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Corporate Tax Models: A Review

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Abstract

This paper evaluates alternative approaches to corporate tax modeling, highlighting the strengths and limitations of each approach and their potential role in tax policy analysis. The existing official models in the major OECD countries (USA, Canada, UK, France, Italy and Ireland) and the modeling approaches taken by academic research institutions and non-governmental organizations are discussed, highlighting their purposes. The lessons from existing modeling approaches are drawn up.

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1. Introduction

The role of tax models in policy analysis requires no emphasis. As Creedy (2001) has noted "tax policy questions may relate to specific problems, concerning perhaps the revenue implications of a particular tax, or they may involve an extensive analysis of the cost and redistributive effects of a large number of taxes and transfer payments". It has been argued that the most useful role of models is to provide a rational policy analysis which involves the examination and reporting of the implications of alternative policies, so that policy-makers can form their own evidence-based judgments [Creedy (2001)].

The literature reviewing tax models of personal direct and indirect taxes is voluminous, but corporate tax models have received limited coverage. Several approaches to corporate tax modeling co-exist, each with its own strengths, limitations, and potential role in analysis. A recent review of several alternative approaches to tax modeling for personal and household taxes may be found in Creedy (2001); a more technical survey of behavioural microsimulation modeling is given in Creedy and Duncan (2000). Rubin et al. (1999) review tax modeling approaches for both personal and corporate taxes in the context of USA and Spahn and Pearson (1998) examine tax models in transition economies as well as those of the UK and France.

The aim of this paper is twofold: (1) to evaluate alternative corporate tax modeling strategies highlighting the pros and cons of different approaches and their potential role in tax policy analysis; and (2) to provide a review of the official corporate tax models in major OECD countries, with some discussion of approaches followed by academic research institutions for the analysis of tax policy regimes. The focus is on strengths and limitations of each type of model and purposes they serve. Critical comments are offered.

This paper is organized as follows. Section 2 discusses purposes and nature of corporate tax modeling, and throws light on some issues related to revenue estimating and forecasting which are the main purposes of official corporate tax models. Section 3 provides an outline of various corporate tax modeling approaches, and discusses strengths and limitations of each approach identifying their main users. Section 4 evaluates existing individual country corporate tax models in the USA, Canada, the UK, France, Italy, and Ireland, highlighting differences between countries in purposes served. It also describes the nature of the models used by the IMF, Institute for Fiscal Studies, and the Manchester Business School. Section 5 presents conclusions drawn from the modeling experiences of countries and institutions examined.

2. Corporate Tax Modeling: Purposes, Nature and Some Issues Involved

This section provides an overview of corporate tax models discussing their main purposes, highlighting issues in revenue estimating and forecasting and some discussion of issues in measuring bias and accuracy of revenue forecasts.

2.1. Purposes of Corporate Tax Models

Corporate tax models can potentially serve the following purposes:

- Estimate tax burdens (including compliance costs) of individual firms;
- Estimate tax revenues for the economy;
- Forecast revenues from a particular tax and/or analyze the revenue effects of tax policy; and,
- Determine effects of taxation policies on investment decisions, corporate financial policy and transfer pricing behavior of firms.

The main use of tax models in the area of corporate taxation is revenue estimation, forecasting and analysis of impacts of policy shifts. “Revenue estimating” is the process of assessing the impact of tax law changes proposed at the time of the budget or subsequently. In the UK, the same process is commonly referred to as “tax costing” [King (1995)]. This is closely related to revenue forecasting but different from it. For example, in some countries (including the US), it may be performed by different people. Forecasts are needed even when no change of tax law is envisaged, and revenue estimates must often be made for evaluating proposals that may not be subsequently adopted [King (1995)].

Since 1960s many governments in the OECD countries have constructed microsimulation models, mainly for the use of revenue estimating and forecasting. Because the development of microsimulation models needs access to confidential data on tax returns, as well as considerable time and resources, MSMs for corporate taxes have generally been the territory of governments, while the focus of the academics and independent research institutions has been on the development of models for policy analysis using aggregate data. Many studies have examined the effects of effective average tax rates and corporate tax systems in different countries on investment decisions, ownership structures, financial policies and income shifting/transfer pricing behavior of companies.

As far back as 1929, A.E. Buck described three methods of revenue forecasting generally used by governments at that time: (1) the penultimate year method, (2) the moving average method, and (3)

the direct valuation method [Buck (1929)]. In the penultimate method, current year revenue is used to forecast next year's revenue; the moving average based forecast is based on not just one year, but on the average performance of the revenues during past few years; and in the direct valuation method which was applied at the start of the year, actual data collection is used as the basis for the within-year forecast. The first two methods are still used by many governments to forecast revenues. Modern methods involve highly sophisticated quantitative models, including time series methods, macroeconometric modeling, and microsimulation models. In the USA, all such methods are applied at levels of the federal government, state, and local governments; there are defined responsibilities at each level of the government for preparing tax forecasts or estimates. In the UK, at the heart of such forecasting process is the microsimulation model developed internally by the Inland Revenue which benefits from macroeconomic forecasts supplied by the Treasury [see Eason (1996), (2000); Eason and Elmore (1998) for a detailed account of the model]. Similar models also exist in France [see Schneider (1998) for a detailed description] somewhat more macroeconomic in nature than its UK counterpart. Very recently, a microsimulation model has been developed in Italy with the objective of estimating tax revenues and the impacts of tax policy changes on tax burdens of the firms. France also uses microsimulation for forecasting revenues from corporation tax though the model is more macroeconometric in approach. Canada has a comprehensive model with dynamic forecasting and simulation properties for federal revenues and expenditures. A corporate tax microsimulation model also exists at the Canadian department of finance mainly for estimating the revenue impact of law changes and policy analysis (for example, estimating changes in the distribution of tax revenues, industry analysis, firm size analysis, "winners and losers", and other issues of concern). The Republic of Ireland uses a rather simpler approach of tax elasticity for the forecasts of its corporation tax revenues, as the ratio of tax/GDP has remained fairly constant in recent years.

2.2. The Nature of Corporate Tax Modeling

Depending on the nature of the policy question, a tax model can follow either a macro or micro approach and in practice often combine the two. Models employing macro approaches include tax revenue extrapolation, elasticity analysis, and macroeconometric models, while microsimulation models, using micro level data, have been used in many countries including in the USA, Canada, UK, France, and Italy. Every model has its own limitations, and so mixed methods are often used. For instance, microsimulation models used for revenue forecasting are applied against backgrounds of uncertainty and changing economic conditions, raising the possibility of errors in projected tax estimates. Many countries including the USA, Canada, France, employ different quantitative (and qualitative or subjective) methods for forecasting tax revenues alongside their microsimulation models.

The increasing use of microsimulation models for policy analysis and the success of multi-country microsimulation (MSM) tax-benefits models for the household sector, such as EUROMOD, have generated increasing interest at policy levels on similar models for the business sector[1]. Ahmed et al. (2003) analyze and discuss the prospects and problems of developing a multi-country microsimulation model for corporate taxes in the context of EU and the purposes such a model could serve.

Corporate tax models can be 'static' or 'dynamic' depending on whether they use information from one or more time periods. If tax policy affects 'behavior' of individual companies, the modeling exercise becomes more complicated. Behavioural responses to tax policy are important for the outcome of simulations and such responses must be incorporated into the model. Such 'behavioural models' are often the focus in academic research but are seldom used for economic policy purposes. Microsimulation models employed in the OECD countries for tax reform analysis are generally static and do not account for behavioural responses. Models may include assumptions or parameter estimates that allow simulation of behavioural reactions, or they may represent simple manipulations of behaviorally exogenous inputs. Besides, they can assume tax policy to be either stochastic or deterministic [Spahn (1998)].

While governments have developed modeling capacities mainly for the purpose of estimating and forecasting corporate tax revenues, there is a major role played by independent tax modelers or researchers who are obliged to publish full details of models and receive peer evaluation.

2.3. Issues in Revenue Estimation and Forecasting

Corporate tax modeling faces a number of issues when it is used for forecasting and tax revenue estimating. With reference to revenue forecasting, the problems include data availability, the accuracy of the underlying economic forecast, definition of the tax base, and the temporal relationship between economic factors and revenues. Revenue estimation is not without problems either. [King (1986), (1995)] highlights difficulties that arise in summarizing tax changes in a single number. First, a particular change to the tax law can generally be expected to have revenue effects that are spread out over time. Second, a change to one tax may affect revenues from other taxes.

[1] MSMs have been developed and are in use in many OECD countries [see Sutherland (1995) and the references cited therein]. Tax-benefit microsimulation models (MSMs) are computer programs that calculate tax liabilities and benefit entitlements for individuals, families or households in nationally representative micro-data samples of the population and are used by both governments and academics to study existing social and fiscal policies as well as policy reforms. Specifically, they can be used to study (a) processes at the level of individual units; (b) distributional issues; and (c) effects of policy changes on overall tax revenues and social security expenditure.

The failure to take behavioural effects into account in costing tax changes has often been criticized [King (1995)]. For instance, a reduction in income tax rates should lead to an increase in consumer spending through incomes after tax. An estimate of the revenue effect that accounted for tax on the increased income but not on the increased spending would clearly be artificial. The most controversial issue in revenue estimation, therefore, is how to assess the behavioural effects of a proposed change to a tax law. On the direct effects, there may be little disagreement, but the indirect effects of proposed tax law changes may be disrupted. Rubin et al. (1999) have noted that there are at least four ways to categorize the direct and indirect effects: (1) as partial equilibrium or general equilibrium effects; (2) as primary, secondary, and tertiary effects; (3) as microeconomic and macroeconomic effects; and finally (4) as static and dynamic effects. Most discussion that has taken place about behavior assumptions in the political arena uses the static-dynamic dichotomy, with dynamic effects sometimes referred to as "feedback" effects. There are controversies relating to each of the effects to be included in revenue estimates consequent to a proposed tax law change. For example, Auerbach (1999) writes, "whether to include macroeconomic *feedback* effects is perhaps the most controversial question in revenue estimation. But the controversy is not really about whether taxes have macroeconomic effects: essentially all taxes have macroeconomic effects. The question is whether revenue estimates should incorporate these effects".

2.4. Measuring Bias and Accuracy in Tax Revenue Forecasts

Since the primary focus of official corporate tax models in many countries is on revenue forecasting, it is pertinent to expend on accuracy and bias in tax revenue forecasts and place these issues in perspective. The accuracy of a forecast can be defined as the degree to which forecast values are narrowly dispersed around actual outcomes. Whether forecasts are overestimated or underestimated can be determined by measuring forecast bias and forecast accuracy. Statistical 'bias' is defined "the extent to which forecasts can be expected to differ from what actually occurs" [US Congress, CBO (1996)]. The most widely used measure for bias is the mean error of the forecast, which will equal zero if there is no bias. This measure maybe inaccurate since the mean error of two forecasts could be identical if, for example, one had small errors and the other had large, but balancing errors. The "track ratio" measure of bias, tracks or keeps a running total of forecast errors, divided by the absolute value of the average error. If the absolute value of this ratio exceeds a predetermined positive number, the model is said to be biased. Third measure of forecast bias is based on linear regression analysis of forecast versus actual values. Bias is indicated when the residuals grow or decrease monotonically instead of tending to be random. [Rubin et al. (1999)]. As regards accuracy, two of the commonly used accuracy measures are the mean absolute percentage error (MAPE) of forecasts and the root mean square error. The MAPE is the average of the absolute differences between the actual and predicted values of the forecast over several time

periods. The root mean square error (RMSE) is the square root of the average of the sum of the squared differences between actual values and forecasted values.

$$RMSE = ([\sum (P - A)^2] / n)^{1/2}$$

Where, P = predicted value and A= actual value.

In the wider literature on economic forecasting, the accuracy of tax revenue forecasts has received much less attention than the accuracy of GDP forecasts [Golosov and King (2002)]. Under- or over –prediction of tax revenues in government budgets persisting over a period of years has emerged as a problem in several developed countries in recent years. In the United States, tax revenue forecasts were generally too high in the 1980s – but too low from 1990s onwards [Auerbach (1999)]. In Canada, an apparent upward bias in revenue forecasts that was identified in the mid-1990s led to radical changes to budget procedures [Golosov and King (2002)]. In the United Kingdom, persistent errors in forecasts of revenues from the corporate and value added taxes are reported [UK Treasury (1997); Orme and Mellor (1999)]. In Ireland, the experience of persistent under-prediction of revenues led to a thorough review of forecasting procedures [Ireland (2000)].

Studies of the possible sources of error, or bias, in tax revenue forecasts have largely been confined to the states of the United States. Klay (1992) observes that the direction of forecast errors generally differs according to the level of government. On the federal level, forecasts tend to be optimistic or overstated, with the executive branch's forecasts somewhat rosier than those of CBO. In contrast, amongst the states, most studies have found that revenues tend to be underestimated [Rogers and Joyce (1996)]. Among local governments, underestimation of revenue is persistent and substantial. This is seen as an effort aimed at self-protection to ensure that expenditures do not exceed revenues.

Golosov and King (2002) examined the accuracy of forecasts of total tax revenues in the context of IMF programs supported by ESAF in the years 1993-99. The focus of their study was on the accuracy of these forecasts, on whether they display any *ex post* bias, and on the sources of any such bias. Two forecast measures were analyzed: (a) forecasts of tax revenues as percentage of GDP; and (b) forecasts of percentage changes in nominal tax revenues. Their findings have shown that the overall accuracy of these forecasts is low. The mean percentage error is 1.86 percent for tax revenues on GDP, and 16.8 percent for changes in nominal tax revenues. The RMSE of the forecasts of tax revenues as a percentage of GDP is actually higher. Forecasts of tax revenues as a percentage of GDP were biased upwards, but there was no significant bias in forecasts of nominal tax revenues. Upward bias in tax revenue forecasts was associated with subsequent interruptions to

the program, and the length of time between the commencement of the program and the beginning of the year for which the forecast was made.

Analysis of the forecasts produced by the UK Inland Revenue corporate tax microsimulation model shows that the mean absolute percentage errors in the estimated growth of nominal corporate tax revenues for the period from 1970 to 1999 is 12.5 percentage points (Appendix 4).

3. Alternative Approaches to Corporate Tax Modeling

A number of methodologies for revenue estimation and forecasting co-exist with structural microsimulation models; including those conditional on other economic variables, such as GDP, and those that are made unconditionally; classified according to the approach they represent:

(a) Macro approaches
- (1) Extrapolation (Trend Analysis)
- (2) Conditional approach using elasticities
  - o Tax buoyancy approach
  - o Tax elasticity approach
- (3) Macroeconometric models
- (4) Gap approach
- (5) Audit approach
- (6) Cash flow Model

(b) Micro approaches
- (7) Integrated forecasting system or microsimulation models
- (8) Econometric models using enterprise (micro) data
- (9) Effective tax rates approaches

In addition to the above "quantitative methods," often 'qualitative methods' are also applied for revenue estimation and forecasting. These subjective methods rely on expert judgment and opinions. Although governments rarely depend solely on 'judgment' to forecast or estimate revenues, it is often used to inform and modify the results of more formal forecasting methods [Rubin et al. (1999)]. According to Mikesell (1995), subjective judgments are "based on the experience, intuition, and guesswork of people in the public-finance process from the revenue department, budget or finance agency, legislative fiscal staff… [They] can be devastatingly accurate and immensely useful."

Table 1. Alternative approaches to corporate tax modeling

Approach	Brief description	Strengths	Limitations	Main users
Extrapolation of tax revenue (Trend Analysis)	Extrapolates an established linear trend in revenue collection.	Useful for revenue collections *during* fiscal year. Shows seasonal trends in revenue collections.	Does not use the knowledge of tax system or economy.	Rarely used by national governments. Mainly used by state or local governments or within tax administrations.
Conditional approach – (i) tax buoyancy or (ii) tax elasticity	Forecasts made using elasticity of revenue from a particular tax with respect to G.D.P. Tax buoyancy approach measures responsiveness of tax revenue to a change in income or tax base. Elasticity approach similar but it removes from tax revenue data the impact of discretionary changes in the tax system (e.g. increase/decrease in tax rate).	Since tax collection by and large depends on the growth of the economy, this is the most useful and practicable approach. Very useful in revenue forecasting and performance evaluation of tax functionaries.	Assumes relevant elasticities to be constant, which is not a valid assumption.	Most widely used in practice, including IMF.
Macroeconomic (regression) models	Use regression methods to estimate functional relationships between tax revenues and certain macroeconomic variables.	Revenue forecasts are integrated with corresponding macroeconomic forecasts, ensuring consistency between the two.	The approach constrains the revenue forecasts to depend on only a small number of macroeconomic variables. e.g. in case of CT, the macro forecasts of aggregate profits in different sectors may breakdown if a substantial number of companies are subject to losses.	Governments (e.g. USA, France), research and academic institutions.
Gap approach	Determines the "true" tax base independent of the tax returns, and then with the use of a tax calculator model, computes the *potential tax collection.*	Useful for impact analyses of policy shifts. It also reflects the volume of 'tax evasion' in the economy. Also useful for performance evaluation.	Does not reflect actual revenue forecasts needed for balancing budgets.	Governments, research and academic institutions.
Audit approach	Equates the amount of 'tax gap' to the additional taxes assessed on taxpayers.	Adds the estimated tax gap to the actual tax receipts to arrive at an adjusted tax receipts figure.	It cannot be used in isolation. Once 'tax gap' is identified, then forecaster will depend on other approaches such as 'elasticity'.	Governments and tax authorities.
Cash flow models	A monthly cash plan, once revenue is forecast, derived using a historical average of monthly collection patterns from prior years.	(i) Reflects the seasonality of the collections (ii) Takes into consideration payment expectations for both calendar and fiscal years, (iii) Reflects trends resulting from legislative or behavioural changes.	Its accuracy depends on the primary forecast methods used.	Tax administrations; state and local governments (e.g. New York City)

Microsimulation models	Computer programs that project future tax position of firms on the basis of tax returns data. The results then grossed up for forecasting overall tax revenues.	(i) Use actual data in tax returns; (ii) Compute firms' tax liabilities with alternative policy scenarios; (iii) Suitable for 'tax costing'; (iv) Useful for distributional analysis.	(i) Difficult to use in forecasting without an integrated macroeconomic model and expertise of users; (ii) Hard to cope with uncertainties and economic changes; (ii) Requires time and resources to construct models (cost-benefits); (iii) Difficult to infer behavioural responses to changes in tax policy. (iv) Depends on accuracy of macroeconomic forecasts and business cycles.	(i) Developed countries, e.g. UK, France, Italy, Canada etc. In the USA, Congressional Budget Office uses MSMs for personal income tax, estate and gifts taxes, and social insurance payroll taxes only. No MSM used for CIT. IRS produces a sample of corporate tax returns that could be used for CIT forecast. In many countries, (e.g.USA, Austria) resources necessary for building and maintaining MSMs for CIT are judged to be too high with payoff seen from the effort involved.
Microeconometric model	Uses firm level data from company accounts as input into panel data model to examine the effects of various variables on firms' profiles, financial policy, components of accounting profits and different tax allowances and reliefs on tax liabilities of firms.	(i) Very useful for investigating determinants (drivers) of tax; (ii) Capable of understanding behavioural responses to tax policy, (iii) Control for firms heterogeneity. (iv) uses actual data in company accounts.	(i) Relies on published accounts data; (ii) explanatory model	Recently developed. Potential users include policy analysts, tax authorities, academics and users of other models.
Effective tax rates (ETRs)	Employ a forward-looking approach to determine the present discounted 'net value' of future benefits from an hypothetical investment project.	(i) Gives an idea of the cost of user capital for deciding on investments; (ii) Useful in multi-country analysis of tax burdens.	Use hypothetical data.	Policy analysts, academics.
Qualitative or subjective methods	Rely on expert judgment and opinions.	Used to inform and modify the results of more formal forecasting methods. These are based on the experience, intuition, and guess work of people in public finance.	It provides only intuitive support to the formal methods employed in forecasting.	Revenue department, budget or finance agency, legislative fiscal staff.

Table 1 provides a description of these models in summary, highlighting strengths, limitations, and main users of each approach and each of the quantitative methods in Table 1 are discussed below.

3.1. Extrapolation (Trend Analysis)

Extrapolating an established linear trend in receipts is a straightforward method of making an unconditional forecast of revenues from a particular tax. Various procedures including Box-Jenkins ARIMA procedure are used, though Box-Jenkins also require longer data series than simple trend analysis and are more difficult to implement [King (1995)]. In such univariate procedures, the revenue forecast τ_t^i from a particular tax i, in a particular time t, depends only on revenues observed in the past:

$$\tau_t^i = f(\tau_{t-1}^i, \tau_{t-2}^i, \ldots\ldots\ldots\ldots) \tag{1}$$

This approach does not require any knowledge of the tax system, or of the relationships between the revenues and other economic variables. This approach is not widely used for revenue forecasts.

3.2. Conditional Approach Using Elasticities

The 'conditional approach' to revenues forecasting for a particular tax is to estimate the elasticity of revenue from the tax with respect to GDP. This is defined as:

$$\varepsilon^i = (dT^i / dY).(Y / T^i) \tag{2}$$

where ε^i is the elasticity of a particular tax T^i with respect to GDP, denoted by Y. If ε is assumed to be constant, a forecast of ε^i in the forecast period may be derived in a straightforward way for a forecast of Y in the same period, together with actual figures for both ε^i and Y in some previous periods.

This methodology of revenue forecasting may either be the *tax buoyancy approach* or the *tax elasticity approach*. Tax buoyancy measures the responsiveness of tax revenue to a change in income or tax base. The base is usually a country's GDP while other bases could also be used. Tax elasticity is similar to tax buoyancy, however, the former approach removes from the tax revenue data series the impact of discretionary changes in the tax system on tax revenues, such as increase/decrease in tax rates or expansion/reduction of tax base. There are various methods that

may be applied to remove the discretionary changes in the tax system. Three methods reported in Gamboa (2002) are in Appendix 1.

Tax buoyancy or elasticity approach may either be a 'point estimate' or the regression coefficient of the explanatory variable, usually a tax base. The Ordinary Least Squares (OLS) procedure minimizes the errors between the actual and the estimates while in the simple point estimate method, the errors are likely to grow over time.

In practice, this is the most widely used approach. Besides national governments (e.g. Ireland, Austria, Philippines), the IMF also makes use of this approach for forecasting tax revenues of its member countries. In the context of emerging economies, two studies carried out for Philippines [Manasan (1981) and Gamboa (2002)] confirmed that among tax forecasting methodologies, the elasticity approach gives a better fit for corporate as well personal income taxes forecasting equations.

3.3. Macroeconomic (Regression) Models

King (1995) has noted that the assumption that underpins the conditional approach- that relevant elasticities are constant- is questionable. A more general approach is to use regression methods to estimate functional relationships between revenues from particular taxes and a variety of macroeconomic variables. An advantage of econometrically estimated tax revenue function is that revenue forecasts are integrated with the corresponding macroeconomic forecasts, ensuring consistency between the two. There are, however, certain limitations:

(1) This approach constrains revenue forecasts to depend on only a small number of macroeconomic variables. In addition, macroeconomic relationships are likely to break down in case a substantial number of companies are subject to losses [King (1995)], which can lead to misleading results.
(2) One of the difficulties in building an econometric revenue-forecasting model is forecasting economic variables that are fed into the equations. This is especially true during periods of economic uncertainty.
(3) Another problem in generating revenue forecasts from an econometric model stems from the indirect relationship between economic activity and tax 'collection'. In econometric models, relationships are posited between economic activity and tax liability. However, tax liability can be very different from tax collected (the key variable of interest for budget preparation).

(4) Another problem in building an econometric model for revenue forecasting arises from the difficulty in measuring the tax base. This can be solved by using proxy variables for the tax base but can lead to forecast biases.

(5) Econometric revenue models are built at either annual or quarterly frequency. The major disadvantage of annual models (used for long term forecasts) is to do with timing. Most economic data are available for calendar years, while most revenue data are available for fiscal years. Quarterly models are likely to be used if a short term forecast is the goal and/or if the timing of future collection is of interest.

Econometric models can be used for forecasting tax revenues, as well as for estimating the impact of changes in tax rates and rules on revenue. Many countries use this approach mostly in conjunction with microsimulation models and other methodologies. Canada and France are the notable examples.

3.4. Gap Approach

The purpose of the *gap approach* is to compute the *potential* tax collection in a system independent of the information on *actual* tax collections from the tax returns data. The "true" tax base is first determined independent of the tax returns, and then using a tax calculator model, the potential tax collection is computed. The reliability of the approach depends on the availability of independent data sources that closely track taxable income of corporations.

Gamboa (2002) uses the following method to calculate the corporate income tax gap. First, the potential taxable corporate income is derived. To derive the potential taxable income of corporations, the first step is to add up the net operating surpluses *(NOSs)* of private corporations, government owned and/or controlled corporations, and partnerships. This is called the adjusted NOS of corporations. The net operating surplus of private corporations (*NOSpvc*) may be obtained from the national income accounts and are represented by the equation below:

$$NOS_{pvc} = NIBT - IR_{osb} - NOI + IP + NCIP_r + D - CCA$$

NIBT: net income or profit before taxes of the top 1,000 corporations;
IRosb: interest receipts by banks on loans financed by bank funds other than depositors' money;
NOI: non-operating income generally observed to be consisting of property income and capital gains;
IP: interest payments;

NCIPr: net casualty insurance premiums;
D: donations and contributions; and
CCA: depreciation based on replacement cost of the asset less depreciation based on book value.

The net operating profits of government controlled corporations (NOSgocc) is also taken from national accounts, which is derived from the gross output of enterprises less the expenses incurred to produce the output. The gross output is equal to the sum of the operating income and other income from secondary activities. Expenses include the cost of supplies and materials, communications, utilities, insurance, transport, repair and maintenance, compensation, taxes and licenses, and adjusted depreciation.

To derive the NOS of partnerships, the ratio of the number of newly registered partnerships to the total number of newly registered corporate business organizations is calculated and then multiplied with the total NOS of corporations.

Finally, the NOS of tax-exempt corporations are deducted from the sum of NOSs of private corporations, government owned or controlled corporations, and partnerships. The difference is equal to the net taxable income of corporations. By multiplying the net taxable corporate income by the appropriate corporate income tax rate, the potential corporate income tax revenue is obtained. To derive the corporate income tax gap, the actual CIT collections is deducted from the potential CIT.

This approach is useful for impact analysis of policy shifts. Identifying the gap between potential and actual tax collections can be useful for evaluating performance of tax functionaries. This approach also reflects the volume of taxes evaded due to existence of the hidden economy. The approach does not reflect actual revenue forecasts needed for balancing budgets.

3.5. Audit Approach

Audit approach equates ‘tax gap’ to the additional taxes assessed on taxpayers as a result of tax audit. The method includes adding the estimated tax gap to the actual tax receipts to arrive at an adjusted tax receipts figure. However, this approach and the ‘tax gap’ approach (discussed in section 3.4 above) cannot be utilized in isolation for revenue forecasting. Once ‘tax gap’ is identified, the forecaster may depend on other forecasting methods such as ‘elasticity’. The approach is used by governments and tax authorities for performance evaluation [Gamboa (2002)].

3.6. Cash Flow Model

Once revenue from a particular tax is forecast, next stage is to prepare a periodical (monthly) cash plan, derived using a historical average of monthly collection patterns from prior years. Cash flow model reflects the seasonality of the tax collections and the complexity of the fiscal year cash flows. This takes into account payment expectations for both calendar and fiscal years.

The initial plan is then adjusted to reflect current or expected trends resulting from legislative or identifiable behavioural changes. Growth rates over prior year collections are closely monitored and analyzed in order to determine if collections are consistent with over all assumptions [City of New York (2003)].

3.7. Corporate Tax Microsimulation Models

Tax microsimulation models (MSMs) are computer programs that calculate the net tax liabilities for individual unit – households or firms – in nationally representative micro-data samples and are used to study existing fiscal polices as well as policy reforms. As 'micro' models, the basis of their analytical framework is the 'micro-level.' As 'microsimulation' models, they simulate the details of institutional rules and thus are in a position to evaluate existing tax legislation and aid in the design of new components of schemes or entire systems [Ahmed et al. (2003)]. They calculate applicable amounts of each element of the system in the legal order so that interactions between different elements of the system are fully taken into account. The resulting taxes and net income or profit measures for each unit can be weighted to provide results at the population level. As a result, MSMs provide accurate measures of tax liabilities and overall net income or profits for individual units (observations), which can be aggregated to the macro level. They can thus be used to study (a) processes at the level of individual units; (b) distributional issues; and (c) effects of policy changes on overall tax revenues. Household MSMs have been developed and are in use in many OECD countries [see Sutherland (1995) and the references cited therein]. These typically simulate entitlements to benefits (transfers) and liabilities for social insurance contributions as well as income taxes. They produce estimates of the distribution of income after benefits and taxes under alternative policy scenarios and can be used to estimate the net cost of policy changes. Corporate MSMs are less widespread or well known.

Microsimulation models for corporate taxes could potentially have the following purposes:

To Estimate Tax Liability of Individual Firms

These models are constructed from samples of tax return data and work on the basis of detailed application of tax regulations to the structure of the tax base, at the level of individual firms' tax liabilities. The effects of changes in tax rules and regulations on tax liabilities of the individual firm can be calculated. Where the representativeness of the input data is known calculations can be weighted and aggregated to estimate average or economy-wide effects.

In many EU countries such models can be developed using data in company accounts, but in the case of the UK and Ireland, company accounts, including profit and loss statement and balance sheets do not contain sufficient information for microsimulation modeling. A UK model would require more detailed information than is contained in commercial accounts. Income liable to corporate tax, while based upon accounting income, is subject to adjustments in accordance with tax law (e.g. depreciation is added back to taxable profits and replaced by 'capital allowances'). Notes to the accounts contain substantial contextual information but their manual coding requires time and resources. Ahmed et al. (2003) have constructed a spreadsheet model that can effectively compute tax liabilities of UK firms**.** The model is flexible to accommodate changes in the policy parameters and can be potentially used to create different policy scenarios within the UK tax system.

To Estimate Tax Revenues for the Economy

For many years the main use of microsimulation models has been revenue estimation rather than forecasting (see next subsection). "Revenue estimating" is the process of assessing the impact on revenues of tax law changes proposed at the time of the budget, or subsequently. It is a process closely related to revenue forecasting, but sufficiently different that in some countries (including the US), it may be performed by different people. Forecasts are required even when no change to the law is proposed; on the other hand, revenue estimates must often be made for proposals that are not subsequently adopted, and that therefore do not need to be taken into account in any revenue forecasts [King (1995)]. In the UK and elsewhere, microsimulation models have primarily been constructed to estimate revenue effects of changes to personal and corporate taxes. UK models have been adapted and improved since 1970s to reflect changing tax systems, greater policy support requirements and substantial improvements in computing power and software [Orme and Mellor (1999)].

In the UK, non-government models include those of the Institute for Fiscal Studies (IFS) and the Manchester Business School (MBS). These are discussed separately in section 4.8.

To Forecast Revenues and/or Analyze the Revenue Effects of Tax Policy

Alongside their primary purpose of revenue estimation, in some countries microsimulation models are also used for revenue forecasting. Forecasts of government revenues from different taxes are produced to serve a variety of purposes, most importantly, government budgeting. A forecast of total revenues is useful to estimate the deficit that will have to be financed. Forecasting is often carried out by projecting the data in the sample forward over the forecast period on the basis of macroeconomic forecasts of the relevant driving variables. The microsimulation model is then used to estimate future tax liabilities with adjustments made for collection lags, estimates of liabilities can be converted into estimates of tax receipts during the period [King (1995)].

Many corporation tax models used for revenue forecasting fail to forecast revenues accurately. The forecast errors are usually due to the heterogeneity (in terms of types, size, age, business activity, corporate financial policy, structures) of firms, volatility of annual profits or losses of companies, skewness in the distribution of tax payments, and some limitations of the methods employed. An obvious problem in the use of microsimulation models for revenue forecasting is the potential inconsistency between macroeconomic forecasts (which are used as inputs in projecting the sample data over the forecast period) and revenue forecasts themselves. While macroeconomic forecasts depend on the movements of business cycles, tax revenue projections depend on the past profit/loss record of companies. In the UK (and some other countries) this has led to the development of iterative procedures, under which a macroeconomic forecast is first made and revenues are estimated using simple tax revenue functions. Microsimulation models are then used to adjust those revenue forecasts, using residuals in the macro tax revenue functions, and the process is repeated several times until convergence occurs [King (1995)].

3.8. Econometric Models Using Enterprise (Micro) Data

Since microsimulation models of firms are constructed from samples of tax returns data, which are protected by privacy laws, the literature on corporate taxation has been limited to examining the impact of tax policies and effective tax rates (ETRs) in different countries on firms' investment decisions and their choices regarding ownership structure, debt/equity, and dividend payouts. The ETR approaches (discussed in sub-section 3.9 below) use hypothetical data to compute the cost of user capital for deciding investments and are useful in multi-country analyses of tax burdens. There is also some work examining the impact of taxation on income shifting/transfer pricing behavior of companies.

For the most part, however, the existing literature does not examine endogeneity of tax liabilities and the causation that runs from firms' economic decisions to their tax liabilities. Econometric analysis that establishes the link between the commercial factors at the level of the firm and taxes paid is non-existent. Ahmed (2004) supplies a micro level analytical framework to fill this gap. The model highlights the non-neutralities of corporate income tax with respect to the choice of organizational form, financial structure, accounting practices and the use of tax allowances and reliefs. Such non-neutralities result in complex transactions and unstable tax system as taxpayers devise new ways of minimizing their taxes. Existing microsimulation models for corporate taxes fail to capture the revenue effects of tax planning by multinational firms with complex organizational structures and the resulting forecasts are often inaccurate. The "tax behavior" of bigger firms therefore can be best explained by econometric models. Using firm level panel data of UK companies in three diverse sectors, Ahmed (2004) studies the effects of firms' size, organizational structure, financial policy, and various sources of taxable profits on their corporate tax liabilities. The findings convincingly suggest, *inter alia*, that firms with large number of subsidiaries and holdings reduce their tax liabilities through different channels. This would suggest that subsidiaries and holdings help in 'tunneling'. Moreover, firms' tax liabilities are sensitive to the provisions of tax codes as firms carefully plan to take tax advantages. The study further shows that each component of taxable profits is individually significant determinant of corporate taxes.

3.9. Effective Tax Rate (ETR) Approaches

Effective tax rates are indicators which provide a basis for comparing the effects of tax systems across countries and are useful in analysing how different systems affect companies' investment behaviour. Existing approaches to measure the effective tax burden are based on two types of analyses implying either backward-looking concepts or, alternatively, forward-looking concepts. Both approaches have their respective advantages and disadvantages and can lead to different quantitative results. Even when the results of the application of different methodologies are not directly comparable, the existence of tax induced distortions seems to be confirmed by a variety of studies regardless of the particular approach adopted [European Commission (2001)].

a. Backward-Looking Approaches

One approach to measure the effective tax burden in policy-making is based on aggregated data from existing firms. As this looks at capital stock, profits or other relevant data accumulated in the past it is called a backward-looking approach. By referring to the observation of ex-post data, it measures "actual" rather than "hypothetical" tax rates. These approaches are appropriate for measuring incomes of capital owners, revenues of government and the size of public sector, and

distributional burdens [Fullerton (1984)]. Within this framework, one can distinguish between those approaches based on firm-specific data and those based on aggregate economic data.

Approaches based on *firm-specific* data generally express the effective tax burden as a percentage of tax liability relative to profits from companies' annual accounts. Data can either be taken from individual financial statements or consolidated returns. Although these measures have the advantage of showing the actual tax burden borne by companies, they could be misleading if they are used to assess and compare effective domestic tax burdens in international comparisons [EC (2001)]. This is due to the reason that approaches based on ex post company-specific data do not take into account the interaction between personal and corporate taxation which is relevant when the marginal investor is domestic. Moreover, these approaches fail to measure the incentive for additional investment or to correctly consider the foreign source income in individual or consolidated company accounts. Moreover, data sometimes tends to show significant yearly fluctuations depending on business cycle effects. For these reasons backward-looking profit based indicators are imprecise indicators of investment incentives of taxation. Nonetheless, they do allow an assessment of effective actual tax burdens by firm size, sector or industry, which are useful in addressing equity issues.

Measures for the tax burden using *aggregate economic data* from national accounts are computed as a percentage of domestic corporate taxes relative to various income measures, such as aggregated domestic corporate profits or the corporate operating surplus. Although these formulae are correct, it is hazardous to make an international comparison of corporate tax rates on the basis of aggregated economic data. Moreover, the methods and definitions of the National Accounting Systems differ between countries, besides being insufficient to distinguish between different sources of taxation.

b. Forward-Looking Approaches

Forward looking approaches are designed to capture incentives to use new capital. The most commonly used indicators for analysing the impact of taxation on investment behaviour are based on forward-looking concepts and involve computing and comparing the effective tax burden for *hypothetical future investment projects* over the assumed life of the project or, alternatively, the effective tax burden for *hypothetical future model firm behaviours*, using statutory features of tax regimes. These approaches are suitable for international comparisons and are tailored to disentangle the effects of taxation, providing an indication of general patterns of incentives to invest, that are attributable to different national tax laws. The measurement of effective corporate tax differentials does not provide evidence of effects of taxation on actual business location.

All the above mentioned methodologies are used by governments, research and academic institutions, as also private consulting firms, for forecasting and estimating revenues from particular taxes, for impact analyses of policy shifts, and performance evaluation of tax collecting departments. Given limitations and biases, none of the methods in vogue can forecast and estimate tax revenues very accurately. Grizzle and Klay (1994) suggest that combining forecast methods could result in more accurate forecasts than single-model forecasts, especially when the models being combined differ in their information content.

4. Existing Corporate Tax Models in Major OECD Countries

As noted in the previous section, there are alternative approaches to corporate tax modeling, each with their own potential role in policy analysis. The balance between the use of microsimulation and other methods for revenue forecasting differs across countries. Corporate MSMs are relatively rare and many official models rely on other methods that use aggregate data. A notable exception is the UK where the Inland Revenue's Corporation Tax Model, first developed in the 1970s, has undergone substantial improvements and is now being used for revenue forecasts as well as other applications [Eason (2000)]. This section reviews country-specific corporate tax models in the USA, Canada, UK, Ireland, France, Italy and includes a discussion on corporate tax modeling approaches followed by the International Monetary Fund, and academic and independent research institutions.

4.1. US Approaches to Corporate Tax Modeling

Corporate income taxes in the USA contributed 207 billion dollars in the fiscal year 2000, amounting to 10.2 percent of the total revenues and 2.1 per cent of the GDP. In the USA, different methods of revenue estimation and forecasting are applied at different levels of the federal government, states, and the local governments. There are defined institutional responsibilities at each level of the government for preparing tax forecasts and estimates [see Rubin et al. (1999) for a description of institutional arrangements]. The first US microsimulation models of personal income tax were developed in the 1960s for revenue estimation and distributional analysis; they were not used for forecasting until the late 1980s. Both the executive and legislative branches of the federal government prepare tax forecasts and tax estimates. Private organizations also prepare estimates of proposed federal tax law changes for groups interested in specific proposals [Rubin et al. (1999)].

At the Federal Government level, the Office of Tax Analysis (OTA) in the executive branch, and Congressional Budget Office (CBO) and the Joint Committee on Taxation (JCT) in the Congress rely primarily on the individual income tax simulation model (a microsimulation model), and the

corporate tax model (an econometric model) for revenue estimation and forecasting. When these models are not appropriate, others are used, including the Treasury's depreciation model and models for the estate tax and the foreign tax credit. Macroeconomic forecasts serve as the basis for revenue estimates in the congressional budget resolution in the President's budget proposals.

CBO's baseline projections assume no policy changes. Consequently, the methodology for projecting revenues involves a great deal more than using past relationship of receipts to GDP as a guide and determining that revenues change by some given percentage for every percentage change in macroeconomic activity. CBO models each tax source separately and projects total tax revenues by summing the projections over the separate sources.

CBO currently employs microsimulation techniques for three of its revenue sources: personal income taxes, estate and gift taxes, and social insurance payroll taxes. CBO approach is to use microsimulation in conjunction with other techniques for doing forecasts. However it does not use microsimulation for all sources of revenues where it might be possible. For example, the Internal Revenue Service produces a sample of corporate tax returns that could be used for corporate income tax forecasts. CBO finds that the amount of resources necessary to build and maintain a model are too high with little payoff seen from the effort involved. They start with a macroeconomic forecast that is close to the tax base, and while there are graduated tax rates under the corporate system, most income is taxed at the top rate. Therefore, it is not necessary to spend much time modeling the tax base or the distribution of income with firm level data. CBO may use some of the available corporate data to analyze issues associated with the corporate income tax, *but there would not be much improvement in the forecast from building microsimulation models for the corporate income tax* [Weiner (2003)].

At the State governments level, the use of complex econometric models for revenue estimation and forecasting has increased substantially in recent years – from just 10 states in 1980 using such models to 34 states in 1996. The Council of State Governments attributed the growing use of econometric techniques to the "proliferation of microcomputers in the *statehouse"* that are capable of estimating complex econometric equations. Rubin et al. (1999) has tabulated the summary of revenue forecasting methodologies used by States, which shows that although states are relying more heavily on sophisticated models for revenue forecasting and estimation, they continue to use subjective approaches and trend analysis as well. Methodologies used by states for revenue estimation vary slightly from those used for revenue forecasting; however, states generally commit more resources to the former than the latter.

Based on anecdotal evidence and limited publicly available information, Klay (1992) reports that local governments tend to rely to a large extent on qualitative approaches to revenue forecasting and estimation. Time series methods are, however, becoming more commonly used by local governments. Of the seventeen local governments included in the PEL survey, eleven relied to a greater or lesser extent on judgment or intuition; six used time series methods; five incorporated econometric modeling; and four used some other approach, such as outside experts or consensus forecasting. Local governments' reliance on subjective approaches is not surprising given the paucity of data available to them.

4.2. Canadian Corporate Income Tax Models

Canada is distinctive in corporate tax modeling. The Canadian Economic and Fiscal Model (CEFM), developed internally by the Department of Finance, forecasts key economic and fiscal indicators (including corporate income tax) and simulates the economic and fiscal impacts of policy or economic changes. The fact that the Canadian model embodies economic theory and appropriate econometric foundations makes it distinct from the other models examined in this paper. Despite the fact that the model has to perform in a forecast mode, it has properties that closely approximate those of a well specified theoretical model. A detailed description of the theoretical structure and empirical specification can be found in Robidoux and Wong (1998) and Cao and Robidoux (1998), respectively. DeSerres, Robidoux and Wong (1998) document the dynamic forecasting and simulation properties of the model. In addition, a microsimulation model, based on SAS structured programming language, simulates the federal corporate tax system to capture revenue impact of tax changes. These models are discussed, as follows.

Canadian Economic and Fiscal Model (CEFM)

The first version of the Canadian Economic and Fiscal Model (CEFM) was completed in 1986. Since then, CEFM has been used by the Department of Finance for macroeconomic forecasting and policy analysis, with many rounds of revision. The model serves the dual purposes of dynamic forecasting and policy analysis. In addition, one main objective of the forecasting process in the Department of Finance is to predict, at a fairly detailed level, the outlook for federal government revenues and expenditures. As a result, CEFM96 has quite a detailed government sector. The estimation process involves three stages: First, unit root and cointegrating tests are performed to validate the underlying economic model suggested by economic theory. In a second step, the model uses a general-to-specific approach to specify an error correction process. Finally, the statistical adequacy of the model is checked by applying diagnostic and forecasting tests. Here we describe the corporate income tax component of CEFM96 only.

The data for the corporate income tax block of CEFM96 are based on Revenue Canada, Taxation's *Corporation Sample Summary Statistics*, which are derived from corporate income tax forms (knows as T2). The key variables determined by this block are corporate taxable income (that is, tax base) and federal corporate tax liabilities (after applying tax rates and adjusting for surtaxes and tax credits).

The main determinant of corporate taxable income is corporate profits before taxes from the income block of CEFM96. However several adjustments, reflecting allowances and requirements under the Income Tax Act, are needed to establish the linkage between corporate taxable income and corporate profits before taxes. Much of the corporate income tax block is devoted to specifying these adjustment items. Because of the large number of adjustments, not all adjustments are modelled explicitly in the corporate tax block. Adjustments that are explicitly modelled are current-year losses, prior-year losses, exploration and development expenses for book and tax purposes, the depletion allowance, the resource allowance, provincial royalties, depreciation for book and tax purposes, and net capital gains. Eleven addition and deduction items are modelled in the corporate income tax block. After these items are estimated, corporate taxable income is calculated by adding these items to, or subtracting them from, corporate taxable profits before taxes.

The final step is to estimate federal corporate income tax liabilities – that is, the amount of tax on profits owed to the federal government by corporate enterprises. This is calculated by applying the weighted-average federal corporate income tax rate and the corporate surtax to corporate taxable income, and adding the large corporation tax and miscellaneous income and capital taxes net of various tax credits allowed under the Income Tax Act.

The modeling of the federal corporate tax sector is based on 17 stochastic equations. Annual data up to 1993 are used in estimation. The empirical results are reported in Cao and Robidoux (1998). Out-of-sample dynamic forecast tests suggest that about half of these equations predict with bias. In most of them, however, the bias is relatively small as suggested by low mean absolute percentage errors. The notable exceptions are expenditures qualifying for the non-scientific research and experimental development investment tax credit, the cumulative Canadian exploration expenses opening balance, and the resource allowance. The difficulties in forecasting these variables reflect the complexity of the tax system for corporations.

Corporate Income Tax Microsimulation Modeling

The Canadian microsimulation model is used for the following purposes:

- Establishing a “baseline” forecast of tax receipts;
- Estimating the revenue impact of law changes;
- Estimating changes in the distribution of the tax revenues:
    - Number of firms
    - Industry analysis
    - Firm size analysis
    - “Winners and losers”
    - Other issues of concern to policy makers.

The Canadian microsimulation model of corporate income tax uses a stratified sample of about 18,000 corporations representing a total population of around 900,000 (in 1998). The sample includes all the large ‘hit-list’ corporations. The model exploits two sources of micro information – limited information on all corporations and extended and validated information on sampled corporations. For the first, a population data file called CORPAC collects data from main T2 form (corporate income tax return) and specific fields from T2 accompanying schedules and selected information from balance sheet/income statement. There are a total of around 900 fields representing variables on tax revenues, tax base and major deductions and credits. This file is used for the purposes of tax auditing, evaluation of policy, revenue statistics, and it provides a base for sampling. The file is dynamic and is updated with results of audits and carry-backs. A unique Corporation identifier allows for longitudinal analysis. The second file, Canadian Corporate Sample File (CSF) is used in tax modeling.

Simulations are carried out through the Canadian T2- Model for scenario impact study and tax expenditures. Sectoral microsimulations are run through structured programming languages, for example, SAS. The stratified information is used by the Fiscal Policy Division (for revenue monitoring/forecast) as well as the Federal-Provincial Relations division (which uses data in the equalization program).

The stratification criteria include: national status, taxation status, level of assets (size) industry sub-grouping, geographic region, and outliers. This results in 2, 803 strata. After defining these criteria, a random sample is drawn from each resulting stratum and there is a compulsory selection of every large corporation with an asset of level 4.[2] Also the corporations on the department of finance’s ‘hit-list’ are automatically added to the sample. The sample is then weighted by stratum to reflect the overall economy. The Revenue Agency (CCRA) keys in, manually, the required information on all sampled corporations. Canadian corporate sample is composed of approximately 1.4% of the

[2] Corporations are classifed into levels depending on the quantum of their assets.

total population. These corporations represent more than 60% of tax paid. The sampling method has its own shortfalls. It cannot be used for robust analysis in a subsection of the economy that is not a stratification criterion (e.g. analyzing the federal capital taxes paid by corporations doing R&D in Canada). Moreover, longitudinal analysis can be difficult.

Canadian T2- Model (Tax calculator): Structure and Modeling Issues

The Canadian T2-Model of corporate income tax simulates the federal corporate tax system to capture revenue impact of tax changes. The model is composed of modules (distinct programs). Each module simulates a specific tax form, for example, depreciation, taxable capital gains or investment tax credit. The results are sent into the main program that calculates total taxes. For each simulation, the model is run twice: first the simulation is done assuming the status quo and then the model is run with tax changes. The difference in total taxes paid in the two calculations gives the estimated revenue impact of a measure.

The important flex points in Canadian corporate taxation include treatment of losses, depreciation system, book accounting versus tax accounting, and policy parameters. On the basis of these flex points, the following policy parameters are included in the model:

- Tax rates
- Tax credits (refundable or non-refundable)
- Tax exemptions
- Treatment of capital investment
- International taxation
- Inter-temporal rules.

The Canadian corporate tax modeling approach reflects major attributes of the tax system, such as, income and capital taxes, capital cost allowances (depreciation), tax credits and carry backs/ carry forwards, business losses carry backs/carry forwards, and graduated rate structures. The model is generally based on firm-level data reflecting actual tax positions, while in some instances adjustments to non-tax data are made to impute tax values.

Structured programming language used by the Canadians is superior to spreadsheet modeling and is much easier to create and control inter-connected tax calculator modules. It also makes it easier to create, import, and manipulate databases, ensuring more flexible output parameters.

The model does not take into account tax planning strategies such as impact of discretionary deductions and profit repatriation policies and foreign tax credits. Impact on revenue estimates is, however, mitigated if one assumed tax-minimization regardless of firm's strategy.

4.3. UK Corporation Tax Model

When it comes to modeling corporate taxes, the UK is an exceptional case where a microsimulation model, developed internally by the Inland Revenue, is the key component in revenue forecasting. MSMs were primarily constructed in the 1970s to estimate revenue effects of changes to personal and corporate taxes (tax costing), and have also been used in forecasting corporation tax receipts for over twenty years. Eason (2000) and (1996) and Eason and Elmore (1998) describe procedures involved in use microsimulation for forecasting corporation tax. Orme and Mellor (1999) provide a review of the UK experience of microsimulation modeling especially in the wake of changes in 1999 to the system of advance corporation tax.

The CT model is based on a stratified random sample of approximately 15,000 taxpayers (including the 3000 largest companies), and simulate tax liabilities of firms in the following period, using national income forecasts provided by the Treasury. The projection method is disaggregated for broad industry types by size and by history (past three years) of profit or loss. The forecast uses estimated transition probabilities from profit/loss history to make projections for groups of companies. The aggregate level of profit (or loss) in the forecast is distributed across various categories of firms on the basis of historical data. The main determinant of each company's tax liability is its trading profit. Other determinants of tax liability are levels of dividends, capital gains, investment income, rental income and levels of investment which qualify for capital and or depreciation allowances and interest costs [Eason (2000)]. This model involves various sources of data, several different modeling processes, and computer simulation exercises. There are separate forecasts for capital gains, for the financial sector, for giant companies and North-Sea oil and gas companies.

Despite its long history and steady improvements, the IR model cannot simulate some aspects of future tax position of companies accurately [Orme and Mellor (1999)]. Forecasting errors have grown smaller since the microsimulation model was introduced but errors are still significant and can reach up to 10 per cent. The causes may range from measurement errors in the microsimulation methods, to incorrect forecasts of main tax determinants by the Treasury and endogenous firm response-behavior to tax law changes Eason (2000). The use of complex microsimulation modeling procedures prompted by the desire of modelers to allow for 'tax exhaustion' (which

occurs when a company's income is insufficient to exhaust its available tax reliefs and allowances including any losses brought forward from earlier periods) have not helped a great deal in accurate forecasting of corporate tax revenues. The level of forecast errors reported by Eason (2000) and Orme and Mellor (1999) is significant, with average absolute percentage error for the last 10 years at 6.7 and for all years at 7.8. However, the mean absolute percentage errors (MAPE) in terms of changes in nominal corporate tax revenues forecast by the IR microsimulation model for the period from 1969-70 to 1999-2000 are 12.5 percentage points (Appendix 4). This is significantly higher than the simple measure of average absolute percentage error of 7.8 suggesting that the overall accuracy of these forecasts is low and the more complex microsimulation modeling processes have been of little help in improving the overall forecast accuracy.

Given the inherent limitations of static microsimulation models in predicting endogenous tax behavior of companies, it would be prudent for UK modelers to benefit the experience of other countries and make use of other methods, such as elasticity approach or econometric models, in conjunction with microsimulation models. This will help because the corporation tax system has remained relatively stable in the UK for the past several years and tax reform has been low on the political agenda, as compared with other countries (such as Italy and France). It is interesting to note that profits of UK companies grew from £71.6 billion in 1990 to £116.1 billion in 1999, an annual average growth rate of 6 per cent, at current prices [Walton (2000)]. Corporation tax revenues during the same period registered an annual average growth rate of 5.73 per cent; the growth in corporate profitability and the tax revenues has been very close at the aggregate levels. As argued earlier, corporate MSMs are best suited for revenue estimation rather than forecasting. Dynamic microsimulation models, supported by an integrated database of commercial and tax accounts, could achieve the desired objective of making accurate forecasts but their development would be a gigantic task and require time and resources. As the US Congress Budget Office have noted, the pay off may not be commensurate with the efforts involved [Weiner (2003)].

4.4. French Corporation Tax Model

The corporation tax system in France has been extensively reformed since 1986 with a gradual reduction of the rates (from 50 to 33.3 per cent), the introduction of split rates for distributed and retained profits (between 1989 and 1991), changes in the treatment of capital gains and the scheme of quarterly part payments. These changes, coupled with a cyclical downturn, made forecasts of corporation tax revenue subject to considerable uncertainty. To take account of these changes, the French Ministry of Finance moved from forecasting through linear extrapolation from the previous year using macroeconomic forecasts for company income as the base, to a more formal method of forecasting using a tax simulation model. The French model of corporation tax forecasting relies

heavily on the METRIC macroeconomic model used by the *Direction de la Prevision* [Schneider (1998)]. The model estimates short and medium-term changes in the real economy. It is assumed that these changes will have an impact on corporate profits and, eventually, on corporation tax. The forecasts should correspond to the potential payments into government treasury. The corporation tax collected by the government corresponds roughly to the tax booked in company accounts. The French corporate tax forecasting process involves five stages:

1. Reconstitution of the corporation tax liability booked by firms from the corporation tax actually collected during the previous year;

1. Calculation of taxable profit from the corporation tax booked by firms – using rate of corporate tax;
2. Application of trends derived from macroeconomic model (METRIC) to this profit with a view to determining taxable profits for the following years;
3. Calculation of the corporation tax liability that firms should book on the basis of these taxable profits- by applying the rate of corporation tax; and
4. Calculation of corporation tax that the government should receive, from the corporation tax that firms should book, i.e. the reversal of stage 1.

The French model for corporation tax, described by Schneider (1998) is much more macroeconomic in nature than its counterpart in the UK. It uses the definition of taxation profits as derived from company accounts and forecasts for profits are derived from a macroeconometric model for the French economy. The modeling approach emphasizes the dynamic structure of corporate accounts and their relationships with the tax assessment process. However, Schneider (1998) reports measurement errors that arise in estimating the gross operating surplus (and thus in projected profits). The main source of error lies in the fact that taxable profit is derived from macroeconomic indicators in the metric model. For example, comparisons of the trend of taxable profits with gross operating surpluses and net operating surpluses according to National Accounts exhibit certain differences. While the broad trends have been similar, taxable profit has increased only modestly.

The main problem of the French model, as also the UK Inland Revenue model, remains the difficulties in forecasting company profits and losses by sector of the economy or by groups of firms. Both the UK and the French corporation tax modeling approaches started at a highly aggregated macro level, and they are both moving toward micro modeling. Spahn and Pearson

(1998) note that the French modellers are moving in the direction of using sampled micro data for companies.

4.5. Italian Corporation Tax Model

A new corporation tax model for Italian enterprises was developed as a part of the European Commission funded project called "*Development of a System of Indicators on Competitiveness and Fiscal Impact on Enterprises Performance"* (DIECOFIS) coordinated by Italian Statistical Office (ISTAT). The purpose of the model is to estimate tax revenues and ex-post marginal tax rates for different sectors of companies [see Catellucci et al. (2003) for more details]. The model uses an integrated data-set based on a survey of large companies with more than 99 workers and reported company accounts. This dataset allows computation of the corporate income tax base and complete representation of the corporate tax schedule. The modular structure is flexible enough to enable users to amend modules in order to simulate alternative policy scenarios. It allows updating of both parameters and tax rules. Three modules are used to represent the tax system - fiscal adjustment, corporate Income, and corporate tax - which run sequentially in the model. At present, there are no fiscal data available to evaluate the output of the model.

The Italian corporation tax model is still at an early stage of development. It makes use of micro enterprise data collected through primary and secondary sources, integrated and made available to ISTAT. In this case company accounts data can be translated into the corporation tax base. These data are supplemented with information necessary to model the IRAP (social contributions) and information on the take-up of tax incentives. This is a sound basis for the development of a microsimulation model that could be used for policy analysis and revenue estimation. The Italian tax system has been subject to frequent reforms and the nascent model has the potential to be regularly deployed for distributional analysis of alternative tax systems. The initial purpose of the Italian model is substantially different from the UK and French models which are used for forecasting revenues from the corporation tax and which exploit macroeconomic forecasts.[3]

4.6. Corporation Tax Modeling in Ireland

In the Republic of Ireland, there are three main government entities that are involved in tax and macroeconomic forecasting – the Central Budget Office (CBO), the Economic Forecasting Unit (EFU) in the Finance Department, and the Revenue Commission (RC). The EFU prepares a preliminary economic forecast generating economic variables that are used to derive tax forecasts.

[3] There is no reason why the Italian model could not be adapted for this type of application.

The CBO and RC use these forecast economic variables to prepare preliminary disaggregated tax forecasts independently. In the discussion to assess their respective tax forecasts, the final arbitrator is the Finance Department, which decides which forecast to use. Studies undertaken by Irish experts and European Community experts showed that Ireland's corporation taxes are highly sensitive to GDP growth by a 2.5:1 % ratio (assuming no tax reduction measures). In general regression based *tax elasticity* approach is employed to forecast major taxes in Ireland. Macro level econometric modeling has been tried but Irish experts concluded, "there appears to be a limited role for a more intensive use of a macroeconometric model to improve tax forecasting" [Ireland (2000)].

In Ireland, corporation taxes are forecast using elasticity approach applied to corporation tax receipts. Actual corporate tax receipts of previous years are usually used to determine the forecast base for the current year; which is then adjusted for budget or collection factors. It is then increased by the average percentage projected growth in company profits. Preliminary forecasts of corporate profitability use a GNP-related elasticity of 1.5%. But as the year progresses, various sector-based databases are used to determine current year profits. The resultant estimate is the corporation tax forecast.

4.7. IMF Approach to Tax Revenue Forecasting

The tax revenue forecasting method routinely used in financial programs supported by the IMF assumes simple elasticity of tax revenues with respect to GDP. In technical assistance work, the IMF sometimes estimates revenue effects of reforms by taking a sample of CIT returns and grossing up to get an aggregate number. However, it focuses on forecasts of total tax revenues for the coming fiscal year, such as would typically be incorporated into the government's budget for that year. These tax revenue forecasts are sometimes referred to in the context of IMF programme as "targets" or "projections" [Golosov and King (2002)]. The IMF's *Revised manual of Fiscal Transparency* refers to the importance of "realistic revenue forecasts". Although the term "bias" is not used in the manual, the context suggests that a forecast that is known to be biased would, on that account, not be considered a "realistic" one.

Tax revenue forecasts made in the context of IMF programs may differ from revenue forecasts made by national governments in several important respects. Golosov and King (2002) highlight these differences. First, IMF programs are generally adopted by countries that are in severe financial or macroeconomic difficulties. Therefore, these programs, by definition, are expected to show an improved macroeconomic performance over the recent past. Second, IMF programs frequently involve a substantial "fiscal adjustment". In many cases this includes major changes to

tax systems, designed to improve efficiency and to increase revenues. Third, IMF financial programs are not intended to be unconditional predictions of the most likely outcomes for macroeconomic variables during the program period: they are designed to be consistent forecasts of those variables, on the condition that the policies described in the program are carried out. Some programs inevitably "fail". One would expect, however, that "program failure" will lead to an upward bias, ex post, in forecasts of changes in ratios of tax revenues to GDP. Finally, IMF support programs include a variety of conditionalities. In few cases, conditionality has also been attached to performance in terms of tax revenues. It could well be, therefore, that a government facing a deficit higher than that provided for in the program will introduce measures during the program year, including tax increases, with a view to meeting program conditions. One would again expect that this would result in an upward bias, ex post, in the forecast of tax revenues.

4.8. Tax Models Developed by Independent Research Institutions

Alongside government departments in various countries, independent tax modellers and researchers play a substantial complementary role in tax modeling. However microsimulation modeling of corporate taxes by independent research institutions has been seriously constrained by the non-availability of data on tax returns and detailed company accounts on which such models are constructed. Their focus has been to study the tax burden on firms in different locations and examine the impact of tax policies on, *inter alia*, the investment decisions by firms.

4.8.1. Models Using Effective Tax Rates Approaches

As discussed in the previous section, effective tax rates may be of two types. *Ex-post* implicit effective tax rates - *EPITR* – use a *backward looking approach* and relate taxes paid by companies to some aggregate item in company accounts, such as gross profit or gross operating profit. *Ex-ante* marginal effective tax rates- *EAMTR* use a *forward looking approach* and measure the theoretical implicit tax rates on a hypothetical marginal (assuming normal rate of economic rent*)* investment project based on the present discounted value of the future benefits in a hypothetical project. While EPITR are appropriate for measuring incomes of capital owners, revenues of government and the size of public sector, and distributional burdens, EAMTR are designed to capture incentives for use of new capital [Fullerton (1984)]. EAMTR owes its origin to King and Fullerton (1984) and has been recently extended by Devereux and Griffith (1998) to infra-marginal investments. Devereux and Griffith (2002) have computed EAMTRs for all EU countries (reported in Appendix 2).

Recent studies of Buijjak et al. (1999) and Nicodeme (2001) have applied a backward-looking approach based on the financial data of EU companies in order to estimate effective tax rates in the

manufacturing sector. Several studies have used forward-looking methodologies to analyse the impact of taxation on incentives to invest. Among these, see Bovenberg et al. (1989), Canadian Department of Finance (1997), Bordignon et al. (1999), Bond and Chennels (2000).

Models based on a hypothetical firm behaviour is exemplified by Jacobs and Spengel (1999). Their "European Tax Analyzer" allows for international comparisons of company tax burdens. The methodology follows the forward-looking approach for the measurement of effective tax rates on the basis of a model firm. The EATR is computed for investments generating economic rents. This model and others that follow a forward-looking approach using hypothetical data may be useful in comparing tax systems across countries but fall short of accurately representing the distribution of tax burdens across the entire population of firms. The backward looking approach, as Fullerton (1984) points out, is appropriate for measuring cash flows, anticipating tax revenues, and evaluating distributional burdens, while marginal effective tax rates are designed to capture incentives to use new capital.

4.8.2. IFS Corporation Tax Forecasting Model

In the UK, the Institute for Fiscal Studies (IFS) produces a set of public finance forecasts once a year in its annual Green Budget, which is published in the run up to the actual Budget. The IFS sees its role as one of auditing Treasury's forecasts.

The IFS uses following three techniques to forecast corporate tax receipts in the UK.

a. The IFS Modeled Receipts Approach

This approach models corporation tax receipts growth using the forecast growth in the tax base relevant to corporation tax, combined with an estimate of the elasticity of revenue with respect to this tax base. The proxy used for the tax base is corporate profits and so the forecast growth in corporate profits is the input into the model. The forecast is then adjusted for the revenue effects of pre-announced tax changes from previous Budget that are yet to have a full effect.

b. The IFS Current Receipts Approach

The current receipts approach uses information on the corporation receipts received so far in the current financial year and compares this figure with the corresponding sum received until the same point in the previous financial year. The forecast for the current year is based upon the assumption of a uniform rate of growth of receipts over the financial year.

c. The IFS Judgement

The 'IFS judgement forecasts' is the main estimate the IFS produces after taking the latest HM Treasury forecast, the modelled receipts forecast and the current receipts forecast into account.

Basu, Emmerson, and Frayne (2003) evaluate the performance of techniques used by the IFS to produce estimates of corporation tax receipts. They find that for current year forecasts a judgment based forecast performed better than relying solely on a simple model or information on the receipts available so far in the current financial year. For longer time horizons the judgment based forecast performed slightly less well than the model based forecast. They also find that in the short term inaccuracies in the modeling process are more important than errors in forecasting growth in corporate profits. However the latter is still an important component of error and one that grows substantially in relative importance as the forecast horizon increases.

4.8.3. Manchester Business School Tax Models

Manchester Business School tax models developed by Chittenden et al. (1999, 2000, 2001) measure the tax burden borne by small and medium sized businesses and the impact of taxation on growth of small businesses. These models are updated regularly to track changes of tax laws and the indices of tax burden constructed in such models indicate the burden of tax liabilities and the compliance costs on the growth of such firms. The main sources of MBS model data are (a) NatWest Bank's database of clients, (b) Department of Trade and Industry statistics, and (c) SBTR quarterly surveys tracking business owners' perceptions of the problems facing their businesses.

Poutziouris, Kauser and Chittenden (2003) report on the findings of an empirical investigation into the compliance costs incurred by UK firms in administering PAYE. Their study focuses on the impact of compliance costs on business. The paper discusses policy implications of research and outlines a set of recommendations and tax initiatives that will contribute to the amelioration of PAYE-NIC related red tape in order to encourage sustainable growth of the micro-small business sector.

Chittenden et al. (2003) provides a review of the literature on compliance costs of tax regulation on small firms in the U.S.A., the U.K., Australia and New Zealand. They concludes that, in the USA and the UK, compliance costs of taxation comprise the largest single element of the compliance burden faced by businesses and that this is probably the case in Australia and New Zealand. All countries studied, offer best practice guidelines for assessing the costs of proposed regulations but, despite the best efforts of government de-regulation and simplification initiatives which in some

cases began in the early 1980's, there is no evidence of significant progress made in reducing or even containing the burden of tax regulation affecting small businesses in the countries reviewed.

5. Conclusions

This paper has reviewed various approaches to corporate tax modeling, highlighting their potential role in tax policy. How different approaches could improve revenue estimation, forecasting, and policy analysis has been the focus of this paper. Problems involved in tax revenue forecasting and limitations of the methodologies used have also been discussed. Some of the problems are methodological, some theoretical, and some are of practical nature. It would be useful to find solutions to these problems in further research. From the review of different corporate tax modeling strategies, following conclusions may be drawn:

- The tax elasticity approach appears to be most widely used across countries and such institutions as IMF and IFS. Since tax collection depends by and large on the growth of the economy the tax elasticity approach provides reasonably accurate estimates of tax revenue given the accuracy of the forecast of GDP.
- Existing corporate tax microsimulation models are mainly focused on estimating revenue implications of policy shifts, while some models analyze distributional implications, and in few cases (the UK and France) they are used for revenue forecasting. Existing microsimulation models are non-behavioural and may be characterized as arithmetic or accounting models. Behavioural microsimulation models that compute welfare implications of changes to corporate tax policies for firms, especially in the smaller stream, are presently non-existent. They pose a great challenge for all types of taxes, including personal, consumption and environmental taxes. An MSM that estimates the distributional implications of tax changes without modeling behavioural adjustments could be misleading.
- Given the uncertainty associated with forecasting and complexities of company taxation, microsimulation modeling in isolation will not serve the purpose of forecasting revenues. It is advisable to use multiple forecasting methods to inform policy makers of the range of possible alternative outcomes. Tax elasticity approach and macroeconometric methods would appear to be more appropriate than the complex microsimulation models.
- The dynamic character of tax policy requires that microsimulation models should have built-in flexibility to accommodate frequent changes in tax laws. Since 1986 tax reforms have been much more important policy features in some countries than in others- tax reform has been high on the political agenda of Italy, The Netherlands and the USA and less so in the UK and Spain (Messere, 1998). The new International Accounting Standards that come into force in 2005 is

focused on serving the information needs of capital markets and is designed for consolidated accounts. Corporate tax modeling will grow more challenging and existing models will have to be re-developed.

- The development of MSMs for corporate taxes is constrained by data availability, uncertainty, changing economic conditions, changing definitions of tax base, the temporal relationship between economic factors and revenues, and even the impact of politics on revenue forecasting and estimation. Existing models in countries where tax and commercial accounts are tightly linked will have to be adapted in the wake of changes in accounting practices and the adoption of IASB rules. However, this will have the potential of harmonizing tax accounting practices in different countries and promise, in the long run, development of a multicountry , multi-purpose MSM .
- MSMs may be useful in carrying out simulations to study the effects of different tax rates, tax credits, deductions and allowances on the tax burden of firms for cross-country comparisons, and can determine the effects of different tax policy scenarios. The “behavior” of large firms presents difficulties in estimating their tax liabilities. Profits of large corporations are subject to strategic financial innovations.
- Since rational firms deploy strategies to reduce their tax liabilities in response to tax policy changes, the behavioural aspects of taxation can be best captured by econometric models. Econometric models, such as that developed by Ahmed (2004), tracing the corporate architectural basis of the vulnerability of various revenue forecasting methods can help understand the dynamics of corporate taxation. Non-neutralities generated by corporate taxation, such as the use of organizational form and structure and financial and accounting policies result in erosion of tax base and forecast errors.A micro analytical framework that explains changes in tax liabilities of firms relative to changes in earnings and profitability should be useful in predicting corporate taxes accurately.
- The academic and independent research institutions have traditionally relied on constructing effective tax rates models to compute levels of tax burden across jurisdictions. A greater role of academics that would help governments in improving their methods of revenues estimating and forecasting is desirable.

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Appendix 1. Methods of Removing the Effect of Discretionary Changes in Tax System

1. The *Allan Prest Forward and Backward Adjustment Methods* was used to remove the impact of discretionary changes for study of the sensitivity of the British Tax System to these changes. The methods are conceptually the same, except for the reference year for each method. The forward method takes the first year of the series as the reference year while the backward method adopts the last year of the series as the reference year. These methods eliminate the effects of discretionary changes in the affected years and re-estimate the yields for all the other years taking into account the tax policy changes. The "output" is a set of "cleaned" data series for tax collections. The formula for the forward method is as follows:

$$T_{i,j} = T_{i,j-1} + \{([(T_j - D_j) - T_{j-1}]/[T_{j-1}]/[T_{i,j-1}])\}$$

T_j is the actual tax collection in the j^{th} year;

$T_{i,j}$ is the actual tax collection in the j^{th} year adjusted to the structure of the base year (i^{th} year);

D_j is the imputed tax collections due to discretionary changes;

$T_{i,j-1}$ is the preceding year's revenue adjusted to the base year's structure; and

j is the years in the series from i,…,n where the first year (i) is the base, and n is the last year in the series.

Backward method involves adjusting data series by using the following formula:

$$T_{n,j} = T_j \times (T_{j+1} / T_{j,j+1}) \times .... \times (T_n / T_{n-1,n})$$

T_j is the actual tax collection in the j^{th} year;

$T_{n,j}$ is the actual collection in the j^{th} year adjusted to the structure of the base (n^{th} year);

j is the years in the series where j =1,…,n, and where 1 is the first year in the series, and n is the base year or the end-year of the series.

2. The *Constant Rate Structure Method* involves the use of the current year as the reference year to calculate the tax yield in the past years, based on the present tax rate structure or construct past year's time series data as the initial step for tax forecasting. This method, however, requires sufficiently disaggregated data series. For example, with respect to corporate taxes, the method requires the calculation of effective tax rates per income bracket for corporate taxpayers for the

reference year and subsequent application of these rates to taxable income across income brackets in all the other years. The output so generated is a set of “cleaned” data series for corporate tax collections.

3. Another method of adjustment is to include a dummy variable to represent important discretionary changes in the tax system for each year when a policy shift occurred. This method is relatively simple to use and may be utilized when other methods find it hard to “clean” the tax data series of the impact of changes to the tax system. The dummy variable technique is particularly useful when it is difficult to quantify the effects of any changes to the tax law, due to non-availability of the relevant data.

Appendix 2. Statutory Tax Rates, EMTRs and EATRs in the selected OECD countries in 1999

Ref.		CANADA	FRANCE	GERMANY	ITALY	JAPAN	NETHER LANDS	SPAIN	SWEDEN	UK	USA
A1	Statutory tax rates *	36%	40%	52%	41%	41%	35%	35%	28%	30%	39%
A5	EMTR ** , base case	25%	22%	30%	15%	32%	24%	29%	16%	20%	24%
A6	EMTR, financed by debt instead of equity	-37%	-50%	-77%	-51%	-37%	-33%	-27%	-28%	-27%	-45%
A7	EMTR, investment in industrial buildings instead of plant and machinery (assuming an economic depreciation rate of 3.61%)	36%	36%	50%	28%	40%	30%	25%	25%	29%	41%
A8	EMTR, country and time specific inflation instead of fixed inflation	23%	19%	27%	13%	28%	23%	28%	14%	19%	23%
A9	EATR*** , base case	31%	32%	43%	31%	37%	30%	32%	23%	26%	33%
A10	EATR, financed by debt instead of equity	10%	10%	16%	11%	16%	11%	13%	7%	9%	11%
A11	EATR, investment in industrial buildings instead of plant and machinery (assuming an economic depreciation rate of 3.61%)	36%	38%	51%	36%	40%	33%	31%	26%	29%	40%
A12	EATR, country and time specific inflation instead of fixed inflation	30%	31%	42%	30%	35%	30%	32%	22%	25%	32%
A13	EATR, 20% rent instead of 10%	33%	35%	46%	35%	38%	32%	33%	25%	27%	35%
A14	EATR, 30% rent instead of 10%	33%	37%	48%	37%	39%	33%	34%	26%	28%	36%
A15	EATR, 40% rent instead of 10%	34%	37%	49%	38%	39%	33%	34%	26%	28%	37%

Source: Devereux and Griffith (2002)

* Def: For countries using different tax rates, the manufacturing rate is chosen. Local taxes (or the average across regions) are included where they exist. Any supplementary taxes are included only if they apply generally.

** Def: See Devereux and Griffith (2002) for formula. Assumptions: investment in plant and machinery, financed by equity or retained earnings, taxation at shareholder level not included, real discount rate: 10%, inflation rate: 3.5%, dep. rate: 12.25%.

*** Def: See Devereux and Griffith (2002) for formula. Assumptions: investment in plant and machinery, financed by equity or retained earnings, taxation at shareholder level not included, rate of economic rent: 10% (i.e. financial return: 20%), real discount rate: 10%, inflation rate: 3.5%, depreciation rate: 12.25%.

Appendix 3. Percentage of certain tax receipts in total tax receipts and tax/GDP ratios of selected OECD countries in 1999

	CANADA	FRANCE	GERMANY	ITALY	JAPAN	NETHER-LANDS	SPAIN	SWEDEN	UK	USA	EU 15
A. Percentage of certain tax receipts in total taxation											
Personal income tax	38.1%	17.6%	25.1%	26.4%	18.5%	18.7%	19.5%	35.6%	28.8%	40.7%	25.6%
Corporate income tax	9.8%	6.4%	4.8%	7.7%	12.9%	10.1%	8.0%	6.0%	10.4%	8.3%	8.7%
Social security contributions	13.6%	36.1%	39.3%	28.5%	37.2%	40.0%	34.8%	25.3%	17.1%	23.9%	27.5%
Payroll taxes	2.1%	2.1%	-	0.0%	-	-	-	7.5%	-	-	1.2%
Property taxes	10.1%	7.0%	2.5%	4.6%	11.0%	5.1%	6.2%	3.7%	10.9%	10.7%	4.9%
Taxes on goods and services	24.7%	26.8%	28.0%	27.5%	20.1%	28.0%	30.0%	21.4%	32.3%	16.4%	30.4%
Consumption taxes	23.0%	25.9%	27.1%	25.0%	17.9%	25.6%	27.7%	20.8%	30.6%	14.4%	28.9%
Taxes on general consumption	14.3%	17.3%	18.4%	13.7%	9.6%	16.9%	17.5%	13.8%	18.8%	7.6%	18.1%
Taxes on specific goods and services	8.7%	8.6%	8.7%	11.2%	8.2%	8.7%	10.2%	7.0%	11.9%	6.8%	10.8%
B. Percentage of certain tax receipts to GDP											
Personal income tax	14.6%	8.1%	9.4%	11.4%	4.8%	6.4%	6.9%	18.6%	10.5%	11.8%	10.9%
Corporate income tax	3.7%	2.9%	1.8%	3.3%	3.4%	4.2%	2.8%	3.2%	3.8%	2.4%	3.5%
Social security contributions	5.2%	16.6%	14.8%	12.3%	9.7%	16.8%	12.2%	13.2%	6.2%	6.9%	11.4%
Payroll taxes	0.8%	0.9%	-	0.0%	-	-	-	3.9%	-	-	0.6%
Property taxes	3.9%	3.2%	0.9%	2.0%	2.9%	2.2%	2.2%	1.9%	3.9%	3.1%	2.0%
Taxes on goods and services	9.4%	12.3%	10.6%	11.9%	5.3%	11.8%	10.5%	11.2%	11.7%	4.7%	12.4%
Consumption taxes	8.8%	11.9%	10.2%	10.8%	4.7%	10.8%	9.7%	10.9%	11.1%	4.2%	11.8%
Taxes on general consumption	5.5%	8.0%	6.9%	5.9%	2.5%	7.1%	6.1%	7.2%	6.8%	2.2%	7.4%
Taxes on specific goods and services	3.3%	3.9%	3.3%	4.9%	2.1%	3.7%	3.6%	3.7%	4.3%	2.0%	4.4%
C. Total tax revenue/GDP	38.2%	45.8%	37.7%	43.3%	26.2%	42.1%	35.1%	52.2%	36.3%	28.9%	41.6%

Source: OECD statistics, 1965-2000 (OECD, 2001)

Appendix 4. UK Corporation Tax: Errors in year- ahead budget forecasts (millions of £)

Financial Year	CT revenue (I.R. forecasts)	Outturn	Forecast error	Percent-age error	Absolute percent-age error	Growth rate of CT revenue (IR forecasts)	Actual growth rate of CT revenue	Error in revenue growth forecast	Absolute errors in CT revenues
1969-70	1805	1696	-109	-6.427	6.427				
1970-71	1900	1582	-318	-20.101	20.101	5.263	-6.722	-11.985	11.985
1971-72	1620	1552	-68	-4.381	4.381	-14.737	-1.896	12.841	12.841
1972-73	1395	1533	138	9.002	9.002	-13.889	-1.224	12.665	12.665
1973-74	2045	2264	219	9.673	9.673	46.595	47.684	1.089	1.089
1974-75	3265	2859	-406	-14.201	14.201	59.658	26.281	-33.377	33.377
1975-76	2125	1996	-129	-6.463	6.463	-34.916	-30.185	4.730	4.730
1976-77	2650	2655	5	0.188	0.188	24.706	33.016	8.310	8.310
1977-78	2560	3344	784	23.445	23.445	-3.396	25.951	29.347	29.347
1978-79	4170	3940	-230	-5.838	5.838	62.891	17.823	-45.068	45.068
1979-80	4850	4646	-204	-4.391	4.391	16.307	17.919	1.612	1.612
1980-81	4860	4645	-215	-4.629	4.629	0.206	-0.022	-0.228	0.228
1981-82	4600	4930	330	6.694	6.694	-5.350	6.136	11.485	11.485
1982-83	4850	5679	829	14.598	14.598	5.435	15.193	9.758	9.758
1983-84	6200	6184	-16	-0.259	0.259	27.835	8.892	-18.943	18.943
1984-85	8400	8341	-59	-0.707	0.707	35.484	34.880	-0.604	0.604
1985-86	10100	10708	608	5.678	5.678	20.238	28.378	8.140	8.140
1986-87	11700	13495	1795	13.301	13.301	15.842	26.027	10.186	10.186
1987-88	15000	15734	734	4.665	4.665	28.205	16.591	-11.614	11.614
1988-89	19800	18537	-1263	-6.813	6.813	32.000	17.815	-14.185	14.185
1989-90	22400	21495	-905	-4.210	4.210	13.131	15.957	2.826	2.826
1990-91	20700	21495	795	3.699	3.699	-7.589	0.000	7.589	7.589
1991-92	19500	18263	-1237	-6.773	6.773	-5.797	-15.036	-9.239	9.239
1992-93	16800	15783	-1017	-6.444	6.444	-13.846	-13.579	0.267	0.267
1993-94	14600	14887	287	1.928	1.928	-13.095	-5.677	7.418	7.418
1994-95	17600	19390	1790	9.232	9.232	20.548	30.248	9.700	9.700
1995-96	26400	23570	-2830	-12.007	12.007	50.000	21.558	-28.442	28.442
1996-97	26600	27644	1044	3.777	3.777	0.758	17.285	16.527	16.527
1997-98	27200	30437	3237	10.635	10.635	2.256	10.103	7.848	7.848
1998-99	30000	30032	32	0.107	0.107	10.294	-1.331	-11.625	11.625
1999-2000	29900	34160	4260	12.471	12.471	-0.333	13.745	14.079	14.079
Mean Absolute Percentage Error – All years					**7.8**				**12.5**

Source: Table 1 from Orme and Mellor (1999) and author's own computations.