NBER WORKING PAPERS SERIES

DECOMPOSING THE WELFARE COSTS OF CAPITAL TAX DISTORTIONS: THE IMPORTANCE OF RISK ASSUMPTIONS

Bob Hamilton

Jack Mintz

John Whalley

Working Paper No. 3628

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
February 1991

An earlier version of this paper was presented at The Canadian Economics Association annual meetings in Windsor in May, 1988, where discussants' comments were helpful in revising. This paper reflects the personal views of the authors and should in no way be construed as representative of the position of the Department of Finance, Government of Canada. This paper is part of NBER's research program in Taxation. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #3628
February 1991

DECOMPOSING THE WELFARE COSTS OF CAPITAL TAX DISTORTIONS: THE IMPORTANCE OF RISK

ABSTRACT

This paper analyzes the implications of alterative risk assumptions for estimates of the distorting effects of the corporate tax in Canada. These distortions are decomposed into three broad categories: inter-asset distortions; inter-industry distortions; and inter-temporal distortions. Estimates of marginal effective corporate tax rates are used in a multi-asset general equilibrium model to evaluate the costs of the various distortions, with marginal effective tax rates calculated under alterative risk assumptions. Results indicate that assessments of the relative importance of these distortions are sensitive to alterative risk assumptions used in marginal tax rate calculations. The paper also explores the sensitivity of results to key elasticity parameters in the model.

Bob Hamilton
Department of Finance
140 O'Connor St., 16th Floor
L'Esplanade Lauriet
Ottawa, Ontario
CANADA K1A 0G5

Jack Mintz
Department of Economics
University of Toronto
Toronto, Ontario
CANADA M5S 1A1

John Whalley
Department of Economics
University of Western Ontario
London, Ontario
CANADA N6A 5C2
and
NBER
1050 Massachusetts Avenue
Cambridge, MA 02138

I. INTRODUCTION

During the 1980s, both the Canadian and U.S. corporate tax systems have been reformed in an effort to reduce the variance in the tax treatment of investments across various assets and sectors. These reforms have sparked considerable debate regarding the merits of corporate tax reform and the relative importance of the distortions it creates. It is also well known that assumptions regarding risk can significantly affect marginal effective tax rates on investments and, therefore, can influence perceptions on the distortions created by the tax.

This paper analyzes the importance of risk assumptions for the analysis of various distortions in the corporate tax using a multi-asset general equilibrium model of Canada. Marginal effective tax rates are calculated under alternative risk assumptions and these are used to evaluate the welfare costs of various distortions. Results indicate that the magnitude and relative importance of these distortions are significantly different under alternative assumptions towards risk.

The paper begins with a discussion of the various methods of treating risk in computing marginal effective tax rates for Canada. This is followed by a brief description of the general equilibrium model of Canada used to evaluate the welfare cost of the distortions of the corporate tax. Finally, results are presented, along with some concluding comments.

II. RISK, EFFECTIVE TAX RATES AND CORPORATE TAX DISTORTIONS

Recent studies of corporate tax distortions have, for the most part, focused on only a subset of the wider distortions caused by the tax, such as the analysis of inter-asset distortions in Gravelle (1981) and Auerbach (1987)[2], and have paid only limited attention to the

---

[2]An exception is Fullerton and Henderson (1985), which uses a disaggregated general equilibrium model along with marginal effective tax rates computed using the King and Fullerton (1985) methodology to jointly examine inter-asset and inter-industry distortions. They suggest that the distortions caused by the corporate tax are small, with inter-asset distortions being more important than inter-industry distortions. Their analysis does not assess the relative importance of inter-temporal distortions.

treatment of risk. Here we use a series of calculations of marginal effective tax rates under alternative risk assumptions to provide estimates of the importance of the various distortions involved for Canada, and introduce them into a numerical dynamic general equilibrium model to analyze their welfare consequences.

As discussed in King and Fullerton (1984) and Boadway, Bruce and Mintz (1984), effective corporate tax rate calculations incorporate all of the relevant corporate tax provisions that affect the investment decisions of the firms. These provisions include capital cost allowances, statutory tax rates, investment tax credits and, in the case of resource firms, earned depletion, exploration and development write-offs and provincial resource taxes and royalties.[3]

Although studies of marginal effective tax rates generally use the same basic methodology, the underlying assumptions often differ across these studies (see Boadway (1988)).[4] The most important of these differences is the treatment of risk.[5] For instance, Boadway, Bruce and Mintz explicitly incorporate risk in their analysis while King and Fullerton assume that firms face complete certainty in their investment decisions.

Recent work on the cost of capital highlights two types of risk: income risk (Gordon, 1984) and capital risk (Bulow and Summers, 1984). Income risk arises from uncertainty with respect to the revenues and current costs faced by firms, whereas capital risk arises from uncertain capital good prices and physical rates of depreciation.

---

[3]The tax provisions included in the measure of effective corporate tax rates in Canada used here are similar to Boadway, Bruce and Mintz (1982, 1984) and, in the case of resources, Boadway, Bruce, McKenzie and Mintz (1987).

[4]See also Daly, Jung, Mercier and Schweitzer (1985), Daly and Jung (1987).

[5]There are other important differences between the two methodologies particularly with respect to financial arbitrage assumptions. Boadway, Bruce and Mintz explicitly model a small open economy while King and Fullerton assume that the economy is closed. Daly and Jung have estimated effective corporate tax rates using both closed and open economy assumptions and found that the level and pattern of effective corporate tax rates do not differ much.

The distinction between income risk and capital risk is important because the tax treatment of these two types of risk is quite different. In the case of income risk, the government treats gains and losses symmetrically when the firm is fully taxpaying.[6] On the other hand, capital risk is penalized by the tax system since tax depreciation is based on the original cost of assets rather than their replacement cost. As a result, this reflects the fact that the government does not allow the cost of capital risk to be (implicitly) deductible from the tax base.

The implications of these two types of risk for calculations of effective tax rates are analyzed, using the approach outlined in Gordon and Wilson (1989). Their methodology is used to derive formulae for the cost of capital and effective tax rates that explicitly incorporate income and capital risk (a formal derivation is set out in Appendix 1).[7]

As derived in the Appendix, our marginal tax rate calculations assume that the firm invests in capital until the expected marginal product is equal to the user cost of holding depreciable capital. The user cost is defined as the cost of capital gross of taxes, depreciation and risk. Assuming time invariance, the user cost of capital is given by:

$$\frac{EF'}{q} = \frac{[\bar{\delta} - \Delta\ \bar{q}/\bar{q} + r + h_k]\ [1-A]}{[1-u]} + h_I \tag{1}$$

[6]When the firm makes losses, income risk may not be fully shared. (See Mintz (1988) for a measure of effective tax rates on tax loss firms in Canada.) In this paper, all firms are assumed to be fully taxpaying.

[7]Since the general equilibrium framework used to evaluate the efficiency implications of these effective tax rates requires that the effective tax rate to be time invariant, random shocks to income, capital prices and capital wear and tear are assumed to be independently distributed and non-correlated across time.

where EF' = expected marginal productivity of capital

δ = expected exponential rate of wear and tear of capital

q = replacement price of capital goods

h_k = capital risk premium (taking into account both capital good price and physical depreciation risk)

h_I = income risk premium

u = corporate tax rate

A = present value of tax depreciation write-offs and investment tax credits

r = cost of finance (discount rate of the firm).[8]

Since the firm invests in different types of capital goods, the equilibrium level of capital stock is determined when the risk- and tax-adjusted return on capital (net of depreciation) is the same for all capital goods and equals the net of tax cost of finance faced by the firm. This implies that the effective tax on capital is measured as the difference between gross-of-tax and net-of-tax rates of return on capital:

$$t = Ef'/\bar{q} - [\bar{\delta} - \Delta\bar{q}/\bar{q}] - (h_I + h_k) - r_0 = r_g - r_0. \quad (2)$$

[8]The cost of finance is a weighted average of the cost of debt and equity finance, implying that $r = \beta i' (1-u) + (1-\beta)i(1-m)/(1-c) - \pi$, where β is the proportion of assets financed by debt, i and i' are the nominal interest rate on riskless equity assets and costly debt respectively, m is the personal tax rate on interest, c is the personal tax rate on nominal equity returns and π is the rate of inflation. Note that two types of financial arbitrage are possible. The first requires that in the absence of any other determinants of leverage, a marginal investor wishes the net of corporate and personal tax rate of return on equity and debt be the same. This requires $m = u + c(1-u)$ (since $i=i'$). Alternatively, in the presence of bankruptcy or agency costs firm issues debt until its tax benefit is equal to its marginal cost (implying that $i' > i$). For a lengthy discussion of these points, see Mintz and Purvis (1988).

The net-of-tax rate of return on capital, r_0, is obtained by setting all corporate tax terms in r_g equal to zero. The tax rate is determined by measuring $t_r = (r_g - r_0)/r_0$.

If the effective tax rate is based on the difference between the marginal gross-of-tax and net-of-tax, risk-adjusted rate of return on capital, one can easily show that the effective tax rate is the same for income risk as for the certainty case (such as in the King and Fullerton methodology). For capital risk, the cost of capital on a risk-adjusted basis includes the additional corporate tax burden imposed on risky economic depreciation. The cost of finance is thus $r + h_k$ which appears in numerator of the formula given by (1). This is similar to the Boadway, Bruce, and Mintz measure of the effective tax rate.

Table 1 provides estimates of effective corporate tax rates for Canada using 1986 data. These are calculated under an assumption of capital risk and are based on the post-reform corporate tax system. Effective tax rates are calculated for investments in three assets (buildings, equipment, and inventories) and ten industries. Table 2 presents effective tax rates computed under an assumption of income risk.

A complete description of the methodology used to measure the effective tax rates can be found in Jog and Mintz (1988). In general, it is assumed that the firms take current tax provisions as a basis for determining their investment decisions over time. Most terms of the effective tax rate are thus measured in their usual way. The only new term that is estimated is capital risk which is specific to the industry and the type of capital good. Unfortunately, we have only limited information on capital risk by industry and no information on asset-specific risk. Industry capital risk is measured by using a Capital Asset Pricing Model based on Toronto Stock Exchange data for the period 1968-80. Firm risk premia are aggregated to represent the industry average and are adjusted to eliminate the effect of leverage. This measure is used as a proxy of capital risk on the assumption that the market risk faced by shareholders reflects primarily riskiness in the replacement value of capital goods held by the firm (Bulow and Summers, 1984). In principle, capital risk has an ambiguous impact on the effective tax rate. As shown in equation (1), the cost of capital is higher (lower) in the

Table 1

Marginal Effective Tax Rates for Canadian Industries

Under Capital Risk Assumptions[1,2]

(%)

Industry	Buildings	Machinery	Inventory	Aggregate Average
Agriculture	46.9	45.0	-18.4	43.7
Manufacturing	52.0	50.3	57.5	53.0
Construction	48.9	53.3	60.7	56.2
Transportation	44.8	52.7	53.2	48.5
Communications	34.9	20.8	39.2	29.7
Utilities	42.2	43.7	54.3	44.1
Wholesale Trade	40.1	42.5	49.4	45.2
Retail Trade	28.6	38.8	43.8	37.8
Services	35.8	45.6	45.2	40.7
Resources	31.1	30.7	38.6	31.3
Aggregate	44.3	47.6	53.3	47.7

[1]Rates are reported as a percentage of gross-of-tax returns $(r_g - r_n)/r_g$.

[2]These calculations are based on 1986 data, and corporate tax rules operating after June 1987.

Table 2

Marginal Effective Tax Rates for Canadian Industries
Under Income Risk Assumptions[1,2]

Industry	Buildings	Machinery	Inventory	Aggregate Average
Agriculture	17.3	18.2	-18.4	9.3
Manufacturing	22.9	26.5	29.7	25.7
Construction	20.5	32.0	42.1	34.7
Transportation	3.8	24.3	15.5	12.8
Communications	17.2	3.2	20.3	11.6
Utilities	9.3	11.6	25.6	12.1
Wholesale Trade	11.0	20.3	22.2	16.5
Retail Trade	0.4	18.1	17.7	10.0
Services	2.6	22.2	13.8	10.5
Resources	31.1	30.7	38.6	31.3
Aggregate	13.8	22.6	26.1	19.0

[1]Rates are reported as a percentage of gross-of-tax returns: $(r_g - r_n)/r_g$.

[2]These calculations are based on 1986 data, and corporate tax rules operating after June 1987.

presence of capital risk if the present value of tax depreciation write-offs and investment tax credits is less than (more than) the corporate tax rate.

As shown in Table 1, incorporating capital risk tends to result in higher effective tax rate measures for most industries. However, the dispersion in tax rates across assets and industries appears to be somewhat smaller under the capital risk assumption.

III. A DYNAMIC SEQUENCED GENERAL EQUILIBRIUM MODEL USED TO ANALYZE THE WELFARE IMPLICATIONS OF CORPORATE TAX DISTORTIONS IN CANADA

To analyze the welfare implications of these alternative effective tax rate calculations reported above for different risk assumptions, we use a dynamic sequenced general equilibrium model of Canada. The model is a multi-asset variant of the Ballard, Fullerton, Shoven, Whalley (BFSW)(1985) model developed for analysis of US tax reform. Unlike the BFSW model, three separate types of capital (structures, equipment, inventories) are identified, enabling the analysis to capture the distorting effects caused by the different tax treatment of these three assets. The model is calibrated to a 1980 benchmark data set for Canada into which we introduce the effective tax rates above.

The same ten sectors are identified in the model as used in the effective tax rate calculations: agriculture, manufacturing, construction, transportation and storage, communications, public utilities, wholesale trade, retail trade, services and resources. This level of aggregation captures the major inter-industry distortions in the corporate tax while, at the same time, keeping the dimensions of the model manageable.

Each sector is assumed to produce one product using both primary factors and intermediate products. Capital is disaggregated into three types - structures, equipment, and inventories. Value-added functions are assumed to be nested CES over composite capital and labour, with composite capital a nested CES function over the three asset types. Industries are assumed to minimize costs, and all excess profits competed away, reflecting a constant return to scale technology. Within each industry, substitution occurs between intermediate products in response to price changes, reflecting nested CES intermediate demand functions.

Since the focus in the modelling is on the efficiency rather than distributional effects of the corporate tax, consuming agents are aggregated into one representative consumer. As in Ballard et al, the single representative consumer is assumed to be infinitely-lived and maximizes current and expected future utility from consumption, represented by a CES function, subject to a budget constraint. The consumer's budget constraint is given by the sum of factor incomes and transfers from the government, less income taxes. Savings are modelled as the purchase of investment goods which yield a stream of capital income in every future period. Savings thus depend on the expected rental return to capital in future periods in the same way as in BFSW (1985).

All major taxes in the Canadian economy are represented in the model in ad valorem equivalent form. The government is modelled simply as a redistributor of tax revenue; i.e., it collects revenues from the various tax sources and then returns them to the single consumer in the form of transfer payments.

The external sector is incorporated through foreign import supply and export demand functions which are consistent with balanced trade. Goods are modelled as homogeneous across countries, so that net trades rather than gross trades enter the import supply and export demand functions. The elasticities of import supply and export demand are assumed to be large, reflecting an assumption that Canada is a small, open, price-taking economy.

The basic approach used in this analysis has been used extensively in other applied general equilibrium analyses. This approach involves calibrating the model's functions to a micro-consistent data set, then computing a counterfactual equilibrium under an alternative policy regime and comparing the benchmark and counterfactual equilibria. The micro-consistent benchmark data set used here is based on 1980 data and is constructed from a number of sources, including tax data, national accounts data, input-output data, and family expenditure survey data. A series of adjustments are required to produce micro-consistency in this data, and these are based on the procedures described in St-Hilaire and Whalley (1983).

Calibration involves using the micro-consistent data set and extraneous elasticity values to determine parameter values for the CES functions in the model. This procedure selects parameter values for these functions such that, with no change in tax policies, the model equilibrium solution is the same as the micro-consistent data set.[9] Substitution elasticity values for the CES functions are specified prior to calibration. The values used are based on literature estimates and are discussed in greater detail in Hamilton and Whalley (1987).

IV. RESULTS

The general equilibrium model described above has been used to determine the welfare costs associated with each distortionary component of the corporate tax.[10] The distortions are analyzed under both risk assumptions, using the marginal effective tax rates shown in Tables 1 and 2.

Table 3 shows the welfare consequences, under each risk assumption, of removing the various distorting components of the corporate tax. The first row reports the total welfare cost of all the distortions in the corporate tax. Since the marginal effective tax rates under capital risk are generally higher than income risk, the welfare gain from abolishing the corporate tax is correspondingly higher. A Hicksian equivalent variation (EV) of 1.93 percent of the discounted present value of economy wide income over the sequence of equilibria considered is obtained under capital risk compared to 0.59 percent for income risk.

The second row reports the effects of eliminating the dispersion in tax rates across assets under each risk assumption. Inter-asset variation in tax treatment is eliminated by replacing actual effective tax rates for each asset in an industry by the average effective tax rate over all assets for that industry. This change eliminates the corporate tax distortions

---

[9]These procedures are discussed at length in Mansur and Whalley (1984).

[10]In each case, the size of the public sector is kept constant, with any revenue shortfall made good by a broadly based sales tax.

Table 3

Welfare Gains From Eliminating Various Distortions in the Corporate Tax Under Alternative Risk Assumptions

	Model Change Considered	Welfare Gains[1] Income Risk	Capital Risk
1)	Abolish the Corporate Tax	0.590	1.93
2)	Eliminate Inter-asset Distortions in the corporate tax	0.330	0.29
3)	Eliminate Inter-Sector Distortions in the corporate tax	-0.060	0.01
4)	Eliminate Inter-Temporal Distortions in the corporate tax	0.297	0.86

[1]Welfare Gains are computed as the discounted present value of Hicksian equivalent variations across model periods as a percentage of the discounted present value of consumption across the same periods.

between assets within an industry, but maintains the distortions created by the corporate tax between industries. The inter-asset distortions caused by the corporate tax are slightly larger under income risk. Although METRs are generally higher under capital risk, their dispersion is slightly greater under income risk leading to larger gains from eliminating these distortions under an assumption of income risk.

Table 3 also reports the effects on welfare resulting from the removal of distortions caused by inter-sectoral variations in effective tax rates. These are eliminated by replacing the actual effective tax rate for an asset in an industry by the average effective tax rate for that asset. This maintains existing distortions between assets within a sector but places all sectors on an even footing.

As might be expected, the welfare effects of inter-sector distortions are smaller, since there is less substitutability between industries than between assets in the model. In fact, a slight welfare loss results when income risk is assumed. The reason for the welfare loss appears to be that the most severe inter-asset distortions are found in large sectors e.g. construction, agriculture and services. In computing a weighted average effective tax rate for each asset, the large inter-asset distortions in these major sectors are extended to all other sectors, worsening the inter-asset distortion in these other sectors, and resulting in an overall welfare loss.

Table 3 also shows the gains from removing the inter-temporal distortions of the corporate tax under each risk assumption. The results suggest that higher overall effective tax rates in the capital risk case cause inter-temporal distortions under capital risk to be considerably larger than under the income risk case.

Taken together, therefore, this combined set of results suggests that the type of risk which is assumed to underly investment decisions can have substantial impacts on policy perspectives. For instance, if one believes the capital risk case, then inter-temporal distortions of the corporate tax swamp any concerns about inter-asset distortions. On the other hand, under income risk the inter-asset distortions are relatively more important. Indeed, inter-asset distortions appear to be just as important as inter-temporal distortions in the income risk case.

Clearly, the results presented in this analysis depend critically on the parameters of the model and especially substitution elasticities relevant to investment decisions. In the model analyses used here, the key elasticities are: the inter-temporal elasticity of substitution; the substitution elasticity between different asset types and the capital-labour substitution elasticities in production in each industry. The sensitivity of model results with respect to changes in these key parameters is shown in Tables 4 and 5.

Sensitivity results in the capital risk case are shown in Table 4. The ranking of the distortions seems not to be altered by changing the key elasticity parameters. However, the relative magnitude of the distortions appear to be strongly influenced by the inter-temporal substitution elasticity and the capital-labour substitution elasticities. Changes to these elasticities have a more dramatic effect on the results than changes to the substitution elasticity between asset types. These results seem to confirm arguments in Hamilton and Whalley (1985) which suggest that the taking account of the larger base upon which broader distortions operates (capital-labour) may be important when comparing the welfare effects of these against narrower distortions (such as between capital types).

Changes to the elasticity of substitution between asset types seems to yield a counter-intuitive result when inter-temporal distortions are eliminated; the higher the elasticity, the lower the welfare gain.

Results also suggest that with a low inter-temporal elasticity, the welfare costs of inter-asset distortions becomes relatively more important - about 25 percent of the total distortion as opposed to about 15 percent in the central case and 12 percent under the high inter-temporal elasticity case.

Table 5 reports similar sensitivity analyses for parameter variations for the income risk case. As in the central case, costs of inter-asset distortions are normally at least as large as with inter-temporal distortions. This reflects the generally lower effective tax rates under income risk relative to the capital risk case. However, with a low inter-temporal elasticity,

Table 4

Sensitivity of Results to Key Elasticity Parameters

Under Capital Risk Assumptions

Policy Change	Central Case[2]	Welfare Gain[1] — Substitution Elasticities: Changes in Inter-temporal Elasticities in Preferences		Changes in Inter-asset Elasticities in Production		Changes in Capital-Labour Elasticities in all Industries	
		1.1	1.7	0.5	1.5	0.5	1.5
Eliminate all Distortions	1.93	1.05	2.52	1.93	1.93	1.41	2.21
Eliminate Inter-Asset Distortions	0.29	0.27	0.30	0.25	0.31	0.25	0.32
Eliminate Inter-Sector Distortions	0.01	0.01	0.02	0.00	0.02	0.01	0.02
Eliminate Inter-Temporal Distortions	0.86	0.01	1.45	1.20	0.36	0.68	0.91

[1]Welfare gains are calculated as the discounted present value of Hicksian equivalent variations summed across each period as a percentage of the discounted present value of consumption summed across each period.

[2]The central case substitution elasticity values are: inter-temporal (1.4); inter-asset (1.0); capital-labour (varies by sector using estimates from Taher et al. (1985)).

Table 5

Sensitivity of Results to Key Elasticity Parameters
Under Income Risk Assumption

Welfare Gain[1]

Corporate Tax Change	Central Case[2]	Substitution Elasticities: Changes in Inter-temporal Elasticities in Preferences		Changes in Inter-asset Elasticities in Production		Changes in Capital-Labour Elasticities in all Industries	
		1.1	1.7	0.5	1.5	0.5	1.5
Eliminate all Distortions	0.59	0.34	0.78	0.62	0.58	0.54	0.63
Eliminate Inter-Asset Distortions	0.33	0.33	0.34	0.31	0.35	0.32	0.35
Eliminate Inter-Sector Distortions	-0.06	0.07	-0.05	-0.06	-0.04	-0.06	-0.06
Eliminate Inter-Temporal Distortions	0.26	0.02	0.45	0.28	0.25	0.19	0.31

[1]Welfare gains are calculated as the discounted present value of Hicksian equivalent variations summed across each period as a percentage of the discounted present value of consumption summed across each period.

[2]The central case substitution elasticity values are: inter-temporal (1.4); inter-asset (1.0); capital-labour (varies by sector using estimates from Taher et al. (1985)).

costs of inter-asset distortions become about five times as large as inter-temporal distortion. This contrasts with the case under capital risk where costs of inter-temporal distortions are always about three to eight times as large as inter-asset distortions. Removing inter-sectoral distortions is again welfare worsening in all cases, for the reasons mentioned earlier.

The basic conclusion drawn from this sensitivity analysis is that while the estimates of these distortions are sensitive to the elasticity values, the relative importance of the distortions is largely unaffected by altering elasticity estimates. The sensitivity of results to elasticity values seems to be clearly dominated by sensitivity to alternative risk assumptions.

V. CONCLUSIONS

This paper analyzes the relative importance of inter-temporal, inter-asset and inter-sectoral distortions caused by the corporate income tax in Canada, and shows how the perception of their relative importance can change under alternative treatments of risk. Effective tax calculations are used in a dynamic sequenced general equilibrium model to measure the welfare costs of the various distortions. Model results reveal that the magnitude and the relative importance of the various distortions in the corporate tax depends critically upon the underlying assumptions regarding the type of risk faced by firms when making marginal effective tax rate calculations.

BIBLIOGRAPHY

Auerbach, Alan J. (1987) "The Deadweight Loss from Capital Income Taxation", mimeo, University of Pennsylvania.

Auerbach, Alan J. (1983) "Corporate Taxation in the United States", Brookings Papers on Economic Activity, pp. 1451-1505.

Ballard, C, D. Fullerton, J. Shoven and J. Whalley (1985) *General Equilibrium Analysis of US Tax Policy*, National Bureau of Economic Research, Inc., University of Chicago Press.

Boadway, Robin W. (1985) "The Theory and Measurement of Effective Tax Rates" in J. Mintz and D.D. Purvis (eds.) *The Impact of Taxation on Business Activity*, John Deutsch Institute, Kingston.

Boadway, Robin, Neil Bruce, Ken McKenzie and Jack Mintz (1987) "Marginal Effective Tax Rates for Capital in the Canadian Mining Industry", *Canadian Journal of Economics* XX, No. 1, pp.1-16.

Boadway, Robin, Neil Bruce and Jack Mintz (1984) "Taxation, Inflation and the Effective Marginal Tax Rate on Capital in Canada", *Canadian Journal of Economics* 17, pp.62-79.

Bulow, Jeremy and Lawrence Summers (1984) "The Taxation of Risky Assets", *Journal of Political Economy*, pp. 20-39.

Daly, Michael and Jack Jung (1987) "The Taxation of Corporate Investment Income in Canada: An Analysis of Marginal Effective Tax Rates", *Canadian Journal of Economics*, pp. 555-87.

Daly, Michael, Jack Jung, Pierre Mercier and Thomas Schweitzer (1985) "A Comparison of Effective Marginal Tax Rates on Income from Capital in Canadian Manufacturing", *Canadian Tax Journal* 33, pp.1154-92.

Department of Finance, Canada (1985) *The Corporate Tax System: A Direction for Change*, Ottawa.

Fullerton, Don and Yolanda K. Henderson (1985) "A Disaggregate Equilibrium Model of the Tax Distortions Among Assets, Sectors and Industries", mimeo.

Gordon, Roger H. (1985) "Taxation of Corporate Capital Income: Tax Revenues versus Tax Distortions", *Quarterly Journal of Economics*, pp. 1-28.

Gordon, Roger H. and John W. Wilson (1986) "Measuring the Efficiency Cost of Taxing Risky Capital Income", manuscript.

Hamilton, Bob and J. Whalley (1987) "Efficiency and Distributional Effects of the Tax Reform Package" in J. Mintz and J. Whalley (eds.) *Economic Impacts of Tax Reform*, Canadian Tax Foundation, Toronto, forthcoming.

Hamilton, Bob and J. Whalley (1985) "Tax Treatment of Housing in a Dynamic Sequenced General Equilibrium Model", *Journal of Public Economics*.

Jog, Vijay and Jack M. Mintz (1987) "Corporate Tax Reform and its Economic Impact: An Evaluation of the June 18, 1987 Proposals" in J. Mintz and J. Whalley (eds.) *Economic Impacts of Tax Reform*, Canadian Tax Foundation, Toronto, forthcoming.

King, Mervyn A. and Don Fullerton (1984) *The Taxation of Income from Capital*, University of Chicago Press, Chicago.

Mintz, Jack M. (1988) "An Empirical Estimate of Corporate Tax Refundability and Effective Tax Rates", *Quarterly Journal of Economics*, pp. 225-31.

Mintz, Jack M. and Douglas D. Purvis (1988) "Introduction" in *Impact of Taxation on Business Activity*, John Deutsch Institute, Kingston.

Taher, M.A., M.L. McMillan, D.W. Gillen and A. Buse (1985) "Renewable and Non-Renewable Resource Demand in Canadian Manufacturing Industries", *Resources and Energy*.

APPENDIX

Derivation of the Cost of Capital Under Income and Capital Risk

Following Gordon and Wilson (1989), we assume the economy consists of identical consumers with infinite lives, with the expected utility function:

$$W = E_0 \sum_{t=0}^{\infty} \beta^t U_t [\tilde{C}_t] \tag{1}$$

where	β	=	discount factor for instantaneous utility
	$U_t[\cdot]$	=	strictly concave utility at time t (U) denotes marginal utility of stochastic income at time t)
	E_0	=	expectations operator defined over an arbitrary distribution function based on information available at time t=0.
	$\tilde{C}_t$	=	stochastic consumption realized at time t.

Consumers have an exogenous income, $\tilde{A}_t$, that includes government transfers that are stochastic (since public revenue is stochastic). This income plus accumulated wealth is invested in a risky equity and riskless bonds. To keep matters simple, it is assumed that the firm does not borrow (it is straightforward to allow for debt if we introduce bankruptcy costs). The equity asset is the claim on capital invested by the firm which pays a dividend in each period equal to $(1\text{-}u)\theta_t f(K_t) - (1\text{-}uz)\tilde{q}_t \tilde{I}_t'$ where u is the corporate tax rate, $\tilde{\theta}_t$ is a random variable associated with "income", $\tilde{q}_t$ are stochastic capital good prices and $\tilde{I}_t$ is stochastic gross investment. Stochastic investment is equal to new investment plus random economic depreciation:

$$\tilde{I}_t = K_{t+1} - K_t + \tilde{\delta}_t K_t \tag{2}$$

The bond asset pays a rate of return equal to r in each period (we assume no uncertainty with respect to the real interest rate). Bonds last for one period and are retired at the end of period t. New bonds for period t+1 are purchased in period t.

The budget constraint faced by consumers is denoted as:

$$\tilde{C}_t = (1-u)\tilde{\theta}_t f(K_t) - (1-uz)\tilde{q}_t \tilde{I}_t + B_t(1+r) - B_{t+1} + \tilde{A}_t \qquad (3)$$

No personal taxes are involved with this formulation of the problem.

The consumer maximizes his lifetime expected utility in (1) choosing the capital stock of the firm (which maximizes the value of equity) and one period bond holding subject to the constraints (2) and (3). At each point in time, the first order conditions for K_t and B_t are derived:

$$\frac{\partial W}{\partial K_t} = -(1-uz)q_t U'_t + E_0\, \beta\, U'_{t+1}\{(1-u)\tilde{\theta}_{t+1} f'_{t+1} - (1-uz)\tilde{q}_{t+1}(1-\tilde{\delta}_{t+1})\} = 0 \qquad (4.1)$$

$$\frac{\partial W}{\partial B_t} = -U'_t + \beta\, E_0 U'_{t+1}(1+r) = 0 \qquad (4.2)$$

These two first order conditions may be combined and manipulated to derive the following cost of capital formulations:

$$S_t = f'_{t+1}(\bar{\theta}_{t+1} - h^I_{t+1}) = \frac{[E(\tilde{\delta}_{t+1}\tilde{q}_{t+1}) - (\bar{q}_{t+1} - q_t) + h^K_{t+1} + rq_t]}{(1-u)}(1-uz)$$

$$h^I_{t+1} \equiv \frac{-\mathrm{Cov}[\,\tilde{\theta}_{t+1}, U'_{t+1}]}{EU'_{t+1}} \quad (\text{"income" risk})$$

$$h^K_{t+1} = \frac{-\mathrm{Cov}[\tilde{\delta}_{t+1}\tilde{q}_{t+1}, U'_{t+1}]}{EU'_{t+1}} + \frac{-\mathrm{Cov}(\tilde{q}_{t+1}, U'_{t+1})}{EU'_{t+1}} \quad \text{(capital risk)}$$

$\bar{\theta}_{t+1} \equiv$ mean value of $\tilde{\theta}$

$\bar{q}_{t+1} - q_t$ = expected capital gains by holding K_t.

Firms invest in capital so that the net-of-depreciation risk-adjusted return on assets is equal to the cost of finance r (which is the opportunity cost for the investors to undertake sluity investments). This implies the gross-of-tax marginal return to capital is equal to the following:

$$R^G_t = \frac{S_t}{q_t} - \frac{h^K_{t+1}}{q_t} - \left\{\frac{E\{\tilde{\delta}_{t+1}\tilde{q}_{t+1}\}}{q_t} - \frac{(\bar{q}_{t+1} - q_t}{q_t}\right\}$$

$$R^N = r$$

The effective tax rate is $(R^G_t - R^N)/R^G_t = \tau_t$.