A Dynamic Micro-Econometric Simulation Model For Firms

Hovick Shahnazarian
Sveriges Riksbank, S-103 37 Stockholm/Sweden; email: hovick.shahnazarian@riksbank.se

ABSTRACT: The firm-based simulation model presented in this paper aims to help practical policy making, by providing a tool for analyzing the behavioural effects induced by changes in the tax code and for forecasting corporate tax revenues. To achieve this end, one of the key innovations adopted in the paper is the use of robust estimation techniques designed to ameliorate the undue impact of influential observations. The simulation results indicate that a statutory corporate tax rate reduction does not reduce the effective corporate tax rate to an equal extent because firms adjust their behaviour to new tax rules. The simulation also reveals that even though the macroeconomic environment is important for the taxes paid by the firm, it is not obvious that the effective tax rate for these firms may change because of the changed macro conditions.

INTRODUCTION

One task of the Ministries of Finance in many countries is to produce revenue estimates with regard to corporation tax. Such estimates have to a large extent, when it comes to corporations, been restricted to theoretical evaluation of the behavioural effects induced by changes in the tax code. The lack of micro data has typically made it difficult to conduct a valid empirical investigation. Estimation of behavioural factors, therefore, plays an important role in assessing the financial implications of proposals for changes in the tax code. It is desirable that more qualified assessments are enabled. A change in this direction will imply a better revenue estimate with regard to corporation tax. Another main task of the typical Ministry of Finance is revenue forecasting. Corporation tax is an area where forecasts have been unreliable. The forecasting failure blurs the assumed connection between the development of the economy and income tax. The aggregate material used has not enabled the necessary provisions in the forecasts for corporations' allocation of profits over time. It may be assumed that such provisions are utilized to a varying degree depending on the individual firm’s economic situation (see, for example, Forsling, 1998). To capture the individual firm’s economic behaviour, it is necessary to use micro data. The estimation of behavioural factors is thus an important part of improving the methods for forecasting corporation tax revenue. Ministries of Finance are to a large extent dependent upon the development of a micro simulation model for this purpose.

As Shaym-Sunder and Myers (1999) rightly mentioned, corporate financing decisions reflect many motives, forces and constraints, and they called for more elaborate theoretical and empirical models that can deal with these issues. Shahnazarian (2005) shows, using a theoretical model, that combining an upper constraint on dividends, a lower constraint on dividends due to shareholder preferences, an interest rate that increases with the debt ratio, a “tax incentive” for firms to substitute debt for retained earnings, and retained earnings for new share issues (which is the case in most OECD countries) leads to a pecking-order financial structure: a typical firm will start to finance a new investment by issuing new shares in combination with debt, then grow by financing its investments with retained earnings and borrowing, and eventually stop growing and distribute all profits. The study also shows that repurchases of shares will speed up this growth path and that economic depreciation may make the firm want to stop the decline in its capital stock earlier. Findings in these studies indicate that estimation of behavioural factors is an important part of improving the methods for evaluating and forecasting the business performance. However, the evaluations of tax revenue effects induced by changes in the tax code within Ministries of Finance in many countries often exclude these behavioural effects.

The simulation model introduced in this paper is aimed to help practical policy making, by providing a tool for analyzing the behavioural effects induced by changes in the tax code and for forecasting tax revenues. Furthermore, the model is also aimed at improving the business practice for analyzing business performance.

The idea behind the dynamic micro econometric simulation model presented can be summarized in the following way. In *the simulation module,* we define the stock and flow variables of firms and specify the evolution of the stock variables over time in terms of difference equations, using the information in the firm’s three basic financial statements: the balance sheet, the income statement, and the statement of changes in financial conditions. This so-called system dynamic approach has more frequently been used in natural and technical sciences. It has also been used in the business field. An original reference is Forrester’s (1961) industrial dynamic system. The idea behind system dynamic modelling of corporate firms has also been called financial statement modelling. A very simple example of such modelling is given in Benninga (1989). Kumar and Vrat (1989) and Clarke and Tobias (1995) provide a review of system dynamic modelling with regard to a corporation. This way of modelling has, to our knowledge, not been used extensively in the field of economics. This could be due to the fact that the implementation of the idea into a functioning model is not an easy task. There is of course one exception. Tongeren (1995) uses this approach in micro simulation modelling of Dutch firms. This is achieved by focusing on the relationship between the firms and the economy as a whole. However, Tongeren's simulation model explores micro-macroeconomic relationships. This is not the case in the model presented in this paper. The behaviour of firms is instead decided by using econometric tools. In our model, we use macro economic variables as explanatory variables in our estimations of the behaviour of the firms. As a result, we do not see the repercussions from the behaviour of the firms on the macroeconomic variables.

There is, however, an extensive literature in the field of dynamic optimization that indirectly uses a system dynamic approach. In the field of corporate taxation and finance there are many examples of this indirect use of a system approach. Sinn (1987), Kanniainen and Södersten (1995) and Shahnazarian (1996, 2005) are examples of such studies. Shahnazarian (1997) uses such an approach in his theoretical and numerical evaluation of the Swedish tax reform act of 1994. In this paper the emphasis is on the way in which the complex structure of a firm's dynamics is specified, though the micro foundations of such dynamics are analogous to the existing academic literature on investment behaviour of firms under taxation. More generally, the models used in these papers are often a simplified version of basic system dynamic models, since in this field the authors are usually interested in examining the impact of taxation on corporate financial policy and the cost of capital.

The focus in this paper, on the other hand, is on the use of econometric tools rather than theoretical ones. In *the statistical module (behaviour modelling),* the behaviour of the firms is modelled and estimated in two steps. We use a dynamic optimization model to derive the relationships between different decision variables. These relationships are derived by subjecting the optimization to investigations of a comparative static sort. The relationships between different decisions variables are then estimated using robust estimation methods depending on the nature of the variable. The major gain in building and employing micro simulation models is that such models utilize information derived from existing microdata. The use of microdata enables the economic behaviour of individual firms to be captured. However, analysis of microdata often reveals that influential observations are present. This is especially the case for micro data on firms. The data in hand include both large corporations and small enterprises. Therefore, it is not advisable to exclude the information on these firms just because they happen to be big or small corporations. The estimation method that is used to estimate firms' behaviour regarding different decision variables must be able to deal with this fact. This is especially important for models that are aimed to be used for practical purposes. When influential observations are present and have an unacceptable effect on derived least squares estimate, the best remedy is to apply a robust estimator rather than deleting these observations.

In our estimations, we use pooled data derived from accounting and taxation information from 1997-1999 resulting in a three-year panel. In this paper, we use the data for stock companies from the database named FRIDA (which stands for Firm Register and Individual Databases). FRIDA was developed in 1997 by the Swedish Ministry of Finance and Statistics Sweden. FRIDA is composed of several databases for firms with different organization forms. This includes databases for joint stock companies (which also includes close companies), cooperatives, partnerships, associations, foundations, and proprietorship (or sole trader).

The purpose of this paper is to provide an overview of the model we have developed without going too far into technical details, highlighting one or two key areas of innovation, and presenting some illustrative results/applications. The aim is therefore to show how the simulation model can be used to simulate firms' three basic financial statements and to evaluate the impact of changes in tax laws. This is the reason why we refrain from presenting the dynamic optimization problem, the estimation methods and the results and refer the reader to Shahnazarian (2004) for the details. However we introduce the framework of the simulation model within a simple model with two assets in Appendix 2. We strongly recommend the reader to read this appendix before continuing with subsequent sections. In Section 1, we give a brief overview of the corporate tax system in the period covered in the analysis. In Section 2, we describe the structure of the different modules in the simulation model. However, we provide a formal description of the simulation model in Appendix 3. To make this paper easier to read, we also include an index with an explanation of the symbols used in Appendix 1. In Section 3, we describe the data used in both the statistical and the simulation modules. In Section 4, we present the simulation results using the current tax rules. Section 5 provides an evaluation of the simulation model by examining the forecasting accuracy of the simulation results. In Section 6, we analyze the simulation results for a hypothetical corporate tax rate reduction of three present. In Section 7, we present the simulation results for a hypothetical change in the macro economic development. The discussion that follows sums up and concludes the paper.

1. THE TAXATION OF INCORPORATED BUSINESSES IN SWEDEN

Prior to 1991, Swedish company taxation was characterized by high statutory tax rates combined with liberal reserve facilities. The government used the company taxation, as part of the general economic policy, to direct firms' behaviour. The gap between the statutory tax rate and the effective tax burden on a company's profits became very large because of the generous reserve facilities. The belief that the tax burden was different for different companies was one of the reasons why a reform was believed to be necessary. The direction of the 1991 reform and reforms thereafter were to broaden the tax bases, cut the tax rates and simplify the tax rules. The corporate income tax rate was lowered to 28 per cent, while the tax base was broadened. The reason for choosing this particular tax rate was to achieve uniformity between the taxation of the corporation's income and the taxation of capital income.

In Sweden the tax balance sheet of the firm must coincide with the commercial balance sheet (so-called uniform reporting). The main connection between the accounting profit and the taxable profit is that the calculation of taxable income must be undertaken according to good accounting practice, which is based on accounting laws (except where the tax rules specifically differ from the accounting rules). Most of the balance-sheet allocations prior to 1991 were removed. An exception was the new reserve option periodical reserve fund. Enterprises are allowed to allocate, tax-free, a maximum of 25 per cent of their annual profits to a periodical reserve fund. A firm which has made an allocation to a periodic reserve fund can make a deduction from its taxable income. The deduction is limited to a maximum of 25 per cent of the current year's profit. The reserve must be returned to taxable status no later than the fifth year of allocation. The reason for introducing this option was to bring about an effective average tax rate lower than 28 per cent. Among the remaining balance-sheet allocations it is important to mention accelerated depreciation of machinery and equipment. The depreciation rate, for tax purposes, for machinery and equipment is 30 per cent if the declining-balance method is used, while it is only 20 per cent if the straight-line method is used. For buildings the straight-line method applies and, depending on type of asset, the depreciation rate is 1.5-5 per cent.

2. THE DIFFERENT MODULES IN THE SIMULATION MODEL

The basic idea behind the simulation model is to combine the dynamic behaviour of the corporate system with a statistical model that captures the development and the interrelationships between the firms' different decision variables. The dynamic behaviour of the corporate system is captured in the simulation module by several difference equations that identify how different variables in the firms' balance sheets change over time using the information in the firms' three basic financial statements: the balance sheet, the income statement, and the statement of changes in financial conditions. The firms' decisions regarding the flow variables are modelled in a statistical module. We use the dynamic optimization problem to derive the relationships between these variables. These relationships are then estimated using different robust estimation methods. The estimated functions from the statistical module are then inserted into the difference equation system. The difference equation system together with the estimated relationships is finally solved numerically in a recursive manner to be able to simulate new financial statements.

The simulation module maintains three interrelated sets of accounts: a balance sheet account, a profit-loss account, and the statement of changes in financial conditions. Altogether, these three accounts provide a financial description of the firms at a given moment in time. The first is the income statement. A second document is a statement of sources and uses of funds (the cash flow statement). These two statements are flow statements, showing various financial flows occurring during the course of one year. The third statement is the balance sheet, which is a stock concept. It shows the value of various company assets and liabilities outstanding at the end of each financial year. Appendix 3 gives a technical description of the simulation model.

The structure of the statistical module can be summarized as follows. The approach we use to identify the recursion follows the traditional approach in economic theory. We use the solution (total differentiation of the first order condition) of a dynamic optimization model to find out the economic relationships between the changes in different balance sheet items (see Appendix 1). However, the derived relationships only include firm-specific variables such as income-statement variables, balance-sheet variables, and variables that capture the legal and accounting constraints. But, we know that firms operations are highly dependent on the firms' expectations regarding the business cycle and the development of the market. Therefore we also include other regressors in our estimations of corporate decision variables to control for these factors. The market conditions are captured by the following three variables: a variable that identifies the market in which firms may have their business, a variable that captures the market share of these firms, and a variable that captures the location of the firms. Moreover, we use two different variables as proxies for the maturity of firms. The firms' expectations regarding the business cycle are captured by including one of the two following macroeconomic variables: the change in GDP and the real interest rate on a government bond with a maturity of 10 years. To be able to include the macro economic variables and variables that capture the development of the market in our estimations, it proved necessary to pool data from 1997-1999.

The recursive method used in the statistical module is as follows. First, we estimate the economic depreciation of machinery and equipment, the sale of machinery and equipment, and the investments in these assets. Second, we estimate the economic depreciation of buildings, the net investments in these assets, the net change in other fixed assets and the net change in current assets. Third, having established the net changes in different assets, we go on to investigate the funds available to undertake such investments. This is done in the following order. We estimate the net change in long-term liabilities, the net change in current liabilities, the net change in share capital, and the net change in restricted reserves. Finally, we estimate operating income before depreciation, financial income, financial expenditure, tax allowances for depreciation, reversals from periodical reserves, allocations to periodical reserves, changes in other untaxed reserves, net group contributions, other allocations, tax liabilities, other tax adjustments, the tax depreciation of buildings, and reductions in taxes.

We use robust estimation methods to estimate these variables. The use of robust estimation methods is one of the main innovations we wish to emphasize. The reason for using robust estimation methods is the fact that microdata on firms often reveal that influential observations are present. The estimation method that is used to estimate firms' behaviour regarding different decision variables must include this fact. This is especially important for models that are aimed to be used for practical purposes. When influential observations are present and have an unacceptable effect on the least squares method, the best remedy is to apply a robust estimator rather than deleting these observations. OLS regression models are quite sensitive to influential observations, which may be a consequence of heavy-tailed distributions. Hampel (1985) argues that robust estimators are superior in practice to classical non-robust estimators and shows that they are even better than classical methods combined with rejection. Huber (1964) proposed as a robust estimator (the maximum-likelihood estimator) of the location parameter associated with a density function that is normal in the middle part, but like a double exponential in the tails. In our analysis, we apply a bounded-influence technique proposed by Schweppe (Handschin *et al*., 1975). This technique reduces the impact of influential observations in both *y*-space as well as *x*-space. However, different variables have different characteristics. Some of the variables take non-negative values while other variables may be either negative, zero or positive. Depending on the nature of the dependent variable we combine four different robust estimation methods: Huber-Schweppe robust estimation method, a logistic model with the cumulative logistic distribution function, a logistic model with the complementary log-log distribution function, and a Tobit model with a logistic distribution function.

The estimation results indicate that firms' utilization of different tax allowances as well as different accounting constraints have important impact on firms' investment and financial behaviour. These results indicate that estimation of behavioural factors has an important role in assessing the financial implications of proposals for change in the tax code and accounting rules. This was originally observed in Forsling's (1998) study of the utilization of different tax allowances.

3. DESCRIPTION OF DATA

In 1997, the Ministry of Finance and Statistics Sweden (SCB) started developing FRIDA, which stands for Firm Register and Individual DAtabases. FRIDA is composed of several databases for firms with different organization forms. This includes databases for joint stock companies (which also includes closed companies), cooperatives, partnerships (which also includes limited partnerships), associations, foundations, and proprietorships (or sole traders). Apart from partnerships and proprietorships, these enterprises are subject to corporation tax. In this paper, we will present the database for stock companies which is used in the simulation model. The information gathered for these firms includes accounts, balance sheets, wages and other compensation, depreciation, untaxed reserves and dividends, etc. Moreover, it also includes information on tax adjustments.

The data at our disposal come mainly from the National Tax Board (RSV) and include the Standardized Accounting Statements (SRU) and the Tax Assessment (TA). The SRU contains information on accounts and tax adjustments and the TA contains information on the income tax paid by the firms. The TA files contain pure information on assessed income, preliminary tax, final tax, and some administrative data. However, the TA data do not contain any background information on how the final tax is calculated (accounts, balance sheet and tax adjustments). Both the TA and the SRU files are designed to cover the total population of firms. We chose to have 1997 as a base year for our database as the quality of the data were better from this year. The sampling frame for the database is based on register data in TA and SRU. For the joint stock companies, we select those firms that provide the income tax return form S2. This register is then supplemented with further information about the organization form from SCB's Central Register of Enterprises and Establishments. The sampling frame is then adjusted by removing the income tax return form for those firms that have provided two identical forms. The stratification is made according to company size and whether they are a close company. For this purpose, we select those firms that complete their income tax return forms with another form (K10) that is used by shareholders in close companies. The firms' size is based on total assets (*K*), net income (*NI*), and net business income (*NBI*). The sampling frame is stratified in three different strata.

The first stratum contains each and every financial firm that has the industry classification 65, 66, and 67 according to the Swedish Standard Industrial Classification 1992 (SNI92). This classification standard is based on the classification used by Eurostat, NACE Rev. Further, this stratum also contains all those firms that fulfil the following conditions: Total assets (*K*) are higher than 100 MSEK, net income (NI) is higher than 5 MSEK (which is the case for both positive and negative net income), and net business income (NBI) is higher than 5 MSEK (which is the case for both positive and negative net business income). Remaining firms are classified between two different strata depending on whether there is a K10 form assigned to the company. In the first stratum, all units are selected. In the other two strata, the numbers of units drawn are a function of *NBI*. For this purpose a simple random sampling (SRS) was used. The idea behind the database is to gain a fairly good approximation of the total net business income and final tax payments.

In our estimations, we use the information from 1997-1999. For these years, we have two time series observations on different variables for each and every firm. For 1997-1999, we have 27 370, 27 440, and 35 457 cross-sectional observations respectively (see Table 1). This gives us a total of 90 227 pooled observations. The sample sizes were originally bigger (column 3 in Table 1). However, these samples were checked for inconsistencies and errors. Observations that did not fulfil the constructed criteria were excluded from the original samples (column 4 in Table 1). Moreover, for estimation purposes, we also need two time series observations on different variables. Therefore, we exclude those firms that did not provide information the previous year (column 5 in Table 1). We obtain a smaller sample size by doing so. The samples were then re-weighted.

Check for Inconsistencies and Errors: As we mentioned earlier, the original sample for each and every year is checked for inconsistencies and errors. We regard those firms that do not pass through the error and correction program as outliers and exclude them from our sample. The sample is then re-weighted. The data program for auditing and correction contains 30-60 modules. The structure of auditing and correction is as follows. First, the program starts by controlling whether the observations lack balance sheet data, income statement data, or tax adjustments. Although the firms are under a statutory obligation to supply the data, non-response does occur. We do not use imputation methods to handle the non-response. Instead, we regard these firms as outliers and exclude them from our sample. Second, the balance sheet, income statement, and tax adjustments undergo a detailed examination by the program developed. Routines for testing and improving the data quality have been developed to make the SRU and TA files reliable. Usually the errors originate from the following: clerical or typing errors, summation errors, or changes in the assessment of tax that is not registered in SRU files. In each module, we check whether firms have made a correct addition of the information requested by the tax authorities. If the deviation is lower than 100 SEK, we accept the addition made by firms. If not, we correct the information. All corrections are made automatically to avoid costly revision.

Table 1 A description of the sample for 1997, 1998, and 1999

Year	Sampling frame	Initial sample size	Sample size after data correction*	Sample size with observations for t-2
1997	256171	33887	29363	27370
1998	250058	35107	31400	27400
1999	243131	36566	36238	35457
Total	749360	105560	97001	90227

* After the sampling, we check for inconsistencies and errors. If the firm does not fulfil the constructed criteria, it is regarded as an outlier and excluded from the sample. The sample is then re-weighted.

Table 2 Simulation results using current rules, MSEK

	2000	2001	2002	2003	2004
Assets					
CA	2157244	2626464	2991256	3285191	3576919
MA	655068	737831	812583	885209	956082
BU	526931	1034464	1255277	1323282	1387825
OFA	3697248	3325529	3441718	3646573	3658999
Total	7033491	7724288	8500834	9140255	9579825
Liabilities					
CL	1481818	2698440	3449106	3842111	4231449
LL	2607697	2729837	2833233	3917740	3000933
ASD	228662	235496	240215	244820	248510
OUR	10524	10760	10939	10987	11138
SC	338181	361574	384821	406226	429033
RR	614792	869063	1124540	1377906	1631679
URE	1558227	592813	201132	50403	-293084
PFt	193585	226301	256844	290058	320165
Total	7033486	7724284	8500830	9140251	9579823
Income statement					
OIBD	280257	405649	416275	409780	417883
EDEPma	104559	128439	132789	131337	132571
EDEPbu	9084	20342	19701	18767	18602
OIAD	166613	256867	263784	259675	266709
EBA	184907	250162	269569	274013	281933
EBT	144302	220969	245122	247502	263326
NI	90460	180345	200673	195417	211841
FTAX	47735	42842	42689	42980	43766
Olt	410084	488375	546493	606410	652192
NBI	96566	178126	202432	204522	219559
Selected flow variables and financial ratios					
CR	1.456	0.973	0.867	0.855	0.845
DR	0.599	0.720	0.756	0.756	0.772
DER	1.492	2.570	3.094	3.103	3.384
ECR	0.401	0.280	0.244	0.244	0.228
FQ	-0.292	-0.380	-0.404	-0.397	-0.399
ICR	1.493	.634	1.682	1.684	1.693
DI	0.089	0.071	0.062	0.058	0.055
ROE	0.097	0.097	0.108	0.100	0.105
ROI	0.080	0.083	0.078	0.074	0.072
EFFTAX	0.258	0.171	0.158	0.157	0.155
RROI	0.072	0.062	0.059	0.061	0.062
ER	0.007	0.022	0.019	0.013	0.010

NOTES: See Appendix 1 for key to variable names

4. THE SIMULATION RESULTS USING CURRENT TAX RULES

Table 2 summarizes the simulation results from 2000-2004 that were obtained by solving the difference equation systems numerically. Let us now penetrate some of the most important results. Firms' operating income before depreciation (*OIBD*) increases between 2000 and 2002. In 2003, this increase continues. This variable shows a large increase between 2000 and 2001. The reason for this is that *OIBD* is estimated to increase with the level of current assets (*CA*), the level of machinery and equipment (*MA*), the net investment in machinery and equipment (I^{MA}), economic depreciation of machinery and equipment ($EDEP^{MA}$) at a decreasing rate, the level of buildings (*BU*), the net investment in buildings (I^{BU}), economic depreciation of buildings ($EDEP^{BU}$) at an increasing rate, the net change in current assets (*dCA*) at a decreasing rate, the change in the utilization of tax rules regarding allocations to periodical reserves (*ddmpa*) at a decreasing rate, and the change in cash flow (*dcashfl*) at an increasing rate. These variables are also estimated and simulated to increase during the simulation period mainly because of the macroeconomic development. Despite the fact that *OIBD* increases in 2001, final taxes paid (*FTAX*) by the firms decreases. This has to do with the development of tax adjustments made by the firm. This is especially the case for losses from previous years (*OL*) which increase during the entire simulation period. The development of *OIBD* is important for the development of earnings before allocations (*EBA*) which increases as *OIBD* increases. This together with the development of *FTAX* imply that the effective tax rate (*EFFTAX*) decreases in 2001 and continues to decrease during the simulation period.

We use financial ratio analysis to summarize the simulation results. Four major categories of financial

Table 3 Forecasting accuracy for year 2000

	Population weighted, Year 2000, MSEK				
	Sample		Predicted		Matched pairs t-test***
Variable name	Mean (A)	Standard deviation (B)	Mean (C)	Standard deviation (D)	(t)
EDEPMA	0.447	15.150	0.458	10.439	-0.280
SMA	2.206	1097.177	0.092	50.235	0.920
IMA	2.945	1096.308	0.834	10.150	0.920
EDEPBU	0.069	1.821	0.039	1.251	6.233
IBU	0.161	29.319	0.029	7.808	2.083
dofa	-2.600	2373.374	2.671	87.504	-1.061
dca	0.417	578.716	0.546	26.748	-0.106
dll	-3.446	2104.863	0.283	23.357	-0.847
dcl	0.114	432.930	-0.502	30.057	0.678
dsc	-0.035	48.833	0.090	5.457	-1.217
drr	0.456	113.333	1.157	12.723	-2.937
OIBD	1.398	81.459	1.227	17.734	0.980
FI	1.880	153.795	.722	103.292	0.407
FE	1.150	55.330	1.641	112.435	-1.875
TDEPMA	0.538	18.430	0.522	6.936	0.408
ZPF	0.095	8.401	-0.001	0.444	5.485
Dour	-0.015	2.216	0.087	8.181	-5.775
GC	0.033	45.076	0.032	35.622	0.008
OA	0.068	42.842	0.072	35.470	-0.041
TL	0.233	7.468	0.236	37.691	-0.041
OTA	-0.678	147.590	-0.221	19.762	-1.465
TDEPBU	0.086	3.688	0.080	1.308	0.668
PALLO	0.224	32.200	0.274	2.580	-0.733
ROT	0.002	4.355	0.091	7.970	-1.007
TAX	0.212	6.360	0.230	2.168	-1.270
FTAX	0.210	6.000	0.209	8.168	0.060

NOTES:
See Appendix 1 for key to variable names
* Calculated by dividing weighted sum of variable in the sample by population size
** Calculated using the population rather than sample size
*** The match pair t-test of equal predicted and sample means is performed as follows:
t = (A-B)/sqrt(C**2/N)+D**2/N) where N = 228344 is the population size.

ratios have been developed, each designed to address an important aspect of the firms' financial condition: liquidity ratios, leverage ratios, profitability ratios, and market value ratios (see Appendix 3). Corporate debt in relation to total assets (*DR*) is simulated to grow rapidly during the simulation period. This is believed to be due to the strong credit growth in the corporate sector. This indicates that the extent to which firms use borrowed funds to finance their total assets increases. The debt/equity ratio (*DER*) also increases during the entire simulation period, which indicates that the capital contributed by creditors increases compared to the capital contributed by owners. However, the interest coverage ratio (*ICR*) increases during the entire simulation period indicating that firms' ability to meet their interest payments out of their operating earnings improve over coming years. But, companies' current ratio is simulated to gradually deteriorate, which means that companies have diminishing liquid assets to use for their short-term payment commitments. The worsened current ratio does not pose any problem that companies will be unable to meet their payment commitments as long as companies' earnings capacity and profitability remain sound. As is evident from the simulation results, companies increase their profitability (*ROI*) during 2001, after which it decreases from 2002-2004. Return on investment focuses on the earnings power of ongoing operations. This return must be compared to the required return on investment (*RROI*) to be able to draw conclusions about the value of TOBINS q. Excess return increases in 2001 before it decreases three years in a row. This indicates that return on investment is constantly reduced relative to the required return on investment. This in turn implies that the value of TOBINS q becomes lower and lower, indicating that the value of the firms compared to the replacement costs of the firms' assets decreases. Hence, the market's prediction of the value of the returns generated per 1 SEK of additional investment becomes lower.

5. THE FORECASTING ACCURACY

In Table 3, we present a matched pairs test of the hypothesis that the weighted mean of different variables in the sample for the year 2000 coincides with the predicted mean for the same variables. The table shows that *t*-values for these variables lie

Table 4 The actual and predicted distribution

	The actual distribution	*The predicted distribution*
Mean	202425.364	220221.588
Standard Deviation	16057919.6	22966100
Skewness	51.3292645	-155.64327
Curtosis	3517.11279	25481.8173
100% Max	1380103929	390261309
90%	176232	437049
75% Q3	43411	271427
50% Median	4076	182961
25% Q1	0	0
10%	0	0
0% Min	0	-3702063348

within the acceptance region with the exception of $EDEP_t^{BU}$, drr_t and $dour_t$. The most crucial variable in the simulation model is the sum of the corporate taxes that firms pay to the government. The sum of taxes paid by all firms, in 2000, equals 48 026 MSEK. Our simulated tax payment for 2000 is 47 735 MSEK. The difference is 291 MSEK, which indicate an underestimation of the tax payments by 0.6 per cent. Table 3 reinforces the forecasting accuracy of the firms' tax payments when we use both the information about the mean and the standard deviation. The matched pairs test indicates that we cannot reject the hypothesis that the weighted mean of tax payments in the sample for the year 2000 coincides with the predicted mean for the same variable.

Another way of evaluating the forecasting accuracy is to compare the distribution of predicted tax payments with the actual distribution. This is done by looking at the mean, the standard deviation, the skewness, the kurtosis, and the median of the distributions (Table 4). As can be seen, the predicted distribution is more skewed on the left side and more tapering compared to the actual distribution. It is also evident that the median of the predicted distribution is much higher than the median for the actual distributions. Moreover, there are negative simulated final taxes (*FTAX*) which may be due to the following. To be able to derive firms' final tax payments (*FTAX*), we adjust firms' tax payments (*TAX*) for their reduction of taxes (*ROT*) so that *FTAX* = *TAX* – *ROT*. We impose a non-negative constraint on *TAX* as follows: $TAX_t = \tau \max[0,(NI_t + TA_t)]$ where τ is the corporate tax rate, TA_t (which either can be positive, negative or equal to zero) is the firms' tax adjustments. However, we do not impose non-negative constraint on *FTAX* because firms can obtain tax refunds due to a reduction in taxes (*ROT*). But, we found out that *ROT* was very difficult to estimate and simulate because of the appearance of data errors and outliers. We have obviously simulated a very high reduction of taxes which in turn generates a negative value for *FTAX*. One way to overcome this problem is to also impose non-negative constraint on final taxes. Finally, while 10 percent of companies are paying more than around 180 000 kronor, we simulate that 50 percent of the companies will pay more than this amount in final taxes. This evaluation exercise shows that only general tax rule changes should be applied in this model. This has to do with the fact that the method used to estimate different variables is a non-parametric estimation method that gives different weight to different observations. This means that small, medium and large companies are weighted up or down in relation to an average "medium" enterprise. This is why we cannot replicate the distribution of FTAX. One way around this problem is to estimate the behaviour of small, medium and large companies instead of estimating the behaviour of all companies. However, this is very time-consuming. After all, it should be borne in mind that a simulation model must be updated each year as new data bases become available.

At present, the selection of the sample is a function of corporate final tax payments (*FTAX*). In other words, the sample is drawn so that the ratio of the weighted sum of the final taxes in the sample and the sum of the final taxes in the total population will come close to unity. For 1999 and 2000 this ratio equals 1.03 and 1.04 respectively. However, for other variables, we are aware that it is very uncertain whether this ratio will come close to unity. Even more important is the fact that the ratio may change significantly between sampling years. For example, precision ratio of investment in machinery and equipment (I^{MA}) in 1999 is close to 1, indicating a good precision. On the other hand, the ratio is more than three times higher in 2000. A comparison of the precision ratio for I^{MA} in 1999 and 2000 indicates that the selections of the samples for 1999 and 2000 are not comparable. Another way to interpret these results is that the sample (in the case of variable I^{MA}) is randomly drawn in 1999 while the selection for 2000 is not a random sample. This makes it almost impossible to evaluate the model in terms of other variables (i.e. the 24 estimated decision variables in the simulation) than final taxes (*FTAX*).

Table 5 Simulation results for a proposed tax reduction by 3 per cent, MSEK

	2000	2001	2002	2003	2004
Final taxes paid					
FTAX	47735	42842	37651	37888	38581
Financial ratio analysis					
CR	1.456	0.973	0.867	0.855	0.845
DR	0.599	0.720	0.754	0.754	0.770
DER	1.492	20570	3.064	3.073	3.350
ECR	0.401	0.280	0.246	0.246	0.230
FQ	-0.292	-0.380	-0.402	-0.395	-0.397
ICR	1.493	1.634	1.682	1.684	1.693
DI	0.089	0.071	0.062	0.058	0.055
ROE	0.097	0.097	0.108	0.099	0.105
ROI	0.080	0.083	0.078	0.074	0.072
EFFTAX	0.258	0.171	0.140	0.138	0.137
RROI	0.072	0.062	0.058	0.059	0.060
ER	0.007	0.022	0.020	0.015	0.012
The cost of the proposed tax rule					
Periodic net cost (*FTAXP – FTAXC*)	0	0	-5038	-5092	5185

NOTES: See Appendix 1 for key to variable names

6. SIMULATION RESULTS FOR A HYPOTHETICAL CORPORATE TAX RATE REDUCTION OF THREE PER CENT

To illustrate the application of our model, in this section we present a simulation exercise, in which the statutory corporate tax rate is reduced by 3 percent (from 28 percent to 25 percent) from 2002. This is only a hypothetical simulation exercise and does not refer to a government proposal.

The best way of analyzing the implication of the new rules for the corporations is to compare the development of weighted average financial ratios for current tax rules (Table 2) with the development of the financial ratios for a hypothetical corporate tax rate reduction of three per cent (Table 5). The reduction of the tax rate by 3 percent implies that the final taxes paid by the firms (*FTAX*) decreases. The cost of the proposed tax rule is about MSEK 5 038 in 2002, MSEK 5 092 in 2003, and MSEK 5 185 in 2004 (see Table 5). The decrease in *FTAX* implies that the effective tax rate (*EFFTAX*) decreases from 15.8 percent to 14.0 percent in 2002, 15.7 percent to 13.8 percent in 2003, and 15.5 percent to 13.7 percent in 2004. An interesting observation is that a decrease in the statutory corporate tax rate by 3 percent only decreases the effective taxes paid by the firms by about 1.8 percent. It is the effective tax rate which is important for corporate investment and financial decisions. The lesson from this simulation exercise is that if the statutory corporate tax is reduced to stimulate corporate investment, one should bear in mind that the impact may be lower than expected because firms have the opportunity to adjust their utilization of the tax rules, and their financial behaviour. Behavioural factors play an important role in assessing the financial implications of proposals for change in the tax code.

The current ratio is not affected by the new rule. This means that the new tax rule does not have any impact on firms' ability to meet their short-term obligations, which means that the tax change does not improve the liquidity position of firms. The new tax rule causes a small decrease in the weighted average debt ratio. The tax decrease has a small impact on the extent to which firms use borrowed funds to finance their total assets. The required return on investment decreases because of the tax decrease, and hence the weighted average excess return increases. This indicates that the value of TOBINS q becomes higher, which in its case indicates that the value of the firms compared to the replacement costs of the firms' assets increases. This means that the proposed tax reduction will have a positive impact on corporate investment.

7. SIMULATION RESULTS FOR AHYPOTHETICAL CHANGE IN THE MACRO ECONOMIC DEVELOPMENTS

The simulation results for a hypothetical change in the macro economic developments are summarized in Table 6. In this case, we compare the macroeconomic development forecast presented in the government's budget bill for 2000 with the macroeconomic development forecast in the government's spring fiscal policy bill in 2000 (see Table 7). An interesting observation is that the forecast was not revised so much in the spring bill except for GDP growth for 2001 and 2002 which were revised downwards by 1 and 0.7 percentage points respectively.

The best way of analyzing the implication of the new macro economic development for firms is to compare the development of weighted average financial ratios for the initially assumed macro

Table 6 Simulated results from an alternative macroeconomic development, MSEK

	2000	2001	2002	2003	2004
Final taxes paid					
FTAX	48642	41072	39760	39984	40807
Financial ratio analysis					
CR	1.339	1.064	0.998	0.972	0.933
DR	0.627	0.700	0.724	0.734	0.762
DER	1.682	2.337	2.620	2.574	3.196
ECR	0.373	0.300	0.276	0.266	0.238
FQ	-0.310	-0.357	-0.366	-0.365	-0.376
ICR	1.511	1.590	1.642	1.652	1.666
DI	0.086	0.074	0.066	0.062	0.058
ROE	0.082	0.082	0.090	0.089	0.101
ROI	0.081	0.082	0.078	0.075	0.073
EFFTAX	0.253	0.178	0.160	0.156	0.153
RROI	0.072	0.063	0.062	0.062	0.061
ER	0.009	0.109	0.016	0.013	0.012
The cost of the proposed tax rule					
Periodic net cost (*FTAXP* – *FTAXC*)	907	-1770	-2929	-2996	-2959

NOTES: See Appendix 1 for key to variable names

Table 7 Macroeconomic forecast in the government's budget bill and spring fiscal policy bill (in parenthesis)**,** SEK billion, percentage change, and percent

	1999	2000	2001	2002	2003	2004
GDP	2010 (2010)	2083 (2098)	2118 (2115)	2169 (2151)	2225 (2207)	2277 (2262)
dGDP	79 (79)	72 (88)	35 (16)	51 (37)	56 (55)	51 (56)
dlGDP		3.60 (4.38)	1.70 (0.77)	2.40 (1.73)	2.60 (2.58)	2.30 (2.52)
r10*	4.83 (4.83)	5.40 (5.37)	5.20 (5.10)	5.20 (5.00)	5.20 (5.11)	5.20 (5.20)
Inflation	1.20 (1.20)	1.40 (1.30)	2.70 (2.60)	1.80 (2.10)	2.00 (2.20)	2.00 (2.00)
Real r10	3.59 (3.59)	3.94 (4.02)	2.43 (2.44)	3.34 (2.84)	3.14 (2.85)	3.14 (3.14)

NOTES: See Appendix 1 for key to variable names; * r10 is the nominal interest rate on a government bond with a maturity of 10 years.

economic development (Table 2) with the development of the financial ratios for the new macro economic development (Table 6). In the new macroeconomic environment, the government receives higher taxes from firms during 2000. However, from 2001, firms' tax payments to the government (*FTAX*) decrease. This is a natural consequence of the lower GDP growth forecast in the government's spring fiscal policy bill in 2000. However, the effective tax rate (*EFFTAX*) is almost the same even when firms' tax payments to the government decrease during the simulation period.

The current ratio decreases, which means that the new macro economic development degrades firms' abilities to meet their short-term obligations. This means that the new macro economic development impairs the liquidity position of firms. The new macro economic development causes a small decrease in the debt ratio which indicates that the new macro economic development has a small impact on the extent to which firms use borrowed funds to finance their total assets.

CONCLUSIONS

The basic idea behind the simulation model is to combine the dynamic behaviour of the corporate system with a statistical model that captures the development and the interrelationships between the firms' different decision variables. The dynamic behaviour of the corporate system is captured by several difference equations that identify how different variables in the firms' balance sheets change over time using the information in the firms' three basic financial statements: the balance sheet, the income statement, and the statement of changes in financial conditions. The firms' decisions regarding the flow variables are modelled in a statistical module. From the dynamic optimization problem we derive the relationships between these flow variables. These relationships are then estimated using different robust estimation methods. The estimated functions from the statistical module are then inserted into the difference equation system. The difference equation system together with the estimated relationships is finally solved numerically to be able to simulate new financial statements. Tests indicate that the model's ability to predict firms' final tax payments as well as other variables is satisfactory.

We pointed out that estimation of behavioural factors plays an important role in assessing the financial implications of proposals for a change in the tax code. Moreover, we also pointed out the importance of using robust estimation methods. The reason for using robust estimations methods is because microdata on firms often reveal that influential observations are present. The estimation method that is used to estimate firms' behaviour regarding different decisions variables must be able to deal with this fact. OLS regression models are quite sensitive to influential observations, which may be a consequence of heavy-tailed distributions. The estimation results using robust estimation methods revealed that firms' utilization of different tax allowances as well as different accounting constraints have an important impact on firms' investment and financial behaviour.

The lesson from this simulation exercise is that if the statutory corporate tax is reduced to stimulate corporate investment, one should bear in mind that the impact may be lower than expected because firms have the opportunity to adjust their utilization of the tax rules, and their financial behaviour. Behavioural factors play an important role in assessing the financial implications of proposals for changes in the tax code.

This is also confirmed by the simulation results which indicate that the cost of a proposed corporate tax rate reduction increase over time. The simulation results also indicate that a statutory corporate tax rate reduction does not decrease the effective corporate tax rate equally. This is mainly because firms have the opportunity to adjust their utilization of the tax rules and their financial behaviour to the new tax rules. Moreover, the simulation results also indicate that a corporate tax change has a significant impact on the extent to which firms use borrowed funds to finance their total assets, the capital contributed by creditors compared with the capital contributed by owners, and the market's prediction of the value of the returns of additional investment.

Finally, the simulation model gives us the opportunity to examine the impact of combined changes of the macroeconomic variables. The simulation results indicate that macroeconomic developments have major impact on corporate taxes paid by the firms. However, it is not obvious that the effective tax rate for these firms will change dramatically because of the changed macro conditions. This is due to the fact that firms have the opportunity to adjust their utilization of the tax rules and their financial behaviour and thereby adjust their effective tax rate.

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APPENDIX 1 Variable Listing

A1.1 Balance sheet and income statement variables

Symbol	Variable name	Symbol	Variable name
K	Assets	$EDEP^{BU}$	Economic Depreciation of Buildings
CA	Current Assets	$OIAD$	Operating Income after Economic Depreciation
FA	Fixed Assets	FI	Financial Income
MA	Machinery and Equipment	FE	Financial Expenses
BU	Buildings	EBA	Earnings Before Allocations
OFA	Other Fixed Assets	$TDEP^{MA}$	Tax Depreciation of Machinery and Equipment
CMA	The Taxable Residual Value of Machinery and Equipment	OA	Other Allocations
WC	Working Capital	zpf	Change in Periodical Reserves
B	Liabilities	p^{allo}	Allocations to Periodical Reserves
CL	Current Liabilities	EBT	Earnings Before Taxes
LL	Long-Term Liabilities	TL	Tax Liability
UR	Untaxed Reserves	NI	Net Income
ASD	Accumulated Supplementary Depreciation	TA	Tax Adjustments
OUR	Other Untaxed Reserves	OTA	Other Tax Adjustments
PF_t^{t-i}	Remaining Periodical Reserves From t-i in period t	$TDEP^{BU}$	Tax Depreciation of Buildings
EC	Equity Capital	OL_t^{t-1}	Losses From Previous Years
SC	Share Capital	TAX	Calculated Tax Payments
RR	Restricted Reserves	ROT	Reduction Of Taxes
URE	Unrestricted Equity	$FTAX$	Final Tax Payments
$OIBD$	Operating Income Before Depreciation	OL_t	The Stock of Old Losses
$EDEP^{MA}$	Economic Depreciation of Machinery and Equipment	NBI	Net Business Income

A1.2 Flow variables, Financial Ratios, Legal Constraints, and Parameters

Symbol	Variable name	Symbol	Variable name
I^{MA}	Net Investment in Machinery and Equipment	DI	Average Debt Interest
I^{BU}	Net Investment in Buildings	ROI	Return on Investment
dca	Net Change in Current Assets	$RROI$	Required Return on Investment
$dofa$	Net Change in Other Fixed Assets	τ^{eff}	Effective Corporate Tax Rate
dcl	Net Change in Current Liabilities	ER	Excess Return on Investment
dll	Net Change in Long-Term Liabilities	$TDDB^{MA}$	Tax Depreciation (Declining Balance Method)
$dour$	Net Change in Other Untaxed Reserves	$TDSL^{MA}$	Tax Depreciation (Straight-Line Method)
dsc	Net Change in Share Capital	$TDRV^{MA}$	Tax Depreciation (Rest Value Method)
drr	Net Changes in Restricted Reserves	$MTDM$	Maximum Amount of Tax Depreciation
$dURE$	Net Change in Unrestricted Equity (Retained Earnings)	$dmtdm$	Difference Between MTDM and $TDEP^{MA}$
$cashfl$	Cash flow	$ddmtdm$	Change in the Utilization of Depreciation Allowances
S^{MA}	Sales of Machinery and Equipment	MPA	Maximum Amount of Allocations to Periodical Reserves
IG	Investment Grant	$dmpa$	Difference Between *MPA* and p^{allo}
DIV	Dividends Paid to Shareholders	$ddmpa$	Change in the Utilization of Periodical Reserves
GC	Net Group Contribution	$dcashfl$	The Change in Cash Flow
CR	The Current Ratio	$mcash$	Maximum Dividends
DR	The Debt Ratio	$dmcash$	The Difference Between *mcash* and *cashfl*
DER	The Debt/Equity Ratio	$ddmcash$	Change of Dividend Policy Closer to the Legal Constraint
ECR	The Equity Capital Ratio	δ^{DB}	The Depreciation Rate (Declining Balance Method)
FQ	The Financial Q	δ^{S}	The Depreciation Rate (Straight-Line Method)
ICR	The Interest Coverage Ratio	δ^{RV}	The Depreciation Rate (Rest Value Method)
ROA	Return on Total Assets	M	Number of Months in the Firms' Income Year
ROE	Return on Equity	τ	The Statutory Corporate Tax Rate

APPENDIX 2 The Framework of the Simulation Model

In this appendix, we present the framework of the simulation model within a simple model with two assets. In the balance sheet the value of the firms' assets must be equal to the firms' liabilities, so that

$$CA_t + MA_t = URE_t \quad \text{(A2.1)}$$

where CA_t is current assets, MA_t is machinery and equipment, and URE_t is the firms' unrestricted equity. These are the stock (state) variables of this model. The income statement includes only the operating income before depreciation ($OIBD_t$). This implies that firm's earnings before taxes coincides with the operating income before depreciation: $EBT_t = OIBD_t$. Firms pay corporate taxes based on their earnings before taxes: $TAX_t = \tau\ EBT_t$ where τ is the corporate tax rate. We can thus write net business income as $NBI_t = EBT_t - TAX_t = (1\text{-}\tau)OIBD_t$. Net business income increases unrestricted equity. However, unrestricted equity decreases also because of the maximum amount available for dividends in the current period (the so-called net cash flow, $cashfl_t$). Thus, unrestricted equity in period t can be derived from

$$URE_t = URE_{t-1} + NBI_t - cashfl_t\ . \quad \text{(A2.2)}$$

The level of current assets at the end of time t equals the level of current assets at the end of time *t-1 plus* the net change in current assets

$$CA_t = CA_{t-1} + dca_t \quad \text{(A2.3)}$$

The level of the firm's machinery and equipment at the end of time t equals the level of machinery and equipment at the end of time *t-1 plus* the net investment in new machinery and equipment

$$MA_t = MA_{t-1} + I_t^{\mathrm{MA}} \quad \text{(A2.4)}$$

Inserting the difference equations for URE_t, CA_t and MA_t (from (A2.2)-(A2.4)) into (A2.1) we obtain the cash flow constraint

$$cashfl_t = (1\text{-}\tau)OIBD_t - I_t^{MA} - dca_t \quad \text{(A2.5)}$$

Equations (A2.2)-(A2.5) are the major equations in our simulation model. We use equations (A2.2)-(A2.4) to simulate the values of different balance sheet items in the next period, while equation (A2.5) makes sure that we achieve a balance between the asset and the liability sides of the balance sheet during the simulation. As shown, we need initial values for I_t^{MA}, dca_t, and $\mathrm{OIBD_t}$ to be able to solve the difference equations system in (A2.2)-(A2.5). These initial values are obtained by estimating these variables.

A2.1 The Dynamic Optimization Model

Let us begin by defining the value of the firms at time t as

$$\mathrm{V}(t) = \int_{u=t}^{\infty} cashfl\ e^{-i(u-t)} du$$

where i is the shareholders' return on holding bonds and $cashfl = (1 - \tau)OIBD - I^{MA} - dca$. We define operating income before depreciation as:

$$OIBD = f(MA, CA)$$

where $f(MA,CA)$ is the production function with $f_{MA}>0$, $f_{CA}>0$, $f_{MAMA}< 0$ and $f_{CACA}<0$. The firms' production function is equal to the firms' revenue because the product price is assumed to be equal to one. As we mentioned in the previous section the changes in current assets and machinery and equipment are

$$\dot{MA} = I^{MA} \text{ and } \dot{CA} = dca\ .$$

We also impose non-negativity constraints on each and every balance sheet item:

$$MA \geq 0 \text{ and } CA \geq 0\,.$$

Further, we assume that the interest rate is exogenously given. Firms will choose the time path of $I^{MA}$and dca so that the market value of their shares is maximized. The current-value Hamiltonian for this problem is:

$$F = (1-\tau)f(MA,CA) - I^{MA} - dca + \mu_{MA}\, I^{MA} + \mu_{CA}\, dca + n_{MA} MA + n_{CA}\, CA$$

where μ_{MA} and μ_{CA} are the shadow prices or co-state variables of the stock of machinery and equipment and the stock of current assets. n_{MA} and n_{CA} are the Khun-Tucker shadow-price of constraints MA≥0 and CA≥0. The first order necessary conditions are:

$$I^{MA}:\ -1 + \mu_{MA} = 0 \quad \text{(A2.6)}$$

$$dca:\ -1 + \mu_{CA} = 0 \quad \text{(A2.7)}$$

$$MA:\ \dot{\mu}_{MA} = i\mu_{MA} - [(1-\tau)f_{MA} + n_{MA}] \quad \text{(A2.8)}$$

$$CA:\ \dot{\mu}_{CA} = i\mu_{CA} - [(1-\tau)f_{CA} + n_{CA}] \quad \text{(A2.9)}$$

$$n_{MA}:\ \frac{\delta F}{\delta n_{MA}} \geq 0\ ,\ n_{MA} \geq 0\ ,\ n_{MA}\frac{\delta F}{\delta n_{MA}} = 0 \quad \text{(A2.10)}$$

$$n_{CA}: \; \frac{\delta F}{\delta n_{CA}} \geq 0\,, \; n_{CA} \geq 0\,, \; n_{CA}\frac{\delta F}{\delta n_{CA}} = 0 \qquad \text{(A2.11)}$$

Stationary constraints

$$\dot{\mu}_{MA} = \dot{\mu}_{CA} = 0$$

together with (A2.8) and (A2.9) give the values of μ_{MA} and μ_{CA}:

$$\mu_{MA} = \frac{1}{i}[(1-\tau)f_{MA} + n_{MA}]$$

and

$$\mu_{CA} = \frac{1}{i}[(1-\tau)f_{CA} + n_{CA}]\,.$$

Using the steady state solutions for μ_{MA} and μ_{CA}, the first order conditions in steady state become

$$I^{MA}: \; -i + (1-\tau)f_{MA} + n_{MA} = 0 \qquad \text{(A2.12)}$$

$$dca: \; -i + (1-\tau)f_{CA} + n_{CA} = 0 \qquad \text{(A2.13)}$$

$$n_{MA}: \; n_{MA}\, MA = 0 \qquad \text{(A2.14)}$$

$$n_{CA}: \; n_{CA}\, CA = 0 \qquad \text{(A2.15)}$$

The rate of change in the equilibrium values of the endogenous variable are found by total differentiating the first order conditions in equilibrium (A2.12)-(A2.15). After some simple derivations we obtain the following conditions

$$\beta_1^{MA} dCA + \beta_2^{MA} dMA = \beta_0^{MA} \qquad \text{(A2.16)}$$

$$\beta_1^{CA} dCA + \beta_2^{CA} dMA = \beta_0^{CA} \qquad \text{(A2.17)}$$

where

$$\beta_0^{MA} = di + f_{MA} d\tau\,,$$

$$\beta_0^{CA} = di + f_{CA} d\tau\,,$$

$$\beta_1^{MA} = (1-\tau)\, f_{MA\,CA}\,,$$

$$\beta_2^{CA} = (1-\tau)\, f_{CAMA}\,,$$

$$\beta_2^{MA} = [(1-\tau)\, f_{MA} - (n_{MA} / MA)]\,,$$

and $\beta_1^{CA} = [(1-\tau)\, f_{CA} - (n_{CA} / CA)]$

are evaluated in the initial values and are therefore constants.
Let us now solve (A2.16) for $dMA = I^{MA}$ and (A2.17) for dCA. This yields

$$\begin{aligned} I^{MA} &= (\beta_0^{MA} / \beta_2^{MA}) - (\beta_1^{MA} / \beta_2^{MA})\, dca \\ &= \gamma_0^{MA} + \gamma_1^{MA}\, dca \end{aligned}$$

and

$$\begin{aligned} dca &= (\beta_0^{CA} / \beta_1^{CA}) + (\beta_2^{CA} / \beta_1^{CA})\, I^{MA} \\ &= \gamma_0^{CA} + \gamma_1^{CA}\, I^{MA}\,. \end{aligned}$$

As is evident from these two equations, we have an interrelationship between $I^{MA}$and dca. This means that the equation system must be solved or estimated simultaneously. In this simple model, it may not seem to be a complicated task. The complication has to do with the nature of the data in hand. The most important statistical difficulty is the presence of extreme observation on both dependent and explanatory variables. Solving this statistical problem within the context of simultaneous estimation is very difficult. Therefore, we have chosen a recursion system to estimate each and every decision variable within a firm. Let us now introduce the time index to make the recursive system more straightforward.

$$I_t^{MA} = \gamma_0^{MA} + \gamma_1^{MA}\, dca_{t-1} \qquad \text{(A2.18)}$$

$$dca_t = \gamma_0^{CA} + \gamma_1^{CA}\, I_t^{MA} \qquad \text{(A2.19)}$$

In this recursion system, we assume that firms first make decisions about their fixed assets before making decisions about net investment in current assets. After the investment decisions, firms undertake different financial decisions. For these decisions, it is important to estimate the operating income before depreciation. We know that OIBDt = $f(MA_t, CA_t)$. By using (A2.3) and (A2.4), we find the following relationship for $OIBD_t$:

$$\begin{aligned} OIBD_t = \gamma_0^{OIBD} + \gamma_1^{OIBD} I_t^{MA} + \gamma_2^{OIBD} dca_t + \\ \gamma_3^{OIBD} MA_{t-1} + \gamma_4^{OIBD} CA_{t-1} \end{aligned} \qquad \text{(A2.20)}$$

Adding a disturbance term to each and every equation above and giving the errors a random interpretation converts our economic models into statistical probability models which gives us a basis for statistical inference. Equations (A2.18) to (A2.20) are estimated using robust estimation techniques. They will all be estimated one-way, with no feedback looping. Crucial for this model, however, is the fact that it is assumed that disturbance terms for the endogenous variables are uncorrelated.

A2.2 The Dynamic System Used for Simulation Purposes

Equations (A2.18), (A2.4), (A2.19), (A2.3), (A2.20), (A2.5), and (A2.2) are simulated recursively. We begin our simulation from year t −1 = 1999. We use the information for the net investment in current assets in the current period (t −1 = 1999) to draw conclusions about the investment in machinery and equipment in the next period t = 2000 (equation (A2.18)). The investment in machinery and equipment increases the stock of machinery and equipment in the balance sheet for the next period (equation (A2.4)). As is evident from (A2.19), the net investment in current assets in the next period is a function of firms' investment decisions regarding machinery and equipment. This net investment in current assets increases the stock of current assets in the balance sheet for the next period (equation (A2.3)). Firms' investment must be financed in one way or another. In this simple model, the financing comes from equity capital, which is a function of operating income before depreciation. Operating income before depreciation in the next period is a function of firms' investment in different assets in the next period and the stock of the same assets in the current period (equation (A2.20)). Having determined the investment in different assets and earnings before taxes, we can use (A2.5) to calculate firms' cash flow. Finally, net business income in the next period increases the stock of unrestricted equity. On the other hand, the cash flow in the next period decreases the stock of unrestricted equity in the next period (equation (A2.2)).

APPENDIX 3: The Structure of the Simulation Model

The balance sheet presents firms' assets, liabilities, and equity. In the balance sheet the value of the firm's assets must be equal to the firm's liabilities so that

$$CA_t + MA_t + BU_t + OFA_t = CL_t + LL_t + ASD_t + PF_t + OUR_t + SC_t + RR_t + URE_t \qquad \text{(A3.1)}$$

The income statement is formalized as follows. Operating income before depreciation ($OIBD_t$) is the operating revenue remaining after operating expenses. Operating income before depreciation is split into two elements: Economic depreciation of machinery and equipment ($EDEP_t^{MA}$) and economic depreciation of buildings ($EDEP_t^{BU}$). The remainder, which is operating income after economic depreciation ($OIAD_t$), is one part of the earnings before allocations (EBA_t). In addition, earnings before allocations include the financial income (FI_t) and excludes financial expenses (FE_t). By adding net allocations to earnings before allocations we obtain earnings before taxes (EBT_t). Allocations to untaxed reserves are purely bookkeeping operations. Net allocations include allocations to the accumulated supplementary depreciation (ΔASD_t), net allocations to periodical reserves (ΔPF_t), and other allocations (OA_t). Allocations to the accumulated supplementary depreciation constitute the difference between allowances for depreciation and depreciation according to plan ($\Delta ASD_t = TDEP_t^{MA} - EDEP_t^{MA}$). The tax code only specifies the maximum amount of tax depreciation which firms may deduct from their taxable income. Moreover, according to the tax legislation regarding periodical reserves, firms may each year allocate a maximum of 25 per cent of their taxable income to a special reserve. Corporations are allowed to have six different periodical reserves. However, the allocated amount in a reserve, *at the latest* six years after the fiscal year when the allocation was made, recurs as taxable income. Net allocation to periodical reserves is the difference between the allocation to and reversals from periodical reserves ($\Delta PF_t = p_t^{allo} - zpf_t$). Finally, other allocations include (net) group contributions. Earnings before taxes (EBT_t) is defined as follows

$$EBT_t = OIBD_t - EDEP_t^{BU} + FI_t - FE_t - TDEP_t^{MA} - p_t^{allo} + zpf_t + OA_t \qquad \text{(A3.2)}$$

Net income (NI_t) is calculated after deducting the tax liability in a specific period for (TL_t). The reason for this is that firms usually close their books for one accounting period long before they fill in the tax return form. For this reason, firms must make a good estimate of their tax liability. Net income (NI_t) can thus be derived as

$$NI_t = EBT_t - TL_t \qquad \text{(A3.3)}$$

However, the cash flow in a company depends on actual tax payments. By adjusting net income for tax purposes, (TA_t), firms are able to calculate the amount of tax they have to pay:

$$TAX_t = \tau \max[0,(NI_t + TA_t)]$$

where τ is the corporate tax rate, TA_t (which either can be positive, negative or equal to zero) is the firms' tax adjustments.

It is worth mentioning that firms pay tax on their income if and only if $NI_t + TA_t > 0$. Tax adjustments are made for the tax depreciation of buildings ($TDEP_t^{BU}$), losses from previous years which are fully deductible for firms (OL_{t-1}), and other tax adjustments (OTA_t):

$$TA_t = OTA_t - TDEP_t^{BU} - OL_{t-1}.$$

However, to be able to derive firms' final tax payments ($FTAX_t$), we adjust firms' tax payments for their reduction of taxes (ROT_t) so that $FTAX_t = TAX_t - ROT_t$. We can thus write net business income, when $NI_t + TA_t \geq 0$, as

$$NBI_t = EBT_t - FTAX_t \tag{A3.4}$$

However, when $NI_t + TA_t < 0$, firms increase their stock of old losses with the same amount

$$OL_t = \min[0,(NI_t + TA_t)] \tag{A3.5}$$

The first financial decision, the proportion of funds to be retained, is then made by dividing net business income into dividends paid to shareholders, the maximum amount available for dividends in the current period (the so called cash flow), allocations to restricted reserves, and retained earnings.

$$URE_t = URE_{t-1} + NBI_t - DIV_{t-1} - \Delta RR_t - cashfl_t \tag{A3.6}$$

The board of directors usually proposes the dividend for year *t-1* in a financial statement bulletin at the beginning of the year *t*. The stockholders' meeting adopts the balance sheet, the amount of dividends that should be paid out, the allocations to be made to restricted reserves and free reserves, and the remaining retained earnings. However, once a dividend has been decided, it becomes a current liability of the corporation. After the stockholders' meeting, firms mail out the dividends as soon as possible. When this happens, the current liability is eliminated, and the firms' current assets decline.

The stock (state) variables of this model are LL_t, CL_t, SC_t, RR_t, URE_t, ASD_t, PF_t, OUR_t, CA_t, MA_t, BU_t, and OFA_t. As the two columns in the balance sheet give the same total in any given time period, the sum of each for all time periods in the past up to the date of the balance sheet will also be equal. The equations of motions that hold for these state variables are

$$LL_t = LL_{t-1} + dll_t \tag{A3.7}$$

$$CL_t = CL_{t-1} + dcl_t \tag{A3.8}$$

$$SC_t = SC_{t-1} + dsc_t \tag{A3.9}$$

$$RR_t = RR_{t-1} + drr_t \tag{A3.10}$$

$$CA_t = CA_{t-1} + dca_t \tag{A3.11}$$

$$MA_t = MA_{t-1} + I_t^{MA} - S_t^{MA} - EDEP_t^{MA} \tag{A3.12}$$

$$BU_t = BU_{t-1} + I_t^{BU} - EDEP_t^{BU} \tag{A3.13}$$

$$OFA_t = OFA_{t-1} + dofa_t \tag{A3.14}$$

$$ASD_t = ASD_{t-1} + (TDEP_t^{MA} - EDEP_t^{MA}) \tag{A3.15}$$

$$OUR_t = OUR_{t-1} + dour_t \tag{A3.16}$$

$$PF_t = PF_{t-1} + p_t^{allo} - zpf_t \tag{A3.17}$$

where S_t^{MA} is sales of old machinery and equipment, ($TDEP_t^{MA}$ – $EDEP_t^{MA}$) is the supplementary depreciation during period *t*, and $dour_t$ is the net change in other untaxed reserves. The financial statement that is closest in reporting cash flow is formally referred to as the statement of changes in financial conditions, more commonly known as the cash flow statement. Inserting the difference equations for LL_t, CL_t, SC_t, RR_t, URE_t, ASD_t, PF_t, OUR_t, CA_t, MA_t, BU_t, and OFA_t (from (A3.6)-(A3.17)) into equation (A3.1) we obtain the cash flow constraint

$$\begin{aligned} cashfl_t = {} & OIBD_t + FI_t - FE_t + OA_t - \\ & FTAX_t - DIV_{t-1} + dsc_t + \\ & dcl_t + dll_t + dour_t - I_t^{MA} + \\ & S_t^{MA} - I_t^{BU} - dofa_t - dca_t \end{aligned} \tag{A3.18}$$

This is the maximum amount available for dividends in the current period. One of the legal constraints that we model is that "dividends" cannot exceed unrestricted equity in period *t-1* (URE_{t-1}) plus the current period's net business income minus allocations to restricted reserves. If dividends were to exceed this amount the equity base of the firm would fall. The conditions can be summarized mathematically as $cashfl_t \leq mcash_t$ where

$$mcash_t = URE_{t-1} + NBI_t - drr_t \, .$$

This constraint is of course only valid for $URE_{t-1}>0$. Another constraint modelled is that firms are not allowed to pay negative "dividends": $cashfl_t \geq 0$. This means that the firms' dividend payments are equal to

$$DIV_t = \max[0, \min(cashfl_t, mcash_t)] \tag{A3.19}$$

Let us now define a variable that is the difference between the maximum dividend firms can pay to their shareholders and the amount of dividends they actually pay to their shareholders:

$$dmcash_t = mcash_t - cashfl_t \, .$$

This variable gives us the opportunity to analyze the way in which firms' investment and financial behaviour would be influenced by the fact that firms' dividend policy does not coincide with the legal constraint on dividends. Let us also define a variable that captures whether firms change their dividend policy so that it comes closer to the legal constraint on dividends:

$$ddmcash_t = dmcash_t - dmcash_{t-1}\,.$$

This variable captures whether firms change their dividend policy so that it comes closer to the legal constraint on dividends.

A3.1 The Constraints on Firms' Tax Depreciation of Machinery and Equipment

For machinery and equipment, there are three kinds of depreciation rules available: The declining balance method, the straight line method, and the rest value method. To be able to explain the implication of the three different methods for depreciation, we need to define the taxable residual value of machinery and equipment

$$CMA_t = CMA_{t-1} + I_t^{MA} - S_t^{MA} - TDEP_t^{MA} \qquad (A3.20)$$

The declining-balance method

The tax code in Sweden specifies the maximum amount of tax depreciation that firms may deduct from their taxable income. The declining-balance method allows a maximum deduction of 30 percent of the remaining taxable residual value and the gross investment made in period *t*. However, the taxable residual value must be adjusted for different investment grants and the sale price of machinery and equipment that has been disposed of during period *t*. Further, the deduction rate must also be adjusted if the income year is longer than 12 months. For example, if the income year is 18 months the depreciation rate must be multiplied by 18/12, which gives a depreciation rate of 45%. The declining-balance method implies that the tax depreciation $TDEP_t^{MA}$ is constrained by

$$TDDB_t^{MA} = (M/12)\delta^{db}[CMA_{t-1} + I_t^{MA} - S_t^{MA} - IG_t] \qquad (A3.21)$$

where M is the number of months in the firms' income year, IG_t is the investment grants, and $\delta^{db} = 0.3$ is the maximum rate of depreciation allowed for tax purposes. The allowed tax depreciation rate is assumed to be higher than the economic depreciation rate.

The straight-line method

The calculation of tax depreciation according to the straight-line method necessitates knowledge about firms' investment during the last three years prior to the income year. This method allows a 20% depreciation of inventories and equipment. Further, the deduction rate must be adjusted if the income year is longer than 12 months. The straight-line method starts from the taxable residual value at period *t-1*. However, this value is reduced by 80% of the firms' investment in year *t-3*, 60% of the firms' investment in year *t-2*, 40% of the firms' investment in year *t-1*, and 20% of the firms' investment in year *t*. The resulting difference is the maximum tax depreciation according to the straight line method. The tax depreciation $TDEP_t^{MA}$ is therefore constrained by

$$TDSL_t^{MA} = CMA_{t-1} + I_t^{MA} - S_t^{MA} - IG_t - [\delta_t^s(I_t^{MA} - IG_t) + \delta_{t-1}^s I_{t-1}^{MA} + \delta_{t-2}^s I_{t-2}^{MA} + \delta_{t-3}^s I_{t-3}^{MA}] \qquad (A3.22)$$

where

$$\delta_t^s = [1 - (M/12)\delta^s]\,,$$

$$\delta_{t-1}^s = \delta_t^s - \delta^s\,,$$

$$\delta_{t-2}^s = \delta_{t-1}^s - \delta^s\,,$$

and $\delta_{t-3}^s = \delta_{t-2}^s - \delta^s$.

δ^s is the allowed tax depreciation rate according to the straight-line method. For example, if we assume that δ^s =0.2 and M = 12 then $\delta^s = 0.8$, $\delta^s_{t-1} = 0.6$, $\delta^s_{t-2} = 0.4$, and $\delta^s_{t-3} = 0.2$. The firm chooses the depreciation rule that gives the highest tax depreciation. The choice can be defined mathematically by a maximum function:

$$\max(TDDB_t^{MA}, TDSL_t^{MA})\,.$$

The rest value method

This method follows the same rules as the declining balance method. However, the rest value method is simpler. The method is mainly used by unincorporated businesses that do not prepare annual accounts. However, incorporated firms are also allowed to use this method. This will give them lower tax depreciation (compared to the declining balance method). The rest value method gives these firms the opportunity to make deductions for tax depreciation even if they do not have annual accounts. It is also important to note that these firms are not allowed to use the supplementary rule for depreciation according to Swedish tax legislation (the straight line method). Mathematically, the rest value method will be handled just like the declining balance method as follows

$$TDRV_t^{MA} = (M/12)\delta^{rv}[CMA_{t-1} + I_t^{MA} + S_t^{MA} - IG_t] \qquad (A3.23)$$

where δ^{db}=0.25 is the maximum rate of depreciation allowed for tax purposes according to the rest value method.

Let us now define a variable that captures the constraints that the tax code in Sweden puts on the amount of tax depreciation that firms may deduct from their taxable income as $MTDM_t$. The tax depreciation of machinery and equipment is constrained by $MTDM_t$ so that $TDEP_t^{MA} \leq MTDM_t$. However, as we mentioned above, $MTDM_t$ depends on following conditions:

If $TDDB_t^{MA} > TDRV_t^{MA}$ and $TDSL_t^{MA} > TDRV_t^{MA}$ then

$$MTDM_t = \max(TDDB_t^{MA}, TDSL_t^{MA}) .$$

However, if $TDDB_t^{MA} \leq TDRV_t^{MA}$ and $TDSL_t^{MA} \leq TDRV_t^{MA}$ then

$$MTDM_t = TDRV_t^{MA}$$

The variable $MTDM_t$ captures the constraint that the tax code in Sweden puts on the amount of tax depreciation that firms may deduct from their taxable income.

Let us now define a variable that is the difference between the maximum amount of tax depreciation and the depreciation for income tax purposes made by these firms ($TDEP_t^{MA}$)):

$$dmtdm_t = MTDM_t - TDEP_t^{MA} .$$

This variable gives us the opportunity to analyze the impact of underutilization (or overutilization) of depreciation allowances on firms' investment and financial behaviour. Let us also define a variable that captures whether firms increase or decrease their utilization of depreciation allowances:

$$ddmtdm_t = dmtdm_t - dmtdm_{t-1} .$$

A3.2 The Constraint on Firms' Allocations to the Periodical Reserves

The tax code in Sweden specifies the maximum amount of allocations firms can allocate to periodical reserves each year. As mentioned above, firms can deduct up to 25 percent (the allocation was reduced to 20 percent in 1998) of its taxable income each year (adjusted for different items). In the balance sheet this deduction is booked as a reserve (under untaxed reserves). The maximum base for the allocation to this reserve during the income year is calculated according to the following equation:

$$\begin{aligned} pbase_t = {} & OIBD_t - EDEP_t^{BU} + FI_t - \\ & FE_t - TDEP_t^{MA} + zpf_t + \\ & OA_t - TL_t + TA_t \end{aligned} \tag{A3.24}$$

The allocation to the periodical reserve fund is constrained to η = 0.25 % of this base:

$$p_t^{allo} \leq MPA_t$$

where

$$MPA_t = \max[0, (\eta \times pbase_t)] .$$

Thus, the constraint can be rewritten as follows

$$P_t^{allo} = \max[0, \min(P_t^{allo}, (\eta \times pbase_t))] \tag{A3.25}$$

The variable MPA_t captures the maximum amount of allocations firms can make to periodical reserves. Let us now define a variable that is the difference between the maximum amount of allocations to periodical reserves and the allocation made by the firms during the current period (p_t^{allo}):

$$dmpa_t = MPA_t - p_t^{allo} .$$

This variable gives us the opportunity to analyze the impact of underutilization (or overutilization) of allocations to periodical reserves on firms' investment and financial behaviour. Let us also define a variable that captures whether firms change their utilization of their allocations to periodical reserves:

$$\begin{aligned} ddmpa_t &= dmpa_t - dmpa_{t-1} \\ &= (MPA_t - p_t^{allo}) - (MPA_{t-1} - p_{t-1}^{allo}) \end{aligned} .$$

Financial ratio analysis

In order to summarize the simulation results, we use financial ratio analysis. Four major categories of financial ratios have been developed, each designed to address an important aspect of the firms' financial condition: liquidity ratios, leverage ratios, profitability ratios, and market value ratios. Current ratio (*CR*) is used as a liquidity ratio and it measures the quality and adequacy of current assets to meet current liabilities as they come due. Debt/equity ratio (*DR*), equity/capital ratio (*DER*), equity/capital ratio (*ECR*), and interest coverage ratio (*ICR*) are used as leverage ratios. Return on total assets (*ROA*), return on equity (*ROE*), and debt interest (*DI*) are used as profitability ratios, as follows.

$$CR_t = \frac{CA_t}{CL_t} \qquad \text{(A3.26)}$$

$$DR_t = \frac{CL_t + LL_t + \tau(ASD_t + PF_t + OUR_t)}{K_t} \qquad \text{(A3.27)}$$

$$DER_t = \frac{CL_t + LL_t + \tau(ASD_t + PF_t + OUR_t)}{SC_t + RR_t + URE_t + (1-\tau)(ASD_t + PF_t + OUR_t)} \qquad \text{(A3.28)}$$

$$ECR_t = \frac{SC_t + RR_t + URE_t + (1-\tau)(ASD_t + \hat{PF}_t + OUR_t)}{K_t} \qquad \text{(A3.29)}$$

$$ICR_t = \frac{OIBD_t - EDEP_t^{MA} - EDEP_t^{BU} + FI_t}{FE_t} \qquad \text{(A3.30)}$$

$$ROA_t = \frac{OIBD_t - EDEP_t^{MA} - EDEP_t^{BU} + FI_t + TL_t}{K_t} \qquad \text{(A3.31)}$$

$$ROE_t = ROA_t + (ROA_t - DI_t)DER_t \qquad \text{(A3.32)}$$

$$DI_t = \frac{FE_t}{CL_t + LL_t + \tau(ASD_t + PF_t + OUR_t)} \qquad \text{(A3.33)}$$

Moreover, we also introduce a market value ratio. We know that Tobin's q, which is a market value ratio, compares the market value of the firm with the replacement cost of the firms' assets. The greater is the real return on investment (*ROI*) relative to the required return on investment (*RROI*), the higher will be the value of q. This is captured by excess return on investment (*ER*), which is the difference between the return on investment and the required return on investment as follows: $ER_t = ROI_t - RROI_t$. Often, firms use return on total assets as an approximation of return on investment: $ROI_t = ROA_t$. It is assumed that the investors' required return on investment (*RROI*) coincides with the pre tax interest rate on government loan:

$$RROI_t = i_t / (1 - \tau_t^{eff})$$

where the effective corporate tax rate is defined as

$$\tau_t^{eff} = FTAX_t / EBA_t \,.$$