares.

The introduction of bankruptcy costs allows one to rewrite equation (9) as

¹¹ The use of an explicit bankruptcy function makes the model tractable, as well as providing a realistic result: firms achieve an optimal interior debt/capital ratio.

$$V_t = \int_t^{\infty} (1-\Psi) \left[\frac{(1-\theta)}{(1-c)} Div_s - S_s^M \right] \left[\exp \int_t^s \frac{-r_u}{(1-c)} du \right] ds. \quad (16)$$

V_t now represents the value of the firm when it is not bankrupt. The expression $(1-\Psi)$ represents the probability that the firm will not go bankrupt. It is assumed that if the firm is bankrupt, the value of the firm is equal to zero. Equation (16) indicates that the bankruptcy costs will be proportional to the value of the firm. As the value of the firm increases, the loss in income that the shareholders would incur if the firm went bankrupt would increase. Therefore, the higher the value of the firm the greater the bankruptcy costs incurred by the firm.

In order to specify the value of the firm over time, it is important to represent explicitly the value of allowable depreciation allowances. The depreciation allowances are composed of depreciation allowances on current capital and the value of depreciation allowances on future capital acquisitions. The value of total depreciation allowances in time t is equal to¹²

¹² At this point, I am not concerned with the actual calculation of the value of depreciation allowances. However, when simulations are run, this will become necessary. In order to calculate the present value of depreciation allowances, I will appeal to the earlier work of Fullerton and Henderson (1989), and Hulten and Wykoff (1981).

$$Dep_t = \int_0^t \delta P_{K,u} I_u \left[\exp(-\delta(t-u)) \right] du. \quad (17)$$

The parameter δ represents the exponential depreciation rate under the tax code.¹³ P_K is the price of capital, and I represents the quantity of investment. Equation (17) says that the value of depreciation allowances at time t is equal to sum of the present value of depreciation allowances at each point in time, from time $t=0$ until current time t . In examining the value of the firm at each point in time, depreciation allowances can be broken down further into depreciation allowances on current capital (B_t) and the value of depreciation on a dollar of capital acquired in the future (Z_s). This is done because the value of depreciation expenses on existing capital may be taken as a fixed parameter, because future investment decisions are independent of B_t . This allows the firm to ignore B_t during its value maximization. The value of depreciation expenses on current capital is expressed as

$$B_t = \int_t^{\infty} \tau_s \delta \exp[-\delta(s-t)] P_{K,t} \left[\exp \int_t^s \frac{-r}{(1-c)} du \right] ds. \quad (18)$$

¹³ Note that the tax code does not actually give exponential depreciation rates. The exponential depreciation rate is used for analytical convenience. See Fullerton and Henderson (1989) for an example of the methodology of transforming depreciation rates.

The value of depreciation allowances on future capital acquisitions will affect the cost of future investment, by providing future tax deductions. The expression for the value of depreciation allowances on a dollar of capital acquired in the future is

$$Z_s = \int_s^{\infty} \tau_u \delta \exp(-\delta(u-s)) \left[\exp \int_s^u \frac{-r}{(1-c)} da \right] du. \quad (19)$$

This expression indicates that the present value of depreciation allowances on a dollar of new investment is equal to the total of the present values at each time period in the future. The earnings of the firm may now be expressed as

$$EARN = (PF(K, L, M) - WL - P_M M - iD) (1 - \tau) + Z_s P_K I + B_t. \quad (20)$$

Substituting earnings into equation (10) implies that dividends are equal to

$$Div = (PF(K, L, M) - WL - P_M M - iD) (1 - \tau) + B + Z P_K I. \quad (21)$$

Equation (21) can then be substituted into equation (16) to yield an expression for the value of the firm at time t . After substituting and rearranging terms, the value of the firm at time t is

The managers of the firm will want to maximize equation (22), by selecting L , M , B^N , I , and S^N subject to four

$$V_t = \int_t^{\infty} \{1-\Psi\} \left[\frac{(1-\theta)}{(1-c)} \{ [PF(K, L, M) - WL - P_K M - iD] (1-\tau) + ZP_K I \} - S^N \right] \left[\exp \int_t^s \frac{-r}{(1-c)} du \right] ds + B. \quad (22)$$

constraints:

$$\dot{K} = I - \delta^R K \quad (23)$$

$$\dot{D} = B^N - \pi D. \quad (24)$$

$$\dot{S} = S^N \quad (25)$$

$$(1-ITC) P_K I + (1-\tau) P \Phi \left(\frac{I}{K} \right) = B^N + S^N \quad (26)$$

The first constraint, equation (23), is the capital accumulation equation. This indicates that the change in the capital stock is equal to new investment less the depreciated capital stock. Note that δ^R is the economic rate of depreciation, which may differ from the depreciation rate allowed under the tax code. Equation (24) gives the change in the value of debt outstanding. It is equal to new debt issues less the decrease in the value of outstanding debt due to inflation, π . The third constraint, equation (25), indicates that the change in value of shares outstanding is equal to the value of new share issues. The final constraint insures that investment expenditures will be equal to the value of new debt plus new shares.

The maximization problem of the firm can be solved by applying Pontryagin's maximum principle. I set up a current-value Hamiltonian and introduce three multipliers, λ_1 , λ_2 , and λ_3 , which are interpreted as the shadow prices of capital, shares, and debt respectively. I also introduce a static multiplier, β , to account for the fourth constraint. Because the depreciation allowances on the current capital stock (B_t) are independent of future investment choices, they can be ignored in the firm's maximization problem.

The firm then selects L , M , I , S^N , and B^N to maximize

$$\begin{aligned}
 H = & \left[e^{\int \frac{-r}{(1-c)} du} \right] \left[\{1-\Psi\} \left[\frac{(1-\theta)}{(1-c)} \langle [PF(K, L, M) - WL - P_M M - iD] (1-\tau) + ZP_K I + \rangle - \right. \right. \\
 & + \lambda_1 (I - \delta^R) + \lambda_2 (S^N) + \lambda_3 (B^N - \pi D) \\
 & \left. \left. + \beta \{ (1-ITC) P_K I + (1-\tau) P \phi \left(\frac{I}{K} \right) I - S^N - B^N \} \right] \right].
 \end{aligned}
 \tag{27}$$

Maximization yields the following first-order conditions:

$$\frac{\partial H}{\partial L} : F_L = \frac{W}{P}
 \tag{28}$$

$$\frac{\partial H}{\partial M} : F_M = \frac{P_M}{P}
 \tag{29}$$

$$\frac{\partial H}{\partial B^N} : \lambda_3 = \beta
 \tag{30}$$

$$\frac{\partial H}{\partial I} : \lambda_1 = - (1-\Psi) \frac{(1-\theta)}{(1-c)} ZP_K - \beta \{ (1-ITC) P_K + (1-\tau) P \{ \phi + \left(\frac{I}{K} \right) \phi' \} \}
 \tag{31}$$

$$\begin{aligned} \frac{\partial H}{\partial K} : \lambda_1 = & \lambda_1 \left(\frac{r}{(1-c)} + \delta^R \right) - (1-\Psi) \frac{(1-\theta)}{(1-c)} PF_K (1-\tau) + \\ & - \beta \left\{ (1-\tau) P \left(\frac{I}{K} \right)^2 \phi \right\} \end{aligned} \quad (32)$$

$$\frac{\partial H}{\partial D} : \lambda_3 = \lambda_3 \left(\frac{r}{(1-c)} + \pi \right) - (1-\Psi) \frac{(1-\theta)}{(1-c)} (-i) (1-\tau) + \Psi' \left(\frac{S}{(D+S)^2} \right) X \quad (33)$$

$$\frac{\partial H}{\partial S^N} : \beta = \lambda_2 - (1-\Psi) \quad (34)$$

$$\frac{\partial H}{\partial S} : \lambda_2 = \lambda_2 \left(\frac{r}{(1-c)} \right) + \Psi' \left(\frac{D}{(D+S)^2} \right) X_t \quad (35)$$

In first-order conditions (33) and (35), X_t is equal to current earnings less the book-value of new share issues. First-order conditions (28) and (29) imply that labor and intermediate outputs should be used up to the point where their marginal products equal their respective input prices. Using the first-order conditions for new debt and new shares, one can solve equations (33) and (35) for the value of β , the static multiplier. Equations (33) and (35) can then be combined to achieve the condition

$$\begin{aligned} \Psi' \left(\frac{S}{(D+S)^2} \right) X_t - \Psi' \left(\frac{D}{(D+S)^2} \right) X_t \left\{ 1 - \frac{\pi (1-c)}{r} \right\} = \\ (1-\Psi) \left\{ \frac{r}{(1-c)} + \pi - \frac{(1-\theta)}{(1-c)} (i) (1-\tau) \right\}. \end{aligned} \quad (36)$$

This expression represents the marginal costs and benefits of transferring a dollar of equity to a dollar of debt. The

left-hand side represents the increase in bankruptcy cost. The right-hand side represents the gain from using debt. The first term represents the required after-tax rate of return that would have been paid on a new share. The second term represents the benefits of inflation on debt. During periods of inflation, the real value of outstanding debt decreases. This causes the benefit of using debt to increase. The final term represents the value of the interest payment on the dollar of debt. This expression implies that a firm should select its level of debt such that the marginal increase in leverage costs on the left-hand side of the equation are just equal to the marginal advantages of using debt on the right-hand side of the equation. This equation implies that changes in the personal and corporate tax rates will affect the firm's debt/capital ratios. This effect will be measured empirically in Chapter 3.

Next, I solve for the investment equation of the firm. Note that equation (22), the value of the firm, is homogeneous of degree one in all inputs K , L , M , and I . This is the result of the constant returns to scale production function and the homogeneous adjustment cost function. This implies that the value of the firm minus the value of current depreciation is proportional to the value of the capital stock, or

$$(V_t - B_t) = \gamma P_K K, \quad (37)$$

where γ is the factor of proportionality, or average q . The maximum principle and the definition of the shadow price imply that

$$\frac{\partial V_t}{\partial K_t} = \lambda_{1,t} . \quad (38)$$

Equations (37) and (38) imply that marginal and average q are equivalent.¹⁴ Because average and marginal q are equal in this model, equations (37) and (38) can be combined to yield

$$\lambda_{1,t} = \frac{(V_t - B_t)}{P_K K} . \quad (39)$$

Included in equation (39) is the value of the firm, after taxes, relative to the value of the capital stock. This is known as Tobin's marginal q adjusted for taxes, or what Summers (1981) refers to as "tax-adjusted Q ."

This expression can then be substituted into the first-order condition for investment, along with the value of β derived from equations (34) and (35), to yield an investment equation of the form

In order to specify the investment equation completely, I must specify the adjustment cost function completely. I adopt the adjustment cost function first introduced by Summers (1981). It is assumed that adjustment costs are zero until

¹⁴ In this model, average and marginal q will always be equivalent. However, it is important to note that empirical evidence has shown that marginal and average q often differ in the real world.

$$\left\{ \phi' \left(\frac{I}{K} \right) + \phi \right\} = \left[\frac{1}{(1-\Psi) - \Psi' \left(\frac{D}{(D+S)^2} \right) X_t} \left\{ \frac{V_t - B_t}{P_K K} + (1-\Psi) \frac{(1-\theta)}{(1-c)} Z_t \right. \right. \\ \left. \left. + (-1 + ITC) P_K \right\} \frac{1}{P(1-\tau)} \right] \quad (40)$$

some level of investment and then rise linearly. The adjustment cost function is assumed to be

$$\phi \left(\frac{I}{K} \right) = \frac{\frac{\omega}{2} \left(\left(\frac{I}{K} \right) - \alpha \right)^2}{\frac{I}{K}} \quad (41)$$

Because adjustment costs have been specified, the investment function can be derived by substituting for $\phi(I/K)$ in equation (40). After substituting and rearranging terms, equation (40) reduces to the investment function

$$\frac{I}{K} = \alpha + \frac{1}{\omega} Q, \quad (42)$$

where Q represents the right-hand side of equation (40) and ω and α are estimated adjustment cost parameters. This investment function can then be used to model the response of firms to changes in tax policy. Econometric estimates of the change in a firm's leverage position with respect to changes in personal and corporate tax parameters can also be used to fully specify the value of the firm embedded in the investment function.

The next section examines empirically the implications of the effect of corporate and personal taxation on firms' leverage decisions implied by equation (36).

Chapter 3

THE EFFECT OF PERSONAL AND CORPORATE TAXES ON FIRMS' DEBT/CAPITAL RATIOS

3.1. Empirical Implications of the Bankruptcy Models

Equation (36) implies that changes in the personal and corporate tax rates will affect the benefits that firms receive from the use of leverage. The effects of changes in the tax rates generated from my model do not differ from those that are predicted by expression (1). This can be seen by examining the effects of changes in the personal and corporate tax rates on the benefits of using leverage. Define Γ as the benefits of using leverage. Gamma is equal the right-hand side of equation (36),

$$\Gamma = (1-\Psi) \left\{ \frac{r}{(1-c)} + \pi - \frac{(1-\theta)}{(1-c)} (i) (1-\tau) \right\}. \quad (43)$$

Differentiation of equation (43) with respect to the marginal personal tax rate θ yields¹⁵

$$\frac{\partial(\Gamma)}{\partial(\theta)} = -(1-\Psi) \frac{i \tau}{(1-c)} \quad (44)$$

Equation (44) indicates that an increase in the personal tax rate will decrease in the advantages of using debt. This will result in a decrease in a firm's debt/capital ratio. Both the

¹⁵ This uses the fact that $r = (1-\theta)i + \eta$.

simple bankruptcy model and my model of firm behavior predict that an increase in the capital gains tax rate and the corporate tax rate will result in an increase in the use of leverage. It may appear that the construction of my model was simply a theoretical excise which could have been avoided, because it reaches the same empirical implications as the simple bankruptcy model. However, although the theoretical predictions of both models are similar, my model provides a framework for the tax policy simulations which are conducted in Chapter 5.

In this chapter, I will examine empirically the role of taxation in the firm's choice of debt/capital ratios.

3.2. Estimation

3.2.1. Model

A fixed-effects model was used to measure the responsiveness of the corporations to changes in the tax rates. The model takes the form:

$$Y_{it} = \beta X_{it} + \lambda_i + \alpha T + \epsilon_{it} . \quad (45)$$

Y_{it} is a measure of the i^{th} firm's debt/capital ratio in year t . X_{it} is a vector containing information on firm sales, corporate and personal tax rates, and a measure of inflation. A time trend, T , is also included. The ϵ_{it} denotes the firm- and year-specific random error. These errors are assumed to

be distributed $\sim N(0, \sigma^2)$. Lambda (λ_i) represents a firm-specific effect that is assumed to be time invariant. This effect allows the estimation to account for the fact that some firms may have consistently high or low debt/capital ratios, over time, due to a firm-specific characteristic.

The fixed-effect model is estimated by differencing each firm's observations around the individual means in the following way:¹⁶

$$\begin{aligned} X^*_{it} &= X_{it} - \bar{X}_i \\ Y^*_{it} &= Y_{it} - \bar{Y}_i \end{aligned} \tag{46}$$

This differencing will remove the fixed effect because it is time invariant. The resulting model is then estimated using ordinary least squares. The natural logarithms of all variables are used, with the exception of the time trend, so that the resulting coefficients are in elasticity form.

3.2.2. Data

Estimation was performed on a panel data set consisting of annual data from 1969 to 1988. Firm-specific data were obtained from Standard and Poor's 1989 COMPUSTAT data tape. Information on a firm's outstanding debt as well as its

¹⁶ Note that this differencing is done for all variables, not just the X and Y vectors.

current capital stock and sales was collected. The firms were separated into twelve sectors, according to their Standard Industrial Classification (SIC). The separation into sectors is to control for sector-specific effects. In Table 2, I provide a listing of the sectors, the number of firms in each sector, and the SIC codes for each sector.

The debt variable for each firm includes both long- and short-term debt, and is based on the book value of the company's debt. The value of the current capital stock is equal to the value of outstanding debt, plus equity, plus any minority interest of the firm. Data on annual sales were obtained for each firm, to control for firm size as well as for fluctuations in business activity. Because the sales variable is used to control for firm size, it was adjusted using the Consumer Price Index (CPI), as reported in The Statistical Abstract of the United States. In addition, the annual percentage change in the CPI was included to control for the effects of inflation on debt/capital ratios. During periods of inflation, the real value of a firm's outstanding debt will decrease. If firms are concerned with maintaining a debt/capital ratio in real terms, they may issue more debt during inflationary periods.

Table 3 contains time-series information on the debt/capital ratios of each sector. The data indicate the differences in the use of debt between sectors. The average debt/capital ratios over the sample period range from .29 in the chemical, rubber, and plastics sector, to .52 in the

transportation, communications, and utilities sector. Almost all sectors show growth in the use of leverage during the sample period, especially in the late 1980's. One may note, however, that even given the growth in debt/capital ratios, the variation over time appears limited. Data on corporate tax rates were obtained from Pechman (1987). The top marginal corporate tax rate was used for each year. Unfortunately, this variable shows little variation over the twenty-year period, changing only four times. The statutory rate is the variable of choice. In my model, the statutory rate is the rate which will affect the value of the interest deduction for the firm. Note that, in my model, changes in the depreciation schedules and investment tax credit have no effect on firms' leverage positions. There may be second-order effects, but those effects are not investigated here.

Data on personal marginal tax rates were obtained by updating the series of average marginal tax rates compiled by Barro and Sahasakul (1983). They build a time series of average marginal tax rates weighted by the amount of adjusted

Table 2
Listing of Corporate Sectors Used in Estimation

<u>Sector</u>	<u>SIC Code</u>	<u>Number of Firms</u>
Food and Tobacco (Food)	2000 - 2141	33
Textiles, Apparel, and Leather (Text)	2200 - 2399 & 3100 - 3199	31
Paper and Printing (Paper)	2600 - 2796	46
Petroleum Refining (Refine)	2910 - 2911 & 2992 - 2999	23
Chemicals, Rubber, and Plastics (Chemical)	2800 - 2899 3000 - 3089	71
Lumber, Furniture, Stone, Clay, and Glass (Lumber)	2400 - 2599 & 3200 - 3299	22
Metals, Machinery, Instruments, and Misc. Manufacturing (Metal)	3300 - 3699 & 3800 - 3999	209
Transportation Equipment (Transportation)	3720 - 3799	23
Motor Vehicles (Motor)	3710 - 3716	19
Transportation, Communications, and Utilities (Communications)	4000 - 4971	187
Wholesale and Retail Trade (Trade)	5000 - 5999	81
Services (Services)	7000 - 8999	35
TOTAL:		780

Table 3
Summary of Debt/Capital Ratios by Sector 1969-1988

<u>YEAR</u>	<u>FT</u>	<u>TX</u>	<u>PP</u>	<u>PR</u>	<u>CH</u>	<u>LM</u>	<u>MT</u>	<u>IE</u>	<u>MV</u>	<u>CO</u>	<u>TD</u>	<u>SV</u>	<u>Std. Dev.</u>
1969	.35	.42	.31	.36	.26	.36	.34	.53	.33	.56	.42	.45	.08
1970	.39	.38	.32	.39	.28	.40	.36	.55	.33	.56	.43	.52	.09
1971	.36	.37	.33	.37	.28	.37	.33	.49	.32	.56	.43	.51	.08
1972	.37	.41	.31	.36	.27	.39	.32	.47	.31	.55	.43	.51	.08
1973	.36	.44	.30	.35	.28	.44	.35	.46	.35	.55	.43	.51	.08
1974	.41	.44	.31	.33	.31	.47	.40	.51	.41	.58	.43	.52	.08
1975	.35	.35	.30	.34	.29	.43	.35	.44	.36	.55	.38	.50	.08
1976	.33	.40	.30	.35	.27	.45	.32	.39	.29	.52	.37	.45	.07
1977	.33	.42	.30	.36	.27	.45	.32	.34	.27	.50	.38	.47	.07
1978	.36	.43	.29	.36	.28	.42	.34	.32	.32	.50	.41	.46	.07
1979	.39	.43	.27	.34	.29	.40	.33	.34	.30	.51	.40	.44	.07
1980	.36	.38	.28	.34	.29	.38	.31	.32	.34	.50	.42	.45	.06
1981	.35	.37	.29	.35	.28	.40	.32	.32	.37	.51	.42	.45	.06
1982	.33	.34	.30	.34	.28	.39	.32	.30	.34	.50	.41	.51	.07
1983	.32	.30	.29	.36	.26	.38	.32	.27	.28	.47	.38	.47	.07
1984	.38	.41	.28	.40	.28	.42	.32	.32	.27	.46	.39	.49	.07
1985	.35	.32	.31	.44	.29	.37	.39	.36	.28	.49	.41	.53	.07
1986	.40	.37	.32	.44	.32	.37	.44	.39	.33	.50	.46	.51	.06
1987	.43	.41	.33	.41	.33	.38	.42	.41	.37	.51	.48	.51	.06
1988	.44	.47	.31	.42	.33	.45	.42	.45	.35	.52	.51	.53	.07
Avg:	.36	.39	.30	.37	.29	.41	.42	.40	.34	.52	.42	.49	
Std. Dev.	.03	.04	.02	.03	.02	.03	.04	.08	.04	.03	.03	.03	

KEY:

FT: Food and Tobacco
 TX: Textiles
 PP: Paper and Printing
 MV: Motor Vehicles
 SV: Services
 CO: Communications
 PR: Petroleum Refining
 CH: Chemicals
 LM: Lumber
 MT: Metals Manufacturing
 TD: Trade

gross income of each marginal bracket. They construct tax rates for 1916 through 1980. I extend their data through 1988. Data on the highest marginal tax rate paid by gross income group are obtained from the U.S. Department of Treasury's Statistics of Income Bulletin. The average marginal rate is obtained by using the formula

$$\bar{T} = \sum_{i=1}^{i=n} (AGI_i / AGI) T_i, \quad (47)$$

where the subscript i refers to the adjusted gross income class, AGI_i refers to the adjusted gross income of class i , AGI refers to total adjusted gross income, T_i refers to the highest marginal tax rate paid by that class, and $\bar{T}$ is the average marginal tax rate. This equation corresponds to Barro and Sahasakul's equation (11).

The capital gains tax rate was based on the effective tax rate on capital gains after allowing for the capital gains exclusion. Between 1969 and 1978, the rate was 50% of the personal tax rate, due to the 50% exclusion of capital gains income. Between 1979 and 1986, the rate was 40% of the personal rate because of the 60% exclusion. In 1987 and 1988, the capital gains and personal tax rates were identical. Data on the highest marginal rate paid by adjusted gross income class were not available for 1987 and 1988. These amounts had to be imputed based on the average taxable income of each

adjusted gross income class. The average marginal tax rate was then calculated using equation (47).

3.2.3. Results

The results of the initial regressions are presented in Table 4. They show that, in four of the twelve sectors (metal, communications, transportation equipment, and lumber), the coefficients on the personal income tax rate were significant and negative.

The coefficients on the inflation measure, CPI, ranged from 0.02 to 0.20. They indicate that, during times of inflation, firms slightly increase their debt loads. The trend variable does not indicate any overall trend in the debt/capital ratios, but instead emphasizes the differences between sectors. In the sectors of refining and lumber, there was a positive trend in the debt/capital ratios over the sample period. In the communications and transportation sectors, there was a downward trend in the debt/capital ratios.

The results from the basic model were not overwhelmingly strong. In order to improve my estimates, I attempted a number of different approaches, including correcting for autocorrelation, aggregation, and estimating lag models.

One possible reason for the insignificance of many of the coefficients may be the presence of autocorrelation in the data. In order to test for autocorrelation, the correlation

Table 4
Initial Regression Results
Dependent variable is a firm's debt/capital ratio

Sector	PTR	CTR	CGTR	SALES	CPI	Trend	F-STAT	R ²
Chemical	0.05 (0.16)	-0.57 (0.85)	-0.10 (0.54)	0.09** (1.97)	0.05 (1.17)	0.03 (0.32)	0.63	.02
Textiles	-.19 (0.39)	.44 (0.46)	0.40 (1.52)	-0.01 (0.37)	0.14** (2.26)	-.001 (-0.09)	3.22**	.03
Metal	-.86** (3.86)	.68 (1.57)	.31** (2.66)	.04 (1.67)	.10** (3.43)	.01* (1.88)	11.28**	.03
Communication	-.23** (3.37)	-.05 (.41)	.06* (1.78)	-.02 (1.46)	.02* (1.8)	-.008** (4.49)	24.28**	.11
Trade	.06 (.25)	-.89* (1.78)	-.14 (.97)	.07** (3.50)	-.04 (1.33)	-.01* (1.82)	3.49**	.01
Food & Tobacco	.08 (1.5)	-1.4 (1.37)	-.23 (.84)	.08 (.92)	.07 (1.04)	.002 (.10)	1.89	.04
Refining	.05 (.11)	.88 (1.04)	.06 (.26)	-.34** (5.60)	.09 (1.54)	.03** (2.7)	2.12*	.08
Transportation Equipment	-1.19** (2.17)	-.37 (.34)	.33 (1.12)	.45** (4.56)	-.10 (1.51)	-.05** (3.40)	11.39**	.20
Lumber	-.92** (2.55)	1.5** (2.19)	.48** (2.48)	.08** (2.05)	.15** (3.45)	.02** (2.39)	2.9**	.05
Motor Vehicles	-.174 (1.13)	-.93 (.73)	.05 (.14)	-.33** (3.56)	.20** (2.49)	.02 (1.00)	4.69**	.09
Paper	.48 (1.24)	-1.6** (2.16)	-.38* (1.84)	.38 (6.19)	.08 (1.59)	-.03** (3.03)	1.78	.05
Services	-.48 (1.54)	.11 (.16)	.10 (.51)	-.20** (3.81)	.03 (.72)	-.03** (2.75)	1.80	.05

** indicates significant at 95% level; * indicates significant at 90% level; T-statistics in parentheses. PTR = Marginal tax rate on interest & dividend income; CTR = Corporate tax rate; CGTR = Personal tax rate on capital gains; CPI = Percent change in the Consumer Price Index; Trend = linear time trend; Sales = a firm's annual sales.

factor for each individual firm's residuals was calculated over the sample period. The correlation coefficients were calculated as

$$\hat{\rho}_i = \frac{\sum_{t=2}^{t=20} e_{i,t} e_{i,t-1}}{\sum_{t=1}^{t=20} e_{i,t} e_{i,t}} * (20/19) \quad (48)$$

for each firm. Table 5 presents the average ρ for each sector. The estimates of the ρ 's ranged from .47 to .60. The estimated ρ 's were then used to transform the individual firm data in the following manner:¹⁷

$$Y_{it} - \hat{\rho}_i Y_{i,t-1} = X_{it} - \hat{\rho}_i X_{i,t-1}. \quad (49)$$

The subscript i refers to the individual firm.

Regressions were then run on the transformed data set, which now contains only 19 observations for each firm. The results of the regressions, after correcting for autocorrelation, are reported in Table 6. After correcting for autocorrelation, the personal tax rate was still significantly negative in the same four sectors (metal, communications, transportation, and lumber). Correcting for autocorrelation also added one more significant estimate to the corporate tax rate. The metal sector's coefficient

¹⁷ Again, this transformation is performed on all of the data, and not just the X and Y vectors.

estimate is now significant, demonstrating an elasticity of 0.73. The autocorrelation correction also reduced the magnitude of the elasticity in the lumber sector from 1.5 to 1.02.

The results for the capital gains tax rate are interesting. The capital gains tax no longer demonstrates a significant effect on the debt/capital ratio of the communications sector. It does, however, have a significant effect on the textile sector. F-tests on the vectors of tax rates indicate that only four of the sectors' debt/capital ratios are affected by the tax rates as a vector. This is a reduction of four sectors from the initial results. This is due to some of the explanatory power of the autocorrelation initially being attributed to the tax rates. The autocorrelation correction removes this.

The strong results for the metal sector, the largest sector in terms of observations, may indicate that, by examining a more aggregated view of the economy, one may get more significant results. I aggregated the 12 sectors on which the results have already been reported into six sectors: Transportation and Communications, Paper and Wood Products, Non-manufacturing, Metals and Fabrication, Chemical and Refining, and Household Products. Regressions were run with and without correcting for autocorrelation. Aggregation

Table 5
Average Autocorrelation Coefficients by Sector

<u>Sector</u>	<u>Average ρ</u>	<u>Standard Deviation</u>
Food and Tobacco	.56	.19
Textiles, Apparel, and Leather	.49	.83
Paper and Printing	.60	.18
Petroleum Refining	.55	.22
Chemicals, Rubber, and Plastics	.58	.23
Lumber, Furniture, Stone, Clay, and Glass	.48	.24
Metals, Machinery, Instruments, and Misc. Manufacturing	.56	.22
Transportation Equipment	.57	.12
Motor Vehicles	.47	.23
Transportation, Communications, and Utilities	.55	.22
Wholesale and Retail Trade	.57	.23
Services	.50	.21

Table 6
Regression Results After Correcting for Autocorrelation
Dependent variable is a firm's debt/capital ratio

Sector	PTR	CTR	CGTR	SALES	CPI	Trend	F-STAT	R ²
Chemical	-.10 (.48)	.29 (.64)	.048 (.36)	.097 (1.53)	.056* (1.88)	.006 (.83)	.957	.01
Textiles	-.38 (.96)	.89 (1.04)	.45* (1.80)	-.02 (.82)	.13 (2.46)	.012 (1.06)	2.23*	.03
Metal	-.72** (4.50)	.73** (2.10)	.011 (2.19)	.23** (.48)	.12** (5.53)	.015** (3.15)	8.36**	.03
Communication	-.11** (2.17)	-.07 (.61)	.01 (.30)	-.05** (3.37)	.025** (3.67)	-.004** (2.33)	6.39**	.03
Trade	-.18 (1.04)	.07 (.17)	.08 (.72)	.06** (3.47)	-.001 (.053)	.004 (.73)	1.23	.01
Food & Tobacco	.15 (.46)	-.94 (1.35)	-.19 (.95)	.24** (2.39)	.07* (1.73)	.008 (.83)	1.07	.05
Refining	-.06 (.19)	.93 (1.29)	.10 (.48)	-.31** (4.14)	.08 (1.51)	.02** (2.35)	1.86	.05
Transportation Equipment	-.71* (1.70)	-.45 (.50)	.10 (.37)	.43** (3.34)	-.02 (.29)	-.04** (2.73)	4.59**	.06
Lumber	-.63** (2.22)	1.02* (1.66)	.35* (1.95)	.23 (4.28)	.10** (2.68)	.006 (.71)	1.95	.08
Motor Vehicles	-.34 (.65)	-1.01 (.89)	-.45 (.44)	-.19* (1.65)	.19** (2.67)	.01 (.81)	1.96	.05
Paper	.30 (1.27)	-.92* (1.77)	-.18 (1.16)	.24** (3.67)	-.05 (1.43)	-.02** (2.75)	1.67	.02
Services	-.43 (.96)	.29 (.34)	.07 (.30)	.28** (7.36)	-.02 (.36)	-.02* (1.92)	1.19	.08

** Indicates significant at 95% level; * Indicates significant at 90% level; T-statistics in parentheses. PTR = Marginal tax rate on interest & dividend income; CTR = Corporate Tax Rate; CGTR = Personal tax rate on capital gains; CPI = percent change in the Consumer Price Index; Trend = linear time trend; Sales = a firm's annual sales.

resulted in less significant coefficient estimates. In addition, only two of the F-statistics on the vector of tax rates were significant at the 90% level. These results indicate that controlling for sectoral differences is important.

In addition to the correction for autocorrelation and aggregation, one- and two-period lag models were estimated for every sector. These lag models were constructed as

$$Y_{it} = \beta_1 X_{it} + \beta_2 X_{i,t-1} + \alpha_1 T + v_{it} \quad (50)$$

for a one-period lag. Construction of the two-period lag model was similar. The results of these regressions indicate that current values of the tax rates have a larger impact on corporate debt/capital ratios than lagged values. This result is consistent with earlier work by Auerbach (1985).

Auerbach uses a panel data set on 200 corporations, covering 1958-1977, to examine the speed of adjustment of corporate leverage to changes in the corporate tax system. A partial adjustment model is used to measure the impact of changes in depreciation allowances on structures and equipment, as well as variance and growth rates of earnings on short- and long-term debt. Auerbach finds that firms are very quick to adjust their debt load as changes in the tax structure occur. Because Auerbach is more concerned with the speed of adjustment than with the magnitude of change, his results are not directly comparable to mine. Auerbach also

examines the effect of net loss carryforwards on corporate debt policy. A firm which has a large carryforward may be exempt from the corporate income tax. This may reduce the incentive for a firm to use debt as a way to reduce its tax liability, because the use of debt has no impact on a firm's current taxable income, which is already zero. He finds that the existence of net loss carryforwards does reduce a firm's use of leverage.

In order to account for this finding in my model, the data set was reduced by eliminating all firms which possessed a net loss carryforward during the sample period. This reduced the sample size significantly to 482 firms. A new set of regressions was run with these data. The results did not differ substantially from the original regressions. The signs and magnitudes of the coefficients in each sector were very close to their values before adjusting for net loss carryforwards. Therefore, these results are not presented here.

3.3. Conclusions

The attempts at estimating the impact of changes in tax rates on debt/capital ratios have shown that firms do not exhibit a large deal of sensitivity to changes in statutory tax rates. The most encouraging result is that the strongest results in terms of significance and magnitude come from the

largest sector, the metal sector with 209 firms. The F-tests indicate that the interaction of the personal and corporate tax rates do affect the debt/capital ratios of the firms in those sectors. The results also appear to point out the need for further research in the area of empirical estimation of the effects of taxation on corporate leverage decisions. The results from this section may be used as base case parameter estimates in the simulation model. Sensitivity analysis can then be used to examine the effects of changes in firm behavior on the tax integration proposals.

Chapter 4

DESCRIPTION OF THE SIMULATION MODEL

4.1. Introduction

The purpose of this section is to describe the CGE model which is used to simulate the effects of corporate tax integration in a dynamic framework. This model is a modified version of the CGE model described in Ballard, Fullerton, Shoven and Whalley (1985). It incorporates features of my model of firm financial behavior, described in Chapter 2, and also the empirical results of Chapter 3. Because my model does not focus on the inter-generational effects of corporate tax integration, I choose to use an infinite-horizon model of consumer behavior, rather than an overlapping generations model. A model incorporating infinite-horizon consumer behavior is described in Ballard and Goulder (1985) and Ballard (1990).

4.2. The Consumer's Problem

The consumer in the model strives to maximize lifetime utility. The consumer is assumed to have an additively-separable lifetime utility function of the form:

$$\tilde{U} = \sum_{t=1}^{\infty} \frac{1}{(1+\rho)^{t-1}} U_t(C_t), \quad (51)$$

where ρ is the subjective rate of time preference and C_t is consumption in time t .

An isoelastic utility function is chosen in order to insure tractability. The consumer's instantaneous utility can be represented as

$$U_t = \frac{(C_t - C_t^*)^{1-\delta}}{1-\delta}, \quad \delta \neq 1 \quad (52)$$

$$U_t = \ln(C_t - C_t^*), \quad \delta = 1,$$

where δ is the inverse of the elasticity of substitution between consumption in adjacent periods. Consumers have a minimum amount of required consumption in period t of C_t^* . The existence of a minimum required level of consumption may reduce the excessive intertemporal sensitivity that sometimes characterizes models of this type. See Starrett (1982).

Combining equation (51) and equation (52) yields the consumer's lifetime utility function:

$$\tilde{U} = \sum_{t=1}^{\infty} \frac{1}{(1+\rho)^{t-1}} \frac{(C_t - C_t^*)^{1-\delta}}{1-\delta}. \quad (53)$$

It is important to note that ρ is assumed to be constant. This assumption is necessary in order to make the consumer's behavior dynamically consistent in the sense of Strotz (1955).

The consumer maximizes his lifetime utility subject to a budget constraint, which insures that the present value of lifetime consumption is less than or equal to the present value of lifetime wealth. The consumer's lifetime budget constraint is given by

$$\sum_{t=1}^{\infty} \frac{p_t C_t}{\prod_{s=1}^t (1+r_s)} \leq W_1 + \sum_{t=1}^{\infty} \frac{w_t H_t + Y_t}{\prod_{s=1}^t (1+r_s)}, \quad (54)$$

where p_t is the price of consumption in period t , r_s is the rate of return in period s , W_1 is the value of initial capital, w_t is the wage in period t , H_t is the hours of labor supplied in period t , and Y_t is the value of transfers received in period t ¹⁸. Note that there are no borrowing constraints in this model.

H_t is specified exogenously for each period. It is specified to grow at a constant rate ξ . This rate accounts

¹⁸ The wealth of physical capital in this model differs from that used in earlier versions of the GEMTAP model. The capital the consumer owns is financial capital. The consumer is assumed to hold both corporate debt and equity. Because the after-tax rate of return is equivalent on both instruments, for a given set of taxes, the consumer demonstrates no preference for either. This allows firms to adjust their debt/capital ratios freely in response to changes in the structure of the tax system.

for both population growth as well as productivity growth, because labor is specified in efficiency units.

The model of consumer behavior will be well behaved as long as $\xi < r$, the rate of return which prevails in the long run. If this were not the case, the present value of wealth would be infinite, and there would be no effective constraint on lifetime consumption.

A Langrangean can be formed from equations (53) and (54) with C_t as the choice variable. The Langrangean yields the following first-order condition for consumption:

$$\frac{\partial L}{\partial C_t} : \frac{1}{(1+\rho)^{t-1}} (C_t - C^*_t)^{-\delta} = \frac{\lambda P_t}{\prod_{s=1}^t (1+r_s)} . \quad (55)$$

This marginal condition is rearranged as follows:

$$(C_t - C^*_t)^{-\delta} = \frac{\lambda P_t (1+\rho)^{t-1}}{\prod_{s=1}^t (1+r_s)} . \quad (56)$$

One can then examine the relationship between consumption in any two adjacent periods:

$$\frac{(C_t - C^*_t)}{(C_{t-1} - C^*_{t-1})} = \left[\frac{P_{t-1}}{P_t} \frac{(1+r_t)}{(1+\rho)} \right]^{\frac{1}{\delta}} . \quad (57)$$

Equation (57) can be solved recursively to yield an equation of motion for discretionary consumption. This is

$$(C_t - C_t^*) = (C_1 - C_1^*) \Omega_t^{\frac{1}{\theta}}, \quad (58)$$

where

$$\Omega_t = \frac{P_1}{P_t} \frac{\prod_{s=1}^t (1+r_s)}{(1+\rho)^{t-1}}. \quad (59)$$

Discretionary consumption in period one can be found by substituting the equation of motion into the lifetime budget constraint. This substitution yields:

$$C_1 - C_1^* = \frac{\sum_{t=1}^{\infty} \left[(w_t H_t^* + Y_t - p_t C_t^*) \prod_{s=1}^t (1+r_s)^{-1} \right] + W_1}{\alpha^{-1} \sum_{t=1}^{\infty} \left[p_t \Omega_t^{\frac{1}{\theta}} \prod_{s=1}^t (1+r_s)^{-1} \right]} \quad (60)$$

Equation (60) can then be used to solve for consumption in period one, as well as consumption in future periods, given the time paths for the price of consumption, the wage rate, the endowments, and the rate of return.

4.3. Producer's Problem

This section describes the incorporation of the essential features of the model of firm investment and financial behavior described in Chapter 2. This model has nine distinct production sectors which are constructed as aggregates of the

original nineteen sectors of the GEMTAP model described in BSWF (1985). The aggregation is done using the capital stocks of the sectors as weights. Table 7 lists the production sectors and the GEMTAP components used in their construction.¹⁹

The production sectors are classified as corporate, noncorporate, or owner-occupied housing, for the purposes of tax treatment. This classification makes it very easy to follow the flow of capital between corporate and noncorporate sectors. This model does not examine the effects of sectors containing both corporate and noncorporate firms.²⁰ The production sectors, with the exception of the owner-occupied housing sector, are classified as corporate or noncorporate based on the proportion of the total capital stock within each sector that is held by corporate and noncorporate entities. Sectors where less than 68 percent of the capital stock was incorporated were placed in the noncorporate sector. Although 68 percent is a large cutoff, it was chosen to insure that

¹⁹ The ninth production sector in this model is government enterprises. This sector functions exactly as it does in the earlier versions of the GEMTAP model. For this reason, it is excluded from the description of the production sector.

²⁰ The interaction of corporate and noncorporate firms within the same sector has been investigated by Gravelle and Kotlikoff(1989). They find that taking into account the existence of corporate and noncorporate capital in the same sector is important. As noted earlier, their results may be due to aggregation bias, or other factors besides the existence of both corporate and noncorporate capital within the same sector.

there would be several production sectors which were classified as noncorporate. The implication of reducing the required percentage of noncorporate capital is explored as part of the sensitivity analysis. Data on the breakdown between the corporate and noncorporate capital within each sector were obtained from Fullerton and Henderson (1987). Table 8 presents data on the capital stocks and the division between corporate and noncorporate ownership.

Production in each sector is specified by a constant elasticity of substitution value-added function of the form:

$$VA = \phi \left[\mu L^{\frac{\sigma-1}{\sigma}} + (1-\mu) K^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad (61)$$

where ϕ and μ are sector-specific production parameters and σ is the elasticity of substitution between labor and capital. Each production sector produces a single output under constant-returns-to-scale technology. Producers face gross-of-tax input prices of P_L^* and P_K^* . Each firm minimizes input between the corporate and noncorporate capital within each sector were obtained from Fullerton and Henderson (1987). Table 8 presents data on the capital stocks and the division between corporate and noncorporate ownership.

Production in each sector is specified by a constant elasticity of substitution value-added function of the form:

$$VA = \phi \left[\mu L^{\frac{\sigma-1}{\sigma}} + (1-\mu) K^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad (62)$$

TABLE 7

PRODUCTION SECTORS USED IN THE SIMULATION MODEL

<u>PRODUCTION SECTORS</u>	<u>GEMTAP COMPONENTS</u>
PRIMARY	(1) Agriculture, Forestry, and Fisheries (2) Mining (3) Crude, Petroleum, and Gas
CONSTRUCTION	(4) Construction
NONDURABLES	(5) Food and Tobacco (6) Textiles, Apparel, and Leather (7) Paper and Printing (8) Petroleum Refining (9) Chemicals and Rubber
DURABLES	(10) Lumber, Furniture, Stone, Clay, and Glass (11) Metals and Machinery (12) Transportation Equipment (13) Motor Vehicles
TRANSPORTATION, COMMUNICATION, AND UTILITIES	(14) Transportation, Communication, and Utilities
TRADE	(15) Wholesale and Retail Trade
OWNER-OCCUPIED HOUSING	(16) Real Estate (17) Finance and Insurance
SERVICES	(18) Services
GOVERNMENT ENTERPRISES	(19) Government Enterprises

where ϕ and μ are sector-specific production parameters and σ is the elasticity of substitution between labor and capital. Each production sector produces a single output under constant-returns-to-scale technology. Producers face gross-of-tax input prices of P_L^* and P_K^* . Each firm minimizes input costs per unit of output subject to the value-added constraint.

A Lagrangean can be set up with K and L as the choice variables.

$$\mathcal{L} = P_K^* K + P_L^* L + \lambda [\phi (\mu L^{\frac{\sigma-1}{\sigma}} + (1-\mu) K^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}} - 1] \quad (63)$$

TABLE 8

Breakdown of Capital Stock Classification by Sector

INDUSTRY	CORPORATE	NONCORPORATE	HOUSING	TOTAL	PERCENT CORPORATE
Primary	\$88,274.80	\$444,606.10	0.00	\$532,880.90	16.57
Construction	13,410.74	6,458.87	0.00	19,869.61	67.49
Nondurables	158,272.50	2,843.17	0.00	161,115.60	98.24
Durables	199,882.40	3,485.08	0.00	203,367.50	98.29
Transportation, Communication, & Utilities	315,647.60	24,586.53	0.00	340,234.10	92.77
Trade	132,785.80	32,384.05	0.00	165,169.90	80.39
Owner-Occupied	0.00	0.00	1,660,132.00	1,660,132.00	N/A
Services	66,412.73	45,275.36		111,688.10	59.46
	*****	*****	*****	*****	*****
TOTALS	974,686.57	559,639.16	1,660,132.00	3,194,457.73	

* All figures in millions of dollars

The Lagrangean yields the following first-order conditions for labor and capital:

$$\frac{\partial \mathcal{L}}{\partial K} P_K^* = -\lambda \phi (1-\mu) \left[\mu L^{\frac{\sigma-1}{\sigma}} + (1-\mu) K^{\frac{1-\sigma}{\sigma}} \right] \frac{\sigma}{1-\sigma} K^{\frac{-1}{\sigma}} \quad (64)$$

$$\frac{\partial \mathcal{L}}{\partial L} P_L^* = -\lambda \phi \mu \left[\mu L^{\frac{\sigma-1}{\sigma}} + (1-\mu) K^{\frac{1-\sigma}{\sigma}} \right] \frac{\sigma}{1-\sigma} L^{\frac{-1}{\sigma}} \quad (65)$$

Dividing the first-order conditions yields the following marginal condition:

$$\frac{P_K^*}{P_L^*} = \frac{(1-\mu) K^{\frac{-1}{\sigma}}}{\mu L^{\frac{-1}{\sigma}}} . \quad (66)$$

This condition can be solved for capital or labor and then substituted back into the constraint to yield the following per unit factor demands:

$$D_K = \phi^{-1} \left[\mu \left\{ \frac{(1-\mu)}{\mu} \frac{P_L^*}{P_K^*} \right\}^{1-\sigma} + (1-\mu) \right] \frac{\sigma}{1-\sigma} \quad (67)$$

and

$$D_L = \phi^{-1} \left[(1-\mu) \left\{ \frac{\mu}{(1-\mu)} \frac{P_K^*}{P_L^*} \right\}^{1-\sigma} + \mu \right] \frac{\sigma}{1-\sigma} . \quad (68)$$

The tax treatment of the production sectors is very important. The tax policies that are simulated involve adjustments to both the corporate and individual marginal income tax rates. This model allows a more complete specification of how changes in a marginal tax rate will affect the firm. In earlier versions of the GEMTAP model, the average tax rates on capital were assumed to equal the marginal tax rates on capital.²¹ The tax rate on capital was calculated by taking the total tax revenue attributed to the sector's capital stock as a proportion of the total capital stock in the sector. The advantage of this method is that the use of the average tax rate will yield the correct amount of revenue, i.e., the amount of revenue raised through the use of the average rate will more closely approximate the amount of revenue raised in reality. In my model, the marginal tax rates are used to calculate the average tax rate. When one uses marginal effective tax rates that derive from the statutory rates, the revenue raised will differ from the amount of revenue raised in the actual U.S. economy. The disadvantage of the standard GEMTAP approach is that it does not correctly measure the effect of a tax rate change at the margin.

Many public finance economists have done calculations for "marginal tax rates." Some of the best work has been done by

²¹ An exception is the version GEMTAP used by Fullerton and Henderson (1989).

Jorgenson and Yun (1986) and Fullerton (1984)²². These authors use the cost-of-capital approach, and I adopt that approach for my model. A program for introducing a cost-of-capital formulation based on marginal tax rates was constructed by Fullerton and Henderson (1987,1989). In their model, the effective tax rate on capital (t_K) is calculated as the difference between the pre-tax rate of return on capital (ρ) and post-tax rate of return on capital (s) as a percentage of the pre-tax rate of return.

$$t_K = \frac{\rho - s}{\rho} \quad (69)$$

Their model uses a Hall-Jorgenson (1967) user cost of capital formulation. A firm pays $q(1-k)$ for a new piece of capital, where q is the price of capital, and k represents the investment tax credit. My formulation differs slightly in that firms face adjustment costs of ϕ per unit, which they are able to expense. The after-tax adjustment cost per unit then is $q\phi(1-u)$, where u is the statutory tax rate. The firm receives an annual gross rate of return on that piece of capital of c . This rate of return is reduced annually by δ , the constant exponential rate of depreciation. The firm is required to pay annual property taxes at a rate of w on the value of the piece of capital at any point in time. The return net of depreciation and property tax is then taxed at

²² It is important to note that these calculations abstract from risk.

the statutory tax rate. The firm is able to take a depreciation deduction of δq ; the present value of those deductions is represented by z . The after-tax return on a piece of capital is then discounted at the firm's after-tax discount rate of r . In equilibrium, the net outlay for the piece of capital must exactly match the present value of the return from the capital. This equilibrium condition is represented by equation (69):

$$q(1-k) + q\Phi(1-u) = \int_0^{\infty} (1-u)(c-wq)e^{-\delta t}e^{-rt}dt + uzq. \quad (70)$$

The user cost of capital ρ^c is found by integrating equation (69) and solving for c/q . The user cost of capital is specified as:

$$\rho^c = \frac{r+\delta}{1-u} (1-k-uz) + w - \delta + (\delta+r)\Phi. \quad (71)$$

Fullerton and Henderson use data on 38 different assets in 18 production sectors, with data on both corporate and noncorporate capital in all sectors. They use asset-specific values for δ , k , z , and w . They also use sector-specific discount rates, r . A common value of i , the nominal interest rate, is used in all sectors. In the current version of the GEMTAP model, there is only one capital good. However, in order for my model to partially capture the impact of the differential tax treatment of assets, all assets within a

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sector are aggregated into a single capital good for each sector. These composite assets contain the weighted average tax characteristics of the individual assets within the sector. It is implicitly assumed that the asset weights within a sector remain constant throughout the course of simulations. Table 9 contains a listing of the different types of assets as well as their exponential depreciation rates, investment tax credit rates, and property tax rates.

All assets in this economy are required to provide a net-of-all-tax rate of return (s) of 0.08.²³ If i is the nominal interest rate on a bond, then s would equal $i(1-\theta)$, where θ is the individual's marginal income tax rate. Because s is specified exogenously, it is easy to calculate i as simply s grossed up by one minus the individual's income tax rate or, $i = s/(1-\theta)$. Once the nominal interest rate is known, one can then calculate each sector's requisite discount rate. Each sector's discount rate is a weighted average of the portion of income taxed as interest on debt (deductible from the income base) and the portion taxed as dividends (which is taxed as corporate as well as personal income).

²³ In the standard GEMTAP model the net of tax rate of return is equal to 0.04. However, that model abstracts from depreciation. If the rate of return from capital is not increased, in the presence of depreciation, there would be no positive growth in the capital stock.

TABLE 9
Assets and Their Tax Parameters
(1983)

Asset	Depreciation Rate	Property Taxes	Tax Credit
(1) Furniture and Fixtures	.110	.00768	.10
(2) Fabricated Metal Products	.092	.00768	.10
(3) Engines and Turbines	.079	.00768	.10
(4) Tractors	.163	.00768	.10
(5) Agriculture Machinery	.097	.00768	.10
(6) Construction Machinery	.172	.00768	.10
(7) Mining & Oil Machinery	.165	.00768	.10
(8) Metalworking Machinery	.123	.00768	.10
(9) Special Industry Machinery	.103	.00768	.10
(10) General Industrial Equipment	.123	.00768	.10
(11) Office and Computing Machinery	.273	.00768	.10
(12) Service Industry Machinery	.165	.00768	.10
(13) Electrical Machinery	.118	.00768	.10
(14) Trucks, Busses, & Trailers	.254	.00768	.10
(15) Autos	.333	.00768	.06
(16) Aircraft	.183	.00768	.10
(17) Ships and Boats	.075	.00768	.10
(18) Railroad Equipment	.066	.00768	.10
(19) Instruments	.150	.00768	.10
(20) Other Equipment	.150	.00768	.10
(21) Industrial Buildings	.036	.01126	.00
(22) Commercial Buildings	.025	.01126	.00
(23) Religious Buildings	.019	.01126	.00
(24) Educational Buildings	.019	.01126	.00
(25) Hospital Buildings	.023	.01126	.00
(26) Other Nonfarm Buildings	.045	.01126	.00
(27) Railroads	.018	.01550	.10
(28) Telephone & Telegraph	.033	.01550	.10
(29) Electrical Light & Power	.030	.01550	.10
(30) Gas Facilities	.030	.01550	.10
(31) Other Public Utilities	.045	.01550	.10
(32) Farm Structures	.024	.01126	.00
(33) Mining, Shafts, & Wells	.056	.01126	.00
(34) Other Nonbuilding Facilities	.029	.01126	.00
(35) Residential Facilities	.015	.01837	.00
(36) Inventories	.000	.00768	.00
(37) Nonresidential Land	.000	.00000	.00
(38) Residential Land	.000	.00000	.00

Source: Fullerton and Henderson (1987)

In this model, I assume individual arbitrage. The consumer in this model is assumed to hold debt and equity from all sectors and to arbitrage away any differences in the rates of return. In the corporate sector, the discount rate on debt is simply $i(1-u)$, where u is the corporate income tax rate. The discount rate on dividends is i , because dividend income is not deductible from the corporate income base. In this model, there are no retained earnings, so the entire return is subject to personal taxation. The firm's total discount rate is the weighted average of these two terms:

$$r = [(1-u) * \frac{D}{P_K K} + (1 - \frac{D}{P_K K})] * i. \quad (72)$$

Here u is the marginal corporate income tax rate, $D/P_K K$ is the firm's debt/capital ratio, and i is the nominal interest rate.

The same weighted average calculation is applied to the owner-occupied housing sector and the noncorporate sectors, except that they apply their marginal tax rates of t_h and t_{nc} , respectively.²⁴

In order to calculate the discount rates, it is also necessary to know the debt/capital ratios of each sector. For the corporate sectors and the noncorporate sectors, the base case debt/capital ratios are taken from the empirical estimation of Chapter 3. Information on debt/capital ratios

²⁴ The tax rates in the owner-occupied housing sector and the noncorporate sectors are taken to be a fixed proportion of the marginal tax rate on debt. The factors of proportionality are taken from Fullerton and Henderson (1986).

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from all of the sectors included in Chapter 3 was used. The debt/capital ratios are aggregated down to the final production sectors used in the simulation model, using the GEMTAP capital stocks as weights. For the housing sector, the primary sector, and the construction sector, data on debt/capital ratios are taken from Goulder and Summers (1989). Equation (74) demonstrates the ability of firms to adjust their effective tax rates by adjusting their debt/capital ratios.²⁵

The owner-occupied housing sector, the primary sector, and the construction sector are assumed to maintain constant debt/capital ratios throughout the course of simulations. This is necessary due to lack of empirical information of their financial behavior in response to the tax system. All corporate sectors and the noncorporate service sector are assumed to adjust their debt/capital ratios in response to changes in the corporate and personal tax rates. The effect of differing tax changes is simulated using the empirical elasticities from Chapter 3. Sensitivity analysis is used to examine the impact of differing degrees of responsiveness of debt/capital ratios in response to changes in personal and corporate tax rates.

²⁵ Note that equation (68) points out that a firm could alter its effective tax rate by adjusting its mix of assets and taking advantage of the differential tax treatment of assets. The incorporation of such behavior is, however, beyond the scope of this paper.

Once the discount rate is calculated, one uses equations (69) and (70) to solve for the effective tax rate on capital in each sector.

4.4. The Government Sector

In addition to the consumers and the production sectors, the model includes a government sector. The government collects taxes on labor, capital, outputs, income, and consumer purchases. The government uses its revenue to purchase goods, to make transfer payments to consumers, and to subsidize government enterprises. Government enterprises is modeled as a separate production sector. In this model, the government is constrained to maintain a balanced budget in every period. This model does not allow for governmental borrowing. Some other models have allowed for the use of government debt, for example, Auerbach and Kotlikoff (1987). The level of governmental transfers is held constant, in real terms, during simulations through the use of a Laspeyres price index. Governmental exhaustive expenditures are held constant, in real terms, by using the expenditure function from a Cobb-Douglas utility function. In both the base case and revised case, government expenditures and government receipts will grow at the exogenously specified rate of growth, ξ . The revised case simulations involve changes in both the individual as well as production sector tax rates. In order to maintain government budget balance, tax revenue

must also remain constant. If a tax policy results in a decrease in tax revenue from one source (corporate income taxes for example), another source of revenue (consumers' marginal tax rates for example), must be increased to maintain a balanced budget. The two sources of revenue replacement used in these simulations are the imposition of a lump-sum tax on consumers or an increase in the consumer's marginal income tax rate.

4.5. General Solution to the Model

At the beginning of each period, eleven prices are called out. They are a price of labor (the numeraire), a tax price, and nine prices of capital, one for each production sector. Based on these prices, the consumer selects his level of saving and consumption in that period. The level of consumption and saving are based not only on current prices, but also on his expectations of future prices, which determine his stream of future income as well as future consumption expenditures. In this model, the consumer is assumed to operate under myopic expectations. He believes that current prices will hold for all future periods. Ballard (1987), for example, has shown that the structure of expectations does not make much difference for simulations like those undertaken here. However, Auerbach and Kotlikoff (1987) and Judd (1985) suggest that the structure of expectations may be important if

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announcement effects are involved, or if the policy change is only temporary in nature.

An important feature of this model is the ability to transform the input prices of capital and labor into intermediate and final goods prices, based on a fixed-coefficient matrix. This is made possible through the application of the Samuelson Substitution Theorem (1951). Hence, consumers are able to convert factor prices into final consumption prices.

The investment good in this model differs from saving in earlier versions of GEMTAP. In earlier versions of the GEMTAP model, the entire amount of saving was net saving, so that all saving translated directly into additions to the capital stock. In this model, the level of saving accounts not only for net additions to the capital stock, but also for the amount of depreciation in each sector, as well as the adjustment costs of purchasing and installing new capital equipment.

At the same time that the consumer is making his consumption decisions, firms, based on the input prices and tax rates, are selecting their levels of output and demands for labor and capital, as well as their demands for intermediate goods. Firms first examine the marginal tax rates to see if there has been any change from the previous period. If there has been a change, firms in the corporate and noncorporate sectors adjust their debt/capital ratios using the empirically estimated elasticities from Chapter 3.

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Based on the new debt/capital ratio and current prices, firms are able to calculate their effective tax rates. The effective tax rates are then used to calculate their levels of production. The levels of output in each sector are converted into demands for intermediate goods based on a fixed input-output matrix.

The model is solved using a modified version of the tâtonnement algorithm of Kimbell and Harrison (1986). Prices are called out, and excess demands for labor and capital are then evaluated. If there is excess demand in any market, prices are adjusted and the process is repeated. Equilibrium is achieved when the total demand for labor in the economy equals the total supply, and when the total demand for capital in each sector is equal to the total supply of capital in each sector. Also, the government budget must be balanced. Once equilibrium is achieved in a given period, capital stocks and labor endowments are augmented and the process is repeated for the next period.

4.6. Calibration

The base case simulations in this model are calibrated in order to insure a steady-state rate of growth ξ , with unitary prices for all inputs. The growth rate is formed based on the initial level of saving and capital contained in the data set. The assumption of unitary price in the base case is important. It allows one to break down the data, reported in dollar

values, into prices and quantities, and also simplifies the algebra of calibration.

4.6.1. Production Sector

In the base case, the capital stock in each sector is required to grow at the growth rate of ξ . Each sector faces a sector-specific rate of depreciation, as well as an exogenously specified amount of adjustment costs per unit of investment, Φ . This requires that the gross rate of investment must be enough to provide net growth to the capital stock at the steady-state rate. The gross rate of investment then can be specified as

$$\frac{I}{K} = \xi + \delta - \Phi I, \quad (73)$$

where δ is the sector-specific exponential rate of depreciation. Given the initial capital stock in the sector, ξ , and Φ , one can solve equation (72) for I , the gross level of investment.

$$I = \frac{\xi + \delta}{\frac{1}{K} - \Phi} \quad (74)$$

Parameters of the production function must also be calibrated. It is assumed that firms act to minimize cost and that they make zero profits. Using the CES value-added function from equation (62), along with the assumption of cost

minimization, one can use the first-order conditions of equations (63) and (64) to solve for equation (65). Equation (65) can be rearranged to solve for μ :

$$\mu = \frac{P_L^* L^{\frac{1}{\sigma}} / P_K^* K^{\frac{1}{\sigma}}}{1 + P_L^* L^{\frac{1}{\sigma}} / P_K^* K^{\frac{1}{\sigma}}} . \quad (75)$$

In the base case, the net-of-factor-tax prices are required to equal unity. Using this assumption, P_K^* can be rewritten as $(1+t_K)$, and P_L^* can be rewritten as $(1+t_L)$, where t_K and t_L are the tax rates on capital and labor respectively. Equation (74) can then be rewritten as

$$\mu = \frac{(1+t_L) L^{\frac{1}{\sigma}} / (1+t_K) K^{\frac{1}{\sigma}}}{1 + (1+t_L) L^{\frac{1}{\sigma}} / (1+t_K) K^{\frac{1}{\sigma}}} . \quad (76)$$

Information on t_K , t_L , K , and L are contained in the benchmark data set. The elasticity of substitution is specified exogenously. Given μ and σ , one can then use the zero profit assumption to solve for ϕ .

Firms in this model demand not only labor and capital but also intermediate goods from other industries. Thus the zero-profit condition and unitary prices imply:

$$(1+t_L) L + (1+t_K) K + A = \Phi \left[\mu L^{\frac{\sigma-1}{\sigma}} + (1-\mu) K^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} , \quad (77)$$

where A represents the vector of intermediate inputs.
Rearranging yields:

$$\Phi = \frac{(1+t_L)L + (1+t_K)K + A}{[\mu L^{\frac{\sigma-1}{\sigma}} + (1-\mu)K^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}} . \quad (78)$$

4.6.2. Consumption Parameters

The consumption and savings decisions of the consumer must also be calibrated to return the values of consumption and saving contained in the benchmark data set and also provide for steady state growth, with unitary prices.

Recall that equation (60), reproduced below, is used to insure that the consumer's initial level of consumption replicates the benchmark value:

$$C_1 - C_1^* = \frac{\sum_{t=1}^{\infty} \left[(w_t H_t^* + Y_t - p_t C_t^*) \prod_{s=1}^t (1+r_s)^{-1} \right] + W_1}{\sum_{t=1}^{\infty} \left[p_t \Omega_t^{\frac{1}{\delta}} \prod_{s=1}^t (1+r_s)^{-1} \right]} , \quad (79)$$

where

$$\Omega_t = \frac{P_1}{P_t} \frac{\prod_{s=1}^t (1+r_s)}{(1+\rho)^{t-1}} . \quad (80)$$

The first parameter that is calibrated is the consumer's subjective rate of time preference, ρ . The equation of motion (58) implies that, in the steady state

$$\left(\frac{1+\bar{r}}{1+\rho}\right)^{\frac{1}{\delta}} = 1+\xi, \quad (81)$$

where ξ is the steady-state growth rate, $\bar{r}$ is the steady-state rate of return, and δ is the inverse of the elasticity of substitution between consumption in adjacent periods. Values for ξ and $\bar{r}$ can be obtained from the benchmark data set. Rearranging equation (80) yields the base-case value for ρ :

$$\rho = \frac{(1+\bar{r})}{(1+\xi)^{\delta}} - 1. \quad (82)$$

The benchmark value is also given for first-period required consumption (C^*). C^* is chosen at the value used by Ballard and Goulder (1985). Required consumption is set at 80 percent of first period consumption, and δ is equal to 1.005. This is done to reduce the sensitivity of the model to large intertemporal swings in consumption. Sensitivity analysis is performed on the required consumption ratio in order to examine its effects on the welfare gains from changes in tax policy. It is assumed that required consumption, as well as transfers, grow at the steady-state growth rate. Using this fact, one can solve equation (78) for first-period consumption (C_1):

$$C_1 = (H^* + Y_1 - C_1^*) + W_1 \left(\frac{\bar{r} - \theta}{1 + \bar{r}} \right). \quad (83)$$

In the standard GEMTAP model, this equation would return the correct level of base-case consumption and saving. In my model, however, the presence of depreciation and adjustment costs will lower the value of initial wealth and lead to a lower growth rate. The lower growth rate, if one does not adjust initial wealth, will imply a lower level of initial consumption. Using the level of consumption from the base-case data set, and the consumption parameters consistent with the lower rate of growth, one can solve equation (78) to yield the correct level of initial wealth, W_1 :

$$W_1 = (C_1 - C_1^*) \sum_{t=1}^{\infty} \left[p_t \Omega_t^{\frac{1}{\delta}} \prod_{s=1}^t (1 + r_s)^{-1} \right] - \sum_{t=1}^{\infty} \left[(w_t H_t^* + Y_t - p_t C_t^*) \prod_{s=1}^t (1 + r_s)^{-1} \right]. \quad (84)$$

Using the calibrated parameters and data from the base-case data set, one can then run a sequence of equilibria which will be used to compare welfare gains in simulations with changes in tax policy.

4.7. Data

The majority of data in this model comes from Scholz (1987). Scholz builds a data set based on 1983 production, consumption, income, and tax data from various sources. The

information on debt/capital ratios and debt/capital elasticities is taken from the empirical estimation of Chapter 3, and Goulder and Summers (1989). Information on the percentage of corporate capital within each GEMTAP sector, as well as information on depreciation rates, property tax rates, and investment tax credits, comes from Fullerton and Henderson (1984). Table 10 lists base-case data for each production sector. It is important to note that the use of effective tax rates on capital reduces the differences between the taxation of corporate and noncorporate capital. This is an important factor in explaining the relatively small size of some of the welfare gains from the various tax policies simulated in Chapter 5. The small difference in effective tax rates is due to the existence of the inclusion of property tax rates, as well as the different composition of assets among the production sectors.

TABLE 10
BASE-CASE DATA

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
Tax Rate	.52868	.45990	.57479	.56483	.58933	.57545	.42050	.46489
Depreciation Rate	.111778	.091492	.057371	.066195	.105127	.069429	.026754	.09499
Investment Tax Credit	0.077	0.092	0.051	0.069	0.078	0.036	0.011	0.052
Debt/Capital Ratio	0.14	0.17	0.30	0.32	0.47	0.38	0.50	0.47
Capital Stock*	28957	7654	44184	12183	50622	38008	2111666	41827
Adjustment Costs Per Unit	0.112	0.039	0.012	0.003	0.089	0.002	0.019	0.051

Key to sectors:

Sector 1: Primary

Sector 2: Construction

Sector 3: Nondurables

Sector 4: Durables

Sector 5: Transportation, Communication, & Utilities

Sector 6: Trade

Sector 7: Owner-Occupied Housing

Sector 8: Services

*** Capital stocks in millions of dollars.**

Chapter 5

SIMULATIONS

5.1. Introduction

Simulations were run to investigate the effect of three separate tax policies. The first plan was full corporate-tax integration. Under this plan, the marginal corporate tax rate is reduced to zero, and all income is taxed at the personal level. Under full integration, all firms are assumed to accept a zero debt/capital ratio. The bankruptcy theory of corporate finance is based on the premise that the tax advantage of corporate debt is offset by the increased probability of bankruptcy, as a firm's leverage ratio increases. Under full integration, there is no longer any advantage to using debt.

The second plan is a reduction in the corporate tax rate. The statutory corporate tax rate is reduced from .46 to .35. This is similar to the Tax Reform Act of 1986. Under this plan, the value of the interest deduction to firms is decreased, and firms will seek lower debt/capital ratios.

The third plan is a dividend exclusion from the personal income tax. Modeling of this plan involves reducing the required discount rate of firms in the corporate sector. Because dividends are not taxed as personal income, the required pre-tax rate of return on dividends is now equal to

s. The interest rate on debt still remains $i = \frac{s}{(1-t_d)}$. The corporate discount rate then becomes $r = \frac{D}{K} * (1-u) * i + (1 - \frac{D}{K}) * s$.

A dividend deduction from the corporate tax base is not explored. Because firms in this model are assumed to pay out all earnings as dividends, a deduction from the corporate income tax base is the same as full integration.²⁶

Simulations were run with two versions of the model, the nine-sector base model, and a four-sector model. The four-sector model consists of corporate, noncorporate, owner-occupied housing, and government enterprises sectors. Firms from the nine-sector model are placed in each of the four sectors based on their capital stock classification. All simulations are run under the requirement of revenue neutrality.

The effects of changes in tax policy are evaluated by examining a 40 year period, calculating equilibria spaced one year apart. In every simulation, by the end of the forty-year period relative prices are changing very little. This is

²⁶ Bagwell and Shoven (1991) have shown that there has been a decrease in the importance of dividends beginning in the late 1980's. They point to the increase in the use of share repurchases as a way of moving income from the firm to its stockholders. Their empirical evidence seems to call into question the assumption of a 100 percent dividend-payout ratio. To relax the assumption of a 100 percent dividend-payout ratio necessitates the incorporation of retained earnings as a third source of finance. It would also require information on the changes in firms' dividend payout ratios with respect to changes in the corporate and personal income tax systems. Due to the lack of empirical data on firms' payout ratios, the assumption of a 100 percent payout ratio is maintained.

important as it indicates the economy has nearly approached the new steady state. Although equilibria are actually calculated for only forty-years, the welfare evaluations are performed by examining the infinite stream under the assumption that the economy has reached a steady state for all periods after the actual equilibrium simulations.

Evaluation of the gain or loss associated with the change in tax policy is based on examination of the consumer's equivalent variation as a proportion of base-case wealth. The consumer's base-case level of utility is computed from the base-case simulation, and compared to his utility level which arises after the policy change. The consumer's endowment of capital is augmented until the original level of utility is achieved. The gains from the new policy are calculated as a proportion of base-case wealth and by taking the consumer's equivalent variation as a proportion of the discounted stream of base-case Gross National Product. In addition, the welfare gains are measured as a proportion of the capital-tax revenue in the model.²⁷

²⁷ The tax revenue from this model is larger, by almost 22 percent, than the actual revenue generated from capital taxation. Note, that capital taxes in this model include state corporate taxes as well as property taxes. In my model the total tax revenue from capital is \$198 billion, compared to actual capital tax revenue of \$162 billion used in the original GEMTAP model.

5.2. Full Integration Results

Once the full integration plan is implemented, the demand for capital in the corporate sectors increases dramatically due to the lower cost of capital. Because capital in this model is assumed to be sector specific, the prices of capital in the corporate sectors rise above their base-case prices of unity. In the non-durables sector, the price of capital rises to 1.34 in the first period. In other words, it increases 34 percent over its base-case price. The durables sector and transportation, communication, and utilities sector show initial increases in their prices of capital of at least 17 percent. The initial increases in the prices of capital in the corporate sectors are quickly reduced as new investment increases the supply of capital in those sectors. After 10 years, the prices of capital in the nondurables and durables sectors fall below unity. After 40 years, the price of capital in every sector is below unity. This is the result of capital deepening in every sector. The price of capital in the primary sector falls about 3 percent, to .969, in the first period. The prices of capital in the other noncorporate sectors and the owner-occupied housing sector also decrease in the first period, since the demand for capital is reduced.

It is important to note that full integration does not equalize the cost of capital across sectors. This is because sectors still maintain sector-specific depreciation rates, property tax rates, and adjustment costs. The majority of

initial investment takes place first in the corporate sectors. The capital stocks in the owner-occupied housing sector and the noncorporate sectors initially show very little increase, due to the low level of investment in those sectors and the presence of depreciation.

The largest increase in the capital stock, relative to the base case, occurs in the durables sector, where the capital stock increased one and one-half times as much as in the base case. The smallest relative increase in the capital stock of an individual sector occurs in the owner-occupied housing sector, where the capital stock increased about 70 percent as much as in the base case. The increase in the housing sector is large in absolute magnitude, because of the large amount of capital that is initially located in that sector. The majority of the increase in the capital in that sector, however, occurs late in the course of the simulation.

The welfare gains from the full integration plan in the nine-sector model were modest. With income-tax replacement the gains were \$402 billion, in 1983 dollars, which is approximately .98 percent of base-case wealth or .78 percent of base-case GNP. The gains using lump-sum replacement were slightly larger, 1.1 percent of base-case wealth, approximately \$463 billion. The gains as a proportion of capital tax revenue were 15.13 percent under income-tax replacement, and 17.6 percent under the lump-sum replacement. These dynamic welfare gains are smaller than those found in earlier studies. Ballard, Fullerton, Shoven, and Whalley

[BFSW] (1985) find dynamic welfare gains of approximately \$1,064 billion, with lump-sum replacement, and \$648.74 billion, with the income-tax replacement, in 1983 dollars. One reason for the lower dynamic welfare gains is the immobility of capital in my model. Because the gains to integration are unable to be realized right away, their present value falls. In addition, my model has less dispersion among capital tax rates.

Full integration simulations were also run with the four-sector model. The welfare gains were lower, approximately \$369 billion with the income-tax replacement and \$447 billion with a lump-sum replacement. These gains are approximately four to eight percent less than the gains in the nine-sector model. An important reason for this appears to be that adjustment costs play a relatively more important role in the four-sector model than they do in the nine-sector model. This issue is addressed subsequently. In addition, aggregation of the production sectors also reduces the dispersion of capital-tax rates.

A four-sector model employing perfectly-mobile capital was used to examine the effects of the capital-mobility restriction. The welfare gains using perfectly-mobile capital were 1.04 percent of base-case wealth under income-tax replacement and 1.08 percent of base-case wealth under lump-sum replacement, (\$426 billion and \$443 billion). These gains are larger than found when the capital mobility restriction is employed. The gains are not extremely large. The existence of

depreciation in this model lowers the gains from the reallocation of capital. A large portion of the economy's capital stock flows out of the housing sector, where it is depreciated at a relatively low rate and into the corporate sector, where it is depreciated at a higher rate. The higher depreciation rates in the corporate sector lead to a faster depletion of the economy's capital stock, and therefore dampen the welfare gains from full integration.

Fullerton (1983) incorporates industry-specific capital and restricted capital mobility to examine the impact of full integration. In his model, he restricts the ability of old capital to leave a production sector after a change in tax policy. In his most restrictive case, full integration he results in dynamic welfare gains of \$380 billion, in 1983 dollars. These gains are very close to mine. The welfare gains in my model are further reduced, due to the presence of adjustment costs and depreciation. Adjustment costs lower the amount of available capital for net investment into the sectors yielding higher than average rates of return on capital.

Another set of full integration simulations was run using the nine-sector and four-sector models. In this set of simulations, firms were not able to set their debt/capital ratios to zero instantly. Instead, firms were assumed to adjust their debt/capital ratios based only on the estimated elasticities. The welfare gains from this set of simulations were larger, under both types of revenue replacement. In the

nine-sector model, the income-tax replacement simulations led to welfare gains of \$492 billion, about 1.2 percent of base-case wealth. This was an increase of almost 22 percent over the initial full integration results. The welfare gains in these simulations were approximately 18.7 percent of capital tax revenue. With the income-tax replacement, firms are able to continuously adjust their debt/capital ratios, as the income tax rates change. The use of debt allows firms to lower the cost of capital further, as their discount rate will be lower than in the case where there is no debt, and hence, no interest deduction. Because I use the estimated elasticities instead of an explicit bankruptcy-cost function, firms are able to receive the benefits of the interest deduction without an explicit increase in the cost of using debt. The increase in welfare in the nine-sector model, using a lump-sum replacement, was substantially larger, \$603 billion, about 1.5 percent of base-case wealth. This was an increase of almost 30 percent over the original full integration simulations. In this case, firms adjust their debt/capital ratios only once, after the initial reduction in the corporate income tax rate. This type of replacement does not allow firms to respond as fully as the income-tax replacement. However, the lump-sum replacement is a less distorting means of revenue replacement.

The gains in the four-sector model, over the previous four-sector full integration simulations, were not as large as the gains based on the nine-sector model. Using an income-tax

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replacement, the welfare results from full integration increased almost 19 percent to \$439 billion. The gains under a lump-sum replacement showed an increase of less than five percent.

5.3. Reduction of the Corporate Tax Rate

The welfare gains from the reduction in the corporate tax rate were lower than the welfare gains under full integration. This was expected, because, although the rate reduction does lower the cost of capital in the corporate sector, it does not lower it as significantly as would outright elimination of the corporate income tax. In the nine-sector model, the welfare gains were \$340 billion under the lump-sum replacement. These gains were 0.82 percent of base-case wealth, or 0.6 percent of the discounted stream of GNP. The gains were \$242 billion under the income-tax replacement (about 0.58 percent of wealth or 0.42 percent of GNP). The reduction in the corporate tax rate with income-tax replacement provides an interesting case for study. Under income-tax replacement, firms are able to adjust their debt/capital ratios each period. Although the elasticities are small, there is still a slight reduction in the corporate debt/capital ratios in the corporate sectors. In the nondurables sector, the debt/capital ratio decreases from 32 percent to 29 percent, the largest change of any of the sectors. The durables sector shows an increase in its debt/capital ratio due to the presence of a positive

debt/capital elasticity with respect to changes in the personal tax rate.²⁸ The movement in the debt/capital ratios is not enough, however, to make the welfare gains from an income-tax replacement larger than the gains from a lump-sum replacement.

In the four sector model, the debt/capital ratio in the corporate sector falls from 36 percent to approximately 34 percent. The welfare gains in this model were \$311 billion under lump-sum replacement and \$242 billion under income-tax replacement. The price of capital in the corporate sector rises above unity, but it does not increase by as much as it does under full integration.

5.4. Dividend Deduction

This plan yielded welfare gains that were larger than the corporate tax reduction in both the nine-sector model and the four-sector model. In the nine-sector model, welfare gains of \$360 billion and \$307 billion were achieved under lump-sum and income-tax replacement. The movement in the debt/capital ratios was very small (usually less than a one-percentage-point change).

²⁸ Simulations were also run using a negative value (-.07), for the elasticity of the debt/capital ratio in the durables sector, with respect to changes in the personal tax rate. This was the sign predicted by the bankruptcy model. This resulted in very little change in any of the simulation results.

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The movements in the prices of capital among the sectors were less dramatic than under the full integration proposal. The largest initial rise in the price of capital occurred in the trade sector, where the price rose approximately nine percent above its base-case price of unity. The trade sector had the lowest debt/capital ratio of any of the corporate sectors. Dividend relief has a larger impact on this sector because it finances a relatively larger portion of its investment with equity. The price of capital initially decreased in the primary, construction, durables, and owner-occupied housing sectors. The increase in capital stocks was more concentrated in the transportation, communication and utilities sector, where the capital stock increased almost 1.7 times as much as in the base case. The other corporate sectors also experience increases in their capital stocks. However, they were not as large relative to the base-case growth as in the transportation, communication, and utilities sector.

The four-sector model yields somewhat lower welfare gains. Under lump-sum replacement, the gains were \$344 billion. Using income-tax replacement, the gains were \$311 billion. A dividend deduction plan was also modeled by BFSW, and their welfare gains were significantly larger than those found here. Their dynamic gains ranged between \$592 and \$709 billion, in 1983 dollars.

Table 11 presents a summary of the welfare gains from all of the base-case tax policy simulations.

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5.5. Sensitivity Analysis

This section examines the sensitivity of the results to changes in various model parameters, specifically depreciation rates, adjustment costs, debt/capital elasticities, and the classification of corporate and noncorporate sectors. To test the sensitivity of the model to changes in the parameters, the new values of the parameters are used to calibrate a new base-

Table 11

Summary of Initial Simulation Results¹

Policy	Nine-Sector Income-Tax Replacement	Nine-Sector Lump-Sum Replacement	Four-Sector Income-Tax Replacement	Four-Sector Lump-Sum Replacement
Full Integration ²	\$402	\$463	\$369	\$447
Full Integration ³	\$492	\$603	\$439	\$468
Dividend Deduction	\$307	\$360	\$311	\$344
Corporate Tax Rate Reduction	\$242	\$340	\$242	\$311

¹ Welfare gains expressed in billions.

² Under these simulations debt/capital ratios were set equal to zero.

³ Under these simulations debt/capital ratios were not set equal to zero.

case simulation. Revised-case simulations are then run, and their results are evaluated relative to the base case formed under the new model assumptions.

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5.5.1. Adjustment Costs

Adjustment costs prevent or make more costly the flow of capital into a sector. The presence of adjustment costs reduces the welfare gains of the new tax policy. Sensitivity analysis was performed first by doubling the adjustment costs of each sector. A second set of simulation was run with the adjustment costs set equal to zero.

Sensitivity analysis was done comparing the results of full integration simulations to the base-case results of section 5.2. With doubled adjustment cost factors in each sector, the welfare gains were lower. There was a reduction in welfare gains of almost 37 percent under lump-sum replacement and 33 percent using the income-tax replacement. These effects were slightly larger in the four-sector model, with welfare reductions on the order of 43 percent.

The elimination of adjustment costs caused a tremendous increase in the level of welfare in the four-sector model, but not a very dramatic increase in welfare in the nine-sector model. In the four-sector model, the elimination of adjustment costs resulted in welfare gains of between \$637 and \$755 billion dollars (between 1.6 and 1.8 percent of base-case wealth), over one and one-half times the base-case results. The results in the nine-sector model were less dramatic. With lump-sum replacement, there was slight increase, about two percent, in welfare gains. The gain in welfare using an income tax-replacement was almost five percent.

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The reason for this is due to the disaggregation of the corporate sector. The corporate sectors which receive immediate investment in the nine-sector model have less than the average adjustment cost parameter of the corporate sector in the four-sector model. In the four-sector model, the weighted average adjustment cost parameter of all corporate sectors is used. This implies that adjustment costs as a proportion of new investment are higher in the four-sector model than they are in the nine-sector model. Therefore, elimination of the adjustment cost parameters will lead to larger welfare gains in the smaller model. The magnitude of difference, however, still seems quite large, even given the difference in adjustment cost parameters.

These results may be attributable to the fact that adjustment costs in the four-sector model are taken as aggregates of the nine-sector model adjustment-cost parameters, using the capital stocks of each sector as weights. One would like to aggregate adjustment cost parameters using the level of investment in each sector as weights. However, because levels of investment are not known *a priori*, this method of aggregation is not used.

5.5.2. Depreciation

Depreciation of the capital stocks plays an important role in this model. It is through depreciation that there is a reduction in the capital stocks of the sectors with relatively low net rates of return. Because of the assumption

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of immobile sector-specific capital, there is no flow of pre-existing capital between the sectors. The construction of the model limits the sensitivity analysis that can be performed on the depreciation parameters. Sensitivity analysis is performed by examining the effects of eliminating depreciation from the model.

The model shows very little sensitivity to elimination of depreciation. Elimination of the depreciation rates results in slight decreases in welfare in both the nine-sector and four-sector models. The reductions in welfare range from two- to seven percent. The reason for this is that the reduction in depreciation rates has a large effect on the consumer's subjective rate of time preference. This is due to the effect of depreciation on the steady-state growth rate used in the calibration of the subjective rate of time preference. The elimination of depreciation increases the consumer's rate of time preference from about .0001 to almost .048. This increase means that the consumer, in the model with no depreciation, is discounting future utility at a very high rate. Consequently, one does not get as large a change in the consumer's behavior when there are changes in the tax parameters of the models, and the gains that occur late in the model are heavily discounted.

5.5.3 Debt/Capital Elasticities

The primary purpose of this dissertation is to examine the effects of endogenous financial behavior on the welfare

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effects of various corporate tax policies. Sensitivity analysis is done on the base-case debt/capital ratios, and on the elasticity parameters.

The first set of simulations that was run was a full integration simulation assuming that firms hold no debt. With no debt in the model, the welfare gains from integration are increased. The welfare gains, in the nine-sector model, increased by almost 60 percent, under income-tax replacement. Using income-tax replacement, the welfare gains were \$644 billion. These gains are 1.6 percent of base-case wealth, 1.1 percent of GNP, or 15.95 percent of capital-tax revenue. With lump-sum replacement, the welfare gains from full integration were \$897 billion (2.2 percent of wealth, 1.6 percent of GNP, or 21.45 percent of capital-tax revenue). The elimination of debt in this model raises the effective tax rate on capital, because firms are unable to deduct any of their distributions from income. Therefore, all income coming from the corporate sector is taxed twice. This should make the implementation of full integration even more important in reducing the distortion between the return to corporate and noncorporate capital. Partial integration (a reduction in the corporate tax rate) with income-tax replacement, yields gains in welfare that are larger than those in the original set of simulations, but the gains are smaller than under full integration.

The gains in the four-sector model were also large. With no debt in the model, the increase in welfare gains under full integration was almost 35 percent, when income-tax replacement

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was employed. Using lump-sum replacement resulted in welfare gains that were 42 percent larger than those in the original simulations. The gains from the reduction in the corporate tax rate averaged about 14 percent over the original simulations, which are almost identical to the results from the nine-sector model.

A set of simulations was also run with the debt/capital ratios in each of the initial sectors set at twice their original base-case values. In the nine-sector model, welfare gains were reduced by almost 50 percent. Full integration yielded welfare gains of 0.45 percent of base-case wealth, about \$181 billion, using lump-sum replacement. Income tax replacement yielded even lower gains in welfare. The gains from full integration were 0.29 percent of base-case wealth, about \$116 billion.

The four-sector model showed similar reductions in the welfare gains. With the original debt/capital ratios doubled, the welfare gains from full integration decreased almost 62 percent, under both methods of revenue replacement. The reduction in the corporate tax rate resulted in smaller welfare changes. The welfare gains were 42 percent less than in the original model.

These results seem to indicate that the presence of debt, and the proportion of capital that is financed with debt, does play an important role in determining the size of the welfare gains from changes in tax policies. The larger the debt/capital ratios of firms, the smaller is the distortion

between corporate and noncorporate capital, because a smaller amount of income is subject to double taxation.

A final set of simulations was run to examine the impact of changes in the debt/capital elasticities on the size of the welfare gains. The elasticity estimates from Chapter 3 indicate that firms may respond to changes in the personal and corporate tax rates. The size of the responses is small, as none of the estimates is greater than unity. Poterba (1991) provides evidence that firms' financial decisions may be more sensitive to changes in the tax system than my empirical results indicate.²⁹ He points out that the Tax Reform Act of 1986 was projected to increase federal corporate tax revenue, but failed to do so. One of the primary reasons for this was a large increase in the use of corporate leverage. This may indicate more responsive elasticities than were used in the base-case simulations. In order to test the sensitivity of welfare gains to changes in the elasticities, simulations were run involving the dividend-deduction plan, and the lowering of the corporate tax rate. Both plans were run under income-tax replacement.

The elasticities were first increased by a factor of ten. This makes the firms very sensitive to changes in the tax system. Within the first three periods of both simulations,

²⁹ As more data become available regarding information on debt/capital ratios, it would be of interest to investigate if firms have become more responsive to changes in the tax system. A Chow test (Chow (1960)), could be run to see if there has been a change in firm behavior, compared to the data used in my estimation.

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the debt/capital ratios of the firms were driven to zero. The welfare gains under the lowering of the corporate tax rate were smaller than the gains in the central case with the estimated elasticities. Welfare gains, in the nine-sector model, were \$123 billion compared to \$242 billion in the standard model. Under the dividend deduction plan, the gains were also smaller than in the standard model. The welfare gains were \$258 billion, compared to \$307 billion in the original model. These results indicate the importance of correct specification of firms' financial decisions within the context of general equilibrium models. This is even more apparent after examining the welfare gains from the case where the debt/capital elasticities are set to zero. The reduction in the corporate tax rate results in gains of \$335 billion. These are considerably larger than those that emerge under the other two elasticity specifications. The gains under the dividend deduction plan were on the order of \$360 billion. These results appear to indicate that changes in the debt/capital ratios throughout the simulations are important in determining the actual size of welfare gains, and that, if these effects are ignored, the gains may be overstated.

5.5.4. Classification of Corporate and Noncorporate Sectors

The classification of production sectors into corporate and noncorporate sectors was based on the proportion of capital owned by corporate and noncorporate entities. The original rule was, if more than 68 percent of the capital

stock was incorporated, the sector was classified as corporate for tax purposes. This section examines the sensitivity of the nine-sector model to changes in the classification of the corporate and noncorporate sectors. A production sector, in these simulations, was classified as being corporate if 50 percent or more of the capital in that sector was incorporated. This rule leaves only one noncorporate sector, the primary sector. Full integration simulations and simulations based on the Tax Reform Act of 1986 were run on the new model.

A reduction in noncorporate capital in the model resulted in welfare gains. The welfare gains from both full integration and a reduction in the corporate tax rate were smaller, in every case, than found in the original simulations. The full integration simulations resulted in welfare gains of \$307 billion, using lump-sum replacement, a reduction in welfare gains of almost 24 percent. Full integration with income-tax replacement resulted in welfare gains that were lower, by almost 22 percent than the original simulations. These changes are large. As more capital in the model is incorporated, the capital missallocation distortion between sectors is lessened. In addition, the overall distortion from the corporate income tax is reduced. Thus, the gains from removing the distortions are smaller. Also, implementation of both policies results in a greater loss of tax revenue than under the previous classification of corporate and noncorporate capital.

The reduction in the corporate tax rate from 46 percent to 35 percent also resulted in decreased welfare gains, relative to the original simulations. Lump-sum replacement resulted in welfare gains of \$280.5 billion, a decrease of almost \$50 billion from the model with three noncorporate sectors. The use of income-tax replacement resulted in even larger reductions in the welfare gains. The new model provided welfare gains of \$237 billion, a reduction of almost 23 percent over the original model.

These results are important. They show that the classification of corporate and noncorporate capital in the model is important in determining the benefits to changes in corporate tax policy.

5.5.5. Required Consumption Ratio

In order to test the sensitivity of my model to changes in the amount of intertemporal substitution, the level of required consumption was adjusted and the full integration simulations were repeated. In the original simulations, the consumer was required to consume 80 percent of base-case consumption. The 80 percent consumption requirement was chosen in order to reduce the amount of intertemporal substitution and because it was the value used by Ballard and Goulder (1985).

The first set of simulations increases the amount of required consumption to 90 percent of base-case consumption. This greatly restricts the ability of the consumer to increase

his level of saving. With the higher required consumption ratio there was a decrease in welfare from full integration. Using lump-sum replacement, full integration resulted in a decrease in welfare of 0.13 percent of base case wealth, about \$52 billion. This is a drastic decrease from the \$463 billion welfare gain found in the original simulations. The use of an income-tax replacement resulted in even larger welfare losses. The welfare loss from full integration was \$245 billion, about 0.61 percent of base-case wealth. Restricting the consumer's saving decision plays an important role in the simulation results.

Simulations were also run with the required consumption ratio set at 60 percent of base-case consumption, 40 percent of base-case consumption, 20 percent of base-case consumption and with no required consumption. As the required consumption ratio was reduced, the welfare gains from full integration increased substantially.

With the required consumption ratio equal to 0.6, the welfare gains from full integration were 1.9 percent of base-case wealth (\$763 billion), under lump-sum, and 1.7 percent of base-case wealth (\$692 billion), under income tax replacement. These welfare gains are almost 1.7 times as large as the original welfare gains.

With the consumption ratio set at 0.4, the welfare gains were even larger. Full integration resulted in welfare gains of between \$1,280 and \$1,353 billion. These are almost four-fold increases over the original simulations.

Full integration resulted in welfare gains of \$1,990 billion using lump-sum replacement, when the required consumption ratio was 0.2. The gains using an income-tax replacement were also quite large, 4.8 percent of base-case wealth, \$1,930 billion.

A final set of simulations was run with no required consumption. These simulations allow a very high degree of intertemporal substitution. The welfare gains from full integration were very large. The improvement in welfare ranged between 6.4 and 6.6 percent of base-case wealth. These gains are between \$2,573 billion and \$2,654 billion.

This sensitivity analysis underscores the importance of the restriction of the amount of intertemporal substitution in the model. If the consumer is free to save as much or as little as he wants, the welfare gains increase tremendously. This indicates that the intertemporal gains from full integration are very large, and account for a large portion of the welfare gains in the simulations. It also indicates the caution that must be taken in setting the amount of required consumption in the model. The consumer's response to integration is crucial. This is even more apparent if one examines the first-period savings elasticity of the consumer under the different required consumption specifications.

There has been some controversy regarding the relative importance of the static gains and the human-wealth effects resulting from a change in tax policy. In the simulations reported here, there appear to be large dynamic effects. This

is underscored by the changes in the welfare gains under different required consumption specifications. The static gains also appear to be important as can be seen from the sensitivity analysis on corporate and noncorporate classification and comparing the results of the nine-sector and four-sector models.

It is important to note that I am not able to explicitly separate the dynamic from the static gains in the model. However, it appears that in the central case both effects are important.

With a required consumption ratio of 0.8 the consumer exhibits a first-period saving elasticity of 0.77. However, if there is no required consumption in the model, the consumer's first-period saving elasticity increases to 20.9. This seems to indicate that a required consumption ratio of zero results in extreme saving behavior. This is one reason I chose to set the required consumption ratio equal to 0.8.

5.6. Comparison with Other Studies

There are a number of other studies which have examined changes in tax policy in a general equilibrium setting. Galper, Lucke, and Toder (1988) examine the impact of the Tax Reform Act of 1986, using a model with endogenous financial behavior. They find static welfare gains of approximately

\$11.87 billion, in 1983 dollars.³⁰ Their model has a number of income classes, and they find that the welfare gains accrue to individuals mostly in the upper income tax brackets. The Tax Reform Act of 1986 is similar to my simulation of the reduction in the corporate tax rate.

Fullerton and Gordon (1983) examine full integration in a model featuring endogenous financial behavior. Their model is based on the bankruptcy theory. They find essentially no welfare gains from full integration. The reason for this is that their model focuses on the income risk of firm ownership. As noted earlier, Bulow and Summers (1984) point out that income risk is very small relative to capital risk. Given this fact, their results appear to be extreme in nature.

Jorgenson and Yun (1990) use an econometrically based general equilibrium model to measure the welfare gains of a number of comprehensive federal tax system reforms. Their model has a single production sector composed of corporate, noncorporate and owner-occupied housing components (the same model used in Jorgenson and Yun (1986)). They find welfare gains that are extremely large. They predict dynamic welfare gains from the Tax Reform Act of 1986, of \$1,561.8 billion under lump-sum replacement, and \$1,563.1 billion using income-tax replacement. These are very large welfare gains relative to other studies. One reason for the large gains is that

³⁰ If one were to assume a 4 percent discount rate and the same return over an infinite period, this static gain would correspond to a dynamic gain of approximately \$296 billion.

their model allows for a great deal of intertemporal substitution. My central-case is designed to reduce the amount of intertemporal substitution. The sensitivity analysis indicates that the assumption of no required consumption would result in similarly large welfare gains.

5.7. Conclusion

The results of my simulations point out the importance of a number of things. First, the financial behavior of firms does appear to play an important role in determining the welfare effects of federal tax policy. Second, adjustment costs also appear to be important in determining how large the welfare gains will be, especially when the tax reform leads to a large desire for the flow of capital between sectors. The role of adjustment costs, however, appears to be dampened when the model is disaggregated. Along with adjustment costs, the assumption of sector-specific capital also appears to be very important. Fullerton (1983) also emphasizes this point by showing the reduction in welfare gains, when there is a restriction on the flow of capital between sectors.

The empirical evidence of Chapter 3 indicates that firms do not show a large degree of sensitivity to changes in marginal tax rates. However, the estimation also indicates that in some sectors tax rates do matter. Ignoring the effects of changes in tax rates on corporate leverage

decisions completely may result in an overstatement of welfare gains from changes in tax policy.

The gains from full integration, achieved in this study, are generally smaller than those found in other studies, but still appear to be significant. The sensitivity analysis with respect to the required consumption ratio indicates that it is extremely important in determining the size of the welfare gains, and that if the required consumption ratio is reduced, the welfare gains approach those found in other studies.

Due to the sensitivity of the model to changes in the various parameters the implementation of full integration would appear somewhat unpredictable. Because of the sensitivity of the model, a partial integration solution would appear a more satisfactory result. The fact that this model abstracts from the international sector, and also does not examine the distributional aspects of changes in tax policy is important. However, all forms of integration examined in these simulations appear to be a step in the right direction.

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