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THE SIGNIFICANCE OF TAX LAW ASYMMETRIES: AN EMPIRICAL INVESTIGATION

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ABSTRACT

This study uses tax return data for U.S. nonfinancial corporations for the period 1971-82 to estimate the importance of restrictions on the ability of firms to use tax credits and to obtain refunds for tax losses. Our results suggest that the incidence of such unused tax benefits increased substantially during the early 1980s, though we do not find these increases attributable to increased investment incentives during that period.

Using estimates of a three-state (taxable, not taxable, partially taxable) transition probability model, we calculate the effective tax rates on various types of investments undertaken by firms differing with respect to tax status. We confirm previous findings about the marginal tax rate on interest payments, and that it is important to distinguish current tax payments from marginal tax rates in estimating the incentive to invest.

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1. Introduction

The asymmetric treatment of gains and losses by the corporate income tax has figured prominently in many areas of research about the effects of taxation on firm behavior. One theory of capital structure has focused on the limited deductibility of marginal interest payments to explain the existence of optimal interior debt-equity ratios (DeAngelo and Masulis 1980). Another area of research has considered the impact of the limited loss offset mechanism on the cost of capital and investment incentives (Auerbach 1983, 1986, Cooper and Franks 1983, Majd and Myers 1985, Mayer 1986, Mintz 1985). Yet another line of research has focused on the incentives to transfer unusable tax benefits through leasing (Warren and Auerbach 1982) or merging (Auerbach and Reishus 1987).

The recent tax reform process in the U.S. has paid particular attention to this characteristic of the tax code, without any consistent view emerging about the appropriate treatment of tax losses. Legislation in 1981 liberalized the treatment of leasing to obtain tax benefits, but this provision was repealed in 1982. The Tax Reform Act of 1986 reduces the ability of firms to transfer tax benefits through merger activity, and applies a corporate minimum tax to firms whose losses were attributable to various deviations of taxable income from book income.

When considering the impact of the asymmetric treatment of tax losses, and the reform of such provisions, it is important to have a sense of their quantitative importance. Few studies have provided empirical estimates of the importance of unused tax benefits in the economy. A primary reason is the

lack of data on the tax status of individual corporations. One exception is Cordes and Sheffrin (1983), who, using confidential data on the tax returns of corporations for a single year, estimated the average effective marginal tax rate at which corporate interest payments could be deducted. Auerbach and Poterba (1987b) estimated the size and distribution of tax loss carryforwards and their impact on investment incentives using data collected from the annual reports of several hundred large corporations representing a significant fraction of the value of the corporate sector. However, they conclude on the basis of indirect evidence that they may have seriously underestimated the magnitude of aggregate tax loss carryforwards.

The current study extends these previous efforts in several important ways. Like Cordes and Sheffrin, we use confidential tax return data available from the U.S. Treasury. However, our sample is a panel of firms over the period 1971-1982, rather than a single year's cross-section. This is an important difference, since the effective marginal tax rate for a firm in a given year depends on its status in previous and subsequent years. A firm with a current loss could be fully taxable at the margin, for example, because of its ability to offset the loss against previous gains. Following Auerbach and Poterba, we estimate the quantitative importance of tax losses and their impact on the incentive to invest. However, we also consider the additional effects of the limitations on the use of investment and foreign tax credits by taxable firms. Such credit limitations appear to affect many more firms than does the inability to deduct losses, so their inclusion in the analysis is important if one is to gain an accurate understanding of the effects of tax law asymmetries on corporate behavior.

The organization of the paper is as follows. Section 2 gives a brief discussion of the relevant U.S. tax law. Section 3 describes the data that formed the basis for our analysis. Next, section 4 presents aggregate and industry statistics on the importance of loss and credit limitations. Section 5 presents a general algorithm for using a three-state, second-order transition model for the tax status of the firm to estimate effective marginal tax rates. Section 6 presents estimates of such a model and the effective marginal tax rate distribution they imply. Section 7 discusses the effects of tax constraints on the incentive for corporate investment, and Section 8 offers concluding comments and suggestions for future research in this area.

2. Constraints on the Use of Tax Benefits

The corporate tax in the U.S. is essentially a flat rate tax on taxable income.[1] Like most other countries, however, the U.S. does not provide corporations with a "full loss offset" that would treat positive and negative tax bases symmetrically. Instead, it imposes a different set of provisions for firms with negative taxable income. Moreover, it does not allow a full use of tax credits applicable to taxes payable even for firms which have positive taxable income before credits.

Corporations calculate their taxes payable in two stages. They first estimate taxes due before credits, and then apply credits to reduce taxes as allowed. The constraint on losses applies at the former stage, before credits are considered. Only after the effect of this constraint has been calculated do credits, and constraints on credits, enter the tax computation.

A. Losses

In a given tax year, a firm calculates its taxable income before credits. If it is positive, no loss constraints apply and it goes on to the credit calculation. If it is negative, it must "carry" the loss "back" (to an earlier year) or "forward" (to a subsequent year). Carrying back entails recomputing the tax return of at least one of the previous three years, beginning with the earliest of the three, deducting the current loss from the previous years' taxable income. Thus, if the current loss is smaller in absolute value than the carryback potential of the previous three years, the firm can carry all current losses back. At the margin, an additional dollar of losses would also be carried back, with the firm obtaining an additional tax refund at the statutory corporate tax rate.

If the firm cannot carry all its current losses back, it must carry them forward. In each of the next fifteen years (changed from five by the Economic Recovery Tax Act of 1981) that its taxable income is positive, it may deduct the losses until either losses or income are exhausted. The disadvantage of carrying losses forward is that they are carried with zero nominal interest and may expire.

For the firm with losses in more than one year, the calculation for the second loss (and subsequent ones) follows in the same manner, with the second loss "stacked" after the first. Carrying back is figured net of previous losses carried back, and net operating loss deductions induced by losses carried forward are based on income net of those generated by the earlier loss.

Finally, firms are not required to carry losses back. In any year in which losses occur, the firm may choose either not to carry back, or to carry

back to the previous three years. It may not carry back selectively to one or two of the previous three years. Choosing to carry forward could be optimal for carrying losses back could displace previously taken investment tax credits. If these credits, in turn, had already been carried forward, they might expire upon being displaced.

B. Credits

Firms with taxable income before credits have no losses carried forward. But many have excess credits, and this influences their marginal tax rate. The two primary tax credits received by corporations are the foreign tax credit and the investment tax credit.

The rules governing the foreign tax credit are quite complex, and became more so with the enactment of the 1986 Act. The basic approach is to require firms to add repatriated foreign income to domestic income in the computation of taxable income and then permit a credit for foreign taxes paid on the foreign source income, against U.S. taxes on that income. Firms with positive worldwide taxable income will be unable to use all such credits for one of two reasons:

(1) the effective foreign tax rate is higher than the U.S. rate, so that the U.S. tax liability on foreign source income is exhausted by the credits,

(2) the firm has domestic losses; in this case, the firm may only use foreign tax credits to offset the tax on its worldwide income, i.e., its foreign source income net of domestic losses.

These two cases have fundamentally different implications. In case (1), an

additional dollar of domestic income is fully taxable, so that the foreign tax credit carryforwards are irrelevant for our purposes. In the second case, a reduction in domestic losses would have no effect on tax payments, simply reducing the foreign tax credits being carried forward. Hence, firms with domestic loses but positive total income are in a tax position quite similar to firms with net losses, paying no taxes and carrying forward foreign tax credits rather than losses.

After foreign tax credits have been subtracted, firms compute their investment tax credits. (The ITC was repealed in 1986 but was in place throughout our sample period.)

Until 1986, firms could offset all taxes up to 25,000 dollars and 85 percent of all taxes in excess of 25,000 dollars with investment tax credits. Before 1978, the percentage was 50 percent. Were there no such limitation, unused credits could simply be combined with tax losses in calculating the firm's tax position, as in the second foreign tax credit example. With the credit limit, a firm with taxable income but facing credit constraints was effectively taxed at a low positive rate on its marginal income, since the addition of more income allowed it to increase the credits that it uses.

Since investment tax credits were calculated after losses for foreign tax credits had been subtracted from taxable income, firms with substantial current domestic income could be credit constrained if loss and foreign tax credit carryforward from earlier years were used to offset this income. Moreover, as mentioned above, a firm could displace credits it had already used if a subsequent loss were carried back to the current year, reducing allowable credits. Credits then had to be carried back or carried forward, even though they were allowable on the firm's initial tax return for the year.

C. Summary

Figure 1 (which is very similar to one presented by Majd and Myers 1985) pictures the tax function for a typical firm, ignoring the ability of firms to carry losses and credits back. Current domestic income is on the horizontal axis. The tax on that income is on the vertical axis. The firm will be in one of three regimes. If its tax loss carryforwards and foreign tax credits (current and carried forward) exceed current taxable income, it pays no taxes. This occurs in the example if its domestic income is less than Y_1. We refer to this situation as state 1. In state 1, firms carry foreign tax credits and/or losses forward. If $Y>Y_1$, the firm pays taxes, but unless $Y>Y_2$, it cannot use up all of its accumulated investment tax credits. We refer to this intermediate regime as state 2. The fully taxable regime, where no investment tax credits are carried forward, is referred to as state 0.

The current marginal tax rate (i.e., the derivative of current taxes with respect to current income in these three states) is 0, $\tau(1-\alpha)$, and τ, respectively, where α is the percent of taxes that investment tax credits may offset. However, there are additional effects on future (and previous) taxes that cause the effective marginal tax rates to differ from these values. These are discussed in section 4.

3. Data

The data set employed in this project comes from the Treasury Department Corporate Tax Model. The Treasury data set consists of thirteen annual samples of corporate tax returns for the years 1970-82. We omit financial companies because of their different tax rules.[2] Because there are many

missing observations for 1970, we limit our consideration to the period beginning in 1971. Likewise, we ignore firms with assets under 10 million dollars in 1982 because such firms are intentionally incompletely sampled at source and account for only a trivial fraction of nonfinancial corporate assets (about 3 percent).

By combining the annual samples, we are able to create a twelve-year panel of corporate tax returns. As discussed above, a firm's marginal tax rate depends not only on its current tax status but also its future and past ones, so such a data set is necessary to perform such calculations. Indeed, because of data limitations the firm's current state itself can often only be inferred by looking at several years of data simultaneously. Unfortunately, the attrition caused by requiring that there be no missing observations between 1971 and 1982 is significant. From a sample of 15,575 firms present in our 1982 sample, only 2,808 have complete data for 1971-82. This attrition is strongly related to size, as over half of all nonfinancial corporate assets are accounted for by firms in the panel. (The attrition is not due solely or even primarily to births or deaths of firms. In a large fraction of the cases, for example, firms with missing data have data in noncontiguous years.) Our approach, therefore, is to use the smaller panel data set for calculations requiring such data and then impute values of calculated variables for the remainder of the annual samples for the years 1980, 1981 and 1982. The imputation includes a correction for sample selection bias.

Classified by industry, the 1971-82 panel includes 23 firms in Agriculture, 89 in Mining, 103 in Construction, 1533 in Manufacturing, 361 in Transportation, 545 in Trade and 154 in Services. As measured by book assets

(the only size measure available to us), this represents 61 percent of the universe for Manufacturing, 49 percent for Mining, and 76 percent for Transportation. For the remaining industries, however, the sampling is considerably worse: 24 percent for Trade, 19 percent for Services, 15 percent for Construction, and 4 percent for Agriculture. Overall, the firms in our sample account for 53 percent of the universe of nonfinancial corporate book assets, and a somewhat larger percentage of those in the universe of firms with assets over 10 million dollars.

The Treasury model is built primarily from the Annual IRS Statistics of Income Corporation File. A subset of the income, tax and balance sheet items reported by each corporation on its annual federal income tax return (form 1120) are recorded each year. For our purposes, however, the data possess certain limitations. First, they do not contain revised tax returns that were filed in cases where firms carried back losses or credits. Second, corporations are not required to report the magnitude of losses carried forward, only those deducted in a given year. Together, these limitations prevent immediate inference of the loss carryforward or loss carryback that each firm has in a given year. These variables are of interest in their own right, and are also necessary for the calculation of effective marginal tax rates. For example, a firm reporting negative taxable income could be carrying losses back, or carrying them forward, or both. In the first of these cases, it would be fully taxable on marginal income, while in the second and third cases it would pay no additional taxes.

To correct this omission, we employ an algorithm to simulate the evolution of each firm's tax status, comprising its tax loss carryforward

stock and its potential for carrying back. The algorithm, which is described in more detail in Appendix A, uses the period 1971-75 as a base period from which to derive initial conditions which are updated according to each subsequent tax return. In some cases, no special assumptions are necessary. For example, a firm with taxable income and no net operating loss deduction in 1973, 1974 and 1975 begins in 1976 with no loss carryforward and the carryback potential equal to the previous three years' income. In other cases, however, some assumption about years before 1971 is necessary. For example, if the firm had income without loss deductions in 1971 and 1972, followed by three consecutive years of losses, one cannot know how much of these losses were carried back without knowing the carryback potential offered by taxable income in 1970. In this case, we assume that 1970 offered no such potential, although we did experiment with other assumptions.

In all, we classified firms into one of four mutually exclusive categories based on tax data for 1971-75, using assumptions about earlier years where necessary to generate 1976 initial conditions. Varying our assumptions about earlier tax years did not appear to exert a significant impact on our results.

Once each firm's 1975 carryforward/carryback potential has been established, the algorithm takes reported taxable income in each subsequent year and updates the firm's tax status. Accurate calculation required incorporation of relevant tax code changes, such as the extension in 1981 from five to fifteen years of the maximum period for all tax loss carryforwards then on the books (dating back to 1976) and the extension in the same year of the period for all credit carryforwards (dating back to 1974), also to fifteen years.

A second tax code change concerns the rules governing carrying back. Since 1976, firms with net operating losses have had the option of relinquishing the entire carryback period. As discussed above, the major factor motivating firms to eschew carrying back is the potential displacement of investment tax credits whose use could then be jeopardized. Determining whether firms face this situation requires the integration of data on investment tax credits, credit limitations and investment tax credit carryforward vintages with the data on losses and taxable income. Due to the complexity of doing this, we experimented with different simple behavioral assumptions about when firms choose to carry back. The two that seemed to perform best were that firms always carry back when possible, or carry back only if they were unconstrained in each of the three preceding years. For each firm, we simulated the path of tax payments and net operating loss deductions for 1976-82 deriving from these two alternative behavioral assumptions, and chose the method that minimized the sum of absolute deviations of predicted from actual net operating loss deductions for that firm. Of the 2,808 firms, 178 were estimated to use the first method (always carry back) and 65 the second method (carry back only into years without loss or credit constraints on the initial tax returns). The remaining 2,565 firms, many of which never had any losses, gave the same results under each assumption.

Unlike loss carryforwards, investment tax credit (ITC) carryforwards are reported on corporate tax returns. Thus, we know immediately whether the firms faced limitations on the use of credits in each year.[3] While we do not observe foreign tax credits carried forward, we can identify those firms

carrying them forward because of domestic losses. These are firms who offset all of their taxes before credits with foreign tax credits.

In the aggregate, our simulations track the net operating losses of individual firms quite well. There are persistent errors in some cases, however, leading to an underprediction rate averaging about 6 percent per year with no obvious trend.

There are many possible explanations for this underprediction. Many of the NOL deductions we miss appear to come from firms which continually report loss deductions far below their taxable income. Normally, this should not happen in consecutive years. A small NOL deduction in one year should indicate that the stock of carryforwards has been exhausted, and our algorithm is structured to assume this. One possible reason for the observed pattern is the presence of firms whose records consolidate the returns of several subsidiaries, some with losses and some with taxable income. A second cause could be the acquisition of firms with tax losses. Our information does not allow us to determine the relative importance of these potential sources of observed prediction errors. A third source of error is our algorithm, which assumes that firms follow a fairly simple decision rule about whether to carry losses back. As we already indicated, one could, in theory, use information on the size of taxable income and tax credits in each year to determine a more complicated decision rule, but this would be a difficult procedure to implement. This underprediction of net operating loss deductions suggests that we will slightly underpredict the value of tax losses carried forward, as well. This is worth keeping in mind when we present our estimates for tax loss carryforwards in the aggregate.

4. The Importance of Tax Constraints

Table 1 presents the results of our calculations for 1976-82. The top panel shows the unweighted fraction of the firms in our sample facing no constraints ("taxable"), loss and credit constraints ("nontaxable"), and taxable but facing credit constraints ("credit constrained"). As above, we refer to these as states 0, 1 and 2, respectively. State 1 includes those firms that report positive taxable income before tax credits but offset all taxes with foreign tax credits. The fraction of the sample in this subregime is listed in parentheses next to the state 1 sample fraction. Fairly stable for the period 1976-80, the fraction of firms in the nontaxable state did fall somewhat during the expansion of the late 1970s and increase in the recession year 1980. It then rose noticeably in 1981 and especially in 1982. Note that, except in recent years, a greater fraction of the sample firms were in state 2 than state 1, emphasizing the importance of taking credit constraints into account. The fraction of firms with negative taxable income that carry losses forward, and hence are in state 1, ranges between .52 and .60, suggesting that the opportunity to carry losses back is also important.

The results change markedly once one weights by firm asset size. Until 1981, the weighted percentage of firms in state 1 is well below the unweighted percentage, meaning that losses were concentrated among smaller firms. However, this pattern changes in 1981, and by 1982 over 22 percent of the sample assets are held by nontaxable firms.[4] Another significant effect of weighting is the increased importance of foreign tax credits as a cause of firms being nontaxable. In the 1980s, over 5 percent of the firms (asset weighted) have positive taxable income before foreign tax credits but pay no

taxes at all. The most significant effect of weighting, however, is on the size of the state 2 population. Once weighted by assets, the fraction of firms that pay taxes and have ITC carryforwards increases to a range of between 27 and 35 percent.

As discussed above, firm size is a major factor explaining inclusion in our data panel. Since size is also related to firm tax status, the results for the sample are not necessarily representative of those for the universe of nonfinancial corporations. Therefore, we impute values of the tax loss carryforward for the remaining nonfinancial corporations with assets over 10 million dollars for each of the years 1980, 1981 and 1982, and use the imputed values, along with information on foreign and investment tax credits, to classify firms by state. Because unexplained variation in attrition may be correlated with tax losses, we include a correction for sample selection bias, following Heckman (1979). To minimize attrition from the panel, we base our 1980 and 1981 imputations on panels of firms with complete data through 1980 and 1981, respectively. Further details are provided in Appendix B.

The last panel in Table 1 gives the resulting estimates for universe population fractions for each state, weighted by assets, for the years 1980-82. The results do confirm our prediction that losses are more prevalent in the universe than in our panel, but the differences in fractions are small.

The results in Table 1 lead to a number of important conclusions. First, the number of nontaxable firms increased markedly in the early 1980s. Second, the distribution of unused tax losses, foreign tax credits and investment tax credits is strongly related to firm size. Finally, by 1982 about half the nonfinancial corporate assets were held by firms that were not fully taxable.

Though the picture emerges that losses alone affected a relatively small minority of firms, even in 1981 and 1982, the incidence of losses is not spread evenly across different industries. This is demonstrated in Table 2, which gives the asset-weighted universe calculations for 1980-82 corresponding to the aggregate statistics in the last panel of Table 1, repeated at the top of Table 2. The manufacturing firms in our sample are slightly more likely to have experienced losses than other firms, but also more likely to be fully taxable. The oil industry was less likely to be nontaxable, during this period, while the other three industries experience was quite different. By 1982, only between 13 and 21 percent of the assets in Airlines, Railroads and Steel were held by firms not carrying forward losses or credits.

Having explored the pervasiveness of constraints on tax losses and credits, for the nonfinancial corporate universe, we turn next to an evaluation of the overall magnitude of these unused tax benefits.

The results of our calculations are presented in Table 3. Also presented are estimates of end-of-year investment tax credit carryforwards, provided by the Statistics of Income Corporation Tax Returns volumes. We present three sets of estimates of tax losses. Those in parentheses are for firms in the 1971-80 panel, and are provided to indicate the trend in losses through 1980. Clearly, losses were increasing in importance even as the economy improved through the late 1970s, and jumped in the recession year of 1980.

The column labelled "no correction" gives estimated loss carryforwards for the universe of nonfinancial corporations (above 10 million in assets) with values imputed for firms not in the panel but without any correction for sample selection bias. The third column give universe estimates that

incorporate such a correction, which is extremely important for 1981 and 1982. Other evidence supports the explosion in tax losses depicted here. Using published aggregate statistics, one can determine the current losses of the nonfinancial corporate sector. By subtracting from these the losses carried back (which are available only for the corporate sector as a whole, and hence slightly overstated), one obtains an estimate of the flow added to the stock of losses carried forward. This is an absolute lower bound on the stock itself. For the years 1980, 1981, and 1982, this lower bound is 36.6 billion dollars, 51.1 billion dollars, and 75.6 billion dollars, respectively,[5] suggesting that even our corrected numbers are too low for 1980 and, perhaps, 1982.

Since the revenue cost of tax deductions is obtained by multiplying these deductions by the corporate tax rate, which was .46 during this period, we may conclude that the value of tax losses being carried forward exceeded that of unused investment tax credits in the early 1980s, as the combined stock of carryforwards grew to a level that in 1982 exceeded annual corporate tax collections.

In concluding our discussion of the numbers in Table 3, we note how much the stocks of carryforwards have risen in recent years relative to the fraction of the corporate population facing constraints. This suggests that the importance of the problem facing constrained firms may have increased, in that firms may be less likely to work off such large accumulated tax losses and credits over a short period. We now develop a methodology for estimating the impact of prolonged presence in a tax constrained state.

5. A Model of Tax Status Transitions

In order to estimate the effective marginal tax rate that a firm faces in a given year, information is necessary not only about its current state, but also the prospective future ones. A firm in state 1 (nontaxable) this year clearly has a zero current marginal tax rate on additional income, but this understates the present value of taxes associated with that income, since the income will reduce losses carried forward and result in an increase in tax payments in the year that the firm exhausts its loss carryforwards and resumes payment of taxes. On the other hand, the current tax on a taxable firm's marginal income overstates the present value of taxes associated with that income, since the increased tax also increases the potential for carrying back future losses to offset the tax. The extent of these adjustments for future taxes depends on the transition patterns among the three states defined above (taxable, nontaxable, credit constrained). For example, if firms move quickly out of the nontaxable state, the effective marginal tax rate may be close to the statutory rate.

To estimate such transition patterns in a short panel such as the one we have, one can assume that the evolution of the firm's state is determined by a low order stochastic process. Using a two-state model (which grouped together fully taxable and credit constrained firms) Auerbach and Poterba (1987a) found that a first-order transition process could be statistically rejected in favor of a second-order process, where the current transition probabilities depend on the current and previous year's state.

The rejection of a first-order process is not surprising, since one would expect heterogeneity among firms in a given state relating to the length of

time spent in that state. Being nontaxable for a long time may indicate that the firm began with a very large tax loss carryforward which made transitions unlikely, or that the firm has had continually poor performance. Either of these explanations would predict that firms would be more likely to remain nontaxable if they had been so for the past two years rather than just the most recent year, which is what Auerbach and Poterba found. Their solution was to model transitions as a second-order process, which can be extended in the current three state model.

Once the model has been estimated, it can be used to estimate effective marginal tax rates for firms in different states regarding current tax status. Under the assumption that the estimated transition probabilities apply to the representative, optimizing firm, we may use them to estimate the path that a marginal accrued tax liabilility would take starting from any initial state. Doing so leads to the computation of "shadow" values of future tax liabilities associated with current tax accruals.

This approach of using transition model estimates to calculate shadow values was developed by Auerbach and Poterba, but the current extension involves substantial complication, not only because there are more states to consider, but also because the source of a change in accrued tax liability (ordinary income or tax credits) matters once the separate constraint on credits is included in the analysis.

We begin with some notation. Let p_{ijk} be the probability that a firm now in state j, and in state i during the previous year, will move to state k next year. For simplicity, we may also refer to the current state as ij and next year's state as jk. Let α be the fraction of taxes, before credits but after

accounting for loss carryforwards and carrybacks, that by law may be offset by credits, credit carrybacks and credit carryforwards.

Three general comments are in order before discussing the derivation of the shadow values from estimates of p_{ijk}. First, as already mentioned, the shadow values will differ according to whether the marginal income change is associated with ordinary income or credits. Second, the state the firm was in during the previous year will affect the current shadow value, given this year's state, because future transition probabilities depend on both years' states in the second-order transition model. Third, the shadow values to be derived apply symmetrically to positive and negative marginal tax changes. If we wish to trace through the impact of a change in tax credits accrued today, it doesn't matter whether this change is positive or negative. For example, if the firm is carrying credits forward, an increase in credits will increase the stock carried forward and reduce the tax payments when the firm reaches state 0; a decrease in credits will reduce the carryforward and increase taxes by the same amount in state 0. The key is that we are concentrating on marginal changes that do not affect the transition probabilities themselves.

Consider now the shadow values of tax payments accrued by a firm in a state in which the taxes must be carried forward. For tax credits, this is states 1 and 2, since an increase (decrease) in tax credits in either state simply increases (decreases) the stock of credits being carried forward. These marginal credits will affect the firm's tax liability only when it reaches state 0 and is fully taxable at the margin.

Let $PRC_{ij}^{10}(t)$ be the probability that the firm starting in state ij (j=1,2) first enters state 0 from state 1 and after t years. $PRC_{ij}^{20}(t)$ is the probability that it first enters state 0 from state 2 and in year t. The derivation of these "probabilities of becoming taxable" is discussed below.

Letting TC be the maximum number of years that credits may be carried forward, we obtain the following expression for the shadow value of credits accrued in state ij:

$$(1) \qquad wc_{ij} = \sum_{t=1}^{TC} \beta^t [PRC_{ij}^{10}(t)(1-vc_{10}) + PRC_{ij}^{20}(t)(1-vc_{20})] \quad (i=0,1,2;\ j=1,2)$$

where β is the nominal, after-tax discount factor and vc_{i0} is the shadow value that a change in tax credits has in state i0 in terms of the change in subsequent carryback potential. These terms appear because the use of the accrued credits will offset income that could, potentially, have permitted a carryback of subsequent losses or excess credits. The year limit TC appears since a change in credits carried forward will have no impact if credits at the margin expire anyway.[6]

A change in ordinary tax liability (i.e., taxes before credits) will, as with a change in credits, be charged immediately if it occurs in state 0 and carried forward if occurring in state 1. In state 2, however, it will affect both current taxes and tax credits carried forward. A decline of one dollar of ordinary tax liability will force the firm to use α fewer dollars of tax credits. Hence, we may view a reduction in tax liability as being partially realized (at rate $1-\alpha$) with the rest (α) being "converted" to credit carryforwards. An increase in tax liability works symmetrically, with credit carryforwards being reduced but some tax paid.

Letting $PR_{i1}^{10}(t)$ be the probability of a firm starting in state i1 first leaving state 1 in year t and into state 0, and $PR_{i1}^{12}(t)$ be the probability of the same firm first leaving state 1 in year t and into state 2, we may express the shadow value of a dollar of ordinary taxes accrued in state i1 as:

$$(2) \qquad w_{i1} = \sum_{t=1}^{T} \beta^t \{PR_{i1}^{10}(t)(1-v_{10}) + PR_{i1}^{12}(t)[\alpha wc_{12} + (1-\alpha)(1-v_{12})]\} \quad (i=0,1,2)$$

where T is the number of years that losses can be carried forward and v_{ij} is the shadow value of ordinary tax payments in state ij.

Next, consider the shadow values v_{ij} and vc_{ij}. In computing them, we note that firms are permitted to carry losses and credits back three years. As discussed above, firms have had the option since 1976 of not carrying losses back. Initially, however, we will assume that losses are always carried back when this is possible. If firms follow this policy, then a firm's presence in state 1 or state 2 means it has already exhausted its ability to carry back losses or credits, respectively.

The shadow values vc_{i0} are associated with credits used in state i0 (i=0,1,2). A decrease in credits will permit additional carrying back of losses or credits in the first year of the following three that the firm passes into state 1 or state 2. These credits will then not be carried forward. If the firm passes into state 2, a credit that otherwise would have been carried forward can be carried back. If it passes into state 1, then it will reduce the current credits displaced and carried forward when the losses were carried back from state 1. However, it is possible that no such displaced credits were carried forward. When losses carried back displace previous credits, the firm may, in turn, carry these credits back another three years. This is not possible for the firm in state 10 or 20, for it came into the current year facing credit constraints. However, some firms in state 00 might have had sufficient capacity to carry back every displaced credit, making the reduction in such displacement valueless. For simplicity, we

assume this to be the case for all firms in state 00. Thus, we may express the shadow values associated with credits as:

$$(3.a) \qquad vc_{i0} = (\beta p_{i01}+\beta^2 p_{i00}p_{001}+\beta^3 p_{i00}p_{000}p_{001})(1-wc_{01}) + (\beta p_{i02}+\beta^2 p_{i00}p_{002}+\beta^3 p_{i00}p_{000}p_{002})(1-wc_{02}) \qquad (i=1,2)$$

$$(3.b) \qquad vc_{00} = \beta(1+\beta p_{000}+\beta^2 p_{000}^2)p_{002}(1-wc_{02})$$

We next consider the shadow value of ordinary tax payments that the firm makes in state 0. These can have value if the firm moves into state 1 or 2 in the next three years. In addition, if the firm passes into state 2 and then state 1 within the three year period, it first carries back credits to offset α of the additional income, and then carries back losses offsetting all of the income but displacing credits initially carried back. Taking all these possibilities into account, we have:

$$\begin{aligned}(4) \quad v_{i0} = {} & \beta[p_{i01}(1-w_{01})+\alpha p_{i02}(1-wc_{02})] \\ & + \beta^2\{p_{i00}p_{001}(1-w_{01})+\alpha p_{i00}p_{002}(1-wc_{02})+p_{i02}p_{021}[(1-w_{21})-\alpha(1-wc_{21})]\} \\ & + \beta^3(p_{i00}p_{000}[p_{001}(1-w_{01})+\alpha p_{002}(1-wc_{02})] \\ & \quad + (p_{i02}p_{022}p_{221}+p_{i00}p_{002}p_{021})[(1-w_{21})-\alpha(1-wc_{21})] \\ & \quad + p_{i02}p_{020}p_{201}[(1-w_{01})-\alpha(1-wc_{01})]) \qquad (i=0,1,2)\end{aligned}$$

An extra dollar of taxes paid in state 2 is the result of an increase in tax liability before credits of $1/(1-\alpha)$ dollars and an increase in tax credits of $\alpha/(1-\alpha)$ dollars. A carryback to this state can occur only from state 1. If it does, it will offset the taxes before credits and displace the credits. Thus, we have:

$$(5)\quad (1-\alpha)v_{i2} = [\beta p_{i21}+\beta^2(p_{i22}p_{221}+p_{i20}p_{201})+\beta^3(p_{i22}p_{222}p_{221}+p_{i20}p_{202}p_{021})]$$
$$*[(1-w_{21})-\alpha(1-wc_{21})]$$
$$+ \beta^3[p_{i22}p_{220}p_{201}+p_{i20}p_{200}p_{001}][(1-w_{01})-\alpha(1-wc_{01})] \quad (i=0,1,2)$$

This completes the specification of the shadow values. To obtain a system of equations for the shadow prices in terms of the transition probabilities alone, however, it is necessary to express the "probabilities until taxable" PR and PRC in terms of the transition probabilities p. This may be done recursively, with initial conditions determined by the firm's initial state. We briefly sketch the procedure. In year 1, we have (suppressing the superscripts on PR and PRC):

$$(6)\qquad PRC_{k0}(1) = q_{0k}p_{0k0} + q_{1k}p_{1k0} + q_{2k}p_{2k0} \qquad (k=1,2)$$

where $q_{ij}=1$ if ij is the firm's initial state (indicated by the superscript of PRC) and 0 otherwise. Defining the auxiliary probability $PRC_{km}(t)$ as the probability of the firm going from state k to state m in year t without having passed through state 0 between date 0 and date t-1, we have, for year 1:

$$(7)\qquad PRC_{km}(1) = q_{0k}p_{0km} + q_{1k}p_{1km} + q_{2k}p_{2km} \qquad (k,m=1,2)$$

For $t > 1$, we then have the recursive expression starting with the year 1 values defined in (6) and (7):

$$(8)\qquad PRC_{km}(t) = PRC_{1k}(t-1)p_{1km} + PRC_{2k}(t-1)p_{2km} \qquad (k,m=1,2)$$

For the probabilities PR, we have in period 1 (once again suppressing superscripts):

$$(9) \qquad PR_{1k}(1) = q_{01}p_{01k} + q_{11}p_{11k} + q_{21}p_{21k} \qquad (k=0,2)$$

where, again, the state indicator q_{ij} equals 1 if and only if the firm's initial state is ij, and zero otherwise.

Note that the probability of continuing in state 1 through year 1 is:

$$(10) \qquad PR_{11}(1) = q_{01}p_{011} + q_{11}p_{111} + q_{21}p_{211}$$

For t > 1, we have the recursive expression starting with the year 1 value defined in (10):

$$(11) \qquad PR_{1k}(t) = PR_{11}(t-1)p_{11k} \qquad (i=0,1,2)$$

Expressions (6)-(11) provide solutions for the vectors PR and PRC in terms of the transitions probabilities p, as was desired. Thereafter, we have a system of 18 linear equations ((1)-(5)) in 18 unknown shadow values (v_{i0}, v_{i2}, vc_{i0}, w_{i1}, wc_{i1}, wc_{i2}, i=0,1,2). Though tedious, the solution is straightforward.

The algorithm developed thus far is based on the assumption that firms always carry back losses and credits where possible. As indicated above, however, we also consider the possibility that a firm carries back only when it faced no constraints during the prior three years. This would change expressions (3)-(5) for the shadow values of tax payments. The alternative versions of these expressions are derived in Appendix C.

6. Transition Probabilities and Marginal Tax Rates

In this section of the paper, we present second-order transition probabilities for the three-state model developed above, estimated from our 1971-82 panel of firms taken from the Treasury tax model. We then use the shadow value algorithm developed in the previous section to estimate the shadow values of tax payments and loss and credit carryforwards. These shadow values have several useful applications, of which we demonstrate two. First, we estimate the average effective marginal tax rate at which firms deduct interest payments. Then, in section 7, we estimate the effective tax rates that firms in different initial states face on marginal investment projects with different real and tax attributes.

Table 4 presents estimates of the transitions matrix for the 1971-82 panel of firms for the full sample period (1976-82).[7] Though estimates using firms weighted by asset size are presented, those based on the unweighted sample were similar.

As suggested above, a first-order transition process is unlikely to be very accurate in predicting the movement of firms across states. For example, a firm in state 00 is much more likely to stay in state 0 than firms in states 10 and 20. This is to be expected, since presence in state 0 for two successive years indicates more "distance" from the constrained state. A somewhat different persistence pattern is observed for firms in states 1 and 2. For each state, a firm that has been in that state for two years is more likely to persist in that state than a firm that previously entered that state from state 0. That is, $P_{111} > P_{011}$ and $P_{222} > P_{022}$. However, $P_{122} > P_{222}$ and $P_{211} > P_{011}$, suggesting that there may be substantial mobility among the

constrained states 1 and 2. Once again, this confirms the importance of considering state 2 distinctly rather than grouping taxable credit-constrained firms with those in state 0.

The table indicates a fair degree of persistence in state 0. Over 80 percent of all firms unconstrained for at least two years could be expected to remain so for another year. There is also a lot of persistence in state 1. Again nearly 80 percent of the firms not taxable for at least two years are not taxable for at least one more year. The estimates suggest presence in state 2 is somewhat less long-lived, as one might expect given its intermediate position between taxable and not taxable. In general, firms that transited to or from state 0 in the previous year are more likely to transit again than those in the current state for at least two years. Indeed, firms in state 02 are more likely to return to state 0 than they are to stay in state 2, confirming the view that there is less "permanence" about this state.

The transition probabilities in Table 4 may now be incorporated into the shadow pricing algorithm presented in the previous section to derive shadow prices of tax payments and carryforwards in different states. The calculations apply to a representative firm facing the transition matrix in every year. As we have discussed, there is substantial heterogenity in the sample with respect to the incidence of tax constraints, and the transition probabilities change over time. Taking full account of these variations would involve the use of imprecisely estimated transition probabilities (based in many cells on very small samples) and a substantially more sophisticated model than the already complex one introduced in the last section. Calculations based on sample averages are still quite useful in determining the overall impact of tax status transitions.

Table 5 presents the shadow values estimated for the 1982 tax rules under the assumption that firms always choose to carry back losses when possible.[8] We assume a nominal after-tax discount rate ($1/\beta-1$) of 7 percent. The first two columns present shadow values for tax payments associated with the potential carrybacks facilitated. These act to reduce the effective marginal tax rates for taxable firms. The last two columns give the shadow values for firms not paying the accrued taxes, indicating the present value of each dollar of these taxes that is carried forward. Not every cell in the table has an entry. There are no taxes carried forward from state 0, and no taxes paid in state 1. State 2 is a hybrid, since credits are carried forward but the firm does pay some taxes on ordinary income.

As one would expect, the shadow value for ordinary tax payments made in state 0 is smallest in state 00, and largest in state 10. That is because the firm in state 10 is more likely to return to a constrained state and benefit from the ability to carry losses or credits back. Income taxes associated with a reduction in tax credits generally have a higher shadow value because of their greater ability to absorb tax credit carrybacks in the future. On the other hand, tax credits accrued in state 1 have less value than additions to ordinary tax losses, since their subsequent use is subject to the additional restriction on the use of credits to offset taxable income. In state 11, for example, each dollar of credits carried forward has a present value of only 35.2 cents. Credits carried forward from state 2 have much greater value than those carried forward from state 1 because of the much greater likelihood of the firms entering state 0 from state 2 than from state 1.

The figures in the table indicate that, despite the persistence noted in Table 4, there is enough movement into and out of state 0 to impart a high shadow value to tax payments in that state. Even a firm that has been fully taxable for at least two successive years can expect to recoup 16 percent of its tax payments, in present value, by carrying back subsequent net operating losses and excess tax credits. Combined with the shadow values of carryforwards in state 1, this implies a narrowing of the gap between the different states in effective marginal tax rates, compared to the contemporaneous gap between the full corporate rate and zero.

Given our shadow values, it is simple to construct these effective marginal tax rates. For a taxpaying firm, the tax rate equals the tax on an extra dollar of ordinary income less the shadow value that income generates. For a firm in state 1, the tax rate equals the shadow value of a dollar of ordinary losses carried forward. That is, the effective marginal tax rate in state ij is the statutory tax rate, τ, multiplied by θ, where:

$$(12) \qquad \theta = \begin{cases} (1-v_{i0}) & (i=0,1,2;\ j=0) \\ w_{i1} & (i=0,1,2;\ j=1) \\ [(1-\alpha)(1-v_{i2})+\alpha w c_{i2}] & (i=0,1,2;\ j=2) \end{cases}$$

It will also be useful for subsequent calculations to compare the value of θ for tax payments associated with investment tax credits, rather than ordinary income. We would expect this to be lower for three reasons. First, unlike losses, credits cannot be used at all in state 2. Second, credits carried forward cannot be used at all in a future state 2. Third, tax payments associated with credits have a higher shadow value than those

associated with ordinary income, since they can be offset completely by future excess credits, not just at rate α.[9] We have:

$$(13) \qquad \theta_c = (1-vc_{i0}) \qquad (i=0,1,2;\ j=0)$$

$$wc_{i1} \qquad (i=0,1,2;\ j=1)$$

$$wc_{i2} \qquad (i=0,1,2;\ j=2)$$

The second panel in Table 5 presents estimates of the values of these marginal "effective inclusion" rates, θ and θ_c based on the shadow values in the table. The effective tax rate on ordinary income equals the value of θ multiplied by the statutory tax rate. At the 1982 statutory tax rate of 46 percent, the effective marginal tax rates for corporations vary from a high at 38.6 percent in state 00 to a low of 18.9 percent in state 11, a difference of 19.7 rather than 46 percentage points.

These marginal tax rates on ordinary income are those that are relevant for determining the corporate tax advantage from borrowing. As stressed in our introduction, one of the most important effects attributed to the limited loss offset present in the tax system is that it could conceivably explain the existence of interior debt-equity ratios as an optimal policy of the firm. The argument is extremely simple. Despite the apparent tax advantage to borrowing, firms might reach a point where marginal interest deductions receive such a small deduction, in present value, that other factors, such as the personal tax advantage to equity (via the treatment of capital gains) balances what remains of the advantage of interest deductibility. Clearly, the restrictions are more important for the firm in state 11 than the firm in state 00. One measure of its overall importance is the average of the

different marginal tax rates across the different tax states, weighted by assets of firms in the different states. The last row in Table 5, gives such averages, based on the average state population fractions for the entire sample period.[10] The implied average marginal rate of deduction for interest payments is 31.8 percent. This is quite close to the estimate by Cordes and Sheffrin (1983) (who reported a value of .31 for a 1978 sample based on 1983 law) but considerably below those of Auerbach (1983) and Auerbach and Poterba (1987b). It suggests that the combination of all tax constraints, including investment and foreign tax credits, must be considered in any model attempting to explain corporate borrowing decisions.

7. The Effective Tax Rate on Investment

As in previous studies (Auerbach 1983, Auerbach and Poterba 1987a), we may also consider the impact of loss and credit restrictions on the incentives for firms to invest. This is more complicated than the marginal tax rate calculations just presented for several reasons.

First, an investment project generates tax liabilities over several years. In order to estimate the impact of the tax code, one must arrive at a method of aggregating these tax payments into a single statistic. The standard approach is to calculate an "effective tax rate," equal to the proportional difference between the project's internal rates of return before and after taxes.

A second difficulty is that, in the current context, the firm's marginal tax rate depends on its state, and this state is likely to change over time. For example, a firm currently in state 00 is not certain to remain there over

time. As time goes on, there is an increasing probability that it will experience state 1 or state 2. Likewise, the "loser" in state 11 will, with some probability, reach state 0 or state 2. To account for this we must, when evaluating the marginal tax rate on tax accruals at different future dates, apply the probabilities of each state occurring at each date, conditional on the state observed initially at date 0. As in earlier work, we estimate these future state probabilities by applying the estimated transition matrix recursively to the initial state distribution of the firm. Given our modelling of transitions, this means that the effective marginal tax rates over time for different firms will converge, as the initial state condition becomes less important.

The final problem introduced by loss and credit limitations is one ignored in earlier studies. For a given state, the effective marginal tax rate a firm faces depends on whether the accrued tax liability is associated with ordinary income or credits. For example, investments in equipment have traditionally received the investment tax credit in the year of investment, along with a substantial first-year depreciation allowance. Given the additional limitations on the use of credits, however, it is likely that the credit is less valuable than a deduction of equal, after-tax value. This is easily accommodated by our analysis, since we have calculated separate shadow values for the two different types of tax accruals.

Our approach to estimating the impact of the tax system on the incentive to invest proceeds as follows. First, we posit an asset with an associated cash flow stream and tax accruals determined by the tax code. Second, we posit the firm's state at date 0, and calculate the state probability

distribution at each subsequent date. Third, we estimate the average effective marginal tax rate on credit-type and ordinary income at each date, using this conditional state probability distribution and the shadow values estimated above. Fourth, we apply these effective marginal rates to the accrued tax payments calculated for each date in the first step. Finally, we estimate the effective tax rate on the investment as the proportional difference between the before-tax internal rate of return and the internal rate of return of expected cash flows, after-tax.

Table 6 presents estimates of the effective tax rates on investment for firms in three different states as well as the average effective tax rates over all nine states. Also presented for comparison are the effective tax rates that would prevail under a system with full loss and credit offset. Two assets are considered. One is a representative piece of equipment, qualifying for the full investment tax credit and having an exponential depreciation rate of 12.25 percent. The other is a representative building, which does not receive the investment tax credit and depreciates exponentially at 3.61 percent.[11] Both assets are assumed to deliver a real, certain return, after depreciation, of 6 percent, and are assumed to be financed entirely by equity (and hence generating no additional interest deductions). We apply the provisions of the 1982 tax law, with a corporate tax rate of 46 percent, the Accelerated Cost Recovery System (ACRS) for both equipment and structures, and a 10 percent investment tax credit for equipment.

As is well known, ACRS lowered effective tax rates (ignoring loss and credit constraints) substantially. This is quite evident from the negative tax rate on equipment under a hypothetical system of full loss offset. This

negative tax rate simply indicates a present value of depreciation deductions and investment tax credits in excess of the taxes due on the asset's gross quasirents.

The effects of tax constraints are to lower the average effective tax rates for structures but to raise them slightly for equipment. To understand this result, consider the effective tax rates for firms in selected states for each of the assets. We choose the three states where the firm has been taxable for two years, nontaxable for two years, and credit-constrained for two years, respectively.

As is evident from the table, the tax system's constraints affect different firms in quite different ways that depend on the investments chosen. The taxable firm encounters the lowest effective tax rate on equipment, the nontaxable firm the highest. For structures, however, tax status is of little importance, despite the fact that firms in each state face lower effective rates than under a full loss offset system. This pattern is consistent with earlier findings for two-state models by Auerbach (1983) and Auerbach and Poterba (1987a). It is explained by the presence of two offsetting effects of tax constraints.

On the one hand, the presence, or prospect of, tax constraints reduces all tax payments in present value by pushing them forward in time. On the other hand, this reduction is greater in the early years for nontaxable firms, and less for taxable firms, before the different firms converge to the same long run state distribution. For assets with large immediate tax benefits, that make early year tax accruals negative, such as equipment, the advantage goes to the taxable firm. For other assets, such as structures, the advantage

is neglible. That, for structures, the tax rates of all firms are below the nominal rate simply reflects the importance of the first effect of tax constraints just alluded to, the pushing back of positive tax payments. For equipment, however, the tax rate is actually higher for firms in state 1, since the effects of pushing back early, negative tax payments outweighs the tax reduction gained by pushing back later, positive ones. This explains why the average effective tax rate is lower than the statutory rate for structures, and, given the sample population weights, is slightly higher for equipment.

8. Conclusions

In this paper, we have presented results based on a large panel of actual corporate tax returned concerning the importance of tax loss and credit constraints on the behavior of U.S. corporations. Among our findings have been:

(1) Taking account of constraints on the use of investment tax credits, a significant fraction (about ½, weighted by book assets) of firms in the nonfinancial corporate sector have unused tax benefits that must be carried forward.

(2) This fraction increased substantially in 1981 and 1982 to unprecedented levels.

(3) The incidence of tax constraints varies by firm size. Larger firms are more likely to have positive taxable income but also more likely to have unused foreign and investment tax credits.

(4) The average marginal rate of deduction for interest payments in the early

1980s was just over two-thirds the statutory rate, a fact that could help justify theories of an optimal interior debt-equity ratio based in part on the limited deductibility of interest payments.

(5) The presence of tax constraints does not, in itself, imply the discouragement of investment. We estimate that, on average, it actually reduces substantially the effective tax rate on some investments.

There are obviously many ways in which this study could be extended. One that we attempted ourselves was to see how much of the increased incidence of tax losses in 1981 and 1982 was due to the change in the tax law in 1981 allowing more generous depreciation benefits. Unfortunately, not all the data from the corporate tax returns (form 1120) were available on the Treasury tax file. Our attempts at inferring the extra depreciation allowances due to the change in tax regime produced imprecise estimates. It is still worth reporting, however, that though actual depreciation exceeded what would have been predicted on the basis of pre-1981 experience, there was virtually no change in the number of firms with tax losses associated with this shift. On this point, one should also cite the evidence presented by Auerbach and Poterba (1987a) that the major factor behind the reduction in corporate tax revenues that occurred during this period was a significant decline in the rate of profit.

The panel data we have used ends in 1982. This is all that is currently available to us. The addition of more years to the existing panel would enable us to determine whether the striking increase in loss and credit carryforwards that occurred in 1981 and 1982 has continued during the recent economic recovery. At least after the fact, this will aid in the evaluation of the recently enacted reform of the corporate tax.

Appendix A

In Section 3 above, we described the data used in this paper, pointing out that raw tax return data do not contain direct information on the presence and size of tax loss carryforwards. To obtain this important information, we used the first five years of tax information (1971-75) to establish initial tax conditions, from which complete information for all subsequent years could be inferred by applying provisions of the tax code to the data provided.

In each year, we have two relevant pieces of information for each firm: its taxable income (before credits and net operating loss deductions, but after deductions of intercorporate dividends), TI, and its net operating loss deductions, NOLD. Net operating loss deductions cannot exceed taxable income, when TI is positive. When taxable income is negative, the net operating loss is zero. Therefore, there are four possible combinations for these two variables:

A: TI > NOLD = 0

B: TI < 0; NOLD = 0

C: TI = NOLD > 0

D: TI > NOLD > 0

Case A is the most common. These are firms with positive income and no net operating loss deductions. We may infer that they have no tax losses being carried forward. Case B firms are those with negative taxable income, and hence no NOLD. These firms may or may not have a tax loss carryforward, depending on whether the losses can be fully carried back to the three

previous tax years. This means that, to determine the carryforward for such firms, we will need information on potential carrybacks, as well. Firms in case C are those who are offsetting taxable income to the maximum extent. These firms have tax loss carryforwards, but the size cannot be inferred without an examination of their history. Firms in case D are those who are "using up" their tax loss carryforward: since they could take a larger deduction, we infer that they have no more to take.

Our strategy is to use data for the years 1971-75 to establish either vintages of tax loss carryforwards or vintages of potential carrybacks for each firm. We choose the five year period because, at that time, losses could be carried forward at most five years. Thus, no losses from before 1971 could be carried forward into 1976. For the majority of firms, we have sufficient information to deduce the initial conditions without making any assumptions. For some firms, however, assumptions are required. Where this is so, we experimented with different assumptions. In most cases, the choice of assumption made little difference. Where it appeared to matter, we chose the assumption that gave the best prediction of net operating losses taken after 1975.

As indicated in Section 3, we assigned to firm to four mutually exclusive classes for calculation of initial conditions. We now discuss the algorthm used for each of these classes.

I. Firms in case A for three consecutive base period years. (1626 firms)

These firms were inferred to begin the subsequent year with no tax loss carryforward and a potential carryback equal to the three years' taxable income.

II. Firms who fall into case D during the base period.
(720 firms)

These firms were inferred to start the following year with no tax loss carryforward and a potential carryback equal to the difference between taxable income and the net operating loss deduction for the case D year.

As mentioned in the text, we did observe firms with consecutive years of case D. This occurrence could result from the continual acquisition of smaller loss firms, or from the consolidation of separate returns, some in case A and some in case D. This is probably the major reason for our understatement of net operating loss deductions in the period after 1976.

III. Firms experiencing at least one year (but fewer than three consecutively) of positive income without NOLDs (case A) during the base period.
(198 firms)

Many of these firms had losses in the base period before the case A year but, we may infer, had sufficient carryback reserves that the losses were carried back to the period before 1970. For these firms, we start history with the first case A year in the base period. This has the effect of assuming that no further carry back to the pre-1971 period would be possible. In most cases, this is not restrictive. For example, a firm with losses in 1971 and 1972 and taxable income without at net operating loss deduction in 1973 would, for any losses incurred subsequently, be able to carry back no earlier than 1973. However, in a few cases, our approach may slightly understate the ability to carry back. For example, a firm taxable income in 1971 and 1972 and a loss in 1973 might be able to carry part of the 1973 loss back to 1970.

IV. Firms experiencing no years of case A or case D during the five-year base period.
(264 firms)

These are firms that spent the entire base period losing money (case B) or sheltering taxable income fully (case C). They paid no taxes in any of the years. We assumed that all net operating loss deductions in the base period came from losses incurred before 1971. This means establishing a tax loss carryforward at the end of 1975 equal to the sum of losses

incurred in the 1971-75 period. An alternative assumption tried was to start history with the first year of losses and assume that subsequent base period net operating loss deductions came from these, and not pre-1971 losses. This leads to a 1975 carryforward equal to base period losses net of intervening net operating loss deductions. We opted for the first assumption on the basis of performance after 1975.

A final imputation that was necessary was the investment tax credits carried forward at the end of 1982. Our aim here is to determine only whether they are present, not their size, since aggregate statistics on investment tax credits carried forward are already provided by the Internal Revenue Service's Statistics of Income Division.

To infer the presence of tax credit carryforwards at the end of 1982, we used the following algorithm. Firms which carried credits forward at the end of 1981 and had tentative ITCs in 1982 in excess of those taken were inferred to be constrained at the end of 1982 as well. Those who were not constrained at the end of 1981, but had tentative ITCs in excess of those taken, carried some credits back. To determined whether they were able to carry all excess credits back, we assumed that firms which had carried credits back in the previous year would not be able to carry all their credits back during the current one as well.

Appendix B

The paper reports estimates for 1980, 1981 and 1982 of state populations and aggregate tax loss carryforwards for the entire nonfinancial corporate sector, excluding only firms with less than 10 million dollars in assets in the respective year. This appendix describes the derivation of these estimates.

We begin with the panel of firms with complete data from 1971 through the year in question. These panels have 3343, 3086 and 2808 firms for the periods 1971-80, 1971-81 and 1971-82, respectively. For each year, we then add that year's tax return data for all other corporations above 10 million in assets to obtain a universe of all firms. We then take out all those firms for whom we would know from a single year's tax return that the firm has no tax loss carryforward, including those in state 1 because they offset all taxable income with foreign tax credits.

We divided the remaining firms into three classes: those with negative taxable income, those with positive taxable income equal to net operating loss deduction, and those with taxable income greater than the (positive) net operating loss deduction. Firms in this last class should normally be taxable but, as discussed above, we turned up several cases in studying the panel in which this appeared not to be so.

For each year, and each of the three classes, we then estimated an equation relating the ratio of tax loss carryforward to assets to several explanatory variables taken from that year's tax return, using all firms from that year's complete panel in that class. (Where the tax loss carryforward

was zero, we followed the approach in Auerbach (1983) and included the firm's potential carryback multiplied by -1.) Among the explanatory variables were assets, sales, foreign tax credits, investment tax credits, ITC carryforward, and taxable income. We then used these equations to impute the tax loss carryforward for firms not in the complete panels and assumed those firms were in state 1 if the imputed values were positive.

To correct for sample selection bias, we first estimated a probit equation for sample inclusion before performing the regressions. We added to the list of explanatory variables the firm's tax return filing date, which proved to be a significant explanatory variable, consistent with our view that data problems are an important reason for absence from the panel. We then constructed and used the appropriate Mills ratio corrections in the regressions based on firms in the panel and the imputations for firms not in the panel.

A minor complication is involved in classifying a small number of taxable firms into state 0 or 2. Firms with tentative investment tax credits in excess of those claimed, but no investment tax credit carryforward from the previous year, are in state 2 if they cannot carry all the excess credits back but remain in state 0 if they can. This classification problem was encountered for the panel for the last year, 1982 (see Appendix A), but we cannot use the classification algorithm employed there with only one year of data. Therefore, we calculate upper and lower bounds for the state 2 population by assuming all or none of these firms are in state 2, and take a simple average. The difference between the two estimates of the state 2 population is typically quite small.

Appendix C

Section 5 of the text presents expressions for the shadow values of tax payments under the assumption that firms always carry losses and credits back. In this appendix, we show how these expressions must be amended when firms only carry losses back when the carry back period contains no years in which they already faced constraints. The expressions affected are (3)-(5).

First, firms will never carry losses back into state 2. Since they cannot carry credits back to this state in any event, we have:

$$(5') \qquad v_{i2} = 0 \qquad (i=0,1,2)$$

Second, tax payments in state 0 will not be used to offset tax credits and, in subsequent years, the tax losses, since this would involve carrying the losses back to a state 2 year. For a firm in state 10 or state 20 (i.e. currently taxable but not fully taxable in the previous year), losses will be carried back to the current year only if the firm is in state 0 for the next two years as well. Other wise, the three-year carryback period will include the previous year in which the firm was not in state 0. Thus, for states 10 and 20, (4) in the text is replaced by:

$$(4.a') \qquad v_{i0} = (\beta p_{i02}+\beta^2 p_{i00}p_{002}+\beta^3 p_{i00}p_{000}p_{002})\alpha(1-wc_{02}) + \beta^3 p_{i00}p_{000}p_{001}(1-w_{01}) \qquad (i=1,2)$$

Firms initially in state 00, however, will carry back to the current year if state 1 occurs two years hence (after state 0), since by then the three previous years would all have been state 0. If the firm reaches state 1

immediately, however, we must allow for the fact that it could have been in state 1 or state 2 two years before the current one. For the firm currently in state 00, the probability that it was also in state 0 two years ago is:

$$\text{(B1)} \qquad Pr(000|x00) = (q_{00}p_{000})/(q_{00}p_{000}+q_{10}p_{110}+q_{20}p_{200})$$

where q_{ij} is the population weight of state ij. Thus, for state 00, (4) in the text is replacd by:

$$\text{(4.b')} \qquad v_{00} = \beta(1+\beta p_{000}+\beta^2 p_{000}^2)p_{002}\alpha(1-wc_{02}) + \beta(Pr(000|x00)+\beta p_{000}+\beta^2 p_{000}^2)p_{001}(1-w_{01})$$

A similar argument affects the value of taxes associated with changes in tax credits. For i=1 or 2, expression (3.a) in the text becomes:

$$\text{(3.a')} \qquad vc_{i0} = (\beta p_{i02}+\beta^2 p_{i00}p_{002}+\beta^3 p_{i00}p_{000}p_{002})(1-wc_{02}) + \beta^3 p_{i00}p_{000}p_{001}(1-wc_{01}) \qquad (i=1,2)$$

Since, as discussed above, losses carried back into state 00 are already assumed to produce no shadow value for a reduction in tax credits, there is no change in the shadow value of a change in credits in state 00 caused by the change in assumption about when firms carry losses back (i.e. (3.b) is unchanged).

Footnotes

1. Since 1986, a strengthened corporate alternative minimum tax acts as a second level, parallel tax system, but the minimum tax in place during our sample period was much less important.

2. Our universe also contains Subchapter S Corporations, which are taxed as partnerships. Since they represent just over 1 percent of corporate assets, their inclusion should have an insignificant impact on the results.

3. Actually, each year's return reports the carryforward from the previous year. Thus, carryforwards from 1982 are not directly available from 1982 tax returns; to estimate these, we used an algorithm described in Appendix A.

4. Our weighted and unweighted percentages for firms in state 1 for 1981 and 1982 (the only years of overlap) are substantially higher than those found by Auerbach and Poterba, even if we substract firms in state 1 due to foreign tax credits. This suggests that losses are more prevalent among the firms with poor public accounting data that were omitted from their sample.

5. Further details of the method and data source used for this calculation is provided by Auerbach and Poterba (1987a).

6. This may slightly overstate the average length that marginal changes in tax credits can be carried forward from state 2. If the firm is in the process of reducing, rather than increasing, its stock of unused tax credits, the marginal tax credit in the carryforward stock may have been accrued in an earlier year. This would make the appropriate expiration date in expression (1) earlier than TC. A similar issue arises with ordinary losses carried forward. There does not seem to be any simple way of correcting this rather

minor error.

7. The annual transition patterns vary quite substantially, but we focus on the sample average to reduce sampling error and because we are interested in the long run transition patterns.

8. This presents a small problem, because a small number of firms in the sample on which our transition matrices are based were assumed to follow a policy of only sometimes carrying losses back. For such firms, the shadow value algorithm is slightly different (see Appendix C). However, the difference and the number of firms involved are so small that estimation using separate transition matrices did not seem worthwhile. All subsequent calculations also are based on the "always carry back" algorithm given in section 5.

9. Offsetting these effects is the fact that credits accrued in state 00 may have reduced value under the assumption, which we have made, that firms will be able to carry any displaced credits back an additional three years. This explains why, in table 5, the shadow value of credits is lower in state 00 than the shadow value of ordinary tax payments.

10. The sample state population weights are: 00: .439, 01: .033, 02: .098, 10: .004, 11: .075, 12: .023, 20: .101, 21: .031, 22: .195.

We would prefer to use universe state weights, but we have estimates only of the state 0, 1 and 2 populations and not the additional breakdown within each of these states. The major state fractions for the universe, given in Table 1, are quite close to those calculated for the sample, so the differences should be small.

11. These depreciation rates are those for general industrial equipment and industrial buildings estimated by Hulten and Wykoff (1981).

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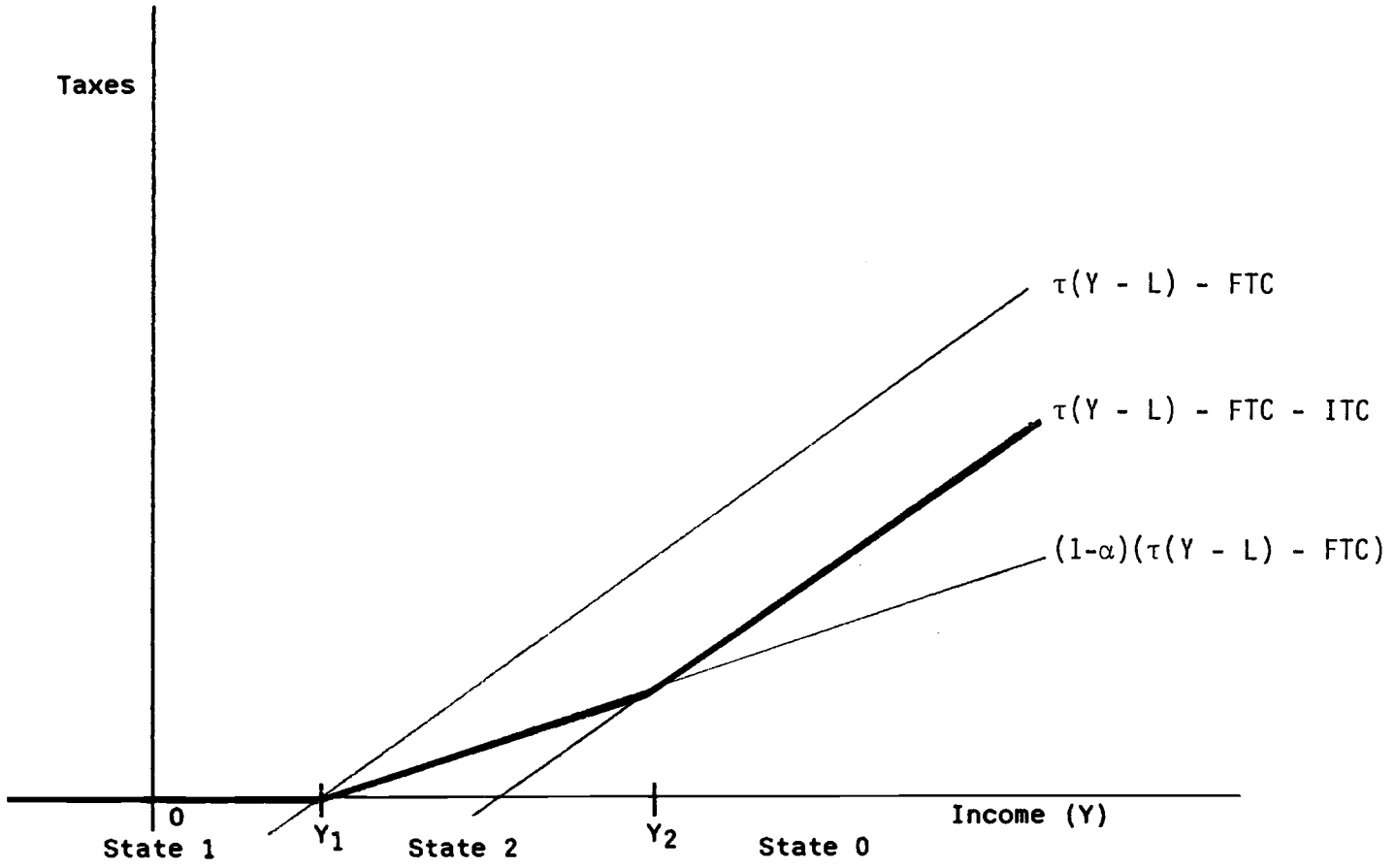
Figure 1

Tax Payments Versus Domestic Taxable Income



Definitions:

τ - statutory tax rate

α - rate of investment tax credit offset

L - tax losses carried forward from previous year

FTC - current foreign tax credits accrued plus foreign tax credits carried forward from the previous year

ITC - current investment tax credits accrued plus investment tax credits carried forward from the previous year

Table 1

Fraction of Firms by State

Year	State 0	1		2
Unweighted				
1976	0.748	0.114	(0.008)	0.138
1977	0.769	0.099	(0.006)	0.132
1978	0.769	0.099	(0.007)	0.132
1979	0.763	0.099	(0.011)	0.138
1980	0.740	0.124	(0.016)	0.136
1981	0.724	0.145	(0.014)	0.131
1982	0.668	0.197	(0.014)	0.135
Weighted by Assets				
1976	0.561	0.088	(0.015)	0.351
1977	0.616	0.072	(0.028)	0.312
1978	0.575	0.075	(0.020)	0.351
1979	0.554	0.096	(0.038)	0.349
1980	0.516	0.138	(0.051)	0.346
1981	0.540	0.167	(0.056)	0.292
1982	0.504	0.223	(0.052)	0.273
Weighted by Assets (universe, corrected)				
1980	0.552	0.141	(0.045)	0.307
1981	0.552	0.187	(0.053)	0.261
1982	0.483	0.230	(0.054)	0.287

State definitions: 0 - fully taxable
1 - nontaxable
2 - taxable but credit-constrained

Numbers in parentheses are sample fractions of firms in state 1 because of foreign tax credits.

Table 2

Fraction of Firms by State, Weighted by Assets
Selected Industries

Year	State 0	1		2
All Industries				
1980	0.552	0.141	(0.045)	0.307
1981	0.552	0.187	(0.053)	0.261
1982	0.483	0.230	(0.054)	0.287
Airlines				
1980	0.224	0.413	(0.074)	0.363
1981	0.185	0.630	(0.070)	0.185
1982	0.127	0.618	(0.063)	0.255
Oil				
1980	0.566	0.101	(0.051)	0.333
1981	0.587	0.186	(0.102)	0.227
1982	0.525	0.113	(0.042)	0.362
Manufacturing				
1980	0.596	0.165	(0.068)	0.239
1981	0.582	0.201	(0.066)	0.217
1982	0.506	0.241	(0.069)	0.253
Railroads				
1980	0.200	0.338	(0.000)	0.462
1981	0.120	0.612	(0.000)	0.268
1982	0.211	0.631	(0.000)	0.158
Steel				
1980	0.382	0.146	(0.000)	0.472
1981	0.593	0.070	(0.001)	0.337
1982	0.189	0.760	(0.002)	0.051

State definitions: 0 - fully taxable
1 - nontaxable
2 - taxable but credit-constrained

Table 3

Loss and Investment Credit Carryforwards

(end of year)

Billions of Dollars

Year	(Sample 71-80)	Losses		Credits
		No Correction	Correction	
1976	(3.4)			6.6
1977	(4.6)			7.7
1978	(5.1)			9.5
1979	(6.5)			11.7
1980	(12.8)	36.2	37.1	15.0
1981		56.4	122.2	18.0
1982		67.2	107.8	21.4

Sources: Losses are for nonfinancial corporations with assets over 10 million dollars, estimated from our sample. Credits are for all corporations (except DISCs), and are taken from the Statistics of Income Corporation Returns. Numbers in parentheses are those for the 1971-80 panel alone, and are provided as evidence concerning the trend of losses before 1980.

Table 4

Second-Order Transition Probabilities

(weighted by assets)

Initial State	Outcome		
	0	1	2
00	0.820	0.038	0.142
01	0.153	0.502	0.345
02	0.490	0.059	0.452
10	0.475	0.190	0.336
11	0.029	0.782	0.189
12	0.157	0.139	0.705
20	0.585	0.048	0.367
21	0.011	0.841	0.149
22	0.213	0.123	0.664

Table 5

Shadow Values of Tax Payments and Carryforwards

(1982 Tax Rules)

State	Tax Payments		Tax Carryforwards	
	Ordinary Income	Credits	Ordinary Income	Credits
00	0.160	0.136		
10	0.264	0.303		
20	0.217	0.252		
01			0.475	0.410
11			0.420	0.352
21			0.411	0.341
02	0.037			0.562
12	0.054			0.468
22	0.050			0.484

Effective Inclusion Rates

State	Ordinary Income	Credits
00	0.840	0.864
10	0.736	0.697
20	0.783	0.748
01	0.475	0.410
11	0.420	0.352
21	0.411	0.341
02	0.622	0.562
12	0.540	0.468
22	0.554	0.484
Sample Average (weighted)	0.692	0.668

Notes: For ordinary income, effective tax rate is computed by multiplying the effective inclusion rate by the statutory marginal tax rate.

For tax credits, the effective credit rate equals the effective inclusion rate multiplied by the statutory rate of tax credit.

Table 6

Effective Tax Rates on Equipment and Structures
for Firms in Different States

(1982 Tax Rules)

State	Equipment	Structures
Full Loss Offset	-0.083	0.433
00	-0.192	0.267
11	0.117	0.267
22	0.042	0.275
Average (all states)	-0.067	0.267