

UNIVERSIDADE NOVA DE LISBOA

Faculdade de Economia

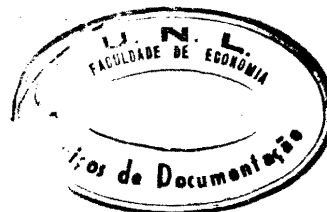
1594

U11-124

"CORPORATE TAX INTEGRATION IN THE UNITED  
STATES: A DYNAMIC GENERAL EQUILIBRIUM  
ANALYSIS"

Alfredo Marvão Pereira

Working Paper Nº 87



UNIVERSIDADE NOVA DE LISBOA

Faculdade de Economia

Travessa Estevão Pinto

1000 LISBOA

Abril, 1988

April, 1988

CORPORATE TAX INTEGRATION IN THE UNITED STATES:  
A DYNAMIC GENERAL EQUILIBRIUM ANALYSIS

Alfredo M. Pereira\*

Department of Economics  
University of California San Diego  
and  
Faculdade de Economia  
Universidade Nova de Lisboa

---

\* I would like to thank Doug Bernheim, Michael Boskin, and especially John Shoven for very helpful comments and suggestions. The implementation of the model in this paper is my joint work with John Karl Scholz.

CORPORATE TAX INTEGRATION IN THE UNITED STATES:  
A DYNAMIC GENERAL EQUILIBRIUM ANALYSIS

by

Alfredo M. Pereira  
Department of Economics, UCSD  
La Jolla, Ca 92093

*Abstract*

This paper analyzes the effects of integrating corporate and personal income taxes using a stylized dynamic general equilibrium model of the United States economy. Simulation results suggest that welfare gains from integration are at best very modest, .17% of the GNP. Also, the average long-run gains are three times as large as the average short-run gains. This intertemporal pattern reflects an adjustment lag in the interindustry investment decisions. Under the Tax Reform Act of 1986, the efficiency gains from integration are much lower than under the previous tax law. This suggests that the change in tax regimes will improve economic efficiency.

## **Corporate Tax Integration in the United States:**

### **A Dynamic General Equilibrium Analysis**

#### **1. Introduction**

The objective of this paper is to study empirically the efficiency and distribution effects of integrating corporate and personal income taxes. It attempts to provide a comprehensive account of both the economic inefficiencies eliminated by integration and the distortions which are created, by focusing on intertemporal investment decisions and optimal allocation of investment across sectors, on intertemporal household consumption/leisure decisions, and on government deficits and financial crowding out.

The corporate income tax has long been criticized for its effects on the economy. First, the corporate income tax introduces a wedge between the rates of return of capital in the corporate and in the non-corporate industries. Thus, the allocation of investment in the economy is distorted in favor of the non-corporate sectors. Second, the existence of differentiated investment tax credits and depreciation allowances creates a wide variety of marginal corporate taxes across industries. Consequently, allocations within the corporate sector are distorted. Third, the special treatment of capital gains distorts the financing of investment by inducing more retained earnings. Fourth, the tax treatment of interest payments distorts the financing of investment by inducing more debt financing. Finally, the corporate income tax represents a 'double' taxation of income at both the personal and corporate levels; corporate earnings are subject to the corporate tax, and the after-tax earnings are either distributed as dividends and taxed at the personal level or retained and potentially taxed as capital gains (See McLure 1979).

The public finance literature often proposes to eliminate or reduce the distortions created by the taxation of corporate income by fully or partially integrating the corporate and the personal

income tax systems. Partial integration includes allowing for dividends paid by corporations to be deducted at either the personal or corporate income levels. This would eliminate the preferential tax treatment of bond financing. In turn, full integration is the complete elimination of the corporate income tax. Full integration is the only way to completely eliminate all the distortions generated by the corporate income tax.

Empirical evidence on the issue of corporate tax integration indicates that integration may have substantial effects. In the path-breaking work of Fullerton-King-Shoven-Whalley (FKSW) (1980, 1981, 1985), total integration was found to yield an annual static efficiency gain of \$4 to \$8 billion of 1973 dollars. Simulated dynamic gains were found to be at least \$300 billion, and could be as large as \$695 billion of 1973 dollars, or about 1.4% of the present value of consumption and leisure in the U.S. economy. Partial integration schemes, in particular, dividend exclusion from the corporate tax base, yield less of a dynamic gain. It is simulated to be between \$58 and \$260 billion of 1973 dollars. Also, corporate tax integration is consistently a Pareto improvement. Corporate tax integration leads to a U-shaped pattern of gains for the different consumer classes, with the lower and higher income groups reaping most of the benefits.

The gains reported by FKSW result primarily from interindustry re-allocations of investment after accounting for the additional distortions in labor-leisure decisions. More recent work in the area of corporate tax integration emphasizes the importance of consumers' asset portfolio decisions and firms' financial decisions in the evaluation of the efficiency gains from integration. Slemrod (1980) focuses on consumers' asset portfolio decisions. In the context of a static model, he finds efficiency gains from full integration which are about twice as large as those reported by FKSW. However, the difference should not be totally attributed to efficiency gains in terms of consumers' asset portfolio decisions. In fact, in Slemrod's model labor supply is exogenously determined. The distortions in the labor-leisure decisions generated by increased marginal personal tax rates which make up for foregone tax revenues, is not captured in his work. In the light of posterior work,

most of the difference in the reported efficiency gains may be induced by exogenous labor supply, rather than endogenous portfolio decisions. Fullerton-Gordon (1983) focuses on firms' financial decisions, in the context of the GEMTAP model (see Ballard-Fullerton-Shoven-Whalley (BFSW) (1985) for a detailed description of this model). Debt-equity ratios are endogenously determined by trading-off the tax preference of debt against bankruptcy costs. Fullerton-Gordon report dynamic efficiency gains of about .6% of the intertemporal GNP from the elimination of the distortions favoring debt financing. However, when they eliminate the corporate tax and replace it with increased personal income tax, additional distortions are created in the optimal labor-leisure decisions. These distortions tend to dominate the analysis such that the overall effects of total integration are very modest, .5% of the intertemporal GNP at the very best, and may even be slightly negative. More recently Galper-Lucke-Toder (1986), in the context of a static model, simultaneously consider consumers' asset portfolio decisions, as in Slemrod's paper, and firms' financial decisions, as in Fullerton-Gordon's. No single efficiency indicator is provided, but exogenous labor supply may bias the results upwards. On the other hand, it is suggested that the way asset return variances are modeled, at both the personal and corporate income levels, has an important impact upon the distribution effects of integration.

The above results, as interesting as they are, may be severely biased upwards. There are several aspects of economic behavior and modeling crucial for the study of income tax integration which have not been captured in the literature. First, all the papers referred to above postulate government yearly balanced budgets. No deficits are allowed to occur. It is true that resource crowding out is still captured in these models, but financial crowding out induced by government spending is not. Therefore, the effects of corporate tax integration upon government deficits are ignored. However, inasmuch as increased government deficits are generated under integration private investment will face less favorable conditions. Secondly, there is no independent investment behavior. Investment is not derived from optimization behavior. In all the papers

referred to above, investment behavior passively accommodates endogenous savings decisions. As a consequence, the differential impacts of policies in the incentives to save and to invest are not captured. Thirdly, full capital mobility across sectors is assumed in all the above papers. Instantaneous and costless adjustments in the capital stock are also assumed. However, full capital mobility and costless adjustments rule out the possibility of different costs of capital across sectors and therefore of differentiated reactions to tax policies changes. Finally, the above models are either static (Slemrod and Galper-Lucke-Toder's) or a dynamic sequence of otherwise static models. However, the modeling of both government deficits and of endogenous real and financial investment decisions necessitates the consideration of a dynamic framework and the introduction of financial assets, namely government bonds and private financial assets. In turn, a dynamic framework highlights the efficiency effects of integration on the optimal intertemporal decisions of the different agents in the economy.

This paper develops a dynamic general equilibrium model of the U.S. economy - DAGEM - to study the efficiency and distribution effects of integrating personal and corporate income taxes. The economy is characterized by an incomplete sequential market structure. Agents face a dynamic environment. Firms maximize the present value of the net cash flow in a technology with adjustment costs to determine endogenously optimal supplies and optimal demands for the different production inputs. In particular, investment decisions are forward looking. Real investment is financed by retained earnings and issuance of new debt and equity according to exogenously defined rules. Government intertemporal behavior is obtained from the maximization of a social welfare function defined over the domain of a public good and subject to an intertemporal budget constraint. The government is allowed to run deficits which are financed by issuing bonds. Optimal household behavior follows a life-cycle type of model generating endogenous savings and labor-leisure decisions. Household asset portfolio decisions merely accommodate to the composition of demand for funds. Economic decisions are formulated in a context of uncertainty about future prices and

interest rates. In each period, expectations are formed as point expectations according to different flexible rules. The concept of Temporary Walrasian Equilibrium (TWE) is adopted to capture the incomplete and sequential aspects of real world trading and the limitations of foresight into the future. All the markets clear, hence the Walrasian nature of equilibrium. Also, equilibrium in the short run is such that market clearing prices are parametric on the expectation formation rules, hence the temporary nature of equilibrium.

Policy evaluations are carried out by contrasting a base case, reflecting the status quo, and several counterfactual, or revised case, equilibria reflecting different policy scenarios. The different equilibria are made comparable by the use of the concept of equal yield generalized to accommodate the existence of government deficits. The information contained in the different equilibria is synthesized in a scalar policy evaluation indicator, Hicksian Equivalent Variations generalized to accommodate intertemporal comparisons when perfect foresight is not assumed and future markets are not open.

Simulation results suggest first, that the net welfare gains from integration are at best very modest and frequently negative. Such a dramatic change in the tax codes, like the complete elimination of the corporate tax and its replacement by increased personal income tax rates, is simulated to yield long-run benefits which are never larger than .17% of the present value of future consumption and leisure. This is between four-times and twelve-times lower than comparable results available in the literature. Secondly, it takes time for the efficiency gains of integration to appear. In particular, the average long run gains are more than three times as large as the average short-run gains. This new intertemporal pattern of efficiency effects reflects an adjustment lag in the interindustry investment decisions due to the existence of costs of adjustment. Thirdly, partial integration, achieved by excluding dividends from the corporate tax base, systematically generates negative effects. This is a new second best effect suggesting that less than complete integration may have perverse efficiency effects. Fourthly, unlike suggested in previous

studies, integration is shown not to be a Pareto improvement action. In terms of the value of current consumption and leisure, the lowest income groups are worse off after the policy implementation. However, all income classes show an increase in wealth accumulation and therefore the potential for welfare gains at some point in the future. Fifthly, under the Tax Reform Act of 1986, the effects of integration show the same patterns and characteristics as under the old tax regime. However, under the new tax law the efficiency gains of integration are much lower. This suggests that the change in tax regimes was in itself efficiency improving. In particular, the efficiency gains from both the new tax treatment of capital gains and depreciation allowances, and the elimination of the investment tax credits dominate the additional distortions generated by an increase in the effective corporate income tax rates. Finally, the expectation formation rules are shown to be of crucial importance for the evaluation of corporate tax integration.

This paper is organized as follows. Section 2 develops the DAGEM model. It discusses the foundations of economic behavior as well as the nature of economic equilibrium and expectations. Section 3 focuses on model implementation issues. Section 4 presents the empirical evidence on corporate tax integration under different policy scenarios. Finally, Section 5 summarizes the results in the paper and provides some concluding remarks.

## 2. The Model<sup>1/</sup>

In this economy there are three types of agents: households; industries; and government. Agents face a dynamic environment. The economic behavior of every agent is derived from an intertemporal specification of its objectives and constraints. Intertemporal transfers of wealth are allowed and economic decisions are forward looking. To make their real and financial decisions at each  $t$ , the economic agents use several types of information. They observe current prices at  $t$ . However, economic decisions are formulated in a context of uncertainty about future prices. The

agents formulate expectations about future prices which are used to determine his intertemporal plans. Intertemporal consistency is not imposed: agents are allowed to commit mistakes due to incorrect expectations. Thus, plans about the future will in general be revised. The actual intertemporal sequence of plans is obtained as the contemporaneous period decisions associated with an intertemporal sequence of optimization problems.

The economy is characterized by a sequential market structure in a finite horizon and discrete time frame. At period  $t$ , the following markets are open:  $J$  consumption goods markets; physical capital good market, labor market; and a financial assets market. There are no future markets at any  $t$ . The concept of Temporary Walrasian Equilibrium, (TWE), is adopted to capture the incomplete and sequential aspects of real world trading and the limitations of foresight into the future which we want to capture in this model. All current markets are assumed to clear, hence the Walrasian nature of equilibrium. Also, equilibrium in the short run is parametric on the expectations of future prices held by the different agents as well as future taxation parameters, hence the temporary nature of equilibrium. Actions of the economic agents are based on expectations which may turn out to be incorrect, i. e. price expectations are not self-fulfilling.

## 2.1 Household behavior

Intertemporal preferences of consumer group  $i$  defined over current and future commodity consumption/labor supply plans are represented by a time separable felicity function of the form:

$$(1) \sum_{z \leq t \leq T} (1 + \partial_i)^{-(t-z)} U_i(L_i^*, L_{it}, y_{i1t}, \dots, y_{iJt})$$

where  $\partial_i$  is the time-invariant, subjective rate of discount for class  $i$ , and  $U_i(\cdot)$  is a well behaved, time-invariant utility function defined over the space of the  $J$  output goods  $y_j$ , and leisure,  $H_{it}$ .

Leisure is given by  $L_i^* - L_{it}$ , where  $L_i^*$  is consumer i's total available time.

The consumer's behavior is constrained by a recursive set of budget constraints relating the intertemporal patterns of income, spending and savings. At  $t$ , consumer group  $i$  receives labor income,  $p_{Lt}L_{it}$ , and lump-sum transfers from the government,  $Tr_{it}$ . Also, consumer  $i$  receives wealth generated income, which includes capital gains:

$$(2) \quad [(1 - \sum_j e_{jt})r_t + \sum_j e_{jt}(\text{Div}_{jt}/p_{jEt-1} E_{jt})]W_{it} + \sum_j [p_{jEt} - p_{jEt-1}]E_{ijt}$$

where  $e_{jt}$  is the share at  $t$  of equity  $j$  in total wealth of individual  $i$ ,  $e_{jt} = p_{jEt-1} E_{ijt}/W_{it}$ , and  $1 - \sum_j e_{jt}$  represents the fraction of public and private debt,  $1 - \sum_j e_{jt} = (\sum_j B_{ijt} + B_{igt})/W_{it}$ .

Labor and wealth income are taxable according to a linear progressive income tax schedule. Lump-sum transfers from the government are considered tax-exempt. Capital gains are taxed at a different rate,  $CGT_{it}$ . Accordingly, disposable income at  $t$  is given by:

$$(3) \quad b_{it} + (1 - T_{it})[p_{Lt}L_{it} + [(1 - \sum_j e_{jt})r_t + \sum_j e_{jt}(\text{Div}_{jt}/p_{jEt-1} E_{jt})]W_{it}] + Tr_{it} \\ + (1 - CGT_{it})\sum_j [p_{jEt} - p_{jEt-1}]E_{ijt}$$

where  $b_{it}$  is negative to reflect the fact that marginal tax rates exceed average tax rates, and  $T_{it}$  is the marginal income tax rate for household group  $i$ .

At each  $t$ ,  $p_{jt}y_{ijt}$  represents pre-tax expenditure of group  $i$  in commodity  $j$ . Purchase of good  $j$  is subject to an ad valorem sales tax. Therefore the total after-tax expenditure of the  $i$ -th group in consumption goods is  $\sum_j (1 + T_{jt})p_{jt}y_{ijt}$ .

Given the information above, the recursive set of budget constraints - the equation of motion for wealth - can for every  $t$  be written as:

$$(4) \quad W_{it+1} - W_{it} = b_{it} + (1 - T_{it})[p_{Lt}L_{it} + [(1 - \sum_j e_{jt})r_t + \sum_j e_{jt}(\text{Div}_{jt}/p_{jEt-1} E_{jt})]W_{it}] +$$

$$+(1 - CGT_{it}) \sum_j [p_{jEt} - p_{jEt-1}] E_{ijt} + Tr_{it} - \sum_j (1 + T_{jt}) p_{jt} y_{ijt}$$

$$(5) \quad W_{iT+1} = 0$$

The terminal constraint on wealth (5) implies that the total present value of current and future expected income receipts has to be equal the present value of current and future expected spending. Savings represent intertemporal transfers of wealth to finance future consumption. Accordingly,  $W_{it+1}$  represents the new total wealth at the end of period  $t$  to be transferred into period  $t+1$  after all expenditures have been incurred. Additional wealth representing the total amount of new funds made available by group  $i$  to the rest of the economy is invested according to criteria detailed below in this section. Savings generated by group  $i$  at  $t$  are given by

$$(6) \quad S_{it} = \sum_j [B_{ij,t+1} - B_{ij,t}] + [B_{igt+1} - B_{igt}] + \sum_j p_{jEt} [E_{ij,t+1} - E_{ij,t}].$$

Formally, at each period  $z$  the economic problem of consumer group  $i$  can be stated as the maximization of the expected value at  $z$  of his felicity function subject to the recursive sequence of budget constraints, to terminal state constraints, and to a sequence of future price expectations.

Such problem can be written as:<sup>2/</sup>

$$(7) \quad \text{Max}_{\{y, L\}} \sum_{z \leq t \leq T} (1 + \rho_i)^{-(t-z)} U_i(L_{it}, y_{i1t}, \dots, y_{iJt})$$

subject to:

i) non-negativity constraint on controls for all  $z \leq t \leq T$

$$(8) \quad y_{ij,t} \geq 0 \text{ for all } 1 \leq j \leq J, \quad 0 \leq L_{it} \leq L_i^*$$

ii) equation of motion of wealth for all  $z \leq t \leq T$

$$(9) \quad W_{it+1} - W_{it} = \sum_j [B_{ij,t+1} - B_{ij,t}] + [B_{igt+1} - B_{igt}] + \sum_j p_{jEt} [E_{ij,t+1} - E_{ij,t}] \\ = b_{it} + (1 - T_{it}) [p_{Lt} L_{it} + [(1 - \sum_j e_{jt}) r_t + \sum_j e_{jt} (\text{Div}_{jt} / p_{jEt-1} E_{jt})] W_{it}] + \\ + (1 - CGT_{it}) \sum_j [p_{jEt} - p_{jEt-1}] E_{ij,t} + Tr_{it} - \sum_j (1 + T_{jt}) p_{jt} y_{ij,t}$$

iii) state terminal conditions for all  $i \leq J+1$  (includes investment good industry)

$$(10) \quad W_{iz} = W_i^* = \sum_j B_{ij}^* + \sum_j p_j E_{z-1} E_{ij}^* + B_{ig}^*$$

$$(11) \quad W_{iT+1} = 0; \quad B_{ijT+1} = 0; \quad B_{igT+1} = 0; \quad p_{j \in T} E_{ijT+1} = 0.$$

## 2.2 Producers' Behavior

Production technology at each  $t$  is represented by a time-invariant Leontieff structure of the form:

$$(12) \quad y_{jt} = \text{Min}\{F_j(L_{jt}, K_{jt}), y_{j1t}/a_{j1}, \dots, y_{jJt}/a_{jJ}\}.$$

The value-added production function,  $VA_{jt} = F_j(L_{jt}, K_{jt})$ , is twice continuously differentiable, strictly increasing in every input, and concave.

We further assume that adjusting capital stock towards its optimal level is not costless. This idea is captured by sector-specific cost functions "à la Gould" (1968), defined over gross capital stock accumulation. The adjustment cost functions can be interpreted to include both acquisition and internal, non-market adjustment costs. The twice continuously differentiable investment cost function for sector  $j$  is:<sup>3/</sup>

$$(13) \quad TC_j(I_{jt}) = p_{1t} [I_{jt} + C_j(I_{jt})],$$

The adjustment cost function has the following properties:

$$(14) \quad C_j(0) = 0, \text{ and } C_j(I_{jt}) > 0 \text{ for } I_{jt} \neq 0$$

$$(15) \quad \partial C_j(I_{jt}) / \partial I_{jt} > 0 \text{ for } I_{jt} > 0, \text{ and } \partial C_j(I_{jt}) / \partial I_{jt} < 0 \text{ for } I_{jt} < 0$$

$$(16) \quad \partial^2 C_j(I_{jt}) / \partial I_{jt}^2 > 0.$$

The evolution of capital stock through time, reflecting actual investment, is given by the

equation of motion:

$$(17) \quad I_{jt} = K_{jt+1} - (1 - \emptyset_{jt})K_{jt}$$

where  $\emptyset_{jt}$  is the depreciation rate of capital stock installed in sector  $j$  at period  $t$ .

The equation of motion of capital reflects the idea that, in the short run, capital stock is fixed, i.e., the capital stock in existence at  $t$  is not a decision variable at  $t$ , but it is determined by optimal decisions in previous periods. However, at  $t$  investment decisions will be made determining the capital stock at  $t+1$ . In the long run, capital stock is variable.

Each sector of production  $j$  faces ad valorem taxes on the use of labor services, which represent the employer's portion of Social Security taxes. Therefore, if  $T_{Lt}$  is the tax rate, assumed constant across sectors of production, the cost for sector  $j$  of one unit of labor is given by  $(1 + T_{Lt})p_{Lt}$ .

As a consequence of its decisions at period  $t$ , the sector realizes gross profits  $\Pi_{jt}$  - payment of capital services plus economic profits, i.e., sales revenues minus non-investment expenditures:

$$(18) \quad \Pi_{jt} = [p_{jt} - \sum_{1 \leq f \leq J} (a_{jf} p_{ft})] y_{jt} - (1 + T_{Lt}) p_{Lt} L_{jt}$$

Each sector  $j$  is subject to an ad valorem corporate tax on  $\Pi_{jt}$ . The after-tax gross profits are  $(1 - T_{cjt})\Pi_{jt}$ , where  $T_{cjt}$  is the sector-specific corporate tax rate at  $t$ .

On the other hand, investment expenditures benefit from an investment tax credit which is an ad valorem subsidy. Actual investment expenditures are  $(1 - ITC_{jt})p_{Lt}[I_{jt} + C_j(I_{jt})]$ .

Interest payments are deductible from the corporate tax base so that the net interest paid on outstanding bonds is  $(1 - T_{cjt})r_t B_{jt}$ .

Also, depreciation allowances  $DA_{jt}$  are to be deducted from the corporate tax base. Let  $\emptyset'_{jt}$  and  $K'_{jt}$  be the depreciation rates for tax purposes and capital stock for tax purposes, respectively.

The after-tax gross profits are increased by  $T_{cjt} \phi'_{jt} K'_{jt}$ .

Industry j's net cash flow at t  $NCF_{jt}$  can be written as:

$$(19) \quad NCF_{jt} = \\ = (1 - T_{cjt}) \{ [p_{jt} - \sum_f (a_{jf} p_{ft})] F_j(K_{jt}, L_{jt}) - (1 + T_{Lt}) p_{Lt} L_{jt} \} - (1 - ITC_{jt}) [p_{jt} l_{jt} + C_j(l_{jt})].$$

The discounted value at t of the intertemporal sequence of net cash flows is obtained from the sequence of current and future expected market rates of return  $r_t$ 's.

The producers' dynamic behavior with respect to real economic variables is determined by the maximization of the present value of net discounted cash flows at each moment z subject to strictly convex adjustment costs, the equation of motion for the capital stock, and future price expectations.

Formally, this is for  $z \leq t \leq T$ ,  $z \leq s \leq t$ ,

$$(20) \quad \text{Max}_{\{y, L, l; K\}} \sum_t [\Pi_s (1 + r_s)^{-1}] NCF_{jt} = \sum_t [\Pi_s (1 + r_s)^{-1}] \\ \{ (1 - T_{cjt}) \{ [p_{jt} - \sum_f (a_{jf} p_{ft})] F_j(K_{jt}, L_{jt}) - (1 + T_{Lt}) p_{Lt} L_{jt} \} - (1 - ITC_{jt}) [p_{jt} l_{jt} + C_j(l_{jt})] \}$$

subject to:

i) non-negativity constraints for all  $z \leq t \leq T$  and  $1 \leq j \leq J$ ,

$$(21) \quad y_{jft} \geq 0, \quad L_{jt} \geq 0, \quad K_{jt} \geq 0;$$

ii) equation of motion of capital stock for all  $z \leq t \leq T$

$$(22) \quad l_{jt} = K_{jt+1} - (1 - \phi_{jt}) K_{jt};$$

iii) state end conditions

$$(23) \quad K_{jz} = K_j^*$$

(24) scrap value of capital at T+1 is zero.

### 2.3 Government Behavior

The government engages in four economic activities. First, it collects taxes according to an exogenously given tax regime. Second, it transfers discretionary lump-sum amounts to the private sector. Third, it purchases consumption goods, capital, and labor to accomplish general government activities through the production of a public good. Finally, since general government activities are constrained by a recursive set of budget constraints, and it is allowed to run yearly deficits, the government is also allowed to engage in the sale of public bonds to finance such imbalances.

The government raises revenue by levying taxes on the private sector. It is assumed that the government knows exactly how to compute the tax revenue it is going to collect at  $t$ . It is as if the government knows the closed form net demands of all the agents in the economy and therefore the tax base. The government can also infer future tax revenues which are relevant for current decisions from future price expectations.

The tax system and tax policies are institutionally given as the outcome of a process not captured by the model. Six classes of taxes are considered in this model as described in the preceding sections. The total revenues they generate at  $t$  are accumulated as follows:

1. ad valorem labor tax on labor services used by the different industries ( $j=i, \dots, J; l$ ) and government, representing Social Security taxes, unemployment insurance, and workmen's compensation and which generates revenue  $LT_t$ :

$$(25) \quad LT_t = (\sum_j T_{Lj} P_{Lj} L_{jt}^D) + T_{Ll} P_{Ll} L_{lt}^D + T_{gl} P_{Ll} L_{gt}^D$$

It should be noted that government is seen as paying taxes to itself on the use of labor. Consequently, the income effects of such a tax cancel out. However, the price effects measure the opportunity cost to government of hiring labor. Notice also that marginal labor tax rates in the private and public sectors are different, reflecting better pension plans for government employees.

2. ad valorem corporate income tax on industry  $j=1, \dots, J, I$  generates revenue  $CT_t$  net of interest deductibility and depreciation allowances:

$$(26) \quad CT_t = \sum_j T_{cj} [(p_{jt} - \sum_f a_{ft} p_{ft}) y_{jt}^S - (1 + T_{Lt}) p_{Lt} L_{jt}^D - r_w t B_{jt} - \phi'_{jt} K'_{jt}].$$

3. ad valorem investment tax credits  $ITC_t$ , on industry  $j=1, \dots, J, I$ ,

$$(27) \quad ITC_t = \sum_j ITC_{jt} p_{jt} [I_{jt} + C_j(I_{jt})].$$

4. ad valorem sales tax generates revenue  $ST_t$ :

$$(28) \quad ST_t = \sum_j [\sum_j T_{jt} p_{jt} y_{ijt}^D];$$

5. a progressive personal income tax represented by a linear function for each  $i$  generates revenue  $IT_t$ :

$$(29) \quad IT_t = \sum_i \{-b_i + T_{it} [p_{Lt} L_{it}^D + [(1 - \sum_j e_{jt}) r_t + \sum_j e_{jt} (Div_{jt}/E_{jt})] W_{it}]\}$$

6. capital gains tax:

$$(30) \quad CGT_t = \sum_i CGT_{it} (p_{jEt} - p_{jEt-1}) E_{ijt} + \sum_j CGT_{jt} (p_{jEt} - p_{jEt-1}) E_{jt}.$$

Accordingly, total taxes collected at time  $t$  are  $TT_t$ :

$$(31) \quad TT_t = LT_t + CT_t + ST_t + IT_t - ITC_t + CGT_t.$$

Total lump-sum redistributive transfer payments, i.e., transfers to households at  $t$  (Social Security, food stamps, AFDC, etc.) are exogenously given and represented by  $Tr_t = \sum_i Tr_{it}$ .

The basic intertemporal consistency requirement imposed on government behavior is that its actions are constrained by an intertemporal balanced budget condition. The discounted sum of all the government expenditures on commodities, labor, and new capital investment cannot exceed the discounted sum of all its revenues, i.e. tax revenues net of transfers. The intertemporally recursive specification of the budget constraint can be written for each  $z \leq T$  in the form:

$$(32) \quad LG_{t+1} = (1+r_t)LG_t + [Tr_t + \sum_j p_{jt} y_{gjt} + (1+T_{gL_t})P_{L_t}L_{g_t} + P_{I_t}I_{g_t}] - TT_t$$

with end conditions

$$(33) \quad LG_2 = LG^*$$

$$(34) \quad LG_{T+1} = 0.$$

Optimal government spending is derived from the maximization of a social welfare function over the domain of an aggregate public good. Such public good is produced using capital, labor, and intermediate inputs according to a well behaved production function. This public good is not subject to market pricing. Accordingly, its production is financed by tax income and other sources of government income. This optimization objective is consistent with our modeling of consumers' behavior in which the public good does not enter the set of budget constraints and is not a decision variable. This is equivalent to having the public good enter additively in time  $t$  to the private utility functions. Thus the marginal rates of substitution between private goods do not depend on the level of availability of the public good. The government is then assumed to act empathetically with the private consumers according to a constrained social utility maximizing problem.

The social welfare function over the domain of the aggregate public good can be expressed indirectly in terms of a well-behaved, time invariant utility function defined at every  $t$  over the  $J$  commodities and labor and capital services:

$$(35) \quad U_g(K_{gt}, L_{gt}, y_{g1t}, \dots, y_{gJt}).$$

The intertemporal government preferences at  $z$  are characterized by an additively separable intertemporal felicity function of the form:

$$(36) \quad \sum_{z \leq t \leq T} (1+\partial_g)^{-(t-z)} U_g(K_{gt}, L_{gt}, y_{g1t}, \dots, y_{gJt})$$

where  $\partial_g$  is the time invariant subjective rate of discount for the government.

The government's optimization problem at each period  $z$  can be formally stated as the

maximization of the expected value of its felicity function subject to the recursive sequence of budget constraints as follows:

$$(37) \text{Max}_{\{y, K, L\}} \{ \sum_{z \leq t \leq T} (1 + \partial_g)^{-(t-z)} U_g(K_{gt}, L_{gt}, y_{g1t}, \dots, y_{gJt}) \}$$

subject to:

i) non-negativity constraints for all  $z \leq t \leq T$ ,

$$(38) y_{gjt} \geq 0 \text{ for all } j=1, \dots, J, L_{gt} \geq 0, K_{gt} \geq 0$$

ii) equation of motion for government liabilities for each  $z \leq t \leq T$ ,

$$(39) LG_{t+1} = (1 + r_t) LG_t + [Tr_t + \sum_j p_{jt} y_{gjt} + (1 + T_{gL_t}) P_{Lt} L_{gt} + P_{lt} l_{gt}] - TT_t$$

iii) end conditions for government liabilities

$$(40) LG_z = LG^* \quad (\text{initial condition})$$

$$(41) LG_{T+1} = 0 \quad (\text{terminal condition})$$

iv) equation of motion for capital stock for all  $z \leq t \leq T$

$$(42) K_{gt+1} = l_{gt} + (1 - \delta_{gt}) K_{gt}$$

v) end conditions for government capital stock

$$(43) K_{gz} = K_g^* \quad (\text{initial condition})$$

(44) scrap value of capital at  $T+1$  is zero.

## 2.4 Financial Markets and Financial Decisions

The DAGEM model considers a whole menu of financial assets, private and public bonds, and firm-specific equity. In terms of equilibrium analysis, consumers typically supply funds and production sectors, and government typically demands funds by issuing equity and private bonds and

public bonds, respectively.

The current interest rate as well as the individual and market availability of funds are endogenously determined by the equilibrium conditions. On the other hand, individual asset portfolio decisions are passive. Also, corporate financial rules and retention policies are either exogenous to the model or follow exogenous reaction rules parametric on the state of crucial variables in the economy.

The non-optimality of the allocation of saving and the absence or exogeneity of corporate financial rules reflect the way uncertainty is treated in the model. Uncertainty is solved by endowing the agents with point expectations about future prices. Under such circumstances, consumers either expect different rates of return (inclusive of risk premium) across assets, in which case they will buy only one asset (that with highest rate), or they expect equal rates of return, in which case they are indifferent about the asset composition of their portfolio. There is no way of trading off rates of return and risks to obtain an optimal interior solution to the problem of the allocation of saving. In the DAGEM all the assets are expected to yield the same after-tax rate of return (eventually corrected by exogenous risk premia), and therefore are perceived as perfect substitutes. Also, the endogenous determination of debt/equity policy parameters by trading off expected bankruptcy costs and the preferential tax treatment of bonds is difficult and problematic in the absence of uncertainty.

Despite the shortcomings of the analysis, the consideration of different financial assets is very important. First, it allow consideration of exogenous debt/equity and dividend/retention corporate financing rules and therefore several sources of corporate investment financing: bonds, equity, and retained earnings. Second, it allows the model to capture the fact that different assets are treated differently by the tax code both at the personal and corporate income levels.

Let us address now the financial decisions of consumers. Wealth  $W_{it+1}$ , representing the total

amount of funds made available by consumer group  $i$  to the rest of the economy, is to be invested. There is a menu of assets in which savings  $F_{it}^S$  can be invested: private bonds, equity, and government bonds.

$$(45) F_{it}^S = \Delta B_{igt} + \sum_j \Delta B_{jgt} + p_{jt} E_t [E_{ijt+1} - E_{ijt}]$$

The  $2J+3$  financial assets are perceived by consumers as perfect substitutes, because all the assets are expected to yield the same after-tax rate of return. Accordingly, the asset composition of the portfolio is a matter of indifference for consumers. The only non-trivial financial decision is the amount of funds made available by the group to the rest of the economy.

The actual composition of the portfolio holdings is determined by the market equilibrium conditions. Furthermore, the portfolio composition will be the same for all consumer groups. Each group  $i$  will own, at  $t$ , a fraction of the market portfolio which corresponds to its share of the total wealth owned by consumers at  $t$ . Accordingly, group  $i$ 's holdings at  $t$  of equity and private and public debt are given by:

$$(46) W_{it} = \sum_j B_{ij,t} + B_{igt} + \sum_j p_{jt} E_{t-1} E_{ijt}$$

$$(47) B_{ij,t} = s_{it} B_{jt}$$

$$(48) B_{igt} = s_{it} B_{igt}$$

$$(49) \sum_j p_{jt} E_{t-1} E_{ijt} = s_{it} \sum_j p_{jt} E_{t-1} E_{jt}$$

where  $s_{it} = W_{it} / \sum_i W_{it}$ .

To sum up, financial allocation of savings is exogenous to consumers but endogenous to the model. Also, the equilibrium conditions determine the equilibrium rate of return parametrically on corporate and government financing rules. However, due to the nature of the tax code, different consumer groups will have different after tax rates of return on their portfolios.

Financing its real investment, production sector  $j$  is constrained in the following way for all  $z \leq T$ :

$$(50) \quad F^D_{jt} = (1 - ITC_{jt}) p_{1t} [I_{jt} + C_j(I_{jt})] + (1 - T_{cjt}) r_{wt} B_{jt} + \\ (1 - CGT_{jt}) [p_{jEt} - p_{jEt-1}] E_{jt} - RE_{jt} - T_{cjt} \phi_{jt} K'_{jt}$$

with terminal condition  $FL_{jT+1} = 0$ .

This means that real investment activities and the payment of interest on outstanding debt at  $t$  are financed through retained earnings,  $RE_{jt}$ , and external funds,  $F_{jt}$ , which represent the increment in the financial liabilities of the sector  $FL_{jt}$ . Financial liabilities must be liquidated by the end of the model horizon.

Dividend-retention policies are exogenously given. Corporate dividend-retention policies are represented by parameter  $\phi_{\Pi jt}$ , the fraction of the after-tax gross profits generated at  $t$  which is retained by industry  $j$ . The remainder,  $(1 - \phi_{\Pi jt})$ , represents the distributed portion of after-tax earnings. Total dividends at  $t$ ,  $(1 - \phi_{\Pi jt})(1 - T_{cjt}) \Pi_{jt}$ , are distributed among the  $t$ -th period shareholders. Notice that this criterion is consistent with the fact that the amount of capital in use at  $t$  by sector  $j$  is fixed so that gross profits reflect the existent capital stock and should be distributed among those who own it, the  $t$ -th period shareholders.

Corporate financing policies are exogenously given. External funds totalling  $F^D_{jt}$  are obtained by issuing additional equity and fixed price bonds:

$$(51) \quad F^D_{jt} = \Delta B_{jt} + p_{Ejt} (E_{jt+1} - E_{jt}).$$

Issuance of new bonds and equity is governed by exogenous continuous corporate financing rules represented in this model by parameter  $\phi_{Ejt}$ . Such policy rules can be described as follows:

$$(52) \quad p_{Ejt}(E_{jt+1} - E_{jt}) = \emptyset_{Ejt} F_{jt}$$

$$(53) \quad \Delta B_{jt} = (1 - \emptyset_{Ejt}) F_{jt}$$

with end conditions,

$$(54) \quad p_{jEz-1} E_{jz} = p_{jEz-1}^* E_j^* \quad \text{and} \quad p_{jET} E_{jT+1} = 0$$

$$(55) \quad B_{jz} = B_j^* \quad \text{and} \quad B_{jT+1} = 0.$$

Perfect capital markets are assumed such that the price of equity at  $z$   $p_{Ejz}$  is the present discounted value of the future expected stream of dividends per share  $\text{Div}_{jt}^e/E_{jt}$

$$(56) \quad p_{jEz} = \sum_t [\prod_{s \leq t} (1 + r_s)^{-1}] \text{Div}_{jt}^e / E_{jt}^e, \quad \text{with } z+1 \leq t \leq T.$$

Government deficits and surpluses, which represent changes in government liabilities, are accommodated by open market operations in the bond market. These operations reflect the net demand for new funds by government:

$$(57) \quad LG_{t+1}^D - LG_t^D = \Delta B_{gt} = F_{gt}^D$$

$$(58) \quad F_{gt}^D = r_t LG_t^D + [Tr_t + \sum_j p_{jt} y_{gjt}^D + (1 + T_{gLt}) p_{Lt} L_{gt}^D + p_{lt} l_{gt}^D] - TT_t.$$

The two different methods of government financing spending, taxation, and bond financing have different effects in the economy. This is a central issue in the model.

## 2.5 Economic Equilibrium

Atomistic competition in every market is assumed. Even though the number of agents on each side of the market is finite, it is assumed that enough agents are involved to render their actions negligible in terms of the overall equilibrium outcomes. The concept of Temporary Walrasian Equilibrium is adopted to capture the incomplete and sequential aspects of real world trading and

the limitations of foresight into the future which we want to capture in this model. All current markets are assumed to clear, hence the Walrasian nature of equilibrium. Also, equilibrium in the short run is parametric on the expectations of future prices held by the different agents as well as future taxation parameters, hence the temporary nature of equilibrium. Actions of the economic agents are based on expectations which may turn out to be incorrect, i. e. price expectations are not self-fulfilling. Therefore, the intertemporal equilibrium path in this economy is conceived as a sequence of short-run, temporary equilibria parametric on future price expectations.

The link between adjacent short-run equilibria is provided by the optimal transitions rules for the individual agents. In fact, given equilibrium prices, consumers decide not only how much to purchase of the several commodities available in the economy, but also how much to save, which is the change in the stock of privately owned wealth. The same is true about producers and government in terms of their decisions on the evolution of their capital stock and financial liabilities.

An equilibrium solution for our economy is a sequence of price vectors  $p_t$  and quantity vectors  $q_t$  defined over  $\{1, \dots, t, \dots, T\}$  of the form  $p_t = (p_{1t}, \dots, p_{Jt}; p_{Lt}; p_{1t}; r_t)$  and  $q_t = (y_{1t}, \dots, y_{Jt}; L_t; i_t; F)$ .

The vectors satisfy the following conditions:

i) For each and every  $1 \leq z \leq T$ , and for  $i=1, \dots, I$ , given prices  $p_z$ , consumer group  $i$  maximizes the expected value of its intertemporal preferences subject to a recursive set of budget constraints and, point expectations about future prices  $p^*_z = \{p_{z+1}, \dots, p_T\}$ ;

ii) For each and every  $1 \leq z \leq T$ , and for  $j=1, \dots, J+1$ , given prices  $p_z$ , industry  $j$  (including the investment good sector) maximizes the expected present value of the net cash flows subject to the equation of motion of capital stock, strictly convex adjustment costs, and point expectations about future prices  $p^*_z = \{p_{z+1}, \dots, p_T\}$ ;

iii) For each and every  $1 \leq z \leq T$ , given prices  $p_z$ , the government maximizes the expected value of its intertemporal social preferences subject to a recursive set of budget constraints and point expectations about future prices  $p^*_z = \{p_{z+1}, \dots, p_T\}$ ;

iv) For each and every  $1 \leq z \leq T$ , given prices  $p_z$ , the  $J+3$  markets in the economy clear based on common expectations about future prices  $p^*_z$ , individual preference parameters  $\gamma_j$ , technology parameters, corporate financing rules  $\gamma_j$ , and on social welfare parameters and current and expected tax policy rules  $\gamma_g$ . The market clearing equations are:

$$(59) \quad y^S_j(p_z; p^*_z; \gamma_j) =$$

$$\sum_i y^D_{ij}(p_z; p^*_z; \gamma_i) + y^D_{lj}(p_z; p^*_z; \gamma_l) + y^D_{gz}(p_z; p^*_z; \gamma_g) + \sum_{1 \leq f \leq J} y^D_{fjz}(p_z; p^*_z; \gamma_f)$$

$$(60) \quad \sum_j L^D_j(p_z; p^*_z; \gamma_j) + L^D_l(p_z; p^*_z; \gamma_l) + L^D_g(p_z; p^*_z; \gamma_g) = \sum_i L^S_i(p_z; p^*_z; \gamma_i)$$

$$(61) \quad \sum_j IT^D_j(p_z; p^*_z; \gamma_j) + IT^D_l(p_z; p^*_z; \gamma_l) + IT^D_g(p_z; p^*_z; \gamma_g) = IS(p_z; p^*_z; \gamma_i)$$

$$(62) \quad \sum_j F^D_j(p_z; p^*_z; \gamma_j) + F^D_l(p_z; p^*_z; \gamma_l) + F^D_g(p_z; p^*_z; \gamma_g) = \sum_i F^S_i(p_z; p^*_z; \gamma_i)$$

This economy satisfies Walras's Law for each and every  $z \leq T$  and for all current prices, i.e., the value of market excess demand is zero. This economy is characterized by a system of  $J+3$  equations equating excess demands to zero in every market in  $J+3$  unknown prices ( $J$  consumption goods, investment good, labor, and the interest rate). However, using Walras's Law, only  $J+2$  equations are linearly independent, and therefore only relative prices can be obtained. Some sort of price normalization is necessary. In what follows, the prices are defined to be strictly positive and to sum up to one, i.e. they are defined in the unit simplex.

## 2.6 The Rules of Formation of Expectations

The information set at period  $t$  reflects what is known about the economy at  $t$ . It consists of all the structural information of individual preferences and technologies, and all the past equilibrium prices and quantities. Individual expectations at  $t$ , for all  $t+1 \dots T$ , are based on information as specified in the information set. Price expectations are formed as Hicksian point expectations according to rules to be specified below. In each simulation of the intertemporal model, the agents maintain an intertemporally consistent rule of formation of point price expectations. Therefore, the possibility of the expectation formation rules changing throughout time is ruled out. However, the price expectations are updated when new information comes into the information set. For example, the expectations of prices at  $t+h$  formulated at  $t$  and  $t+1$  will, in general, be different. Finally, in terms of the information structure of the economy it is assumed that all the agents have common price expectations. Therefore, the possibility of informational asymmetries across agents is ruled out.

The rules of formation of expectation are intended to capture the limitations of foresight into the future, and are therefore reasonably simple. In particular, the following three simplifying assumptions are made on the expectational price process.

Assumption 2.1: Bounded rationality - Price expectations depend only on past realized prices, not other variables in  $IS_t$ . This assumption can be interpreted as recognizing that information is costly to acquire and process, thus not all the information in  $IS_t$  is used.

$$(63) \quad p_{t+1}^e = P_t^e(p_t, p_{t-1}, \dots, p_0) \text{ for all } t.$$

This is a crucial assumption. The closed definition of the relevant information set excludes the possibility of the agents knowing, or at least using the knowledge of the model of the economy, hence the bounded rationality nature of the assumption. At a deeper level this assumption may be

construed as revealing the source of uncertainty in this economy. - if the agents knew the model of the economy they would be able to accurately forecast future prices.

Assumption 2.2: Markov Assumption - The price process  $\{p_t\}$  is at most a second order Markov process, i.e., only  $p_t, p_{t-1}$  help to predict  $p_{t+1}$ . Thus for all  $t$ :

$$(64) \quad p_{t+1}^e = P_t^e(p_t, p_{t-1}, \dots, p_0) = P_t^e(p_t, p_{t-1})$$

Assumption 2.3: Stationarity - The parameters of the price process are time-invariant. For each simulation of the model to determine the equilibrium at each period, the agents will maintain expectations according to a stationary process. Thus for all  $t$ :

$$(65) \quad P_t^e(p_t, p_{t-1}) = P^e(p_t, p_{t-1})$$

Several rules of formation of point price expectations satisfying the above assumptions will be considered. Let current price (or interest rate) be  $p_z$ . Agents will form expectations at  $z$  of prices  $h$  periods into the future,  ${}_z p_{z+h}^e$ , (the first subscript will be dropped whenever it is not ambiguous) under several alternative rules. These rules are as follows:

i) Static Expectations: Current prices are expected to prevail into the future. For all  $h \geq 0$ :

$$(66) \quad p_{z+h}^e = p_z$$

ii) Extrapolative Expectations: Expectations about future prices reflect the expected changes in prices in previous periods. Extrapolative expectations are obtained according to the recursive rule for all  $h > 0$ ,

$$(67) \quad p_{z+h}^e = p_{z+h-1}^e + \theta(p_{z+h-1}^e - p_{z+h-2}^e).$$

iii) Constant Rate of Growth: The expectations about future prices reflect the idea that the rate of change in current prices is expected to prevail. Forecasts are given according to the

recursive rule for all  $h > 0$ ,

$$(68) \cdot p^e_{z+h} = (p^e_{z+h-1} / p^e_{z+h-2}) p^e_{z+h-1}.$$

iv) Adaptative Expectations: Expectations of future prices reflect current prices and previous expectations, so that some adjustment is made for expectation errors and new information.

The recursive rule is for all  $h > 0$ ,

$$(69) \cdot p^e_{z+h} = p^e_{z+h-1} + \theta (p^e_{z+h-1} - z_{-1} p^e_{z+h-1}),$$

v) Auto-Regressive Expectations of Order 2 - AR(2): Forecasts are given according to the recursive rule for all  $h > 0$ ,

$$(70) \cdot p^e_{z+h} = b_{z+h} + a_1 p^e_{z+h-1} + a_2 p^e_{z+h-2},$$

Notice that if we set  $b_{z+h} = 0$  for all  $h$ ,  $a_1 = 1$ , and  $a_2 = 0$ , (70) reduces to the static expectations as in equation (66). Also, if  $b_{z+h} = 0$  for all  $h$ ,  $a_1 = 1 + \theta$ , and  $a_2 = -\theta$ , (70) reduces to the extrapolative expectations in equation (67). In turn, if we set  $b_{z+h} = 0$  for all  $h$ ,  $a_1 = (p_z / p_{z-1})$ , and  $a_2 = 0$ , (70) reduces to constant rate of growth expectations in equations (68). Finally, if we set  $b_{z+h} = -\theta z_{-1} p^e_{z+h-1}$ ,  $a_1 = 1 + \theta$ , and  $a_2 = 0$ , (70) reduces to adaptative expectations in equations (69). Therefore static expectations, extrapolative expectations, constant rate of growth expectations, and adaptative expectations are special cases of the AR(2) expectation rule as in (70) above.

To calculate the short-run equilibrium resulting from the different expectations rules above, it is sufficient to replace in the equilibrium expressions in section 2.5, the future price and interest rates according to the expectation rules outlined above.

### **3. Model Implementation and Policy Evaluation**

The implementation of DAGEM involves the specification of a base case equilibrium, which is to be contrasted with the revised case equilibria resulting from different alternative policy scenarios. The link between the base case equilibrium and the revised case equilibria is provided by the concept of equal yield generalized to accommodate the presence of government deficits. The ranking among different equilibria is provided by scalar welfare indicators, the Hicksian Equivalent Variations, generalized to accommodate both the absence of future markets and incorrect expectations.

#### **3.1 Base Case Equilibrium: Data Requirements and Parameter Specification**

The current data set and the parameter specification of the DAGEM is essentially consistent with the 1973 data set and parameter specification of the recent version of Shoven-Whalley's GEMTAP model as reported in BFSW. The data set and specification was enlarged to cover aspects not considered in the GEMTAP. See Tables 1-3 for a detailed description of the data set and parameter specification in the DAGEM. <sup>4/</sup>

The implementation of the model in this paper requires the specification of a data set which consists of the initial values of the stock variables in the economy. The capital stocks for the different industries in the model are obtained from BFSW by applying an average after-tax rate of return to capital income. Industry specific debt and equity are obtained by applying the debt/capital ratios reported in Fullerton-Gordon (1983) to the capital stocks figures. The figure for government capital stock is based on the work of Boskin-Robinson-Roberts (1986) translated into 1973 numbers. Public debt is specified to reflect its current importance in the economy. The 1983 values of debt per capita and the proportion of debt to GNP are applied to the 1973 figures as

reported in BFSW. Since the formulation of the model assumes the existence of a market financial portfolio with individuals allocating savings by buying shares of the market portfolio, it is enough to determine the composition of ownership of global wealth in the economy by income class. This data is obtained from the Office of Tax Planning as reported in Galper-Lucke-Toder (1986). The number of households in each income class is as reported in BFSW.

Running the model requires the specification of functional forms and parameter selection. For tractability, linear homogeneous Cobb-Douglas functional forms are chosen for all the utility and production functions in the current implementation of the model. Individual preference, government, and technology share parameter values, and the input/output structure are obtained from BFSW and correspond to 1973 values. Quadratic adjustment cost functions are postulated. The value of the adjustment cost parameters is consistent with the values reported in Summers (1981) and Goulder-Summers (1987). Finally, the private capital depreciation rates are from Fullerton-Gordon (1983), and public capital depreciation rate are from Boskin-Robinson-Roberts (1986).

Corporate financial rules are constant industry specific debt/equity ratios obtained from Fullerton-Gordon (1983) and the constant industry specific retention/dividend ratios are obtained from the Survey of Current Business (1983).

Tax parameters under the previous tax regime reflect sector specific labor taxes, corporate tax rates, investment tax credits, and capital depreciation rates for tax purposes as reported by Fullerton-Gordon (1983). Marginal personal income taxes are those in BFSW and capital gains taxes are set at 5% as in Goulder-Summers (1987).

### 3.2 Equal Yield Alternatives and Revised Case Equilibria

The policy evaluation of tax changes is based on comparisons between a base case equilibrium

which represents the status quo and a series of revised case equilibria which reflect the tax policy changes under discussion. The link between a base case and counterfactual simulations is usually provided by the concept of equal yield: to be comparable, base and revised equilibrium cases should be such that the size of government is kept constant in a meaningful way.

Shoven-Whalley (1977) provide a detailed discussion of the concept of equal yield in a general equilibrium context. When government is confined to taxation and discretionary transfers, equal yield is interpreted to mean equal tax revenues. On the other hand, when government activities include purchases of private goods in addition to taxation and discretionary transfers, equal yield is interpreted to mean constant "public utility." In this case, government base case utility is maintained in the counterfactual experiments.

In this paper equal yield is also assumed to mean equal government public utility in both the base and revised case equilibria. The intertemporal sequence of government cumulative utility  $\{F_{gt}^b, \dots, F_{gT}^b\}$  is retrieved from the base case. For the revised case, government purchases of commodities will be such that at revised equilibrium prices, the base case sequence of utilities is attained at minimum cost. Thus government behavior is consistent with compensated demand functions for base case utility levels.

Running a revised case requires changes in the equilibrium conditions and the optimal transitions for the stock variables. First, the equilibrium conditions include government compensated demand functions rather than the ordinary demand functions as in Section 2.5. Second, the government expenditure function in its budget constraints also reflects the compensated demands. Accordingly, the revised case transition for government liabilities can be written as

$$(71) \quad TT_t(IT) + \Delta B_g = P_{Lt}L_{gt}(F_{gt}^b) + \sum_j p_{jt}y_{gjt}(F_{gt}^b) + p_{lt}l_{gt}(F_{gt}^b) + r_t B_{gt} + Tr_t$$

In Shoven-Whalley (1977), government is subject to a balanced budget constraint. With balanced budgets, the concept of equal yield is unambiguous. The new equilibrium prices and the

balanced budget condition will determine the minimal expenditure and taxes needed to maintain base case public utility. Revised case tax revenues just match revised case minimum expenditures. Accordingly, in general, equal yield is inconsistent with equal nominal tax revenue. Some change in tax revenue is necessary. Different tax replacement schemes are considered to assure that enough tax revenue is collected.

In the DAGEM, because government is allowed to run deficits, the concept of equal yield tax replacement needs to be refined. If tax revenues are kept equal to new expenditures, the government supply of bonds is changed which introduces marginal financial crowding-out effects. Also, by keeping either revenues or debt constant, there is still one degree-of-freedom since additional expenditures plus discretionary transfers and interest payment on debt, may be financed via tax revenues, bond issuance, or both. Consequently there are several possible equal yield ways of computing a replacement tax rate in the revised case. The optimal level of expenditure for base case public utility can now be tax financed, bond financed or financed by a mix of bonds and taxation. Some measure of financial crowding-out effects of government deficits can be inferred from the comparison of the several equal yield alternatives.

The following three cases are considered.

1) tax financed policy change

In this alternative, equal yield is defined as the same utility levels and same deficits. The size of the deficits is kept as in the base case. A tax rate is endogenously changed such that tax revenues make up for the expenditure net of deficit financing. Formally, this adds to the model the following constraints:

$$(72) \quad \Delta B_{gt}^r = \Delta B_{gt}^b \text{ or } B_{gt}^b = B_{gt}^r$$

$$(73) \quad TT_t(IT) + \Delta B_{gt}^b = p_{Lt} L_{gt}(F_{gt}^b) + \sum_j p_{jt} y_{jgt}(F_{gt}^b) + p_{lt} l_{gt}(F_{gt}^b) + r_t B_{gt}^b + Tr_t$$

2) bond financed policy change

This equal yield alternative implies the same government utility and same tax revenues. It should be emphasized that unlike Shoven-Whalley (1977) equal yield is now consistent with equal tax revenue. Tax revenues are kept constant at base case levels. For different equilibrium prices, the same tax revenue implies endogenous changes in tax rates. Adjustment to deficits, and therefore bond issuance, makes up the difference between tax revenue net of transfers, interest payment on the debt, and the minimizing expenditure to achieve base case utilities. Formally, this adds to the model the following constraints:

$$(74) \quad \Delta B_{gt} = p_{Lt} L_{gt}(F_{gt}^b) + \sum_j p_{jt} y_{gjt}(F_{gt}^b) + p_{It} I_{gt}(F_{gt}^b) + r_t B_{gt} + Tr_t - TT_t^b$$

$$(75) \quad TT_t^b = TT_t^r(IT).$$

3) same composition of expenditure financing

This equal yield alternative implies the same government utility and the same bond-tax revenue financing mix as in the base case. Formally:

$$(76) \quad \Delta B_{gt}^r = [TT_t^b / \Delta B_{gt}^b]^{-1} TT_t^r(IT)$$

$$(77) \quad \{1 + [TT_t^b / \Delta B_{gt}^b]^{-1}\} TT_t^r(IT) =$$

$$p_{Lt} L_{gt}(F_{gt}^b) + \sum_j p_{jt} y_{gjt}(F_{gt}^b) + p_{It} I_{gt}(F_{gt}^b) + r_t B_{gt} + Tr_t.$$

The comparison among these equal yield schemes is central to tax policy evaluation in the presence of government deficits. The three schemes differ in the marginal financial crowding out they generate. Tax financed change blocks marginal financial crowding out by keeping debt at base case levels. Bond financed equal yield maximize marginal financial crowding-out effects by keeping base case tax revenues constant and by allowing deficits to make up the necessary adjustments. Case 3 reflects an intermediate situation.

### 3.3 Tax Replacement Schemes

The equal yield alternatives discussed above involve endogenous replacement changes in the tax rates. Different tax replacement schemes are considered to assure that enough tax revenue is collected. Tax replacements involve changes in the personal income tax rates. The personal income tax collected from individual  $i$  at time  $t$  is in the revised case:

$$(78) \quad b_{it} + [a IT_{it} + b](\text{Taxable Income})$$

where  $a$  is a multiplicative change factor and  $b$  is an additive change factor. This lump-sum tax corresponds to a fraction of the total endogenous tax revenue change equal to the  $i$ -th household share in total wealth.

The two replacement schemes are obtained as follows:

- 1) multiplicative replacement - set  $b=0$  and let  $a$  be endogenously determined;
- 2) additive replacement - set  $a=1$  and let  $b$  be endogenously determined;

In general, not all possible replacements schemes are feasible. The tax base that provides the additional revenues to match the tax revenues foregone by the policy changes has got to be important enough to generate the necessary revenues. Otherwise, counterfactual equilibrium may fail to exist (see Shoven-Whalley (1977) on this issue).

The three replacement schemes suggested here seem plausible on a priori grounds. Using the personal income tax as the base for the tax replacement in the context of corporate tax integration is conceptually appropriate in the light of the concept of "double taxation." Also, personal income tax as the base for the tax replacement in the context of corporate tax integration seems to minimize the likelihood of non-existence in that corporate tax revenues were about 8% of total tax revenues in 1985, while personal income tax revenues accounted for 46%.

### 3.4 Policy Evaluation Indicators

There are several ways of associating a scalar welfare measure to the array of information which defines an economic equilibrium. The concept of Hicksian Equivalent Variations (EV) is among the most prevalent criteria to measure efficiency gains or losses in the public finance literature. EV measures at base case prices the maximum amount of money the consumer is willing to receive or pay to attain the revised case utility level. Positive EV's are to be interpreted as representing welfare gains. Individual compensation EV's are constructed by using optimal cost functions. Therefore they are "objective" money metric indicators. Aggregation of EV's across individuals does not pose any particular problem.

The construction of an EV indicator from individual optimal cost functions in an intertemporal framework deserves some attention. Consider a consumer in an intertemporal framework. In general, the optimal intertemporal cost function associated with a certain path of utility depends on all present and future prices. If all future markets are open, or if future prices are perfectly anticipated - the case discussed by Pollak (1975) - there are no problems with the interpretation and use of the intertemporal cost function and "a fortiori" with the computation of intertemporal EV. When some future markets are not open and/or future prices and interest rates are not perfectly anticipated, the concept of intertemporal cost function and associated policy evaluation indicators needs some refinements. Denton (1982) develops the notion of anticipated cost function to reflect expected long-run cost of utility. He also develops the idea of annuity costs associated with a constant flow of utility.

From the standpoint of meaningful empirical applications Denton's indicators are less than ideal. The true compensation indices must be based on ex-post, one-period, optimal cost function parametric on future price expectations, and not on an ex-ante anticipated cost function which is, in general, not self-fulfilling. Also, the true intertemporal compensation indices must be based on

a consistent sequence of one-period, ex-post, optimal cost functions associated with a certain utility path. This will, in general, involve non-constant utility annuities. The basic concepts used in this subsection to build the true compensation indices are: anticipated cost function, and short-run and long-run realized cost functions.

Consider a sequential economy starting at  $z$ , lasting  $T$  periods. Consider also two different  $(T-z)$ -dimensional equilibrium trajectories for an economy associated with different policy specifications: a base case equilibrium with prices  $\{\dots, p_t^b, \dots\}$  and associated price expectations  $\{\dots, p_t^{eb}, \dots\}$ ; and a revised case equilibrium with prices  $\{\dots, p_t^r, \dots\}$  and associated price expectations  $\{\dots, p_t^{er}, \dots\}$ . In both base and revised cases, the sequence of primal problems for the household induces a one-period utility sequence  $\{U_z^*, \dots, U_t^*, \dots, U_T^*\}$ . This utility sequence generates a decreasing sequence of felicity  $\{F_t^* = \{F_z^*(\cdot), \dots, F_t^*(p_z, p_{z+1}, \dots, p_T; W^*), \dots, F_T^*(\cdot)\}$  through a recursive dynamic programming algorithm,  $F_t^* = U_t^* + (1+\delta)^{-1} F_{t+1}^*$ . From the perspective of dual household behavior, there is a sequence of one-period cost functions  $\{SRC_z^*(F_z^*), \dots, SRC_t^*(F_t^*) = \sum_j p_{jt} H_{jt}^d, \dots, SRC_T^*(F_T^*)\}$ , where  $H^d$ 's is the one-period Hicksian demand functions, consistent with the primal felicity sequence. In turn, the one-period cost functions generates a sequence of cumulative future costs  $\{C_z^*(F_z^*), \dots, C_t^*(p_z, p_{z+1}, \dots, p_T; F_z^*), \dots, C_T^*(F_T^*)\}$  through a recursive dynamic programming algorithm  $C_t^* = SRC_t^* + (1+r_t)^{-1} C_{t+1}^*$ . Now, we want to compare from the point of view of the  $i$ -th household the two equilibrium sequences both in the short run and in the long run.

If the  $i$ -th consumer correctly anticipates all future prices in both the base and revised cases, then all the plans into the future will be implemented without the need for revisions. In such a case,  $F_z^*(\cdot)$  is the actual intertemporal optimal felicity function at  $z$ . In turn,  $C_z^*(\cdot)$  is the actual

intertemporal optimal cost function at  $z$ . The construction of intertemporal compensation tests is, in this context, a straightforward generalization of the static case.

However, if at  $z$  the  $i$ -th consumer cannot perfectly anticipate future prices, then  $p_{z+1}, \dots, p_T$  are to be interpreted as price expectations,  $p_{z+1}^e, \dots, p_T^e$  and not as actual prices. Furthermore, since expectations are not fulfilled, intertemporal primal and dual plans will be revised according to a sequence of optimization problems. At each  $z$  only current plans parametric on the expectation of future prices are actually implemented. Also, only current utility  $U_z^*$  and associated current optimal cost  $SRC_z^*$  are actually realized. Accordingly, the optimal functions  $F_z^*(\cdot)$  and  $C_z^*(\cdot)$  are to be interpreted as the long-run anticipated optimal felicity function and long-run anticipated optimal cost functions at  $z$ , respectively. Since  $C_z^*(\cdot)$  reflects current costs and future anticipated costs of obtaining a certain, expected utility path level, as opposed to actual costs of financing an actual utility path, it should be rewritten as  $C_z^e(\cdot)$ :

$$(79) \quad C_z^e(p_z, p_{z+1}^e, \dots, p_T^e; F_z^*) = \sum_j p_{jz} H_{jz}^d + \sum_{z+1 \leq t \leq T} \prod_{z+1 \leq s \leq t} (1+r_s)^{-1} [\sum_j p_{jt} H_{jt}^{ed}]$$

Now, (79) may be used to generate the EV indicator of the long-run effects anticipated at  $z$  of a certain policy change.

$$(80) \quad EV_z^e = C_z^e(p_z^b, p_{z+1}^{eb}, \dots, p_T^{eb}; F_z^b) - C_{iz}^e(p_z^b, p_{z+1}^{eb}, \dots, p_T^{eb}; F_z^r)$$

Inasmuch as consumers do not anticipate correctly future prices, the anticipated indicators are of no help to evaluate either the actual short-run effects at  $z$  or the actual long-run effects of the alternative policies. The relevant concept for short-run policy evaluation is the realized short-run cost function at  $z$ , which gives current realized costs at  $z$  as a function of current prices as well as future price expectations and a given level of felicity:

$$(81) \quad SRC_z(p_z, p_{z+1}^e, \dots, p_T^e; F_z^*) = \sum_j p_{jz} H_{jz}^d(\cdot)$$

The following is the associated realized short-run EV evaluation indicator:

$$(82) \quad SREV_z = SRC_z(p_z^b, p_{z+1}^{eb}, \dots, p_T^{eb}; F_z^b) - SRC_{iz}(p_z^b, p_{z+1}^{eb}, \dots, p_T^{eb}; F_z^r)$$

Let us now focus on the long-run evaluation indicators. The problem with obtaining such long-run indicators is to get a meaningful sequence of short-run indicators which are comparable and consistent for aggregation. We need first to construct a meaningful sequence of short-run optimal cost functions associated with an actual utility path, so that at each  $t$  the one-period costs reflect current utility and are consistent with future observed felicity.

The true ex-post intertemporal cost function over the period  $z$  to  $T$ ,  $C_z^*$ , corresponding to certain temporary equilibrium prices, future price expectations, and a given felicity sequence, is the present discounted value of the sequence of realized short-run cost functions:

$$(83) \quad C_z^*(p_z, p_{z+1}, \dots, p_T; \{F_t^*\}) = \sum_{z \leq t \leq T} [\prod_{z \leq s \leq t} (1+r_s)^{-1}] [\sum_j p_{jt} H_{jt}^d(p_t, p_{t+1}^e, \dots, p_T^e; F_{it}^*)]$$

where  $r_t$  and  $p_t$  are actual market prices and interest rates at  $t$ , and  $p_{t+h}^e$ 's are expected values at  $t$  of prices at  $t+h$ .

To obtain the intertemporal EV evaluation indicators, we just have to use the long-run optimal cost function as described above.

$$(84) \quad LREV_z = C_z^*(p_z^b, p_{z+1}^b, \dots, p_T^b; \{F_t^b\}) - C_z^*(p_z^b, p_{z+1}^b, \dots, p_T^b; \{F_t^r\}) = \sum_{z \leq t \leq T} [\prod_{z \leq s \leq t} (1+r_s^b)^{-1}] [SREV_t(p_t^b; p_{t+1}^{eb}, \dots, p_T^{eb}; F_t^b, F_t^r)]$$

### 3.4 Computation Techniques

Given the temporary equilibrium structure of the DAGEM, the computation of a  $t$ -dimensional

intertemporal equilibrium path involves the computation of a sequence of  $t$ , one-shot, short-run equilibria parametrically on price expectations. The model is typically run to produce a twenty-year equilibrium sequence in a decision time frame of one hundred years. The optimal transitions of the stock variables between adjacent short-run equilibria are determined endogenously given the equilibrium prices and net demands.

Each one-shot equilibrium is computed using NPSOL, an optimization algorithm developed by Gill-Murray-Saunders-Wright (1986). The equilibrium conditions are seen as nonlinear equality constraints in the minimization of an artificial objective function. The prices are normalized to the unit simplex by an additional linear equality constraint. The algorithm computes an equilibrium by finding a feasible point to this "bogus" minimization problem: by definition a feasible point satisfies the constraints of the problem, in this case the equilibrium conditions.

The DAGEM is implemented using an interactive FORTRAN program running on a IBM 4381. The NPSOL algorithm proved to be extremely efficient for the computation of the economic equilibrium for such a relatively complex model as the DAGEM. In fact it takes generally about one minute of terminal time on an IBM 4381 to compute a one-period equilibrium for an economy with eight markets and a time horizon of one-hundred periods. For the same specification of DAGEM, Merrill's (1972) version of the fixed-point algorithm takes about eight minutes.

#### **4. Simulation Results**

##### **4.1 The Design of the Policy Experiments**

###### **Institutional Settings**

Two institutional settings are considered in this chapter: those before and those after the Tax Reform Act of 1986. From the standpoint of this work, the two institutional settings differ in

crucial aspects. Let us begin by reviewing some relevant aspects in both situations.

Before the Tax Reform Act of 1986, corporate income was subject to a progressive tax structure with a top rate of 46% for incomes above \$100,000. Most of the corporations were actually in the highest echelon. A wedge was thereby introduced between the corporate and non-corporate industries which made investment conditions more favorable for the latter.

Moreover, marked differential treatment of incorporated industries had been induced by special provisions such as the investment tax credit and the favorable treatment of depreciation allowances. The investment tax credit was first enacted in 1962 and was in effect through the end of 1985, except for two short periods. Under this provision, a variable share of expenditures in new investment could be credited against the corporate tax liability. Since the share of new investment allowed to be credited depended on the type of capital, different sectors were differently affected by investment tax credit depending on the composition of their capital formation. Under the Accelerated Cost Recovery System of 1981, capital depreciation allowances were treated very favorably, permitting depreciation for tax purposes which exceeded the true economic depreciation. Because the tax advantage was related to the life of the physical asset, different corporate sectors were differently affected depending on the maturity of their capital. As a consequence of these provisions there has resulted marked differences in the effective tax rates within the corporate sectors, which has generated further distortions in the intersectorial allocation of capital.

The taxation of corporate capital has been seen as leading to the "double" taxation of income in that corporate income is taxed both at the corporate and personal income levels (see McLure (1979)). In fact, corporate earnings are subject to corporate income tax. After-tax earnings are either distributed as dividends and taxed again at the personal income level, or retained by the corporation and potentially taxed as capital gains.

The tax law consecrated a preferential treatment of retained earnings. In fact, retained earnings were only taxed as capital gains and therefore at a lower tax rate - 28%. Furthermore,

capital gains were (and still are) taxed upon realization, and the time deferred treatment of capital gains further favors retained earnings. Therefore, the tax treatment of retained earnings distorts the financing of investment by inducing more retained earnings against dividends.

Finally, interest payments on outstanding corporate debt were deductible from the corporate tax base. Payments on other financial intermediaries, such as dividends, are not. Therefore, the tax treatment of interest payments distorts the financing of investment by inducing more debt financing against equity financing.

The Tax Reform Act of 1986 changes some important parameters in the analysis of corporate tax integration. First, the corporate tax rates diminish. The top corporate tax rate and the rate that most corporations face is now 34%. Inasmuch as the low statutory rate may be passed into a lower effective tax rate, the wedge between corporate and non-corporate sectors will also be reduced. In such a case, there are potentially lower gains to be derived from integration.

Secondly, the lower statutory tax rates go hand in hand with a broader corporate tax base. Investment tax credits were retroactively eliminated effective January 1, 1986, and depreciation allowances made far less favorable. These changes reduce the distortions in the allocation of capital across incorporated production sectors. Therefore, under the current tax code the corporate industries are facing more uniform effective corporate tax rates. However, given the broader corporate tax base the corporate industries may have to face higher effective corporate tax rates. Actually, the presumption is that effective corporate tax rates will increase. Lower intersectorial distortions go in the direction of lower efficiency gains from integration policies under the new tax law. On the other hand, higher effective corporate tax rates will widen the gap between the corporate and non-corporate industries and generate increased distortions. Higher effective corporate tax rates go in the direction of lower efficiency gains from integration policies under the new tax law.

Thirdly, capital gains no longer receive special treatment at either the household or corporate

level. Capital gains are now taxed as is income from any other source. The differential tax treatment of retained earnings and dividends is thereby eliminated, except for the time deferral aspects of taxation of capital gains upon realization. At any rate the tax preference of retained earnings is alleviated. In this margin the potential gains from integration under the new tax law are unambiguously lower.

Finally, personal income tax rates were reduced by the Tax Reform Act of 1986. Thus the tax replacement necessary to accomplish integration under the new tax law will increase and so will its marginal distortionary effects.

It appears that gains from integration under the new tax regime may be lower or greater than under the previous tax regime. There are no a priori grounds for the results to go either way. Lower distortions in the allocation of capital within the corporate sectors, together with lower distortions in terms of corporate dividend-retention decisions under the new tax law, have to be weighted against higher effective corporate tax rates and the necessity of higher personal income tax replacements.

#### Corporate Tax Integration Schemes

Several ways of dealing with the distortionary effects of the taxation of corporate income have either been suggested or implemented in the United States as well as in other countries. (See Pechman (1987) pp. 179-188 and, CBO Study (1985) pp. 141-163 for detailed discussions of different integration mechanisms.)

Several laws for various periods in the U.S. tried to alleviate the "double" taxation of dividends and the tax preference for bond financing. In 1936-1937, a dividend-paid deduction was in effect. The corporations were allowed to deduct dividends from the corporate tax base. This effectively reduced the corporate income tax to a tax on retained earnings. For that reason this tax provision was promptly eliminated. More recently, during the planning that preceded the Tax Reform Act of

1986, the U.S. Treasury Department proposed that 10% of the dividends be deductible by corporations. This plan encountered some opposition from the corporation who claimed they would be forced to pay higher dividends as a result. This plan was not adopted by the Tax Reform Act. A dividend-received credit for individuals was in effect in the U.S. from 1954 to 1963. Households were allowed to deduct 4% of dividends received as a credit against their income tax. Although this method provided some relief from the "double" taxation of dividends, it was perceived as reducing the progressiveness of the personal income tax. When this dividend credit was repealed in 1964, a dividend exclusion was introduced. A basic exclusion from the personal income tax of dividends under \$100 (\$200 for joint returns) was introduced. This dividend exclusion was only eliminated with the Tax Reform Act of 1986 when the personal income tax base was broadened to make up for a statutory tax reduction.

In countries like Austria, Japan, and Norway, a split-rate corporate income tax has been adopted. Retained earnings are taxed at a higher rate than dividends. This method is similar in its effects to a deduction for dividends paid. On the other hand, in countries like France, Italy, United Kingdom, and West Germany an imputation method has been followed. All or part of the personal income tax is regarded as having been paid at the source through the corporate tax.

All of the above methods provide only a partial integration of the personal and corporate income taxes. Full integration would be a way of completely eliminating all the distortions generated by the corporate income taxation. One possibility is a full integration mechanism in the form of partnership. Corporations would be treated like partnerships, and corporate income would be taxed at the personal income level whether distributed or not. The partnership method raises several difficult problems. The most important problem stems from having to impute corporate income to stockholders. To avoid the possibility of an individual having to liquidate assets to pay taxes on earnings he or she did not receive, the corporate tax is kept as a withholding device. Corporations under this full integration mechanism are treated as closely held corporation are

treated under the current tax law. Corporations impute retained earnings among the shareholders in order to withhold their income taxes. Shareholders, in turn, include both imputed and actual dividends in their tax base and would deduct the tax withheld by the firm from their tax payments.

An alternative approach of achieving full integration is to repeal the corporate income tax. All corporate income would be fully taxed at the personal income level. This scheme poses fewer implementation problems than the partnership method.

In this dissertation, two integration methods are considered. The first method is a partial integration scheme. It is designed to partially reduce or eliminate the "double" taxation of dividends, as well as the bias against equity financing. The second method is a full integration plan.

i) Method 1: Partial Integration by Dividend Deduction from the Corporate Tax Base.

A variant of this method was in effect in the U.S. from 1936-1937, and was proposed in the debate preceding the Tax Reform Act of 1986.

Partial integration promotes equal treatment of dividends and interest payments, while maintaining a corporate tax. This partial integration method specifies that dividends can be fully deducted from the corporate income tax base. This eliminates the "double" taxation of dividends. Also, under this partial integration scheme the same treatment is given to dividends and interest payments on debt. This eliminates the tax preference towards debt. Equal tax treatment of dividends induces more equity financing and encourages dividend outlays.

Because dividends are now deductible, the corporate tax is levied solely on retained earnings. Therefore, this method discourages internal financing. This may be an undesirable feature when large deficits generate important financial crowding-out effects and tight fund markets.

This partial integration scheme assumes particular importance in the light of the recent Tax Reform Act of 1986. In fact, unlike the other distortions, the issues of "double" taxation of dividends and the tax preference towards debt were not addressed by the Tax Reform Act. If anything, matters were made worse by the elimination of the basic deduction for dividends received

at the personal income level.

ii) Method 2 - Full Integration Achieved by Repealing the Corporate Income Tax

Under this full integration scheme the corporate income tax is eliminated and individual income taxes are paid on both corporate dividends and retained earnings. According to this scheme the distortions associated with the taxation of corporate capital are completely eliminated.

Full integration seems to have some political clout and occasionally has been suggested. For example, in 1977 full integration was advocated by a group of experts from the U.S. Treasury Department in "Blueprints for Basic Tax Reform. Also, in early 1983 the repeal of the corporate income tax was suggested in an offhand remark by President Reagan.

Given the different nature of the two plans above, different efficiency effects are to be expected. The efficiency gains under full integration are potentially large when compared to partial integration, because all the distortions are eliminated. However, the foregone tax revenues that have to be recovered through replacement mechanisms are higher under full integration. The relative size of the net effect of full integration is unclear on "a priori" grounds.

#### 4.2 Corporate Tax Integration under the Previous Tax Law

The previous tax regime has provided the first institutional setting for the analysis of integration. In all the basic simulation experiments, static expectations are maintained. This makes the results in this work directly comparable to the previous literature.

##### Efficiency Effects of Integration

###### PROPOSITION #1

*The efficiency gains from such a radical measure as the elimination of the corporate income tax are at best very modest. The efficiency gains predicted by the DAGEM are well below previous*

*estimates in the literature.*

Simulation results for full integration are reported in Tables 4-5. The efficiency gains from such a radical measure as the elimination of the corporate income tax are at best very modest. Under the best scenario, the elimination of the corporate income tax under multiplicative replacement has long-run welfare effects which are positive but relatively low. The gains range from 55 to 58 billions of 1973 dollars or .158% to .165% of the present discounted value of consumption and leisure, the adjusted GNP. On the other hand, the elimination of the corporate income tax under additive replacement has long-run welfare effects which are negative and range from -.098% to -.112% of the present value of the adjusted GNP.

The efficiency gains reported are certainly a minuscule proportion of the adjusted GNP. To put things in perspective let us compare the efficiency gains to the corporate tax revenues. The corporate tax revenues have been about 2% of GNP or 1.4 % of the adjusted GNP. Therefore, the efficiency gains from integration are at the very best about 12% of corporate tax revenues eliminated by integration.

The efficiency gains predicted by the DAGEM are well below previous estimates in the literature. That is to be expected since the DAGEM has been designed to provide a better account of both the benefits of integration and the distortions integration creates. In their path-breaking work, FKSW concentrate on the benefits induced by integration on inter-industry allocations of investment and on the intertemporal allocation of consumption. Total integration with lump-sum replacement was found to yield dynamic gains as large as \$695 billion of 1973 dollars, or about 1.4% of the present value of consumption and leisure in the U.S. economy. Dynamic gains under multiplicative replacement are of the order of .62% of the present value of the intertemporal adjusted GNP.

The long-run gains from full integration simulated with the DAGEM are about four-times lower than comparable results in FKSW. This difference can be attributed to two factors. First, in

the DAGEM model investment decisions are subject to rigidities. Therefore, lower efficiency gains are to be expected. Secondly, while both models capture intertemporal consumption and labor-leisure decisions, the endogenously recursive nature of equilibrium in this paper better captures distortions induced by higher marginal income tax-rates. It should be stressed that under Value Added Tax and lump-sum replacements FKS<sub>W</sub> find efficiency gains which are about twice as big as with multiplicative replacement. This suggests that we might have found higher efficiency gains had these alternative replacement schemes been tried. Nevertheless, the results with DAGEM would still be substantially lower.

In the context of a model similar to the one in FKS<sub>W</sub>, Fullerton-Gordon (1983) focus on the optimality of firms' financial decisions. They report efficiency gains of .6% of the GNP from the elimination of the tax distortions favoring debt. However, when they eliminate the corporate tax and replace it with increased personal income tax rates, additional distortions are created in the optimal labor-leisure decisions. These distortions tend to dominate the analysis such that the overall effects of total integration under additive replacement are slightly negative -.058% of the present value of the intertemporal adjusted GNP.

The long-run negative effects from full integration in the DAGEM are more than four-times greater than comparable results in Fullerton-Gordon. Given the similarity of the two models the reasons that explain the differences in the results between DAGEM and FKS<sub>W</sub> also explain the differences between DAGEM and Fullerton-Gordon. Presumably, the difference between DAGEM and Fullerton-Gordon would have been lower had the DAGEM been modeled to capture endogenously the debt-equity decisions. Nevertheless, the results with DAGEM would still be substantially lower.

Slemrod (1980,1983) develops a static general equilibrium model focusing on consumers' asset portfolio decisions. He finds static efficiency gains which are about twice as large as those reported by FKS<sub>W</sub>. Despite the fact that an additional source of efficiency gains from integration is modeled in the form of household portfolio decisions, the results in Slemrod are overly

optimistic. First, Slemrod's model is static. Second, labor supply is fixed exogenously. However, distortions in the intertemporal leisure-labor decisions induced by the replacement mechanisms have been shown in FKSW and Fullerton-Gordon (1983) to be of primordial importance (see Proposition #3 below for confirming evidence).

#### PROPOSITION #2

*Results from integration follow a sharply increasing intertemporal pattern: long-run average benefits are much larger than short-run average benefits.*

The intertemporal pattern of efficiency gains from integration is characterized by relatively small short-run gains followed by relatively large long-run gains.<sup>5/</sup> Multiplicative replacement short-run average results are about .07% of the discounted present value of short-run adjusted GNP, while in the long run welfare effects are about .165%. Therefore, average long-run benefits are more than twice as large as the average short-run benefits, which implies a sharply increasing efficiency pattern. This is a persistent pattern in the simulation experiments.

This intertemporal pattern is explained in part by the existence of adjustment costs. Since capital is not perfectly mobile across sectors and it takes time for capital to adjust towards the optimal levels, it also takes time for the investment efficiency effects to take place. The full benefits of integration in the allocation of capital in the economy will only be reaped in the long run.

Other important factors for the intertemporal pattern of efficiency gains are the distortions generated by the replacement mechanisms in the intertemporal labor-leisure decisions. In fact, for both bond-financed and mixed-financed equal yield and unlike tax-financed equal yield, the average long-run replacement is smaller than the average short-run replacement. In the two cases the intertemporal pattern is even more marked: average long-run benefits are about three times as large as the average short-run benefits.

#### PROPOSITION #3

*The distortions induced by the tax replacement mechanisms on the intertemporal labor-leisure decisions are of primordial importance in terms of the efficiency effects of integration.*

The complete elimination of the corporate income tax under the best scenario of tax financed equal yield and multiplicative replacement would require a permanent increase in the personal income tax rates of around 12%. The distortions induced by the tax replacement mechanisms on the intertemporal labor-leisure decisions are of primordial importance in terms of the efficiency effects of integration. This idea which has previously been suggested in the literature (see Fullerton-Gordon (1983)) is confirmed by the simulation results in this dissertation.

The efficiency benefits from integration are inversely related to the size of change in the personal income tax rates. With full integration, tax financed equal yield requires the lowest increase in personal tax rates and yields the highest efficiency results. In turn, bond financed equal yield requires the largest increase in personal tax rates and yields the lowest efficiency results. This is a persistent pattern in the simulation experiments.

Also, the relative difference in efficiency gains among the several equal yield alternatives is directly related to the differences in the tax replacement factor. Tax financed produces benefits 2.5% higher than mixed financed and requires a tax replacement which is 2.4% lower. In turn, mixed financed produces benefits 1.3% higher than bond financed, and requires a tax replacement which is 1.3% lower. On average, a 1% increase in the tax replacement generates a 1% decrease in the efficiency benefits. This is a persistent pattern in all the simulation experiments.

#### PROPOSITION #4

*Regardless of the equal yield strategy, the multiplicative replacement scheme yields higher efficiency benefits than additive replacement.*

In the previous literature, in particular in FKS<sub>W</sub> the additive replacement is less distortionary than multiplicative replacement. The opposite is true in the simulations in this dissertation. There is nothing counterintuitive about this fact. It has to do exclusively with the

specific data used in the DAGEM model.

It can be shown that in the DAGEM the additive replacement actually leads to an higher increase in the marginal tax rates than the multiplicative replacement, and therefore to higher distortions. Under tax-financed equal yield, the lowest income class would be subject to a personal income tax rate of 11.21% under the multiplicative replacement and to a tax rate of 12.6% under additive replacement. In turn, the highest income group would be subject to a personal income tax rate of 33.6% under the multiplicative replacement and to a tax rate of 32.6% under additive replacement. Given the household income distribution and the relative size of each household group in the DAGEM model, the additive replacement corresponds to an higher distortionary factor than the multiplicative replacement.

The fact that with additive replacement the efficiency effects are actually negatives, reinforces the idea of the primordial importance of the intertemporal distortions in the labor-leisure decisions introduced by the replacement mechanism. Under additive replacement, the increase on the personal marginal tax rates is 13% higher than under multiplicative replacement. The inverse relation between efficiency benefits and the changes in the marginal tax rates is here dramatically illustrated.

#### PROPOSITION #5

*Marginal financial crowding-out effects induced by changes in government deficits seem to be of second-order importance.*

Tax-financed equal yield blocks additional changes in deficits and "a fortiori" blocks marginal financial crowding out. In turn, bond-financed and mixed-financed equal yield are in general accompanied by marginal financial crowding-out effects. The differences among the three equal yield schemes suggest the importance of marginal financial crowding out effects.

Full integration results show slightly lower deficits under both bond-financed and mixed-financed equal yield, .024% and .005% respectively. Therefore, no substantial changes in

the path of government indebtedness are induced by corporate tax integration. That is not surprising since the corporate tax revenues foregone by integration are actually being collected at the personal income level. This is essentially a constant tax revenue experiment.

On the other hand, the small changes in government indebtedness are negatively associated with the efficiency gains. Lower deficits are expected to generate favorable marginal financial crowding out effects. However, these remain unnoticeable in the simulation results. In fact, efficiency gains with tax-financed equal yield are always higher than with bond-financed and mixed-financed equal yield despite the fact that the latter two generate lower government debt. This suggests the second order importance of marginal financial crowding out vis-a-vis the additional distortions in the intertemporal labor-leisure decisions.

There is an interesting corollary to this proposition. The fact that previous studies of corporate tax integration postulate balanced budgets, blocks not only financial crowding out but also marginal financial crowding out. The efficiency results are still biased upwards in absolute terms since financial crowding out is not considered. However, the absence of significant marginal crowding-out effects suggests that the comparisons of different scenarios in the previous studies may not be seriously biased.

#### PROPOSITION #6

*The efficiency effects of partial integration are systematically negative. This is a new second-best situation.*

Simulation results for partial integration are reported in Tables 6-7. Partial integration accomplished by dividend deduction from the corporate tax base, yields systematically negative efficiency effects. The long-run negative effects are at best -.183% of present value of consumption and leisure in the case of tax-financed equal yield with multiplicative replacement.

The persistently negative effects of partial integration contrast with the positive effects of full integration. This is an interesting second-best property of our economy. Partially alleviating

distortions does not necessarily yield global efficiency gains. The elimination of double taxation does not directly generate efficiency gains in terms of allocation of investment across sectors. On the other hand, the tax replacement factors are substantially higher than under full integration. Therefore, large efficiency distortions in the intertemporal consumption and labor-leisure allocations are created.

The second-best nature of partial integration is in contrast with previous results in FKS. Comparable results in FKS show long-run efficiency gains of about .32% of the intertemporal adjusted GNP. This is substantially lower than their full integration results. Still, there are efficiency gains from partial integration. Part of the difference between the results in DAGEM and FKS should be attributed to fact that while both models capture intertemporal consumption and labor-leisure decisions, the endogenously recursive nature of equilibrium in the DAGEM better captures the distortions induced by higher marginal income tax rates. Another reason for the difference between the two models may have to do with the different types of replacement used in the two works. FKS used increased corporate tax rates, not personal tax rates, as a replacement mechanism. Therefore, the primordial distortions on the intertemporal labor-leisure decisions are not operating in FKS. However, increased marginal corporate tax rates increase the wedge between the corporate and non corporate sectors and introduces additional distortion into the allocation of capital in the economy.

This second-best result in this work should be interpreted with some care. The partial integration mechanism alleviates not only the double taxation of dividends but also the distortion in favor of debt financed investment against equity. Partial integration should induce lower debt-equity ratios and improved investment financing efficiency. In this sense the simulation results with the DAGEM may be biased downwards. In fact, corporations are not allowed to react to the partial integration mechanism by optimally adjusting the corporate financing rules, namely the debt-equity ratios. This source of efficiency gains from integration is not captured by the DAGEM.

Fullerton-Gordon (1983) provide unique information of how important the effects are of dividend deduction under endogenous corporate financial behavior. They report efficiency gains of .6% of the GNP from the elimination of the tax distortions favoring debt. Given the size of the results reported here, it does not seem likely that making corporate financial decisions endogenous in the DAGEM would change the qualitative nature of the results, in particular the second-best property.

Two final remarks are in order. First, under partial integration the first-order importance of the distortion in the intertemporal labor-leisure decisions is confirmed. The case of tax-financed equal yield under multiplicative replacement requires the lowest marginal changes in personal income tax rates. It also shows the lowest efficiency losses. Also, this case is unique in that it violates the intertemporal pattern discussed in Proposition 2. Long-term losses are on average higher than short-term losses. However, this case is also unique in that the average replacement factor is higher in the long run than in the short run. Secondly, the secondary order of marginal financial crowding-out effects is illustrated here again. Bond-financed and mixed-financed equal yield generate slightly lower government deficits than tax-financed equal yield. Despite this fact, tax-financed equal yield generates the lowest losses.

#### Distributional Effects of Integration

The distributional effects of integration are reported in Tables 8-10. All the results are obtained under full integration with multiplicative tax replacement.

#### PROPOSITION # 7

*Intertemporal utility gains from integration are positively correlated with wealth. In turn, wealth gains from integration are negatively correlated with wealth. Therefore, utility gains and wealth gains are negatively correlated.*

Intertemporal utility gains from integration are positively correlated with wealth. High

income households benefit most from integration in terms of changes in intertemporal utility. They witness an increase of above 12% in the present value of their consumption and leisure. In turn the lowest income class suffers a utility loss of about -6.5%. The intertemporal utility of the middle income group remains essentially unaltered. To summarize, integration is not Pareto improving in terms of its utility effects.

Wealth gains from integration are negatively correlated with wealth. Low income households benefit most from integration in terms of changes in wealth ownership. Their wealth increases about 7%. In turn, the highest income class group shows a wealth increase below 1%. It should be noticed that integration is Pareto improving from the standpoint of wealth accumulation.

Utility gains and wealth gains are negatively correlated. The highest income group shows the highest utility gains and the lowest wealth accumulation gains. Inversely, the lowest income group shows the lowest utility gains (actually a utility loss) and the highest wealth accumulation gains. Accordingly, in the DAGEM the lowest income groups behaves with the highest savings elasticity with respect to interest rates. The highest income group, in turn, prefers to use the additional available income to finance current consumption and leisure.

Comparatively, in FKSU utility and income effects are both U-shaped and Pareto optimal improvements. Simulations in the DAGEM also suggests that the policy of tax integration is virtually Pareto optimal. Even those who experience reduction in current consumption and leisure, experience simultaneously the highest increase in wealth accumulation. Therefore they have the potential for higher gains in the future.

#### PROPOSITION #8

*Integration induces small changes in the private capital formation. The highly incorporated sectors gain the most with tax integration.*

Integration induces small changes in the private capital formation. Sector 1 (the primary sector essentially) shows a decrease in the capital stock. On the other hand, the other three sectors

which have relatively high degrees of incorporation show increased capital stock. The elimination of the corporate income tax eliminates the wedge in price of capital for the corporate sector. Therefore integration induces a re-allocation of investment in the economy in favor of the corporate sectors. The sector with highest degree of incorporation - Sector 3 (manufacturing sector essentially) gains the most with tax integration in terms of capital accumulation - about a 1% increase.

It should be noted that the gains in capital accumulation are relatively small when compared with FKS. That has to do with the modeling in the DAGEM of an investment behavior induced by adjustment costs. Capital is not fully mobile intersectorially and it takes time for capital to adjust to its optimal levels.

#### 4.3 Corporate Tax integration under the Current Tax Law

##### PROPOSITION #9

*The absolute efficiency gains from integration under the Tax Reform Act of 1986 are still lower than under the previous tax regime. However, the simulation results present the same general characteristics as under the previous tax regime.*

The efficiency results of tax integration under the current tax regime, the Tax Reform Act of 1986, are reported in Tables 11-14. The absolute efficiency gains from integration under the Tax Reform Act of 1986 are still lower than under the previous tax regime. Long-run gains from full integration with tax-financed equal yield and multiplicative replacement are about .3% of the present discounted value of consumption plus leisure. In turn, integration under bond-financed and mixed-financed equal yield generates long-run benefits which are at best .2%.

The intertemporal pattern of efficiency gains is even more marked under the current tax law. In the short run the net efficiency gains from integration are virtually zero. Only in the long run,

the benefits became noticeable.

The differential in the efficiency benefits from integration under the previous and the current tax regimes can be attributed to several factors. First, the lower efficiency gains under the current tax law go hand-in-hand with systematically higher replacement rates. The need for higher tax replacements is justified by the higher corporate tax revenues generated under the new tax law, together with lower personal income tax revenue. Recall that one idea behind the Tax Reform was to shift some of the tax revenues from the personal to the corporate income levels. In turn, higher replacement rates generate higher distortions in the intertemporal labor-leisure decisions. A second reason for smaller benefits under the new tax law is that government optimally increases public deficits by about 20%. Financial crowding-out effects are therefore much higher under the new tax code than under the previous tax regime.

At any rate, the difference in efficiency benefits from integration under the previous and current tax regimes provides an indication of the implicit value of the Tax Reform of 1986 in terms of corporate tax integration, i.e., in terms of the elimination of distortions associated with the corporate income tax.<sup>6/</sup> Gains from integration under the new tax regime might have been lower or greater than under the previous tax regime. Under the current law there are lower distortions in the allocation of capital within the corporate sectors together with lower distortions in terms of corporate dividend-retention decisions. However, higher effective corporate tax rates and the necessity for higher personal income tax replacements work in the opposite direction.

#### PROPOSITION #10

*The absolute distributional effects of integration under the Tax Reform Act of 1986 are smaller than under the previous tax regime. However, the simulation results present the same general characteristics as under the previous tax regime.*

The distributional results of tax integration under the current tax regime, the Tax Reform Act of 1986, are reported in Tables 15-17. The effects of integration on the intertemporal utility

value of consumption and leisure show the same pattern as under the previous tax law. Intertemporal utility gains from integration are positively correlated with wealth. However, the effects are now smaller in absolute value. The lowest income class loses about 3.5%, while the highest income class gains about 10.5%.

The effects of integration on the wealth accumulation show the same pattern as under the previous tax law. Wealth gains from integration are negatively correlated with wealth. The effects are again smaller in absolute value. The lowest income class shows a 4.5% increase in wealth accumulation, while the gains for the two other income groups are negligible.

Integration under the new tax law induces even smaller changes in the private capital formation. Still, the highly incorporated sectors gain most with tax integration. In turn, the unincorporated sector witnesses a decrease in capital formation.

#### 4.4 Sensivity Analysis

This section provides information about the sensitivity of the simulation results with respect to changes in the corporate financing policy rules as well as with respect to changes in the rules of formation of expectations. The sensitivity analysis focuses on the case of tax financed full integration with multiplicative replacement, the best integration scenario.

##### Effects of Changing Corporate Financing Rules

The analysis centers on Sector 2, the sector with the highest degree of incorporation. Together with integration, Sector 2's debt-equity and retention-dividend parameters are changed in the revised case simulations. Results are reported in Table 18.

##### PROPOSITION #11

*Simulation results are rather robust to the specification of debt-equity and dividend-retention*

*parameters.*

Recall that full integration eliminates the tax preference of debt against equity. Accordingly, integration tends to decrease the debt-equity ratio (and increase the equity-capital ratio). However, the behavioral mechanisms that would dictate such an adjustment are not modeled in the DAGEM. In particular, the DAGEM model does not capture bankruptcy costs. Simulation results show small variations around the central equity-capital ratio of .3. Both in the short run and in the long run, efficiency gains from integration decrease with increases in the equity-capital ratio. This seems a counterintuitive result. The reader is warned against a behavioral interpretation of this pattern. It is enough to say that simulation results are robust with respect to the specification of debt-equity ratios.

Full integration eliminates the tax preference of retained earnings against dividends. Accordingly, integration tends to decrease the retention-dividend ratio (and decrease the retention-profit ratio). However, the behavioral mechanisms that would dictate such an adjustment are not modeled in the DAGEM. The changes in the simulation results induced by changes in the retention-dividend parameter are negligible. Simulation results increase slightly as the retention-dividend decreases. It is enough to say that simulation results are very robust with respect to the specification of retention-dividend ratios.

#### Effects of Changing the Rules of Formation of Expectations

In the previous sections static expectations were assumed for the sake of comparability with previous literature. However, it is crucial to try other rules of formation of expectations and see how the simulation results are affected. Simulation results are reported in Table 19.

#### PROPOSITION #12

*The rules of formation of expectation dramatically affect the results of corporate tax integration. Myopic expectations are a "saddle-point" result.*

The rules of formation of expectation dramatically affect the results of corporate tax integration. With constant and common rates of price growth, the higher the expected rate of inflation the lower the gains from integration. In fact, benefits are typically negative even with this best case scenario of tax-financed equal yield with multiplicative replacement. For the other rules considered - adaptive expectations and extrapolative expectations - efficiency gains are positive and comparable with myopic expectations.

Myopic expectations are a "saddle-point" result. Six out of nine parameterizations of the rules of formation of expectations yield lower results. This suggests that the results in previous sections are plausible as "central" reference values for the effects of corporate tax integration. Also, the previous literature, assuming myopic expectations, may be overoptimistic in the evaluation of the potential gains from integration.

#### 4.5 Policy Implications

There are important policy implications to be drawn from the simulation results in this dissertation. The simulation results cast serious doubts on the desirability of repealing the corporate income tax in the U.S.. This work goes beyond the previous literature to suggest that integration may not be a good idea. The benefits of the full integration experiments may be too small when compared to the implementation and compliance costs of an actual policy. At any rate, integration efficiency gains are at best very modest. Corporate tax integration is certainly not a panacea.

Nevertheless, if the goal of corporate tax integration is to be pursued several aspects should be considered. First, the choice of integration strategy is crucial for the success, if limited, of the policy. Second, it is going to take some time for the full benefits of these policies to show up. Political costs should be expected in the short run before the benefits became apparent. Third, low

income groups are likely to lobby against tax integration. In fact, they will experience some welfare loss. However, this welfare reduction is coupled with an increase in wealth accumulation. Ultimately, the welfare of the lower income classes will also increase. Also, corporate tax integration may be attacked on grounds of favoring the high income groups. In reality the policy is virtually Pareto optimal. It is not obvious who gains more ultimately. Those who experience lesser gains in current consumption and leisure, also experience increased wealth accumulation. Therefore they have the potential for higher gains in the future. Fourth, simulation results suggest that arguments in terms of the potential negative effects of integration through bigger government deficits may not be fundamental. Finally, price expectations play a crucial role in the degree of success of integration. Efforts to develop constant prices and within some time lag constant price expectations may guarantee a result sufficiently close to the best scenario.

#### **5 - Summary and Concluding Remarks**

The objective of this paper is to study empirically the efficiency and distribution effects of integrating corporate and personal income taxes. This work attempts to provide a comprehensive account of both the economic inefficiencies eliminated by integration, and the distortions which are thereby created. With that objective, this paper develops a dynamic sequential general equilibrium model of the United States economy - DAGEM - with optimal intertemporal investment decisions and optimal allocation of investment across sectors, intertemporal household consumption/leisure decisions, and endogenous government deficits and financial crowding out.

Simulation results suggest first that the net welfare gains from integration are at best very modest and frequently negative. Such a dramatic change in tax codes, such as the complete elimination of the corporate tax and its replacement by increased personal income tax rates, is simulated to yield long-run benefits which are never larger than .17% of the present value of

future consumption and leisure. This is between four-times and twelve-times lower than comparable results available in the literature. Secondly, it takes time for the efficiency gains of integration to appear. In particular, the average long-run gains are more than three times as large as the average short-run gains. This new intertemporal pattern of efficiency effects is due to the existence of costs of adjustment, and reflects an adjustment lag in the interindustry investment decisions. Thirdly, partial integration, achieved by excluding dividends from the corporate tax base, systematically generates negative effects. This is a new second-best effect suggesting that less than complete integration may have perverse efficiency effects. Fourthly, unlike results in previous studies, integration is shown not to be a Pareto improvement action. In terms of the value of current consumption and leisure, the lowest income groups are worse off after the policy implementation. However, all income classes show an increase in wealth accumulation and, therefore, the potential is there for welfare gains at some point in the future. Fifthly, under the Tax Reform Act of 1986, the effects of integration show the same patterns and characteristics as under the old tax regime. However, under the new tax law the efficiency gains of integration are much lower. This suggests that the change in tax regimes in itself improved efficiency. In particular, the efficiency gains from both the new tax treatment of capital gains and depreciation allowances and the elimination of the investment tax credits dominate the additional distortions generated by an increase in the effective corporate income tax rates.

On a different vein, the results of the simulation experiments confirm the crucial importance of the marginal distortions in the labor-leisure decisions induced by the tax replacement mechanisms: the higher the marginal increases in the personal income tax rates the lower the efficiency gains from integration. In addition, the importance of marginal financial crowding out is confirmed: higher government deficits are associated with lower integration benefits. Also, the importance of expectations is illustrated: different rules of formation of expectations and even different parametrization of the same rule lead to clear changes in the effects of the policies

considered. Finally, the simulation results are very robust to different specifications of the debt-equity and dividend-retention parameters as was expected given the essentially deterministic context of the model.

Despite the contributions brought forth by the previous literature and this paper to the understanding of the effects of corporate tax integration, there is still an area that remains to be comprehensively studied: the changes on optimal financial decisions induced by tax integration. In the DAGEM, real private investment is financed by retained earnings and issuance of new debt and equity according to exogenously defined corporate financing and dividend-retention rules. Government finances deficits by issuing bonds. Household asset portfolio decisions merely accommodate to the composition of demand for funds - private assets and public bonds.

The integration of the corporate and personal income taxes should be expected to change the optimal household portfolio decisions. In fact, the different rates of return of the different financial assets change with integration. By not letting the households optimally adjust their portfolio to the new market conditions after integration, a source of efficiency is not accounted for. Therefore, the results in this work may be biased downwards.

Slemrod (1980) models optimal household portfolio decisions in a static environment and obtains benefits from integration which are twice as large as those reported in FKS. Part of the difference has been attributed to the fact that Slemrod's model is static and labor supply is exogenous. However, let us assume for a moment that the difference in efficiency between Slemrod's results and FKS's results could be attributed entirely to the optimality of household portfolio allocation. (Notice that this is highly unlikely since it was already stressed that the distortions in the intertemporal labor-leisure decisions represent a major efficiency cost of integration.) Let us also assume that the results of DAGEM with optimal portfolio decisions would also be twice as large vis-a-vis the current formulation. The main idea in this paper that the benefits of integration are at the very best modest would still hold true.

The integration of the corporate and personal income taxes should be expected to affect the optimal corporate financial rules and dividend-retention policies. With integration, the tax preference towards bonds against equity disappears or is alleviated. Therefore, the debt-equity ratios in the different corporate sectors would tend to decrease after integration. Also, with integration the tax preference towards retained earnings against dividends disappears. Therefore, the dividend-retention ratios in the different corporate sectors would tend to increase after integration. However, in the event that integration induces higher government deficits, the corporations may want to react by using internal funds more intensively. In this case, the net effect of integration on the dividend-retention ratios would be ambiguous. At any rate, by not letting the corporations adjust their debt-equity ratios and dividend-retention policies to the new market conditions after integration, some efficiency effects of integration are not accounted for. Therefore, the results in this work may be biased downwards. In fact, it was already suggested that the second-best nature of the partial integration results may be essentially due to the lack of optimal corporate financial rules and dividend policies. While the adverse conditions for equity issuance and dividend payout disappear or are attenuated when dividends are exempted from the corporate income tax base, the model assumes that financial rules and retention policies do not change.

Fullerton-Gordon (1983) and Galper-Lucke-Toder (1986) optimally model the debt-equity rules by trading off the tax preference of debt against the potential bankruptcy costs of equity financing. Predictably, integration is simulated to generate substantial changes in the optimal debt-equity rules. However, the changes induced on the overall efficiency results by changes in the optimal debt-equity rules are not discussed by either Fullerton-Gordon or Galper-Lucke-Toder. That may in fact suggest that changes in overall efficiency results are not substantial. Furthermore, the effects of optimal changes in the dividend payout rates weren't ever discussed in the previous literature either.

Modeling uncertainty in a non-trivial way (recall that in the DAGEM uncertainty is "eliminated" by using point expectations) seems to be the only promising approach to meaningful treatment of both optimal corporate financial decisions and optimal household portfolio decisions. In a stochastic context, optimal portfolio decisions may be addressed within a capital-asset-pricing-model framework (see Merton (1973) for seminal work along these lines). Also, corporate financial rules may be addressed by trading off in a stochastic environment the preference of debt against the potential bankruptcy costs of equity financing. Despite the advantages of the stochastic analysis, general equilibrium modeling and implementation in a stochastic setting is a very complex enterprise which is outside the scope of this paper.

FOOTNOTES

1/

See Pereira (1988) for a full documentation of the DAGEM model.

2/

The intertemporal optimization problems are solved using Pontryagin's Maximum Principle to yield optimal net demand functions.

3/

These assumptions are sufficient for existence and uniqueness of optimal intertemporal output plans even with constant returns to scale technologies. See Pereira (1987) on this issue.

4/

The base case with the DAGEM essentially reproduces the main relationships in the U.S. economy. In particular, household behavior implies an average savings elasticity with respect to interest rate of .20. This is well within the range of values in use in the literature (see BFSW for example). On the other hand, household behavior implies an average labor supply elasticity with respect to wage rate of 1.11. This value is at the upper bounds of the set of acceptable values (see Lucas-Rapping (1970)).

5/

Recall that the model is run for a period of twenty years in a decision time-horizon of one hundred years. In this section short-run refers to the first 10 years, long-run to the whole twenty years.

6/

The implementation of a stylized version of the Tax Reform Act of 1986 in the context of the DAGEM model is simulated to yield general efficiency gains over the previous tax regime of as much as 2.5% of the present discounted value of future consumption plus leisure.

REFERENCES

- Ballard, C., D. Fullerton, J. Shoven, and J. Whalley. 1985. A General Equilibrium Model for Tax Policy Evaluation. National Bureau of Economic Research. University of Chicago Press.
- Boskin, M., M. Robinson, and J. Roberts. 1985. "New Estimates of Federal Government Tangible Capital and Net Investment," Center for Economic Policy Research (CEPR) Publication No. 62, Stanford University.
- Congress of the United States: Congressional Budget Office Study. 1985. Revising the Corporate Income Tax. Washington, D.C. Government Printing Office.
- Denton, F. 1982. "Consumer Expectations and the Intertemporal Cost-of-Living Index," Quantitative Studies in Economics and Population Research Report 40. McMaster University.
- Feldstein, M. ed. 1983. Behavioral Simulation Methods in Tax Policy Analysis, National Bureau of Economic Research. University of Chicago Press.
- Fullerton, D., and R. Gordon. 1983. "A Reexamination of Tax Distortions in General Equilibrium Models." In Behavioral Simulation Methods in Tax Policy Analysis. M. Feldstein ed.. Chicago: University of Chicago Press.
- Fullerton, D., A. King, J. Shoven, and J. Whalley. 1980. "Corporate and Personal Tax Integration in the United States: Some Preliminary Findings." In Microeconomic Simulation Models for Public Policy Analysis, H. Haveman and K. Hollenbeck eds. New York: Academic Press.
- Fullerton, D., A. King, J. Shoven, and J. Whalley. 1981. "Corporate Tax Integration in the United States: A General Equilibrium Approach," American Economic Review 71,

677-691.

Fullerton, D. A. King, J. Shoven, and J. Whalley 1985), "Corporate Tax Integration in the United States: a General Equilibrium Approach," in A General Equilibrium Model for Tax Policy Evaluation, Ballard, D. Fullerton, J. Shoven, and J. Whalley. National Bureau of Economic Research. University of Chicago Press.

Galper, H., R. Lucke, and E. Toder. 1986. "Taxation, Portfolio Choice, and the Allocation of Capital: A General Equilibrium Approach," Congressional Budget Office, mimeo.

Gill, P., W. Murray, M. Saunders, and M. Wright. 1986. "User's Guide for NPSOL (Version 4.0): A Fortran Package for Nonlinear Programming," Technical Report SOL 86-2, Department of Operations Research, Stanford University.

Gould, J. 1968. "Adjustment Costs in the Theory of the Firm," Review of Economic Studies 35, 47-55.

Goulder, L. and L. Summers. 1987. "Tax Policy, Asset Prices, and Growth: A General Equilibrium Analysis," NBER Working Paper No. 2128.

Haveman H. and K. Hollenbeck eds. 1980. Microeconomic Simulation Models for Public Policy Analysis. New York: Academic Press.

Lucas, R, and L. Rapping. 1970. "Real Wages, Employment, and Inflation," in Microeconomic Foundations of Employment and Inflation Theories, E. Phelps ed. New York: W. W. Norton.

McLure, C. 1979. Must Corporations Be Taxed Twice? Washington, D.C.: Brookings Institution.

Merrill, O. 1972. "Applications and Extensions of an Algorithm that Computes Fixed-Points of Certain Upper Semi-continuous Point to Set Mappings," Ph.D. dissertation, University of Michigan.

Merton, R. 1973. "An Intertemporal Capital Asset Pricing Model," Econometrica 41,

867-887.

Pechman, J. 1987. Federal Tax Policy. Washington, D.C.: Brookings Institution.

Phelps E., ed. 1970. Microeconomic Foundations of Employment and Inflation Theories. New York: W. W. Norton.

Pereira, A. 1987. "On the Existence and Uniqueness of Optimal Output Path for CRTS Firms in Adjustment Costs Technologies." Department of Economics, Stanford University. Mimeo.

Pereira, A. 1988. "DAGEM - A Dynamic General Equilibrium Models for Tax Policy Evaluation," Department of Economics, University of California San Diego Working Paper 88-17.

Pollak, R. 1975. "The Intertemporal Cost of Living Index," Annals of Economic and Social Measurement 4, 179-195.

Shoven, J., and J. Whalley. 1977. "Equal Yield Tax Alternatives: A General Equilibrium Computational Technique," Journal of Public Economics 8, 211-224.

Slemrod, J. 1980. "A General Equilibrium Model of Capital Income Taxation," Ph.D. dissertation, Harvard University.

Summers, L. 1981. "Taxation and Corporate Investment: a q-Theory Approach," Brookings Papers on Economic Activity, pp. 67-127.

Survey of Current Business. 1983.

U.S. Department of Treasury. 1977. Blueprint for Basic Tax Reform. Washington, D.C.. Government Printing Office.

APPENDIX IDAGEM - NOTATION1. General NotationTime

current time  
 terminal time  
 future time

$z$   
 $T$  (finite)  
 $z \leq t \leq T$

Agents

consumers  
 producers of consumption goods  
 producers of physical capital  
 government

group  $i=1, \dots, C$   
 industry  $j=1, \dots, J$   
 industry  $j=1$   
 $g$

Commodities

consumption of good  $j$  by  $i$   
 labor supplied by  $i$   
 leisure of  $i$   
 total available time of  $i$   
 consumption good  $j$   
 value added by  $j$   
 total investment cost by  $j$   
 adjustment costs  
 use of input  $f$  by  $j$   
 capital stock in sector  $j$   
 investment by industry  $j$   
 total demand for investment by  $j$   
 labor used by industry  $j$   
 investment good  
 use of good  $j$  by  $g$   
 capital stock demanded by  $g$   
 investment by  $g$   
 labor demanded by  $g$

$y_{ijt}$   
 $L_{it}$   
 $H_{it}$   
 $L_i$   
 $y_{jt}$   
 $VA_{jt}$   
 $TC_{jt}$   
 $C_j(\cdot)$   
 $y_{jft}$   
 $K_{jt}$   
 $I_{jt}$   
 $I_{jt} + C_j(\cdot)$   
 $L_{jt}$   
 $I_t$   
 $y_{jgt}$   
 $K_{gt}$   
 $I_{gt}$   
 $L_{gt}$

Financial Flows and Assets

wealth of  $i$   
 savings of  $i$   
 $j$ -th industry bonds owned by  $i$   
 $j$ -th industry equity owned by  $i$   
 dividends from  $j$  received by  $i$

$W_{it}$   
 $S_{it} = F_{it}$   
 $B_{ijt}$   
 $E_{ijt}$   
 $Div_{ijt}$

government bonds owned by i	$B_{igt}$
i's share of the market portfolio	$s_{it}$
share of debt in i's portfolio	$1 - \sum_j e_{jt}$
share of equity j in i's portfolio	$e_{jt}$
j-th's net cash flow	$NCF_{jt}$
j-th's gross/quasi profits	$\Pi_{jt}$
j-th industry bonds	$B_{jt}$
j-th industry capital equity	$E_{jt}$
sector j liabilities	$FL_{jt}$
dividends distributed by j	$Div_{jt}$
retained earnings by j	$RE_{jt}$
new funds demanded by j	$F_{jt}$
government bonds	$B_{gt}$
government liabilities	$LG_t$
new funds demanded by g	$F_{gt}$
labor tax revenue	$LT_t$
corporate tax	$CT_t$
investment tax credit	$ITC_t$
income tax	$IT_t$
sales tax	$ST_t$
total taxes	$TT_t$
transfers	$Tr_t$

### Prices

consumption good j	$P_{jt}$
vector of consumption goods	$P_t$
physical investment	$P_{It}$
labor	$P_{Lt}$
interest rate	$r_t$
price of equity j	$P_{jEt}$

Optimal demands are referred to by superscript D. Optimal supplies are referred to by superscript S. Predetermined stock variables at z are denoted by a superscript \* and do not have time subscript. Future expected prices are referred to by superscript e.

## 2. Structural Parameters

### Preference and Technology Parameters

group i's discount rate	$\partial_i$
Cobb-Douglas j-th share	$a_{jj}$

Cobb-Douglas labor share	$1 - \sum_j a_{ij}$
Leontiff parameters	$a_{jf}$
Cobb-Douglas labor share	$a_j$
Cobb-Douglas capital share	$1 - a_j$
adjustment costs parameter	$b_j$
j-th's capital depreciation rate	$\delta_{jt}$
dividend/retention parameter	$\delta_{\pi jt}$
new debt/equity parameter	$\delta_{Ejt}$
government discount rate	$\delta_g$
Cobb-Douglas labor share	$a_{gL}$
Cobb-Douglas capital share	$a_{gK}$
Cobb-Douglas j-th good share	$a_{gj}$
g's capital depreciation rate	$\delta_{gt}$

#### Tax Parameters

income tax rate	$T_{it}$
income tax rate intercept	$b_{it}$
capital gains tax	$CGT_{it}$
transfers received by i	$Tr_{it}$
sales tax rate	$T_{jt}$
labor tax rate	$T_{Lt}$
j's corporate tax rate	$T_{cjt}$
j's investment tax credit	$ITC_{jt}$
j's depreciation allowances	$DA_{jt}$
j's depreciation for tax purposes	$\delta'_{jt}$

## APPENDIX II

DAGEM - EQUILIBRIUM CONDITIONS AND TRANSITIONS1. Equilibrium Conditions-Consumption Goods Markets: for  $j=1, \dots, J$ :

$$(A.1) \quad \sum_i y^D_{ijt}(p_t; p^*_t; \forall_i) + y^D_{ljt}(p_t; p^*_t; \forall_l) + y^D_{jgt}(p_t; p^*_t; \forall_g) + \\ + \sum_{1 \leq f \leq J} y^D_{fjt}(p_t; p^*_t; \forall_f) = y^S_{jt}(p_t; p^*_t; \forall_j)$$

$$(A.2) \quad y^S_{jt} = K^*_j \{ [(1+T_{Lt})P_{Lt}] / a_j [p_{jt} - \sum_f (a_{jf} p_{ft})] \}^{a_j / (a_j - 1)}$$

$$(A.3) \quad y^D_{jft} = a_{jf} K^*_j \{ [(1+T_{Lt})P_{Lt}] / a_j [p_{jt} - \sum_f (a_{jf} p_{ft})] \}^{a_j / (a_j - 1)}$$

$$(A.4) \quad y^D_{lft} = a_{lf} K^*_l \{ [(1+T_{Lt})P_{Lt}] / a_l [p_{lt} - \sum_f (a_{lf} p_{ft})] \}^{a_l / (a_l - 1)}$$

$$(A.5) \quad y^D_{gjt} = [a_{gj}(1+r_t)] / [q_{gt} p_{jt}]$$

$$(A.6) \quad y^D_{ijt} = a_{ij} \{ 1 + (1-T_{it}) [(1 - \sum_j e_{jt}) r_t + \sum_j e_{jt} (\text{Div}_{jt} / p_{jEt-1} E_{jt})] \} / \{ q_{it} (1+T_{it}) p_{jt} \}$$

-Labor Market:

$$(A.7) \quad \sum_j L^D_{jt}(p_t; p^*_t; \forall_j) + L^D_{lt}(p_t; p^*_t; \forall_l) + L^D_{gt}(p_t; p^*_t; \forall_g) = \sum_i L^S_{it}(p_t; p^*_t; \forall_i)$$

$$(A.8) \quad L^D_{jt} = K^*_j \{ [(1+T_{Lt})P_{Lt}] / a_j [p_{jt} - \sum_f (a_{jf} p_{ft})] \}^{1 / (a_j - 1)}$$

$$(A.9) \quad L^D_{lt} = K^*_l \{ [(1+T_{Lt})P_{Lt}] / a_l [p_{lt} - \sum_f (a_{lf} p_{ft})] \}^{1 / (a_l - 1)}$$

$$(A.10) \quad L^D_{gt} = [a_{gL}(1+r_t)] / [q_{gt}(1+T_{gL})P_{Lt}]$$

$$(A.11) \quad L^*_i - L^S_{it} =$$

$$[(1 - \sum_j a_{ij}) (1 + (1 - T_{it}) [(1 - \sum_j e_{jt}) r_t + \sum_j e_{jt} (\text{Div}_{jt} / p_{jEt-1} E_{jt})]) / q_{it} (1 - T_{it}) P_{Lt}]$$

-Investment Good Market:

$$(A.12) \quad \sum_j I^D_{jt}(p_t; p^*_t; \forall_j) + I^D_{lt}(p_t; p^*_t; \forall_l) + I^D_{gt}(p_t; p^*_t; \forall_g) = I^S_t(p_t; p^*_t; \forall_l)$$

$$(A.13) \quad IT^D_{jt} = I^D_{jt} + .5b_j(I^D_{jt})^2$$

$$(A.14) \quad I^D_{jt} = [1/b_j] \{ (1+r_{t+1})^{-1} q_{jt+1} - (1-ITC_{jt})p_{lt} \}$$

$$(A.15) \quad IT^D_{lt} = I^D_{lt} + .5b_l(I^D_{lt})$$

$$(A.16) \quad I^D_{lt} = [1/b_l] \{ (1+r_{t+1})^{-1} q_{lt+1} - (1-ITC_{lt})p_{lt} \}$$

$$(A.17) \quad I^D_{gt} = a_{gk} / \{ q_{gt} [p_{lt} - (1+r_{t+1})^{-1} (1-\emptyset_{gt+1})p_{lt+1}] (1+\partial_g) (1+r_t)^{-1} \} - (1-\emptyset_{gt})K^*_t$$

$$(A.18) \quad I^S_t = K^*_l \{ [(1+T_{Lt})p_{Lt}] / a_l [p_{lt} - \sum_f (a_{fl} p_{ft})] \}^{a_l / (a_l - 1)}$$

-Financial Market:

$$(A.19) \quad \sum_j F^D_{jt}(p_t; p^*_t; \gamma_j) + F^D_{lt}(p_t; p^*_t; \gamma_l) + F^D_{gt}(p_t; p^*_t; \gamma_g) = \sum_i F^S_{it}(p_t; p^*_t; \gamma_i)$$

$$(A.20) \quad F^S_{it} = b_{it} + (1-T_{it}) [p_{Lt} L^S_{it} + [(1-\sum_j e_{jt})r_t + \sum_j e_{jt} (\text{Div}_{jt}/p_{jEt-1} E_{jt})] W^*_j] + \\ + Tr_{it} + (1-CGT_{it}) \sum_j [p_{jEt} - p_{jEt-1}] E_{it} - \sum_j (1+T_{jt}) p_{jt} y^D_{ijt}$$

$$(A.21) \quad F^D_{jt} = (1-ITC_{jt})p_{lt} I^D_{jt} + (1-T_{cjt})r_t B_{jt} + (1-CGT_{jt}) [p_{jEt} - p_{jEt-1}] E_{jt} - RE_{jt} - \emptyset'_{jt} K^*_j$$

$$(A.22) \quad F^D_{lt} = (1-ITC_{lt})p_{lt} I^D_{lt} + (1-T_{clt})r_t B_{lt} + (1-CGT_{jt}) [p_{jEt} - p_{jEt-1}] E_{jt} - RE_{lt} - \emptyset'_{lt} K^*_l$$

$$(A.23) \quad F^D_{gt} = r_t L G^* + Tr_{gt} + \sum_j p_{jt} y^D_{gjt} + (1+T_{gLt})p_{Lt} L^D_{gt} + p_{lt} I^D_{gt} - TT_t$$

## 2. Transitions

-Capital Stock

$$(A.24) \quad K_{jt+1} = I^D_{jt} + (1-\emptyset_{jt})K^*_j$$

$$(A.25) \quad K_{lt+1} = I^D_{lt} + (1-\emptyset_{lt})K^*_l$$

$$(A.26) \quad K^D_{gt+1} = I^D_{gt} + (1-\emptyset_{gt})K^*_g$$

-Liabilities:

$$(A.28) \quad B^S_{jt+1} = B^*_j + (1-\emptyset_{Ejt})F^D_{jt}$$

$$(A.29) \quad p_{iEt} E_{jt+1}^S = p_{iEt-1} E_{jt}^* + \theta_{Ejt} F_{jt}^D$$

$$(A.30) \quad FL_{jt+1}^S = B_{jt+1}^S + p_{jEt} E_{jt+1}^S$$

$$(A.31) \quad B_{lt+1}^S = B_{lt}^* + (1 - \theta_{Elt}) F_{lt}^D$$

$$(A.32) \quad p_{iEt} E_{lt+1}^S = p_{iEt-1} E_{lt}^* + \theta_{Elt} F_{lt}^D$$

$$(A.33) \quad FL_{lt+1}^S = B_{lt+1}^S + p_{iEt} E_{lt+1}^S$$

$$(A.34) \quad LG_{t+1}^D = (1+r_t) LG_t^* + Tr_t + \sum_j p_{jt} y_{gjt}^D + (1+T_{gLt}) p_{Lt} L_{gt}^D + p_{lt} l_{gt}^D - TT_t$$

-Total Wealth and Composition:

$$(A.35) \quad W_{it+1}^D = W_{it}^* + b_{it} + (1-T_{it}) [p_{Lt} L_{it}^S + [(1-\sum_j e_{jt}) r_t + \sum_j e_{jt} (\text{Div}_{jt}/p_{jEt-1} E_{jt})] W_{it}^*] \\ + Tr_{it} + (1-CGT_{it}) \sum_j [p_{jEt} - p_{jEt-1}] E_{ijt} - \sum_j (1+T_{jt}) p_{jt} y_{jit}^D$$

$$(A.36) \quad W_{it+1} = \sum_j B_{ij,t+1} + B_{igt+1} + \sum_j p_{jEt} E_{ijt+1}$$

$$(A.37) \quad \sum_j B_{ij,t+1} = s_{it+1} \sum_j B_{jt+1}$$

$$(A.38) \quad B_{igt+1} = s_{it+1} B_{igt+1}$$

$$(A.39) \quad p_{jEt} E_{ijt+1} = s_{it+1} p_{jEt} E_{jt+1} \quad \text{for all } j$$

$$(A.40) \quad s_{it+1} = W_{it+1} / \sum_i W_{it+1}$$

### 3. Specification of the Shadow Prices

$$(A.41) \quad q_{it} = \sum_{t \leq s \leq T} (1+\partial_j)^{-(s-z)}$$

$$\{W_{it}^* + \sum_{t \leq s \leq T} [(b_{is} + Tr_{is} + (1-T_{is}) p_{Ls} L_{it}^* + (1-CGT_{is}) \sum_j [p_{jEs} - p_{jEs-1}] E_{ijs}) /$$

$$/ [\prod_{t \leq h \leq s} [1 + (1-T_{ih}) [(1-\sum_j e_{jh}) r_h + \sum_j e_{jh} (\text{Div}_{jh}/p_{jEh-1} E_{jh})]]]\}]$$

$$(A.42) \quad q_{jt+1} = \sum_{t+1 \leq s \leq T} [\prod_{t+1 < h < s-1} A_{jh}] C_{js}$$

$$(A.43) \quad A_{jh} = (1 - \emptyset_{jh})(1 + r_{h+1})^{-1}$$

$$(A.44) \quad C_{js} = (1 - T_{cjs})[p_{js} - \sum_f (a_{jf} p_{fs})] (1 - a_j) \{ (1 + T_{Ls}) p_{Ls} / a_j [p_{js} - \sum_f (a_{jf} p_{fs})] \} a_j^{s-1} / (a_j - 1)$$

$$(A.45) \quad q_{gt} = \{ (1 - a_{kg}) (1 + 1 / (1 + \partial_g))^{T-t} + \sum_{t+1 \leq s \leq T-1} (1 + \partial_g)^{-s} -$$

$$- [a_{kg} p_{IT-1} / (1 + \partial_g)^{T-t}] [ (1 + r_T) / (1 + r_T) p_{IT-1} - (1 - \emptyset_{JT}) p_{IT} ] \} /$$

$$/ \{ LG_t^* + p_{It} K_g^* (1 - \emptyset_{gt}) / (1 + r_t) + \sum_{t \leq s \leq T} (Tr_s - T\bar{T}_s) / \prod_{t \leq h \leq s} (1 + r_h) \}$$

#### 4. Inter-Agent Transfers

-RE<sub>jt</sub>, Div<sub>jt</sub> are given by

$$(A.46) \quad RE_{jt} = \emptyset_{\Pi jt} (1 - T_{cjt}) \{ [p_{jt} - \sum_f (a_{jf} p_{ft})] y_{jt}^S (1 + T_{Lt}) p_{Lt} L_{jt}^D \}$$

$$(A.47) \quad Div_{jt} = (1 - \emptyset_{\Pi jt}) (1 - T_{cjt}) \{ [p_{jt} - \sum_f (a_{jf} p_{ft})] y_{jt}^S (1 + T_{Lt}) p_{Lt} L_{jt}^D \}$$

-TT<sub>t</sub>, Tr<sub>t</sub> are given by

$$(A.48) \quad TT_t = LT_t + CT_t + ST_t + IT_t + CGT_t - ITC_t$$

$$(A.49) \quad LT_t = (\sum_j T_{Lt} p_{Lt} L_{jt}^D) + T_{gLt} p_{Lt} L_{gt}^D$$

$$(A.50) \quad CT_t = \sum_j T_{cjt} \{ [p_{jt} - \sum_f a_{fjt} p_{ft}] y_{jt}^S (1 + T_{Lt}) p_{Lt} L_{jt}^D - r_t B_{jt} \} +$$

$$+ T_{cIt} \{ [p_{It} - \sum_f a_{fIt} p_{ft}] y_{It}^S (1 + T_{Lt}) p_{Lt} L_{It}^D - r_t B_{It} \}$$

$$(A.51) \quad ITC_t = \sum_j ITC_{jt} p_{It} [L_{jt}^D + C_j (I_{jt}^D)] + ITC_{It} p_{It} [L_{It}^D + C_I (I_{It}^D)]$$

$$(A.52) \quad ST_t = \sum_j [\sum_j T_{jt} p_{jt} y_{ijt}^D]$$

$$(A.53) \quad IT_t = \sum_j \{ b_{it} + T_{it} [p_{Lt} L_{it}^D + [(1 - \sum_j e_{jt}) r_t + \sum_j e_{jt} (Div_{jt} / p_{jEt-1} E_{jt})] W_{it}] \}$$

$$(A.54) \quad CGT_t = \sum_j CGT_{it} (p_{jEt} - p_{jEt-1}) E_{ijt} + \sum_j CGT_{jt} (p_{jEt} - p_{jEt-1}) E_{jt}$$

$$(A.55) \quad Tr_t = \sum_j Tr_{it}$$

APPENDIX IIIDAGEM - POLICY EVALUATION INDICATORS-Aggregate Short-Run Indicators:

$$(A.1) \quad ASREV_t = \sum_i \{ \exp[(F_{it}^r - F_{it}^b) / \sum_{t \leq s \leq T} (1 + \partial_i)^{-(s-t)}] - 1 \} SRCF_{it}^b$$

$$(A.2) \quad ASRCV_t = \sum_i \{ 1 - \exp[(F_{it}^r - F_{it}^b) / \sum_{t \leq s \leq T} (1 + \partial_i)^{-(s-t)}] \} SRCF_{it}^r$$

-Aggregate Long-Run Indicators:

$$(A.3) \quad ALREV_t = \sum_{t \leq s \leq T} [\prod_{t+1 \leq h \leq s} (1 + r_h^b)] ASREV_s$$

$$(A.4) \quad ALRCV_t = \sum_{t \leq s \leq T} [\prod_{t+1 \leq h \leq s} (1 + r_h^r)] ASRCV_s$$

-Individual Short-Run Expenditure Functions:

$$(A.5) \quad SRCF_{it}(p_t, r_t, p_{t+1}^e, r_{t+1}^e, \dots, p_T^e, r_T^e; F_t^*) =$$

$$= \exp\{ (F_{it} - \sum_{t \leq s \leq T} (1 + \partial_i)^{-(s-t)})$$

$$\cdot [\sum_j a_{ij} \ln[a_{ij} / (1 + T_{js}) p_{js}] + (1 - \sum_j a_{ij}) \ln[(1 - \sum_j a_{ij}) / (1 - T_{is}) p_{Ls}] +$$

$$+ \ln[(1 + \partial_i)^{-(s-t)} \prod_{t+1 \leq h \leq s} (1 + r_h)] \} / [\sum_{t \leq s \leq T} (1 + \partial_i)^{-(s-t)}]$$

**TABLE 1**  
**CLASSIFICATION OF INDUSTRIES AND CONSUMER GROUPS IN THE DAGEM**

<b>CONSUMER GROUPS</b> (Households classified by \$Thousands of 1973 gross income)	
Group # 1	0 - 6
Group # 2	6 - 15
Group # 3	15+

<b>INDUSTRIES</b>	
Sector # 1	Agriculture, Mining, Energy
Sector # 2	Food, Textiles, Paper, Chemicals, Lumber, Metals
Sector # 3	Trade, Finance, Real Estate, Services
Sector # 4	Capital: Construction, Transportation, Machinery

**TABLE 2**  
**BASE CASE PARAMETER VALUES AND STOCKS FOR EACH INDUSTRY**

	<b>SECTOR 1</b> Agriculture	<b>SECTOR 2</b> Manufacturing	<b>SECTOR 3</b> Services	<b>SECTOR 4</b> Capital
<b>General Parameters</b>				
Cobb-Douglas Labor Share	0.4	0.8	0.7	0.5
Adjustment Cost Parameter	0.035	0.02	0.025	0.016
Depreciation Rate	0.099	0.07	0.067	0.085
Equity/Capital	0.84	0.78	0.35	0.81
Retention/Earnings	0.63	0.3	0.28	0.25
<b>Tax Parameters</b> <b>Old Tax Law</b>				
Corporate Tax	0.01	0.46	0.3	0.45
Investment Tax Credit	0.038	0.04	0.013	0.039
Depreciation Rate (Tax)	0.203	0.13	0.124	0.128
Labor Tax	0.09	0.09	0.09	0.09
Sales Tax	0.024	0.02	0.01	0
<b>Tax Parameters</b> <b>Current Tax Law</b>				
Corporate Tax	0.01	0.3	0.2	0.3
Investment Tax Credit	-	-	-	-
Depreciation Rate (Tax)	0.15	0.9	0.8	0.9
Labor Tax	0.09	0.09	0.09	0.09
Sales Tax	0.024	0.02	0.01	0
<b>Stock Values</b>				
Capital	795	946	2509	110

**TABLE 3**  
**BASE CASE PARAMETER AND STOCKS FOR HOUSEHOLDS AND GOVERNMENT**

	LOW INCOME	MED INCOME	HIGH INCOME	GOVERNMENT
<b>General Parameters</b>				
CD Share of Labor/Leisure	0.201	0.371	0.65	0.432
CD Share-Sector 1	0.011	0.008	0.008	0.004
CD Share-Sector 2	0.226	0.203	0.19	0.169
CD Share-Sector 3	0.562	0.418	0.452	0.062
Discount Rate	0.05	0.05	0.05	0.05
Population Distribution	0.38	0.41	0.21	-
Wealth Shares	0.06	0.25	0.69	-
Dep.Rate of Govrnt Capital	-	-	-	0.06
<b>Tax Parameters</b>				
<b>Old Tax Law</b>				
Personal Income Tax	0.1	0.2	0.3	-
Capital Gains Tax	0.05	0.05	0.05	-
<b>Current Tax Law</b>				
Personal Income Tax	0.08	0.15	0.25	-
<b>Stock Values</b>				
Government Capital Stock	-	-	-	2670
Public Debt	-	-	-	500

**TABLE 4**  
**EFFICIENCY EFFECTS OF FULL INTEGRATION UNDER THE OLD TAX LAW**

FULL INTEGRATION	EQUIVALENT VARIATIONS		TAX REPLACEMENT FACTOR	
	short run	long run	short run	long run
	(billions of 1973 dollars)			
<b>bond financing</b>				
multiplicative replacement	10.195	55.475	1.125	1.121
additive replacement	-34.545	-39.060	.028	.027
<b>tax financing</b>				
multiplicative replacement	12.650	57.675	1.117	1.121
additive replacement	-28.010	-34.585	.025	.026
<b>mixed financing</b>				
multiplicative replacement	11.111	56.345	1.122	1.121
additive replacement	-32.210	-37.100	.027	0.026

NB - Base Case Adjusted GNP is 34991.575 billion 1973 dollars

**TABLE 5**  
**FURTHER EFFECTS OF FULL INTEGRATION UNDER THE OLD TAX LAW**

<b>FULL INTEGRATION</b>	<b>GNP</b> Revised case/Base case	<b>DEFICITS</b> Revised case/Base case
<b>bond financing</b>  multiplicative replacement additive replacement	  0.99881 0.99893	  0.99976 0.99936
<b>tax financing</b>  multiplicative replacement additive replacement	  0.99876 0.99887	  1.0 by definition 1.0 by definition
<b>mixed financing</b>  multiplicative replacement additive replacement	  0.99879 0.99891	  0.99995 0.99969

**TABLE 6**  
**EFFICIENCY EFFECTS OF PARTIAL INTEGRATION UNDER THE OLD TAX LAW**

PARTIAL INTEGRATION	EQUIVALENT VARIATIONS		TAX REPLACEMENT FACTOR	
	short-run (billions of 1973 dollars)	long-run	short-run	long-run
<b>bond financing</b>				
multiplicative replacement	-39.445	-70.480	1.246	1.230
additive replacement	-124.025	-244.875	.052	.049
<b>tax financing</b>				
multiplicative replacement	-31.825	-63.895	1.214	1.217
additive replacement	-104.390	-223.33	.045	.046
<b>mixed financing</b>				
multiplicative replacement	-36.605	-66.795	1.233	1.224
additive replacement	-167.640	-236.105	.049	.048

NB - Base Case Adjusted GNP is 34991.575 billion 1973 dollars

**TABLE 7**  
**FURTHER EFFECTS OF PARTIAL INTEGRATION UNDER THE OLD TAX LAW**

<b>PARTIAL INTEGRATION</b>	<b>GNP</b> Revised case/Base case	<b>DEFICITS</b> Revised case/Base case
<b>bond financing</b>		
multiplicative replacement	0.99927	0.99579
additive replacement	0.99941	0.99559
<b>tax financing</b>		
multiplicative replacement	0.99912	1.0 by definition
additive replacement	0.99926	1.0 by definition
<b>mixed financing</b>		
multiplicative replacement	0.99922	0.9976
additive replacement	0.99935	0.99745

**TABLE 8  
INTERTEMPORAL UTILITY CHANGES UNDER THE OLD TAX LAW**

Revised case/Base case

FULL INTEGRATION with multiplicative replac.	LOW INCOME GROUP	MEDIUM INCOME GROUP	HIGH INCOME GROUP
bond financing	0.92894	1.00966	1.1126
tax financing	0.94057	1.00991	1.11227
mixed financing	0.93782	1.00982	1.11209

**TABLE 9**  
**WEALTH ACCUMULATION CHANGES UNDER THE OLD TAX LAW**

Revised case/Base case

FULL INTEGRATION with multiplicative replac.	LOW INCOME GROUP	MEDIUM INCOME GROUP	HIGH INCOME GROUP
bond financing	1.07159	1.01291	1.00877
tax financing	1.07077	1.01282	1.00874
mixed financing	1.07094	1.01288	1.00879

**TABLE 10**  
**CHANGES IN CAPITAL ACCUMULATION UNDER THE OLD TAX LAW**

Revised Case/Base Case

<b>FULL INTEGRATION with multiplicative replacement</b>	<b>SECTOR 1 Agriculture</b>	<b>SECTOR 2 Manufacturing</b>	<b>SECTOR 3 Services</b>	<b>SECTOR 4 Capital</b>
<b>Bond financing</b>	0.99998	1.00949	1.00145	1.00034
<b>tax financing</b>	0.99998	1.00951	1.00146	1.00034
<b>mixed financing</b>	0.99998	1.00951	1.00146	1.00034

**TABLE 11**  
**EFFICIENCY EFFECTS OF FULL INTEGRATION UNDER THE CURRENT TAX LAW**

FULL INTEGRATION	EQUIVALENT VARIATIONS		TAX REPLACEMENT FACTOR	
	short-run (billions of 1973 dollars)	long-run	short-run	long-run
<b>bond financing</b>				
multiplicative replacement	-1.245	25.470	1.230	1.218
additive replacement	-55.060	-84.800	.029	.028
<b>tax financing</b>				
multiplicative replacement	-.285	23.505	1.226	1.225
additive replacement	-49.905	-84.730	.028	.028
<b>mixed financing</b>				
multiplicative replacement	-.975	25.055	1.229	1.221
additive replacement	-53.730	-84.405	.029	0.027

NB - Base Case Adjusted GNP is 34146.579 billion 1973 dollars

**TABLE 12**  
**FURTHER EFFECTS OF FULL INTEGRATION UNDER THE CURRENT TAX LAW**

<b>FULL INTEGRATION</b>	<b>GNP</b> Revised case/Base case	<b>DEFICITS</b> Revised case/Base case
<b>bond financing</b>  multiplicative replacement additive replacement	  0.99872 0.99896	  1.00113 1.00032
<b>tax financing</b>  multiplicative replacement additive replacement	  0.99874 0.99895	  1.0 by definition 1.0 by definition
<b>mixed financing</b>  multiplicative replacement additive replacement	  0.99873 0.99895	  1.00091 1.0003

**TABLE 13**  
**EFFICIENCY EFFECTS OF PARTIAL INTEGRATION UNDER THE CURRENT TAX LAW**

PARTIAL INTEGRATION	EQUIVALENT VARIATIONS		TAX REPLACEMENT FACTOR	
	short-run (billions of 1973 dollars)	long-run	short-run	long-run
<b>bond financing</b>				
multiplicative replacement	-32.345	-64.570	1.289	1.272
additive replacement	-98.065	-196.915	.035	.034
<b>tax financing</b>				
multiplicative replacement	-30.540	-60.900	1.283	1.279
additive replacement	-90.795	-197.250	.035	.035
<b>mixed financing</b>				
multiplicative replacement	-31.850	-64.690	1.287	1.273
additive replacement	-99.635	-198.030	.036	.034

NB - Base Case Adjusted GNP is 34146.579 billion 1973 dollars

**TABLE 14**  
**FURTHER EFFECTS OF PARTIAL INTEGRATION UNDER THE CURRENT TAX LAW**

<b>PARTIAL INTEGRATION</b>	<b>GNP</b> Revised case/Base case	<b>DEFICITS</b> Revised case/Base case
<b>bond financing</b>  multiplicative replacement additive replacement	  0.99864 0.99891	  1.00101 1.00001
<b>tax financing</b>  multiplicative replacement additive replacement	  0.99865 0.99889	  1.0 by definition 1.0 by definition
<b>mixed financing</b>  multiplicative replacement additive replacement	  0.99863 0.99891	  1.00081 1.00015

**TABLE 15**  
**INTERTEMPORAL UTILITY CHANGES UNDER THE CURRENT TAX LAW**

Revised case/Base case

<b>FULL INTEGRATION with multiplicative replac.</b>	<b>LOW INCOME GROUP</b>	<b>MEDIUM INCOME GROUP</b>	<b>HIGH INCOME GROUP</b>
bond financing	0.96554	1.00575	1.10798
tax financing	0.96643	1.00541	1.10439
mixed financing	0.96535	1.00553	1.1051

**TABLE 16**  
**WEALTH ACCUMULATION CHANGES UNDER THE CURRENT TAX LAW**

Revised case/Base case

<b>FULL INTEGRATION with multiplicative replac.</b>	<b>LOW INCOME GROUP</b>	<b>MEDIUM INCOME GROUP</b>	<b>HIGH INCOME GROUP</b>
bond financing	1.04567	1.00701	0.99967
tax financing	1.04521	1.00739	1.00035
mixed financing	1.04524	1.00731	1.00118

**TABLE 17**  
**CHANGES IN CAPITAL ACCUMULATION UNDER THE CURRENT TAX LAW**

Revised Case/Base Case

<b>FULL INTEGRATION with multiplicative replacement</b>	<b>SECTOR 1 Agriculture</b>	<b>SECTOR 2 Manufacturing</b>	<b>SECTOR 3 Services</b>	<b>SECTOR 4 Capital</b>
<b>Bond financing</b>	0.99998	1.00626	1.00095	1.00036
<b>tax financing</b>	0.99998	1.00628	1.00095	1.00037
<b>mixed financing</b>	0.99998	1.00628	1.00096	1.00037

**TABLE 18**  
**SENSITIVITY RESULTS WITH RESPECT TO CORPORATE FINANCING RULES**

<b>FULL INTEGRATION</b> old tax law tax financed/mult. rep.	<b>EQUIVALENT VARIATIONS</b> short-run                  long-run (billions of 1973 dollars)		<b>NET CASH FLOW</b> Revised case/Base case	<b>GNP</b>
	<b>EQUITY/CAPITAL</b> (sector 2)			
0.2	14.371	62.363	.987	1.
0.25	13.508	60.036	.986	1.
0.3	12.650	57.675	.986	1.
0.35	11.792	55.313	.985	1.
<b>RETAINED EARN/TOTAL</b> (sector 2)				
0.73	12.650	57.682	.98601	1.
0.78	12.650	57.675	.98600	1.
0.83	12.650	57.666	.98599	1.

**TABLE 19**  
**SENSITIVITY RESULTS WITH RESPECT TO EXPECTATION FORMATION RULES**

<b>FULL INTEGRATION</b> <b>old tax law</b> <b>tax finance/mult. rep.</b> <b>EXPECTATION RULES</b>	<b>EQUIVALENT VARIATIONS</b> short-run          long-run (billions of 1973 dollars)		<b>TAX REPLACEMENT FACTOR</b> short-run          long-run	
	<b>myopic expectations</b> 0.    1.    0.	12.650	57.675	1.125
<b>adaptative expectations</b> 0.    .95    .05 0.    .90    .10 0.    .80    .20	15.605 17.490 20.285	61.150 64.720 69.830	1.114 1.112 1.109	1.120 1.120 1.192
<b>extrapolative expectations</b> 0.    1.01    -.01 0.    1.03    -.03 0.    1.05    -.05	12.080 11.129 5.970	57.015 55.905 51.455	1.118 1.120 1.124	1.122 1.123 1.125
<b>constant rate of growth</b> 0.    1.01    0. 0.    1.03    0. 0.    1.05    0.	-1.155 -29.894 -63.285	29.515 -26.060 -87.195	1.128 1.145 1.157	1.132 1.145 1.161

ÚLTIMOS WORKING PAPERS PUBLICADOS

- nº 74 - BAROSA, José Pedro: "Optimal Wage Rigidity: A Suggested Methodology to Test the Theory and an Application". (Outubro, 1987).
- nº 75 - CABRAL, L. M. B.: "Three Notes on Symmetric Games with Asymmetric Equilibria". (Novembro, 1987).
- nº 76 - LUCENA, Diogo: "To Search or Not to Search". (Fevereiro, 1987).
- nº 77 - SÁ, Jorge Vasconcelos e: "A Theory of Synergy". (Fevereiro, 1987).
- nº 78 - VILARES, Manuel José: "Os Bens Intermedios Importados Como Factor de Produção". (Julho, 1987).
- nº 79 - SÁ, Jorge Vasconcelos e: "How To Compete And Communicate in Mature Industrial Products". (Maio, 1988).
- nº 80 - ROE, Rafael: "Learning and Capacity Expansion IN A New Market Under Uncertainty". (Fevereiro, 1988).
- nº 81 - PEREIRA, Alfredo Marvão: "Survey of Dynamic Computational General Equilibrium Models For Tax Policy Evaluation". (Outubro, 1987).
- nº 82 - SÁ, Jorge Vasconcelos e: "Everything IS Important: But Some Things Are More Important Than Others". (Maio, 1988).
- nº 83 - BÁRCIA, Paulo, GASPAR, Vitor e PEREIRA, Pedro T.: "Consumer Theory With NonConvex Consumption Sets". (Maio, 1988).
- nº 84 - CABRAL, Luís Martins Barata: "Política de Preços do Sector das Telecomunicações: Uma Análise de Equilíbrio Geral". (Junho de 1988; Revisto em Maio de 1988).
- nº 85 - PEREIRA, Alfredo Marvão: "DAGEN- A Dynamic Applied General Equilibrium Model For Tax Policy Evaluation". (Abril, 1988).
- nº 86 - D'OREY, Vasco: "On Trade in a Two Country World". (Junho, 1988).
- nº 87 - PEREIRA, Alfredo Marvão: "Corporate Tax Integration in the United States: A Dynamic General Equilibrium Analysis". (Abril, 1988).

Qualquer informação sobre os Working Papers já publicados será prestada pelo Secretariado de Apoio aos Docentes, podendo os mesmos ser adquiridos na Secção de Vendas da Faculdade de Economia, UNL, na Travessa Estevão Pinto, Campolide - 1000 LISBOA.