NBER WORKING PAPER SERIES

TAX LOSS CARRYFORWARDS AND CORPORATE TAX INCENTIVES

Alan J. Auerbach

James M. Poterba

Working Paper No. 1863

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 1986

This paper was prepared for the NBER Conference on Taxation and Capital Formation, February 13-16, 1986. We are grateful to Lars Bespolka, Sandi Fine, William Gentry, and Julie Harrold for help in gathering data, and to Kevin Hassett for excellent research assistance. David Bradford, Paul Healy, and Lawrence Summers made helpful suggestions, and the NBER, NSF and Sloan Foundation provided financial support. The research reported here is part of the NBER's research program in Taxation and project in Taxation and Capital Formation. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #1863
March 1986

Tax Loss Carryforwards and Corporate Tax Incentives

ABSTRACT

This paper investigates the extent to which loss-offset constraints affect corporate tax incentives. Using data gathered from corporate annual reports, we estimate that in 1984 fifteen percent of the firms in the nonfinancial corporate sector had tax loss carryforwards. When weighted by their market value, however, these firms account for less than three percent of this sector, suggesting that loss carryforwards are concentrated among small firms and affect relatively few large corporations. For those firms with loss carryforwards, however, the incentive effects of the corporate income tax may differ significantly from those facing taxable firms. We demonstrate this by calculating the effective tax rates on equipment and structures for both types of firms. Our results suggest that firms which are currently taxable have a substantially greater incentive for equipment investment than firms with loss carryforwards, but that loss carryforwards have a relatively smaller effect on the tax incentive for investing in structures. Overall, firms with loss carryforwards receive a smaller investment stimulus than taxable firms.

Alan J. Auerbach
Department of Economics
University of Pennsylvania
3718 Locust Walk - CR
Philadelphia, PA 19104
215-898-1503

James M. Poterba
Department of Economics
Massachusetts Institute
of Technology
Cambridge, MA 02139
617-253-6673

The U.S. corporate income tax provides only limited tax relief to firms which report tax losses. Firms which have paid positive taxes during the three years prior to the loss year may "carry back" their losses and receive a tax refund, provided it does not exceed their taxes in those three years. For some firms, however, current losses exceed potential carrybacks. This may happen when a firm experiences losses in several consecutive years, or when it incurs an especially large loss in a single year. Firms which exhaust their potential carrybacks must carry losses forward, using them to offset future taxable earnings. For these firms, the marginal tax rate on current earnings as well as the value of tax deductions depends critically upon when, and if, they regain their taxable status. Firms which anticipate persistent loss carryforwards will in effect face very low marginal tax rates.

Imperfect loss-offset provisions may substantially alter the incentive effects of the corporate income tax. Two features of the tax, the incentive to undertake new investment and the incentive to use debt as opposed to equity finance, are particularly sensitive because loss carryforward firms may be unable to claim the benefits of depreciation or interest tax shields.

Standard analyses of corporate investment incentives assume that firms claim depreciation allowances and investment tax credits as they accrue. For firms with loss carryforwards, however, accrual and realization occur at different dates. This timing difference can change both the relative tax incentives for investments in plant and equipment, and the overall investment incentive facing the firm. For assets with high tax burdens, typically those with long depreciation lives such as structures, a loss carryforward firm may have a

greater incentive to invest than a currently taxable firm. This occurs because the gain from postponing the tax payments on the asset's earnings exceeds the loss from postponing its tax depreciation benefits. The opposite result may obtain for assets with highly accelerated depreciation allowances, such as equipment. For these assets, the cost of delayed realization of the depreciation benefits may exceed the gain from deferring taxes on the project's profits, and loss carryforward firms may therefore face smaller investment incentives than taxable firms.

Loss offset provisions may also exert an important influence on corporate financing choices. Interest deductions are worth less to a loss-carryforward firm than to a currently taxable firm, so a firm with a tax loss carryforward has a smaller incentive to use debt finance than a currently taxable firm. In addition, a firm's probability of experiencing future loss carryforwards may depend upon its financial policy, since higher interest deductions lower taxable profits and raise the chance of realizing losses. This has led some to propose a theory of corporate capital structure based on the proposition that firms borrow until the expected marginal cost of additional debt due to the increased probability of becoming non-taxable and losing pre-existing tax shields equals the expected marginal benefit of additional deductions when taxable. This theory implies that tax systems with more generous loss-offset provisions provide a greater incentive for corporate borrowing.

Several recent studies have suggested that the loss-carryforward provisions of corporate tax codes are of more than academic interest. Cordes and Sheffrin (1983) analyzed the distribution of corporate marginal tax rates on additional interest deductions, and estimated that only fifty-six percent of corporate

receipts accrued to firms which paid the maximum statutory corporate tax rate on marginal earnings. This is due to the combined effect of tax loss carryforwards and binding income-linked constraints on the use of investment and foreign tax credits.[1] In Canada, Mintz (1985) reports that only half of the investment in manufacturing is undertaken by currently-taxable firms, and the incidence of loss-carryforward firms is much higher in some other sectors, such as mining. For Great Britain, Mayer (1986) cites evidence that during the early 1980s, only forty percent of British companies were paying corporation tax on marginal profits. The stock of tax loss carryforwards in the U.K. was nearly three times as large as the annual revenue yield of the corporation tax.

This paper presents new evidence on the importance of tax loss carryforwards in the United States. It uses a new data set gathered from corporate annual reports and 10-K forms to investigate the incidence of loss carryforwards, and then examines how loss offset constraints affect effective tax rates on different assets. The most important finding is that tax loss carryforwards are relatively unimportant in the U.S. corporate sector as a whole. Although nearly fifteen percent of the firms in our sample had tax loss carryforwards in 1984, when weighted by market value they accounted for only three percent of the sample. Loss carryforward firms do, however, account for a significant fraction of some industries. Analyzing the effect of the corporate income tax on tax-loss firms is therefore essential to understanding investment and financing incentives in these industries. We estimate the persistence of loss carryforwards and use the results to calculate effective tax rates on new investments in structures and industrial equipment for both currently-taxable and loss-carryforward firms. We find that the presence of a tax loss carryforward has a

dramatic effect on a firm's incentive to invest in equipment, but it has relatively little impact on the incentive to invest in structures.

The paper is divided into five sections. The first outlines the tax rules governing loss carryforwards and carrybacks. It also explains the difficulties which arise in using standard data sources to measure tax loss carryforwards, and describes our new data set. The second section presents our basic findings on the importance of firms with tax loss carryforwards, and examines the persistence of loss carryforwards for the firms which experience them. Section three outlines how loss offset constraints alter the effective tax rates on various assets, and describes our numerical procedures. The fourth section presents our calculations of the effective tax rates on plant and equipment investment for both currently-taxable and loss-carryforward firms. A concluding section discusses the implications of our results for understanding the allocative effects of the corporate income tax, and suggests a number of directions for future work.

1. The Definition and Measurement of Tax Loss Carryforwards

Loss offset constraints restrict a firm's ability to obtain tax refunds when it generates negative taxable profits. A firm which realizes a tax loss may carry the loss back against tax payments in the previous three years, provided it does not claim current refunds in excess of total tax payments in those years. Firms which have exhausted their carrybacks may carry unused losses forward for a maximum of fifteen years, after which the losses expire and can no longer be used to reduce tax liability. Prior to 1981, loss carryforwards expired in five years. For firms with loss carryforwards, an additional dollar of taxable income has no effect on current tax liability. The marginal tax burden on an additional dollar of taxable earnings depends upon when the firm becomes taxable again in the future.

It is important to distinguish between firms with loss carryforwards and "firms that pay no taxes."[2] A firm with a tax loss carryforward in a given year pays no tax, but it may receive a refund if it can carry part of the loss back against previous tax payments. A marginal change in the firm's taxable earnings, however, will have no effect on its current tax liability. Its current marginal tax rate is zero, although if it expects to exhaust its loss carryforwards in the near future, it will face an effective marginal tax rate which differs from the statutory tax rate only by the price of an interest free loan for the duration of its remaining tax-loss period.

Not all firms with negative current tax payments have loss carry-forwards, however. Some firms which are carrying-back current losses may not have exhuasted their carryback potential. For these firms, the marginal tax rate on

additional income is the statutory tax rate, because an additional dollar of earned income will reduce the amount of their carryback. These firms face the statutory marginal rate even though their current tax payments are negative.

Loss carryforwards are not the only factor that may cause a firm's marginal tax rate to differ from the statutory rate. Cordes and Sheffrin (1983) explain how constraints on the use of tax credits and the corporate minimum tax also affect the distribution of marginal corporate tax rates.[3] Unfortunately, publicly available information is not detailed enough to enable us to measure the marginal tax rates facing individual corporations. This would require information on each firm's current tax credits, its credit and loss carryforwards, and even its previous tax payments to calculate its carryback potential. These data can only be obtained from a firm's past and present tax returns, which are confidential.[4] One type of tax data which can be gathered from published sources is the identity of firms with tax loss carryforwards. Corporate annual reports and 10-K filings typically contain some information on carryforwards, so we focus on this source of variation in marginal corporate tax rates.

Data limitations prevent us from assessing the significance of firms with tax credit carryforwards. Most of the firms which we identified as having tax loss carryforwards also reported credit carryforwards. There may be other firms, however, with credit carryforwards but no loss carryforwards; Cordes and Sheffrin (1983) suggest that these credit carryforward firms account for a substantial fraction of the firms facing marginal corporate tax rates below the statutory levels. We implicitly assume that firms either encounter loss and credit carryforwards simultaneously, or that they encounter neither. Future work using tax return information could extend our analysis of effective tax

rates to consider the possibility of separate credit constraints as well.

The standard source of machine-readable information on corporate accounts is the COMPUSTAT data base compiled by the Standard and Poor's Corporation. Although the data set contains a company's tax loss carrryforward if the annual report includes one, there are several serious problems with these data. First, there are two distinct ways of calculating a firm's tax loss carryforward. One is for tax purposes, the other is for financial reporting purposes. One important difference between the two is that in computing financial reporting loss carryforwards, firms exclude depreciation allowances in excess of straight line depreciation. Financial loss carryforwards may therefore be smaller than tax loss carryforwards, because accounting profits are larger than taxable profits. The two measures also differ in the treatment of discontinued operations, write-offs, and many other activities. A firm which decides to write down its investment in an unprofitable subsidiary may book a substantial loss but receive no tax benefits for the transaction, thereby leading financial reporting losses to exceed tax purpose losses. The relevant measure for analyzing corporate incentives is the tax purpose loss; unfortunately, if a firm reports both tax and financial loss carryforwards, COMPUSTAT records the financial purpose carryforward. This may lead to spurious classification of firms. Second, COMPUSTAT aggregates foreign tax loss carryforwards along with U.S. carryforwards. For multinational firms, the data may therefore provide an unreliable description of current tax status.

Firms with loss carryforwards typically report both financial and tax purpose data in their annual reports or 10-K statements. These published data, although not available in machine-readable form, provide the basis for our

study. We began with the list of COMPUSTAT firms reporting loss carryforwards for any of the fiscal years 1981-1984. We then consulted the annual reports for each of these firms; when available, we recorded the tax purpose carryforward. We also investigated all of the firms on COMPUSTAT with either negative federal tax payments or zero investment tax credits. In some cases, we found that firms with COMPUSTAT carryforwards did not have U.S. tax basis carryforwards; these were reclassified as loss-free firms. In other cases, the firms reported only one measure of their loss carryforward and did not indicate whether it was a tax or financial number. These firms (of which there were very few) were deleted from our sample. We also deleted all foreign-based firms before investigating the pattern of loss carryforwards.[5] Our data set includes 1425 firms, of whom 228 experienced tax loss carryforwards at some point between 1981 and 1984. The total market value of the firms in our sample is roughly three quarters of the total market value of the nonfinancial corporate sector.

There are several potential biases in our data sample which should be recognized at the outset. First, COMPUSTAT does not include all of the corporations which file tax returns; there were over three million such firms in 1982! The firms on COMPUSTAT are large, publicly traded firms. If losses tend to be more prevalent among smaller or start-up firms, then we may understate the number of firms with tax loss carryforwards. Second, the data set follows COMPUSTAT in including only firms which were active in 1984. Some corporations which encountered tax loss carryforwards in earlier years may either have been taken over or gone bankrupt, and the end-of-sample sampling rule imparts a clear selection bias. This may cause us to understate the number of loss carryforward firms in 1981 through 1983, although this bias is likely to be small given the

relatively low rate of both bankruptcy and takeover for firms on the COMPUSTAT tape. A third source of bias arises because not all firms with losses may report them. Firms are required to report loss carryforwards only if they are "material"; since some firms with small carryforwards may not appear as carryforward firms on COMPUSTAT, we may understate their importance. Of course, for these firms the tax consequences of the loss carryforward are likely to be especially small.

A final problem with loss carryforward data gathered from annual reports and 10-K filings is the divergence between the divisions of the firm which are included on its consolidated tax return and those which are included on the financial statements. For example, as Dworin (1985) explains, some firms do not include their finance subsidiaries in their financial statements although for tax purposes these subsidiaries are consolidated with the parent corporation.[6] We may therefore classify a parent firm as having a tax loss carryforward even though the total taxpaying entity has no carryforward. This problem is impossible to overcome when using data published in annual reports.[7]

TABLE 1: TAX LOSS CARRYFORWARD FIRMS, 1981-1984

Industry	Number of Sample Firms	Percent of Firms with Loss Carryforwards 1981	1982	1983	1984	Percent of Firms with Loss Carryforwards (Weighted by Value of Equity) 1981	1982	1983	1984
All Nonfinancial Corporations	1425	7.58	12.00	13.96	14.67	1.52	2.21	3.24	2.42
Oil (SIC 1311 & 2911)	69	13.04	23.19	24.64	24.64	1.29	0.89	2.52	2.02
Autos (SIC 3711)	7	42.86	42.86	42.86	28.57	4.08	7.18	11.88	2.21
Steel (SIC 3310)	25	12.00	32.00	32.00	36.00	16.77	55.78	55.84	53.75
Airlines (SIC 4511)	20	30.00	35.00	35.00	40.00	10.95	10.60	9.93	13.44

Notes: All calculations are based on the authors' data set which is described in the text.

2. The Importance and Persistence of Loss Carryforwards

This section uses our annual report data set for the post-1981 period, as well as accounting-purpose loss carryforward data available on COMPUSTAT for a longer sample period, to explore the economic significance of tax loss carryforwards. We ask how many firms have carryforwards, and then examine the persistence of these losses.

2.1 The Importance of Loss-Carryforward Firms

Table 1 presents summary evidence on the importance of firms with tax loss carryforwards in the years since 1981. It considers the total population of nonfinancial firms, as well as some particular industries. The table shows that although about fifteen percent of all firms are in the loss carryforward regime, they are disproportionately small firms; when weighted by the value of their outstanding common stock, only 2.4 percent of the firms (in 1984) show loss carryforwards. Although equity-value weights are attractive because they are market-determined and not subject to accounting biases, weighting firms this way may bias our calculations against finding that loss carryforwards are statistically important. Declining profitability may drive a firm into a loss-carryforward position while also reducing its market value. To address this issue we weighted firms by their 1984 net book assets, an alternative size measure. We found that 5.9 percent of all assets were held by loss-carryforward firms; while larger than our equity-based calculations, this still suggests the limited importance of loss carryforwards.

Table 1 also shows that there is substantial concentration of carryforward firms in some industries. In the oil industry (SIC codes 1311 and 2911) for ex-

ample, nearly a quarter of the firms accounting for two percent of the common stock had loss carryforwards in 1984. In 1982 and 1983, forty percent of the firms accounting for about ten percent of the value of outstanding common stock in SIC classification 3711, motor vehicles and car bodies, reported tax loss carryforwards. In the steel industry, the findings suggest a third of the firms have losses, and in this case, they are not small firms. The firms with loss carryforwards account for half of industry's outstanding equity value. Finally, for airlines we also find a high incidence of loss carryforwards: forty percent of the firms, accounting for roughly one tenth of the industry's equity value.

Table 2 shows the total value of the loss carryforwards for the firms in our sample. These carryforwards aggregated to 5.1 billion dollars in 1981, 10.0 billion in 1982, 15.1 dollars in 1983, and 12.8 billion dollars in 1984. These carryforwards can be compared to corporate tax receipts of roughly sixty billion dollars in 1984. The U.S. stock of carryforwards is therefore small relative to that in either the U.K. or Canada. The center panel in Table 2 relates the value of the tax loss carryforwards to the market value of the affected firms. In 1984, the nominal value of the carryforwards equalled forty-eight percent of the firms with these carryforwards. In some industries, notably steel, autos, and airlines, tax loss carryforwards actually exceed the equity value of the loss-carryforward firms. The bottom panel of Table 2 relates the value of loss carryforwards to the market value of all firms in particular industries. In steel, carryforwards are eighty percent as large as the outstanding market value of the industry. The comparable statistic is twenty-eight percent in airlines, but below five percent in the other industries we consider.

To provide additional perspective on the problem of loss-carryforward firms,

TABLE 2: ESTIMATES OF TAX LOSS CARRYFORWARDS, 1981-1984

Tax Loss Carryforwards, Millions of Current Dollars

Industry	1981	1982	1983	1984
All Nonfinancial Corporations	5070.1	10000.8	15083.6	12841.7*
Oil	45.7	129.4	1353.3	1291.3
Autos	2278.7	2407.0	2853.0	1262.0
Steel	96.8	1274.0	2389.1	3808.3
Airlines	568.5	1054.1	2197.8	2171.5

Tax Loss Carryforwards as a Percent of Affected Firms' Equity Value

Industry	1981	1982	1983	1984
All Nonfinancial Corporations	38.5	44.3	37.2	47.6*
Oil	2.0	9.5	29.2	36.3
Autos	371.9	125.0	65.6	147.4
Steel	10.1	51.7	64.4	148.8
Airlines	127.8	141.1	279.8	204.6

Tax Loss Carryforwards as a Percent of All Firms' Equity Value

Industry	1981	1982	1983	1984
All Nonfinancial Corporations	0.6	1.0	1.2	1.1*
Oil	0.03	0.1	0.7	0.7
Autos	15.2	9.0	7.8	3.3
Steel	1.7	28.8	36.0	79.9
Airlines	14.0	15.0	27.8	27.5

Notes: Calculations are based on the authors' data set consisting of 1425 firms. Tabulations for 1984 exclude the Penn Central Company, for which no data were available. See text for further details.

Table 3 displays the twenty largest loss-carryforward firms in our sample, measured by equity value, with their tax loss carryforwards for 1983. The table depicts the same industry concentrations described above: the twenty firms include three railroads, four auto or heavy machinery manufacturers, four steel companies, and two copper companies. Although most firms on the list experienced tax losses because of poor profit performance, some firms (Storer Communications and Turner Broadcasting, for example) appear because substantial investment programs generated depreciation allowances significantly greater than taxable earnings from current operations.

2.2 The Persistence of Tax Loss Carryforwards

The extent to which the restricted loss-offset provisions in the corporation tax affect investment and financing incentives depends upon the duration of non-taxable spells. If firms with loss carryforwards can expect to recover their taxable status within a year or two, then the absence of loss offset provisions will have relatively little effect on incentives. If firms with carryforwards tend to be constrained for many years, however, then they may face incentive effects which are substantially different from those of taxable firms.

We adopt two different approaches to analyzing the persistence of tax loss carryforwards. First, we use our data for the last four years to fit simple Markov models for transitions into and out of the loss carryforward state. This provides the basis for our analysis of effective tax rates in later sections, but it is limited by the fact that our data span a period of only four years. Moreover, since these years include a very deep recession, transition probabilities from the recent period may be unrepresentative of those confronting firms

TABLE 3: THE TAX LOSS CARRYFORWARD TOP TWENTY, 1983

Firm Name	Equity Value ($ million)	Tax Loss Carryforward
1. Burlington Northern	3677.8	405.1
2. Chrysler Corporation	3365.0	1600.0
3. U.S. Steel	3178.4	1200.0
4. General Dynamics	3064.4	137.3
5. Syntex Corporation	1799.7	110.0
6. Bethlehem Steel	1318.1	682.3
7. Penn Central	1164.0	2097.4
8. LTV Corporation	1017.6	630.0
9. IC Industries	799.1	126.3
10. Asarco Inc.	775.6	12.4
11. Inland Steel	771.8	466.1
12. Phelps Dodge Corp.	622.2	380.0
13. Storer Communication	612.7	39.8
14. Clark Equipment	560.2	44.0
15. Datapoint Corporation	552.8	4.2
16. Alleghany Corporation	524.9	unknown
17. American Motors	514.0	257.0
18. Turner Broadcasting	484.2	17.3
19. Best Products	478.1	1.0
20. International Harvester	466.7	996.0

Notes: Firms are ranked by outstanding equity value at the end of 1983. The Alleghany Corporation reported the presence of tax-purpose loss carryforwards, but it did not report their amount.

over a longer horizon. To obtain information on long-term persistence of loss carryforwards, we therefore perform the same calculations using a second data source, the partially contaminated accounting loss carryforward data from COMPUSTAT, for the period 1968-1984. These data are also used to construct empirical distributions of the number of firms with losses which persisted for one year, two years, three years, etc. Although the differences between tax and book loss carryforwards make these tabulations an imperfect source of information on persistence, they do permit us to compare the recent experience with that in prior years.

Table 4 reports summary statistics, based on our post-1981 data sample, for transitions into and out of loss-carryforward status. The top panel shows probabilities based on the first-order Markov assumption, i.e. treating a firm's current status as containing all relevant information about it's transition prospects. These estimates show that for the 1983-1984 period, the probability that a firm which did not experience a loss carryforward in period t would experience one in period t + 1 is .026. For a firm with a loss carryforward in period t, the probability of remaining in the loss-carryforward state at t + 1 is .913.

In calculating simple Markov probabilities, we are implicitly assuming that all firms have identical transition probabilities and that these probabilities did not vary between 1983 and 1984. Neither assumption is realistic, and these results should therefore be regarded as a simple way of summarizing the data rather than as parameters of a structural model of transition behavior.

There are two significant reasons why the transition probabilities are likely to vary across firms: different firms have loss carryforwards of dif-

TABLE 4: TAX STATUS TRANSITION PROBABILITIES

FIRST ORDER MARKOV MODEL

Previous State	Probability of Moving to State of: No Loss Carryforward	Loss Carryforward
No Loss Carryforward	.974	.026
Loss Carryforward	.087	.913

SECOND ORDER MARKOV MODEL

Previous State	State in Period t + 1: No Loss Carryforward	Loss Carryforward
No Loss Carryforward (t-1) No Loss Carryfroward (t)	.977	.023
No Loss Carryforward (t-1) Loss Carryforward (t)	.099	.901
Loss Carryforward (t-1) No Loss Carryforward (t)	.680	.320
Loss Carryforward (t-1) Loss Carryforward (t)	.083	.917

Notes: All calculations are based on the authors' data set, described in the text, which yields 2849 firm-years of data. The estimates are for transitions observed in 1983 and 1984.

ferent sizes, and there are probably differences in the stochastic processes driving their taxable income streams. Auerbach (1983) estimated a model for tax status in which the firms' tax loss carryforward was modelled as a continuous variable. This requires imputing potential carrybacks to firms with no loss carryforwards, and it also necessitates complicated numerical integration in evaluating effective tax rates. The Markov model used here yields great simplification in computing tax incentives. Both procedures may be sensitive to missing information about the vintages of carryforwards, since two firms with loss carryforwards of identical size, one whose losses were generated fifteen years ago and the other whose losses were generated last year, have radically

The second source of heterogeneity, potential differences in profit processes, is more difficult to treat because it invalidates our assumption of a simple Markov process. A firm's characteristics, and potentially lagged values of its loss carryforward status, may affect its transition probability.[8] We introduce some additional flexibility in our transition matrix by estimating a second-order Markov process.

The results of estimating the second-order process are shown in the second panel of Table 4. We tested the assumption of a first-order Markov process against the alternative of a second-order process (see Anderson and Goodman (1957)) and rejected the first-order assumption at the .10 level but not the .05 level. The $\chi^2(2)$ statistic was 5.02, with a .05 critical value of 5.99. We use the second-order process in later sections to calculate effective tax rates.

Two important conclusions emerge from Table 4. First, it is very unlikely for a firm without a tax loss carryforward to incur one. Second, it is also unlikely for a firm with a tax loss carryforward to "escape" and become taxable

again. These findings are important, because they suggest that the burden of the tax code's asymmetry is not borne uniformly, but rather falls heavily on the relatively few firms with tax loss carryforwards. This also implies that standard calculations of effective tax rates which neglect the role of loss carryforwards may conceal important interfirm variations in tax incentives.

The most significant drawback of our post-1981 data is that we cannot examine the long-term persistence of tax loss carryforwards. We can address this issue using the data on accounting tax loss carryforwards drawn from the COMPUSTAT tape, however. To evaluate the potential biases associated with these data, we compared their second-order Markov transition probabilities for the 1983-1984 period with those obtained from our annual reports data. The probability that a firm with two previous years of loss carryforward would remain in the loss carryforward state was .928 in the COMPUSTAT data, compared with .917 in the annual reports data. The probability of remaining carryforward-free after two years of being currently taxable was .966 rather than .977. The COMPUSTAT data therefore probably overstate the persistence of tax losses because the chances of experiencing a tax loss in a given year, for both firms which have and have not experienced them in the past, are higher in these data. This is consistent with our finding that financial purpose loss carryforwards, because they include asset write-offs and other losses, may appear more significant than the comparable tax-purpose losses. Nonetheless, the close agreement between the COMPUSTAT and annual report-based data suggest that valuable information can be obtained by studying COMPUSTAT transition probabilities over time.

Table 5 presents the pattern of transition probabilities from the COMPUSTAT

TABLE 5: TAX STATUS TRANSITION PROBABILITIES ESTIMATED FROM COMPUSTAT SAMPLE

Year	p_{TTL}	p_{TLL}	p_{LTL}	p_{LLL}
1968	.034	.533	.000	.758
1969	.024	.840	.067	.800
1970	.030	.700	.267	.702
1971	.045	.889	.129	.895
1972	.021	.800	.000	.822
1973	.022	.773	.133	.778
1974	.035	.760	.108	.802
1975	.020	.900	.069	.798
1976	.018	.696	.033	.734
1977	.026	.850	.087	.786
1978	.015	.849	.036	.793
1979	.016	.647	.167	.709
1980	.015	.696	.119	.894
1981	.020	.727	.050	.921
1982	.047	.963	.167	.920
1983	.034	.923	.000	.941
1984	.036	.950	.231	.926
Means:				
1968-1984	.027	.825	.103	.830
1968-1980	.024	.787	.102	.789
1981-1984	.034	.909	.113	.928

Notes: Each column reports the transition probabilities calculated from the COMPUSTAT data set of financial purpose tax loss carryforwards.

sample. It reports our estimates of the four basic transition rates for each year between 1968 and 1984, as well as the probabilities for the full sample period and two subsamples. Two conclusions emerge. First, the probability that a firm with loss carryforwards in the two previous years will experience another year of tax loss increased substantially in 1981. We denote this probability as p_{LLL}, where the subscripts refer to the tax status in periods t-2, t-1, and t, respectively. The subscript takes the value L for loss carryforward, and T for currently taxable. The probability p_{LLL}, which never exceeded .90 in the years prior to 1980 and which was frequently below .80, averages .928 since 1981. The probability of remaining in the loss position rises between 1981 and 1983, then declines in 1984, reflecting in part changing business cycle conditions. There is also a discontinuity in 1981 in the probability that a firm which has experienced a taxable year followed by a loss year will remain in the loss state, p_{TLL} in our notation. From a pre-1981 average of .787, the parameter changes to a post-1981 value of .909.

The table also shows a substantial post-1981 increase in the probability that a taxable firm will experience a loss carryforward. From .024 before 1981, p_{TLL} increased by nearly forty percent to .034. There is a smaller increase in the chance that a firm which has experienced a loss carryforward year followed by a taxable year will re-enter loss status. These movements in the Markov transition probabilities correspond to changes in the steady state distribution of firms with respect to tax status. The pre-1981 probabilities imply that in the steady state, 10.9 percent of all firms have tax loss carryforwards. The comparable steady-state value for the post-1981 probabilities is 33.5 percent, a striking increase.[9] This undoubtedly overstates the long-run effect of the 1981

tax reform, since it is difficult to disentangle the effects of the 1981 tax reform from the post-1981 recession.

Our estimates of second-order Markov transition rates are incomplete because they shed no light on the behavior of firms which have experienced losses for many periods. One way to study this long-term persistence is by calculating the probability that a firm with a loss in a particular year will experience losses for one more year, two more years, etc. Table 6 presents calculations of these long-term transition rates from the COMPUSTAT data sample for the period 1974-1983.[10] The table shows that a significant fraction of firms which experience tax losses in a given year will continue to have such losses for at least four more years. The probability of this much persistence has also risen over time, from .32 in 1974 to .50 in 1980, the last year for which it is possible to calculate the four-year-later transition rate.

The estimates presented in this section are at best a rough characterization of the transition probabilities confronting firms. In the next two sections, we calculate effective tax rates for hypothetical firms whose movements into and out of the tax loss state are given by our estimates. This analysis, which is primarily illustrative, demonstrates the potentially important effect of loss offset provisions on effective tax rates.

TABLE 6: PERSISTENCE OF TAX LOSS CARRYFORWARDS, 1974-1983

Year of Initial Loss	Fraction of Firms with Loss Carryforwards for:									
	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	9 Years	10 Years
1974	.801	.588	.432	.319	.226	.179	.152	.125	.117	.105
1975	.734	.548	.411	.302	.246	.210	.181	.153	.133	
1976	.760	.591	.436	.364	.316	.267	.231	.187		
1977	.782	.559	.472	.418	.355	.314	.259			
1978	.705	.589	.521	.430	.377	.309				
1979	.784	.668	.558	.484	.394					
1980	.813	.696	.601	.500						
1981	.836	.717	.594							
1982	.849	.709								
1983	.818									

Notes: Tabulations are based on the financial-purpose loss carryforwards reported by firms on the 1984 COMPUSTAT Industrial data file. See text for further details.

3. The Incentive to Invest in the Presence of Tax Losses

Unlike more direct forms of investment subsidy, tax loss carryforwards are likely to affect different firms and asset types differently. A firm with substantial unused tax benefits may appropriately view itself as temporarily "tax exempt," while a firm with a small carryforward which it expects to utilize during the next year regardless of its current decisions should take no account of it in making investment decisions. The differences across asset type stem from differences in the timing of taxable income. Many assets, such as equipment under current law, may be expected to generate negative taxable income in their initial years. If a firm has unused tax benefits when the project begins, this will decrease the asset's after-tax income. Since the accruing losses must be carried forward until the firm achieves a positive tax liability, some investments may actually be discouraged by the presence of unused tax benefits.[11] This section describes our methodology for quantifying these incentive effects.

There are a number of approaches to measuring the impact of tax law asymmetries on investment incentives. Ideally, one would specify a dynamic model of firm value maximization in which risky investment would be affected by, and in turn would affect, the magnitude of unused tax benefits present at different dates in different states of nature. This problem is complicated by the joint endogeneity of investment and the firm's tax status.[12] To make the problem more tractable, if less general, one may restrict the endogeneity of either the firm's investment behavior or its tax status. The former approach is taken by Majd and Myers (1985,1986). They value the tax payments associated with risky projects, taking account of the project's impact on the firm's future tax sta-

tus. Their approach highlights the interaction between the project's risk and the risk of other random changes in the firm's tax status, but it ignores potential changes in corporate behavior which may result from variation in tax status.

An alternative approach, the one taken here, assumes that the probability distribution of future tax status is determined by the firm's history alone. This can be interpreted as treating the marginal investment project as small relative to the rest of the firm, so that the firm's tax status is determined by the stochastic returns on its prior investments. The assumption that the probability distribution of tax status is invariant with respect to marginal decisions is justified if this distribution is the direct result of firm optimization decisions. This interpretation highlights one of this approach's shortcomings, however, in that it is necessarily restricted to partial equilibrium analysis of changes in tax rules or other components of the economic environment. We cannot predict how a change in tax regime would affect the incentive to invest, since it could both change the firm's statutory tax benefits holding its investment decisions fixed and alter the probability distribution of its future tax status.

3.1. Effective Tax Rates with Loss Offset Limits

The summary statistic used throughout our analysis is the effective tax rate on a marginal investment project, calculated as the percentage difference between the internal rates of return on expected cash flows before and after tax. We assume that these marginal investments are inherently risk-free, and that the only source of uncertainty is the time profile of future tax payments. We designate the project's before-tax rate of return as ρ, which is set equal to .06 in all calculations. The asset depreciates at a constant rate, δ, so an

investment made at the beginning of period 0 yields a gross return in period t of $(\rho + \delta)(1-\delta)^{t-1}$ per dollar of initial investment.

We assume that the investment tax credit and the first half-year depreciation allowance accrue at date 0. Thus, the firm's project-specific accrued tax liability (B_t) at date t is:

$$(1) \quad B_t = \begin{cases} \tau[(\rho+\delta)(1-\delta)^{t-1} - D_t(1-i)^t] & t > 0 \\ -k - \tau D_0 & t = 0 \end{cases}$$

where τ is the corporate tax rate, k the investment tax credit, D_t is the nominal date t depreciation allowance, and i is the inflation rate. These expressions describe an equity-financed project; with debt finance, interest deductions would also enter the formula for B_t.

Under a symmetric tax system with full loss offset, equation (1) would describe actual tax payments. The project's after-tax internal rate of return, r, would be defined implicitly by the expression:

$$(2) \quad -B_0 + \sum_{t=1}^{\infty} (1+r)^{-t}[(\rho+\delta)(1-\delta)^{t-1} - B_t] = \sum_{t=1}^{\infty} (1+r)^{-t}[(\rho+\delta)(1-\delta)^{t-1}] - T(r) = 1$$

where T(r) denotes the present value of tax payments computed using discount rate r. After simplification, equation (2) yields the more familiar user cost of capital expression:

$$(3) \quad \rho + \delta = (r+\delta)(1-k-\tau z)/(1-\tau).$$

We use z to denote the present value of depreciation allowances discounted at r. The value of r which solves (2) is used to define the effective tax rate:

$$(4) \qquad ETR = (\rho - r)/\rho$$

which is just the difference between pre-tax and post-tax rate of return, measured as a fraction of the pretax return.

When the tax system imposes limitations on the deduction of losses, actual tax payments may differ from B_t. This requires us to amend equation (2) before r and the effective tax rate can be calculated. Each accrued tax liability gives rise to a distribution of expected tax payments, since the firm may not be taxable when the tax liability or benefit accrues. In some states of nature, the firm will be taxable in period t and the accruing tax, B_t, can then be realized immediately. If the firm has a tax loss carryforward and B_t is positive, its loss carryforward will be reduced and the firm will experience an increase in its tax payments in the year when it exhausts its carryforward and becomes taxable. If B_t is negative, loss carryforwards will increase and there will be a reduction in the firm's tax payments in the (future) year when the firm begins paying taxes again.

To describe the distribution of tax payments corresponding to a tax accrual in period t, we need some notation. We define $\pi^t_{LS_T}$ to be the probability that a firm with a loss carryforward in year t returns to being taxable in year t + s. The subscripts denote the firm's tax status in the years beginning in year t, and a T subscript indicates a taxable year while an L indicates a year with a loss carryforward.[13] Thus, π^t_{LT} is the probability that a firm with a loss carryforward in year t will become taxable in the next year. Both π^t_{LLT} and $\pi^t_{L2_T}$ represent the probability that a firm with loss a carryforward in period t will remain non-

taxable for one more period, and then return to current taxable status two periods in the future. These probabilities, which we will ultimately derive from our Markov transition parameters, enable us to compute the expected tax payments corresponding to a tax accrual in period t.

Our analysis so far has omitted two important features of the tax system. First, since there are limits on the number of years (N) an accrued tax payment can be carried forward, the distribution of tax payments from an accrual at t will be truncated after t + N. Second, we have ignored the role of loss carrybacks. Once carrybacks are permitted, each expected tax payment increases the firm's potential ability to subsequently carry back future tax losses. We will use ν_{ts} to denote the shadow value of additional tax payments in year t + s, viewed from the perspective of year t. With these complications, the present expected value of tax payments, T, becomes

$$(5) \quad T(r) = \sum_{t=0}^{\infty} B_t \left(\frac{1-i}{1+r}\right)^t \left[\sum_{s=0}^{\infty} \left(\frac{1-i}{1+r}\right)^s \pi^t_{Ls_T}(1-\nu_{ts})\right].$$

The term in brackets is the expected present value of a one dollar tax accrual in period t. Equation (5) defines T(r), which can in turn be substituted into (2) to compute effective tax rates based on expected tax payments.[14]

3.2. Computing the Time Distribution of Tax Payments

To implement these effective tax rate calculations, we need the probability distribution of tax payment dates for each accrued tax liability. We compute these distributions from the second order transition probabilities in Tables 5 and 6. These calculations are facilitated if we introduce new variables corres-

ponding to the probability that a firm is in each of the four possible states, TT, TL, LT, and LL, in a given period. We use q^t_{ij} to represent these probabilities. For a firm which is known to have a tax loss in the period before, and period of, a new project investment, $q^0_{LL} = 1$ and $q^0_{LT} = q^0_{TL} = q^0_{TT} = 0$. In general, the probability that a firm will be taxable in period one is

$$(6) \qquad \pi^1_T = q^1_{LT} + q^1_{TT} = (q^0_{LL}p_{LLT} + q^0_{TL}p_{TLT}) + (q^0_{TT}p_{TTT} + q^0_{LT}p_{LTT}).$$

The second part of the equation shows how the year one probabilities can be built up recursively from the starting conditions, the q^0_{ij}, and the transition probabilities which were discussed in the last section. Similar calculations permit us to derive the probabilities of finding the firm in other tax states in period one.

The probability that the firm will carry its taxes from the investment year forward exactly one period is $\pi^0_{LT} = q^0_{TL}p_{TLT} + q^0_{LL}p_{LLT}$. Parallel calculations show that the unconditional probability of carrying taxes forward for two years or more is $\pi^0_{LL} = q^0_{TL}p_{TLL} + q^0_{LL}p_{LLL}$, and the probability of carrying a loss forward for exactly two years is $\pi^0_{LLT} = p_{LLT}\pi^0_{LL}$. Probabilities corresponding to longer carryforwards can also be calculated recursively.

While these calculations have considered the distribution of tax accruals from period zero, it is straightforward to apply this approach to compute the distribution of tax payments corresponding to accruals later in the project's life. The initial conditions are just the (q^t_{ij}) corresponding to the firm's probabilities of being in each tax state at the beginning of period t. These can be calculated recursively from the (q^0_{ij}) and the transition probabilities as in equation (6). As we iterate forward, however, the firm's tax status in year zero becomes less important as a predictor of its period t status and the π vec-

tor converges to a steady state value. In practice, we truncate our calculated π vector after twenty elements and let the twenty-first element capture all of the remaining probability.[15]

We incorporate loss carryforwards by assuming that all deferred tax payments may be carried forward N years, where N is the statutory maximum for carrying losses forward.[16] Incorporating carrybacks is more complicated, since the opportunity to carry losses back has the effect of making every tax payment potentially valuable in facilitating the accelerated deduction of future tax losses. This imparts a shadow value to tax payments; we calculate this shadow value in two stages. First, we compute a distribution of expected tax payments under the assumption that there are no carrybacks. Then, we account for carrybacks by reducing each dollar of estimated tax payments by a shadow value which depends upon the firm's current tax status and the estimated transition probabilities. The calculation of the carryback shadow value is described in greater detail in the Appendix.

3.3. Qualifications

All of the analysis in this section presumes that the effective tax rates which apply to a firm's investment choices are a function of its own tax status. This need not be the case. Leasing arrangements are one example of a channel through which the effective tax rates of the firms using and owning an asset can be separated. These institutions have been particularly popular in some of the industries with a significant incidence of tax losses, such as airlines. It is important to realize however that although leasing can reduce the present value of tax payments for a constrained firm, its impact on the firm's incentive to

invest in new capital is less clear. A firm which has a loss carryforward would be better off if it could utilize this tax benefit right away, since it the associated tax benefit loses value over time and may expire. Given that the firm cannot use this tax benefit, however, it may be encouraged to invest more, since additional taxable income generated by new investment will enable it to offset part of the loss carryforward.

A second limitation inherent to our analysis is its exclusive focus on tax policies. For some of the large firms who have tax loss carryforwards, taxation is just one of the many ways in which the goverment and the firm interact. Examples of other policies which clearly affect the performance of the firms and the welfare of their shareholders include direct loan guarantees, regulation (especially for airlines and railroads), tariff policy, and in some cases (such as General Dynamics) goverment purchasing policy. Analyzing changes in tax rules without considering the offsetting changes which might occur in the other policy instruments is therefore necessarily incomplete.

4. Empirical Results

This section presents numerical calculations illustrating how tax losses affect investment incentives. We consider general industrial equipment and industrial buildings, and estimate the effective tax rates associated with each under the tax regimes of 1965, 1975, and 1985. We then explore the sensitivity of these tax rates under current law to changes in both the tax code and the economic environment.

4.1. Changes in Effective Tax Rates Over Time

In 1965, the corporate tax rate was .48 and the investment tax credit, which was available only on equipment, was 0.07 with no basis adjustment. The equipment class could be written off over twelve years using the double-declining balance method with an optimal switch to straight-line, while structures received the same treatment over twenty-nine years. Tax losses could be carried forward for five years and back for three.

By 1975, the ITC on equipment had been raised to 0.10 and, due to the introduction of the Asset Depreciation Range System, equipment could be written off in ten years. In addition, structures had been restricted to using the 150 percent declining balance method. The corporate tax rate was still .48, and the carryforward and carryback provisions were the same as those in 1965.

Through tax changes in 1978, 1981, 1982, 1984, and 1985, equipment now receives a 10 percent ITC with 50 percent basis adjustment and depreciation over five years following the pattern established by the Accelerated Cost Recovery System (ACRS). Structures may be written off over 19 years using the 175 percent declining balance method with switchover to straight line. In 1981, the

carryforward period for losses was increased to fifteen years. The statutory corporate tax rate in 1985 was .46.[17]

We estimate the pattern of before-tax cash flows for each asset assuming that the before-tax rate of return, net of depreciation, is six percent and that the asset depreciates at the rate estimated by Hulten and Wykoff (1981): 3.61 percent per year for buildings, 12.25 percent per year for equipment. We set the inflation rate at four percent throughout our calculations, and use a real discount rate of .03 to compute the shadow values of potential carrybacks.[18]

A firm's tax burden is critically dependent on the vector of probabilities describing the number of years which will elapse before its first passage into currently-taxable status. Using the transition probabilities estimated for the COMPUSTAT sample in the 1968-1984 period, we calculate this vector for two hypothetical firms. The first has just experienced its second consecutive year of tax losses ($q_{LL} = 1$), while the second is "the representative firm" in the sense that it has probabilities of being in states LL, LT, TL, and TT corresponding to the Markov process' steady state.

Table 7 shows the π vectors for each of these firms. The π vector reports the probability that each firm will experience tax loss spells of different lengths. The low probability of switching states leads very little of the representative firm's weight to be in states TL or LT. In the steady state, 83.2 percent of firms are taxable in both the current and the previous year, while 12.1 percent of firms have had tax loss carryforwards in both years. Alternatively, roughly 85 percent of all accrued tax payments will accrue to firms which can deduct them immediately.[19] Firms which are non-taxable remain non-taxable for long periods, however. A firm with tax losses in the previous

TABLE 7: DISTRIBUTIONS OF YEARS UNTIL FIRST PASSAGE INTO TAXABLE STATUS

Number of Years Until Currently Taxable	Firm with Loss Carryforward in Periods t and t-1	Representative Firm
Currently Taxable	0.000	0.854
1	0.170	0.025
2	0.141	0.021
3	0.117	0.017
4	0.097	0.014
5	0.081	0.012
6	0.067	0.010
7	0.056	0.008
8	0.046	0.007
9	0.038	0.006
10	0.032	0.005
11	0.026	0.004
12	0.022	0.003
13	0.018	0.003
14	0.015	0.002
15	0.013	0.002
16	0.010	0.002
17	0.009	0.001
18	0.007	0.001
19	0.006	0.001
20+	0.029	0.005

Notes: All calculations are based on average transition probabilities from the full sample 1968-1984 COMPUSTAT data file. The first column reports the π^t vector for a firm which reports a tax loss carryforward in periods t and t-1. The second column shows the analogous π^t vector for a firm which has the steady-state probabilities of being in each state: TT with 82.9% probability, TL and LT each with 2.5% probability, and LL with 12.1% probability. See text for further details.

two years is more likely than not to wait at least four years until paying a currently accruing tax liability.

Table 8 presents our effective tax rate calculations for the years 1965, 1975, and 1985 based on the assumption that each asset is entirely equity-financed. The table shows the general trend toward reduced effective tax rates on equipment over this time period, with the ETR for a taxable firm falling from 27.5 percent in 1965 to -5.0 percent in 1985. The dramatic reductions in the ETRs for taxable firms are however not reflected in the ETRs for tax loss carry-forward firms, where the reduction is from 30.8 percent in 1965 to 15.0 percent in 1985. For structures, the differences between taxable firms and loss-carry-forward firms are much smaller. This is of course due to the much longer life-time of these assets, and the consequent tendency for initial differences in tax status to be damped out over the project horizon.[20]

The effect of asymmetric treatment of gains and losses on effective tax rates is ambiguous, as noted in Auerbach (1983). Having a loss postpones all tax liabilities, but especially the earliest ones which may be negative. The latter effect is most important for equipment, where the currently taxable firm faces a much lower effective tax rate than the loss-carryforward firm. The impact on structures, for which immediate tax benefits are smaller, is in the opposite direction.

The results also confirm the common view that tax losses prevent firms from receiving the full incentive to invest intended by increases in accelerated depreciation and the investment tax credit over recent years. While holding inflation at four percent the hypothetical firm under symmetric taxation had its effective tax rate on equipment reduced by 33.4 percentage points in the last

TABLE 8: INVESTMENT INCENTIVES MEASURED BY EFFECTIVE TAX RATES

General Industrial Equipment

Firm Type	1965 Law	1975 Law	1985 Law
Loss Carry-forwards at t and t-1	30.8	24.2	15.0
Taxable at t and t-1	27.5	9.2	-5.0
Firm Facing Perfect Loss Offset Code	34.2	15.8	0.8

Industrial Buildings

Firm Type	1965 Law	1975 Law	1985 Law
Loss Carry-forwards at t and t-1	42.5	45.0	39.2
Taxable at t and t-1	49.2	53.3	42.5
Firm Facing Perfect Loss Offset Code	56.7	60.8	48.8

Notes: All calculations assume an inflation rate of .04 and a pretax return to capital of .06. For equipment, δ = .1225 and for structures, δ = .0361. We employ the 1968-1984 transition probabilities from Table 5.

two decades. The taxable firm enjoyed a similar decline of 32.5 percentage points, but the reduction was just 15.8 percentage points for the nontaxable firm. It therefore received less than half of the full statutory benefit.

Our earlier results suggesting the high concentration of tax loss firms in a few industries also indicate that previous estimates of effective tax rates by industry[21] may be misleading. For steel, airlines, and automobiles, for example, it is essential to recognize that a substantial fraction of firms have tax loss carryforwards and therefore face effective tax rates different from those facing taxable firms. In these industries, there are also likely to be important interfirm differences in effective tax rates due to variation in corporate histories and tax status.

Our algorithm also computes the shadow value of carrybacks and the value of a dollar of accruing tax losses for a firm which has just entered the untaxed state. For 1965 and 1975, when the carryforward period was five years, the shadow value of a carryback to a firm which had been taxable for two years was .040; for a firm which had been nontaxable in the previous year and was taxable in the current year, this value was .072. The expected present value of a dollar of currently accruing losses to a firm which had just incurred a tax loss carryforward for the first time was .479 dollars. In 1985, with the longer period for carrying losses forward, these three parameters were respectively .026, .044, and .661.

The magnitude of the carryback shadow values suggest the limited usefulness of current carryback provisions. This is because most losses accrue to firms which experience several years of losses, and because most future losses will be recovered through the carryforward provision. Allowing firms the option of

carrying losses back typically accelerates the recognition of tax benefits, but does not enable the firm to claim tax benefits which would otherwise have expired unused. By contrast, the length of carryforward provision does appear to have a substantial effect on the expected value of a dollar of accruing tax losses. The longer carryforward period in 1985 both raises the value of a marginal dollar of carryforwards, and lowers the value of the carrybacks since accelerating the recovery of a tax loss is less critical with the expiration constraint relaxed.

4.2. Sensitivity of Effective Tax Rates

Our results in Table 8 may actually underestimate the dispersion of effective tax rates facing corporations. Table 9 presents calculations for a number of alternative assumptions about economic conditions, corporate behavior, and tax policy. The second row of each panel shows the effect of an inflation shock which raises the inflation rate from .04 to .10. This causes a large jump in all of the calculated effective tax rates, the largest for taxable firms investing in equipment. The effective tax rate rises by more in each case for currently taxable than for non-taxable firms. This is because loss-carryforward firms are already receiving their depreciation allowances at later dates than currently taxable firms. This reduces the contribution of the depreciation allowances to the project's present value, and hence lowers the sensitivity of the effective tax rate to inflation shocks which further erode the value of these allowances.

The third row of each panel shows the effective corporate tax rate, net of interest deductions, when investments support real interest payments equal to a

TABLE 9: SENSITIVITY OF EFFECTIVE TAX RATES TO ALTERNATIVE ASSUMPTIONS

Estimates Using Transition Probabilities from COMPUSTAT Data Sample

Assumption	Firm with Loss Carryforward in Periods t & t-1	Firm which is Taxable in Periods t & t-1	Hypothetical Firm Facing Perfect Loss Offset
		General Industrial Equipment	
Base Case	15.0	- 5.0	0.8
Inflation = .10	26.7	9.2	19.2
Real Interest Payments = .10* (Pretax Returns)	5.0	-20.0	-15.8
Unlimited Carryforwards	14.2	- 5.0	0.8
Elimination of Carrybacks	15.8	- 5.8	0.8
		Industrial Buildings	
Base Case	39.2	42.5	48.3
Inflation = .10	44.2	51.7	60.8
Real Interest Payments = .10* (Pretax Returns)	28.3	30.0	34.2
Unlimited Carryforwards	39.2	42.5	48.3
Elimination of Carrybacks	40.8	43.3	48.3

Notes: The baseline case corresponds to the 1985 law in Table 8. Maintained assumptions are the same as those in Table 8.

historically typical ten percent of before-tax investment returns. With the addition of interest deductions the value of being taxable increases, particularly as inflation rises. The use of partial debt-finance lowers the expected corporate tax bill, although its effect on total corporate and individual tax payments is probably smaller given the individual tax advantage to holding equity. It is of greatest benefit for taxable firms. The effective tax rate reductions for equipment and structures are 15.0 and 12.5 percentage points for the firm with no losses in the last two years, compared to 10.0 and 10.9 points for the firm with two consecutive loss years and 16.6 and 14.1 points for the firm facing perfect loss-offsets. Overall, the addition of this moderate level of interest expense amplifies the advantage of being taxable. The effective tax rates on structures are very close while taxable firms enjoy a substantial advantage in equipment. Taking interest deductions into account, being nontaxable probably discourages marginal investment and induces a shift away from equipment investment.

The last two sets of calculations in Table 9 consider the impact of altering the tax provisions regarding the loss carryforwards themselves. The first set estimates the effect of permitting unlimited carryforwards, while the second examines the impact of eliminating the ability to carry losses back. Our earlier calculations suggested that increasing the time limit on the use of tax losses from five to fifteen years in 1981 substantially increased the expected present value of a dollar of loss carryforwards. Extending the limit beyond fifteen years appears to be less important. For taxable firms, the effective tax rates on both equipment and structures are only changed in the second decimal place, and for equipment, there is a small (0.8 percent) change in the

effective tax rate for non-taxable firms, as a result of allowing unlimited carryforwards. Similarly, disallowing carrybacks has a relatively small impact. The largest change in an effective tax rate is for structures, where the ETR on a nontaxable firm rises 1.6 percent and that for a taxable firm increases 1.2 percent. Both types of firms experience smaller effects on the equipment effective tax rate. Structures are more affected because the chance of a firm having an opportunity to use a loss carryback provision is substantially greater due to the asset's longer life.

The pattern of ETR changes associated with carryback and carryforward reforms underscores the interaction between these provisions. Eliminating carrybacks raises the effective tax rate on all assets except equipment investment by taxable firms, where the ETR declines. Equipment investments initially had a negative effective tax rate, and the ETR becomes more negative. All of the other asset/firm status combinations had positive ETRs, and they become more positive. This is because eliminating carrybacks raises the shadow cost of tax payments and lowers the the shadow value of tax benefits. When carrybacks are permitted, the firm's shadow cost of a tax payment is less than the actual payment because it may be used to carryback future losses. Eliminating carrybacks removes this option, and thereby raises the present value of the tax payments for all assets with initial positive tax rates. Since tax payments are now more costly, those assets with mostly positive tax payments are reduced in value. By comparison, the value of those assets with net tax benefits (i.e., equipment purchased by a currently taxable firm) increases, because the shadow value of receiving a tax deduction has also increased. This reduces still further the negative effective tax rates.

Allowing for unlimited carryforwards has no noticeable effect on any effective tax rate except that for nontaxable firms investing in equipment, where the effective tax rate rises. This occurs even though the firm carrying losses forward will be better off with an extension of the time limit, because positive marginal tax payments that otherwise might have been entirely avoided may now have to be made.

The results in this section have all been derived using the average transition probabilities estimated over the 1968-1984 period. These suffer from several drawbacks, as suggested in the second section. Table 10 reports the baseline current-law effective tax rate and sensitivity calculations using the second s well as the sen-order transition probabilities estimated for the 1981-1984 period. The results are strikingly similar to those in Table 9, with the one significant exception being the effective tax rate on structures for firms with tax loss carryforwards. Using the full sample probabilities, this effective tax rate was 39.2 percent. In Table 10, it is only 24.2 percent. The difference arises because using the post-1981 transition probabilities, a firm with two years of loss carryforward has a greater chance (.913) of remaining in the untaxed state than under the full sample probabilities (.830). This increases the persistence of tax loss carryforwards and raises the probability that a loss firm will defer the tax payments on the structure's earnings, as well as the (less important) depreciation allowances. This deferral reduces the effective tax rate.

There are other minor differences between the results in Tables 9 and 10. Using the post-1981 probabilities, the equipment ETR for a firm with tax loss carryforwards is 8.3 percent, compared with 15.0 percent if the full-sample

TABLE 10: SENSITIVITY OF EFFECTIVE TAX RATES TO ALTERNATIVE ASSUMPTIONS

Estimates Using Transition Probabilities from 1981-1984 Annual Report Data

Assumption	Firm with Loss Carryforward in Periods t & t-1	Firm which is Taxable in Periods t & t-1	Hypothetical Firm Facing Perfect Loss Offset
		General Industrial Equipment	
Base Case	8.3	-6.7	0.8
Inflation = .10	12.5	8.3	19.2
Real Interest Payments = .10* (Pretax Returns)	3.3	-20.8	-15.8
Unlimited Carryforwards	7.5	-6.7	0.8
Elimination of Carrybacks	10.8	-8.3	0.8
		Industrial Buildings	
Base Case	24.2	40.0	48.3
Inflation = .10	25.0	50.0	60.8
Real Interest Payments = .10* (Pretax Returns)	18.3	28.3	34.2
Unlimited Carryforwards	25.0	40.0	48.3
Elimination of Carrybacks	30.0	40.0	48.3

Notes: Maintained assumptions are the same as those in Table 9 except that we use the transition probabilities from Table 4 rather than those from Table 5.

probabilities describe the transition matrix. The loss carryforward firms are also much less sensitive to the inflation rate under the post-1981 probabilities, primarily because the chance that these firms will ever return to taxable status is lower and so the present value of the tax allowances, the part of the calculation which can be sensitive to the inflation rate, is much reduced.

5. Conclusions

This paper has explored the recent incidence of tax loss carryforwards amongst nonfinancial corporations. Although fifteen percent of all firms report loss carryforwards, when weighted by market value, these firms account for only about three percent of the corporate sector. There are, however, some industries in which losses are being carried forward by a significant minority of firms; in these industries, current loss offset restrictions may have a significant effect on corporate tax incentives.

A firm's current tax status is a key determinant of its investment incentives. For firms with tax loss carryforwards, effective tax rates on plant and equipment may be significantly different from those for taxable firms which are able to utilize tax deductions as they accrue. For equipment investments under present law, taxable firms face lower effective tax rates than do firms with loss carryforwards. The opposite is true for structures. These findings, coupled with the concentration of losses in some industries, suggest that previous attempts to estimate interindustry differences in effective tax rates neglect an important source of tax rate variation. The differences between firms in the same industry, depending on their current tax status, may be even more substantial.

Our calculations may understate the economic importance of tax loss carryforwards for several reasons. First, we have modelled the incentive effects assuming that all firms face the economy-wide probabilities of transiting between taxable and non-taxable states. If some firms have precise knowledge about the pattern of tax liabilities they are likely to face, this may induce much

larger swings in their investment and financial behavior as they take advantage of intertemporal changes in tax rules. Second, our calculations of the incidence of loss carryforwards may not reflect the steady state to which the economy will move if the post-1981 depreciation schedule remains in effect. Since the presence of highly accelerated depreciation allowances increases the chance that firms will generate tax losses, there may be long-term shifts in the fractions of taxable and non-taxable firms which cannot yet be detected.

Finally, data limitations preclude us from considering firms with tax credit carryforwards. Although many of the loss carryforward firms in our sample also report either investment or foreign tax credit carryforwards, there may also be substantial numbers of firms with credit carryforwards but no loss carryforwards. For these firms, the marginal tax rate on additional income may be substantially different from the statutory marginal tax rates. By omitting these firms we understate the importance of firms whose marginal tax rates deviate from statutory values. If the stochastic process governing transitions into and out of credit carryforward status is similar to that for tax loss carryforward status, however, our effective tax rate analyses may still describe the incentives facing these firms.

Our effective tax rate calculations embody a number of strong assumptions about the stochastic process determining firms' tax status. In particular, we maintain the fiction that firms face identical, time-invariant, exogenous probabilities of moving into and out of periods during which tax losses are carried forward. Each of these assumptions is unrealistic, and could usefully be relaxed in future work. Perhaps the most intriguing direction for future work concerns the endogeneity of a firm's tax status. There are a wide range of cor-

porate actions which affect marginal tax rates, ranging from the traditional investment and financing choices (see Cooper and Franks (1983) and Auerbach (1986)) to less-frequently-analyzed accounting choices (see Watts and Zimmerman (1986)). We know relatively little about what firms do in both the real and financial domains in order to alter their tax status. The potential response of these corporate decisions are however fundamental for analyzing the incentive effects of the corporate tax.

The substantial differences across firms in expected future tax status may provide a useful source of variation which can be used to study how taxes affect financing and investment decisions. If the magnitude of debt tax shields are an important influence on firms' capital structure as for example in DeAngelo and Masulis (1980), then we should observe different borrowing policies from firms with substantial tax loss carryforwards and those which have large accumulated potential carrybacks and are currently taxable. The latter has a larger tax incentive for borrowing than the former, and this may yield testable predictions of how taxes affect financing choices.

Footnotes

1. Cordes and Sheffrin (1983) calculate marginal tax rates using corporate tax return data but they assume that firms cannot carry back either losses or credits. This biases their findings toward the result that many firms face tax rates below the statutory maximum.

2. For an excellent summary of the recent debate surrounding average tax rates on large corporations, see the series of essays in Tax Notes 9 December 1985. The claim that sizable numbers of large corporations pay no tax is due to McIntyre and Folen (1984) and McIntyre and Wilhelm (1986). Their calculations are based on the ratio of current tax payments to earnings, which bears no necessary relation to the firm's marginal tax status.

3. The extent to which firms can claim investment tax credits, foreign tax credits, R&D credits, and a number of other credits depends upon their taxable income. The ITC, for example, is limited to $25,000 + .90*max[0,Tax-25,000]. Additional taxable earnings for a firm bound by this constraint would raise tax liability by only .10*τ, where τ is the statutory tax rate.

4. Cordes and Sheffrin (1983) were affiliated with the Office of Tax Analysis when they used the Treasury Corporate Tax Model to calculate the distribution of corporate marginal tax rates.

5. We also tried to find examples of loss carryforward firms which did not appear in the COMPUSTAT sample. For example, we examined the 50 firms with the smallest current tax payments in McIntyre and Folen (1984) and found no cases of firms with loss carryforwards which were not in our sample.

6. Stickney, Weil, and Wolfson (1983) provide a detailed analysis of one firm, General Electric's, accounting for its financial subsidiary.

7. It is difficult to gauge the importance of omitting the financial subsidiaries of some firms. We studied the published financial statement of several large financial subsidiaries, those of General Motors, Chrysler, General Electric, Ford, and Westinghouse, and in no case did we find evidence of tax loss carryforwards in the subsidiary; this suggests the biases from annual reports which exclude these subsidiaries may not be too severe.

8. Although in principle we could model firm heterogeneity and estimate separate transition probabilities for firms with similar characteristics, the sparseness of some off-diagonal cells in our transition matrices suggests that it would be difficult to obtain precise estimates. For example, there are only 14 firms which make the Taxable-Loss Carryforward-Taxable transition in 1983-1984, and only 20 firms in the Loss Carryforward-Taxable-Taxable cell. Another possibility is using a mover-stayer model to describe the data, allowing some firms to be "stayers" in the taxable state. This might be explored in future work.

9. The steady state probabilities are defined as follows: q_{LL} =

$q_{LT}*(1-p_{TLT})/p_{LLT}$, $q_{LT} = q_{TL} = 1/[2 + p_{LTT}/(1-p_{TTT}) + (1-p_{TLT})/p_{LLT}]$, and $q_{TT} = q_{TL}*p_{LTT}/(1-p_{TTT})$.

10. The transition probabilities in this table are not directly comparable to those in Table 5 for two reasons. First, in looking at COMPUSTAT data over a period of many years, we confront the problem of missing values for the tax loss variables. We assume (very conservatively) that all missing values correspond to taxable years; this substantially overstates the chance of escaping from the tax loss state. Second, the sample selection problem alluded to in the text with respect to firms which merged or went bankrupt is likely to be much more important in this analysis of transitions over a long time period than in our previous tabulations which spanned only four years. The net effect of this bias is unclear.

11. An asset need not have a negative total tax liability for this to occur. Consider a project with negative taxable earnings in its early years, followed by significant taxable income later in its life. Even if the project's tax payments have a positive net present value, the cost of foregoing tax benefits in the near-term may exceed the gain from postponing tax liabilities later in the project.

12. Previous work treating this endogeneity has considered only very simple models; see, for example, Auerbach (1986).

13. The notation L^S refers to s consecutive years of tax loss carryforwards.

14. By focusing on expected returns, we are implicitly assuming that tax-status risk is entirely nonsystematic. In practice, most firms are more likely to experience tax loss carryforwards during recessions; this imparts a potentially important systematic component to these tax streams.

15. We also truncate project returns and accrued tax liabilities after forty years. The results are insensitive to these truncations.

16. This overstates the effect of carryforward provisions. When a non-taxable firm incurs a tax liability, there are two possibilities concerning its current income: it may be negative, adding to previous losses, or it may be positive but completely offset by previous losses. In the former case, the additional tax liability (if negative) will add new losses to be carried forward. If the additional tax liability is positive, it will reduce the new losses carried forward. In either case, the tax liability will have a limit of fifteen years during which it can be realized. After that time, the marginal impact on the stock of loss carryforwards disappears. In the case where the firm is currently offsetting some of its previous tax losses, however, the situation is more complicated, since the marginal impact of the accrued tax liabilities will be to increase or decrease the working off of old loss carryforwards. The marginal contribution of a new gain or loss to the tax losses carried forward therefore has fewer than N years to expiration.

17. An additional restriction which has been changed over the years governs the extent to which firms can use investment tax credits to offset taxable

income before credits. To model this provision, we would have to modify our analysis to include an intermediate state between taxable and nontaxable, in which a firm pays taxes but has tax credits carried forward. Unfortunately, because our data limitations prevent us from estimating transition probabilities with respect to this state, we must omit it.

18. Ideally, the rate used to discount the components in the carryback shadow price would be the after-tax rate of return for the project. However, this would have required an iteration procedure which seemed inappropriate given the parameter's minor role.

19. This is higher fraction initially in a taxable state than was found in Auerbach (1983). The difference is probably due to the different specification of the transition process.

20. We assume that structures are only depreciated once when they are purchased. Gordon, Hines, and Summers (1986) conclude that "churning" is not profitable for corporations, although it may be attractive to partnerships. We also ignore asset-related differences in leverage capacity. If structures can carry more debt than equipment, as is commonly supposed, then loss carryforward firms may face greater disincentives to purchasing structures than we have reported.

21. For examples of previous calculations of industry-specific ETRs, see Auerbach (1983), Fullerton (1985), or Fullerton and Henderson (1984).

References

Anderson, Theodore W. and L.A. Goodman. 1957. Statistical inference about markov chains. Annals of Mathematical Statistics 28: 89-110.

Auerbach, Alan J. 1983. Corporate taxation in the United States. Brookings Papers on Economic Activity 2: 451-505.

_____. 1986. The dynamic effects of tax law asymmetries. Review of Economic Studies, forthcoming.

Cooper, Ian and Julian Franks. 1983. The interaction of financing and investment decisions when the firm has unused tax credits. Working paper, London Business School, London, England.

Cordes, Joseph J. and Steven M. Sheffrin. 1983. Estimating the tax advantage of corporate debt. Journal of Finance 38: 95-105.

DeAngelo, Harold and Ronald Masulis. 1980. Optimal capital structure under corporate and personal taxation. Journal of Financial Economics 8: 3-30.

Dworin, Lowell. 1985. On estimating corporate tax liabilities from financial statements. Tax Notes 9 December: 965-970.

Fullerton, Don. 1985. The indexation of interest, depreciation, and capital gains: A model of investment incentives. Working Paper No. 1655, National Bureau of Economic Research, Cambridge, Mass.

Fullerton, Don, and Yolanda Henderson. 1984. Investment effects of taxes on income from capital: Alternative policies in the 1980s. In The legacy of Reaganomics: Prospects for long term growth, edited by Charles R. Hulten and Isabel Sawhill. Washington: Urban Institute Press.

Gordon, Roger, James Hines, and Lawrence Summers. 1986. Notes on the tax treatment of structures. Department of Economics, Harvard University, Cambridge, Mass.

Hulten, Charles R. and Frank C. Wykoff. 1981. The measurement of economic depreciation. In Depreciation, inflation, and the taxation of income from capital, edited by Charles R. Hulten. Washington: Urban Institute Press.

McIntyre, Robert S. and Robert Folen. 1984. Corporate income taxes in the Reagan years. Washington: Citizens for Tax Justice.

McIntyre, Robert S. and David Wilhelm. 1986. Money for nothing: The failure of corporate tax incentives, 1981-1984. Washington: Citizens for Tax Justice.

Majd, Saman and Stewart Myers. 1985. Valuing the government's tax claim on risky corporate assets. Working Paper No. 1553, National Bureau of Economic Research, Cambridge, Mass.

_____. 1986. Tax asymmetries and corporate income tax reform. Sloan School of Management, MIT, Cambridge, Massachusetts. Mimeo.

Mayer, Colin P. 1986. Corporation tax, finance, and the cost of capital. Review of Economic Studies 53: 93-112.

Mintz, Jack. 1985. An empirical estimate of imperfect loss offsetting and effective tax rates. Department of Economics, Queens University, Kingston, Ontario.

Stickney, Clyde, Roman Weil, and Mark Wolfson. 1983. Income taxes and tax transfer leases: GE's accounting for a Molotov cocktail. Accounting Review 58: 439-459.

Watts, Ross and Jerold Zimmerman. 1986. Positive accounting theory. Englewood Cliffs: Prentice-Hall.

APPENDIX: COMPUTING THE SHADOW VALUE OF TAX PAYMENTS WITH CARRYBACKS

This appendix describes our procedure for calculating the shadow value of tax payments which arises from their possible future use in permitting loss carrybacks. A dollar of tax payments is valuable because, according to current law, it may be used to offset a tax loss occurring in the following three years. However, its value is less than the present value of such deductions because there is some probability that the loss that is made deductible in the next three years would have been offset through carryforwards at some future date. Tax losses foregone in future periods also have a shadow value because the associated increase in taxable income will in turn lead to the possibility of eventual carryback.

To compute the value of the carryback option, consider a taxable firm and define ν_{TT} as the expected carryback value of a one dollar tax payment made in the second of a pair of adjacent taxable years. Define ν_{LT} in parallel fashion. Let ω_{TL} denote the present value of the future deductions foregone when a loss is realized; it is also the present value of the tax payments which result from a one dollar increase in taxable income for a firm which was taxable in the previous year but is currently not taxable. This follows from the fact that a carryback is used as soon as possible, which means the first year in which there is insufficient taxable income. The value of ν_{TT} is given by:

$$(A.1)\quad \nu_{TT} = [\beta p_{TTL} + \beta^2 p_{TTT} p_{TTT} + \beta^3 p_{TTT}^2 p_{TTL}](1-\omega_{TL})$$

$$= \beta p_{TTL}[1 + \beta p_{TTT} + \beta^2 p_{TTT}^2](1-\omega_{TL})$$

where $\beta = (1-i)/(1+r)$ denotes the discount factor applied when shifting a tax payment one year into the future. Equation (A.1) denotes the expected present

value of the carrybacks associated with a one dollar tax payment. By the same logic, we can define

$$(A.2) \quad \nu_{LT} = [\beta p_{LTL} + \beta^2 p_{LTT}p_{TTL} + \beta^3 p_{LTT}p_{TTT}p_{TTL}](1-\omega_{TL})$$

for currently-taxable firms which were not taxable last year. Each of these expressions depends upon ω_{TL}, which is in turn given by

$$(A.3) \quad \omega_{TL} = p_{TLT}\beta(1-\nu_{LT}) + p_{TLL}p_{LLT}\beta^2(1-\nu_{LT}) + \ldots + p_{TLL}p_{LLL}^{N-2}p_{LLT}\beta^N(1-\nu_{LT})$$

where N is the maximum number of periods for which a loss may be carried forward. Solving these three equations for ν_{TT}, ν_{LT}, and ω_{TL} yields:

$$(A.4) \quad \nu_{TT} = [\alpha_{TT}(1-\alpha_{TL})]/(1-\alpha_{LT}\alpha_{TL})$$

$$(A.5) \quad \nu_{LT} = [\alpha_{LT}(1-\alpha_{TL})]/(1-\alpha_{LT}\alpha_{TL})$$

$$(A.6) \quad \omega_{TL} = [\alpha_{TL}(1-\alpha_{LT})]/(1-\alpha_{LT}\alpha_{TL}).$$

where $\alpha_{TT} = \beta p_{TTL}[1 + \beta p_{TTT} + \beta p_{TTT}^2]$, $\alpha_{LT} = \beta p_{LTL} + \beta^2 p_{LTT}p_{TTL} + \beta^3 p_{LTT}p_{TTT}p_{TTL}$, and $\alpha_{TL} = (1-\nu_{LT})[\beta p_{TLT} + \beta^2 p_{TLL}p_{LLT} + \ldots + \beta^N p_{TLL}p_{LLT}p_{LLL}^{N-2}]$.

These shadow values are used in calculating the expected present value of tax liabilities. To account for firms' ability to carry losses back, we multiply each of the expected tax payments generated by the no-carryback analysis by either $(1-\nu_{TT})$ or $(1-\nu_{LT})$, depending on the firm's tax status. When a firm accrues a tax liability with a distribution of expected payments across

many periods, the concurrent value of q_{TT} determines the fraction of the expected tax payment which will be paid immediately in a state following a taxable year. This amount is multiplied by $(1-\nu_{TT})$. All of the remaining components associated with this accrued liability are multiplied by $(1-\nu_{LT})$, since they occur in states where the firm will have just re-entered taxable status. In the notation of section three, this implies

$$\text{(A.7)} \qquad \nu_{ts} = \begin{cases} \nu_{LT} & s > t \\ (q^t_{TT}\nu_{TT} + q^t_{LT}\nu_{LT})/(q^t_{TT} + q^t_{LT}) & s = t. \end{cases}$$

This can be substituted into equation (5) to evaluate the internal rate of return, r, and then the effective tax rate.