Loss Carryforward Valuation and Corporate Tax Policy*

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Abstract

The U.S. corporate tax code allows firms to carry negative profits into the future and deduct them from taxable income in a future period. These carried losses, known as net operating loss carryforwards (NOLCFs), affect the decision-making and valuation of firms. To understand how the deductibility of NOLCFs affects key variables, such as firm investment, equity distributions, and tax outlays, a standard dynamic firm investment model is expanded to include the accumulation of these losses and estimated using simulated method of moments. After inferring the deep parameters of the model, the framework is used to measure the valuation of the carried losses and evaluate alternative policies by changing the tax rate and the degree of NOLCF deductibility, as in the U.S. corporate tax reform of 2017.

Keywords: loss carryforwards; firm heterogeneity.

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1 Introduction

A critical and consequential feature of the U.S. corporate tax code, as well as the corporate tax codes of several U.S. states and other national governments, is the deductability of previous losses from current taxable income. Such losses carried are known as *net operating loss carryforwards* (NOLCFs), and the availability of these deductions influences how firms make key decisions. The availability of NOLCFs also influences how firms respond to changes in the corporate tax structure, such as those implemented in the corporate tax reform of 2017. To evaluate this feature of corporate taxation, this paper studies the role of NOLCFs in the decision-making and valuation of firms and measures the effects of changes in the corporate tax code.

The implementation of NOLCF deductability aims to reduce an inherent tax bias against firms with higher volatility or growing firms that incur large losses as they expand. The bias results from the asymmetry of corporate taxation levied exclusively on positive corporate income. If this restriction were relaxed entirely (i.e., if losses were immediately subsidized at the corporate tax rate), it could result in excessive moral hazard corresponding to managerial risk or the pursuit of corporate earnings. As a result, NOLCF deductions provide a reasonable alternative to mitigate issues resulting from asymmetric corporate profit taxation.

The goal of this paper is to understand the role of the government's NOLCF policy in the decision-making and valuation of firms. To this end, I first consider a simple three-period dynamic firm optimization problem. This exercise provides insight into the effect of NOLCF deductibility and determines the general conditions under which the government might unambiguously wish to allow some deductibility of NOLCFs. While this outcome is not the case in the full model, it serves to illustrate the trade-off faced by the government. Next, I consider a full version of the model, where firms experience idiosyncratic productivity shocks and choose investment and NOLCFs. The government applies a proportional tax on positive profits and allows the deduction of NOLCFs. To obtain parameter values, I estimate the model using simulated method of moments with data from the WRDS COMPUSTAT data set.

To measure the effects of policy changes on key variables, I conduct three experiments. The first two experiments coincide with actual limitations of NOLCFs implemented by certain states and the federal government, while the third evaluates changes in the corporate tax rate. The results show significant capital accumulation effects of the 2017 corporate tax reform. The simulations show that the limitation of NOLCFs implemented in the 2017 tax reform has no long-term effect on either tax revenue or any other corporate variables, but analysis of the transition path shows interesting consequences immediately following the reform.

Several papers have formalized the role of NOLCFs in the decision-making of firms. Auerbach and Poterba (1987) study the implications of loss deductions on a firm's effective tax rate and find that NOLCFs have a significant effect on a firms' investment incentives. This paper confirms that result and quantifies the magnitude of investment induced by the availability of NOLCF deductions. Edgerton (2010) proposes a firm model to measure the role of NOLCFs in the effectiveness of investment incentives. That paper finds that the concurrence of investment stimulus and NOLCF (and loss carryback) deductions during macroeconomic downturns reduces the effectiveness of investment incentives. Although this paper does not evaluate aggregate shocks, the framework could be extended to include cyclical investment incentives. More recently, Kaymak and Schott (2019) calibrate a model of corporate taxation with NOLCFs in stationary economies with entry and exit. The authors find that implementation of corporate taxation with NOLCFs leads to large distortions in the allocation of capital, relative to an economy that levies a value-added tax. By contrast, this paper rigorously derives the parameters of the underlying model through structural estimation and finds important consequences of corporate tax reform along the transition path.

This paper appears to be the first to use structural estimation to derive the parameters of a standard corporate finance model with explicit NOLCF stocks. This approach follows several papers that have used structural estimation to obtain parameters of similar models. Cooper and Haltiwanger (2006) estimate a basic version of the model presented herein with alternative specifications of the capital adjustment cost function. This paper builds on the convex adjustment cost version of that model by adding corporate tax policy features relating to asymmetric taxation. Hennessy and Whited (2005) estimate a model with tax policy but focus on the role of debt deductibility. That paper uses a modified tax function to account for loss carryforwards in a tractable way. While this paper does not include debt, it explicitly accounts for NOLCFs by expanding the state space to allow for dynamic NOLCF accumulation and exhaustion.

NOLCFs may also play an important role in the capital structure and financial policy decisions of firms. Graham (1996) finds evidence that firms with positive NOLCFs face significantly lower marginal tax rates, which impacts their financial decisions. Hennessy and Whited (2007) estimate a basic model with external financing constraints and find financing frictions play a significant role in firms' financial structures. Since NOLCFs can be used to shift tax liabilities over time, exhaustion of these tax loss assets may be influenced by financing constraints and choice of capital structure. Indeed, Heitzman and Lester (2018) find important interactions between a firm's financing decisions and NOLCFs. While it would be ideal to consider debt and external financing costs in the estimated model, such extensions to the model reduce its tractability and are left for future research.

The paper is organized as follows: Section 2 introduces a simple model and corresponding theoretical results, as well as the benchmark theoretical model. Section 3 discusses the data, explains the methodology, and presents the estimation results. Section 4 shows the results of the counterfactual experiments, and Section 5 concludes.

2 Model

2.1 Simple Three-Period Model

This simple model highlights the role of NOLCFs in optimal investment decisions and determines the circumstances in which restricting its deductability reduces government revenue. The initial goal is to show that under reasonably general conditions, optimal investment is increasing in the availability of NOLCFs. Then, total revenue is characterized with respect to changes in NOLCF deductibility to understand its general properties.

The firm wishes to maximize its expected value, which is the sum of its expected income in each of the three periods. A permanent investment choice k is made in period 1, and production occurs in periods 2 and 3. For a given capital choice, the firm receives $R(k)$ in net revenue, which has properties for $k \in \mathbb{R}^+$: $R(k) \geq 0$, $R'(k) > 0$, $R''(k) < 0$, and $\lim_{k \to 0} R'(k) = \infty$. Period two production is risky; with probability p, the firm receives a shock $z < 0$, and net revenue (i.e., loss) is $zR(k)$. Positive net revenue is taxed at rate $\tau \geq 0$ and allows for the deduction of previous losses. For analytic purposes, suppose a fraction γ of losses can be deducted, which could only happen in period 3.

The firm's expected profits $\Pi(k)$ over the three periods can be written as follows:

$$\Pi(k) = \underbrace{-k}_{\text{period 1}} + \underbrace{(1-p)(1-\tau)R(k) + pzR(k)}_{\text{period 2}} + \underbrace{R(k) - (1-p)\tau R(k) - p\tau(R(k) - \gamma|zR(k)|)}_{\text{period 3}}. \tag{1}$$

The term $|zR(k)|$ in the third period term is just the NOLCF, which reduces the expected tax bill in the third period.[1] Equation (1) can be rewritten as:

$$\Pi(k) = -k + R(k)\left[(1-p)2(1-\tau) + p(1+z-\tau+\gamma\tau|z|)\right] \tag{2}$$

Notice that the term in the brackets is a constant that is increasing in the term related to the NOLCF: $\gamma\tau|z|$. Then, the optimality condition is:

$$R'(k^*) = \left[(1-p)2(1-\tau) + p(1+z-\tau+\gamma\tau|z|)\right]^{-1}. \tag{3}$$

Equation (3) is decreasing in γ, so by the concavity of R, k^* is increasing in γ. In other words, investment is increasing in the availability of the NOLCF deduction. What remains is to determine the conditions under which increasing the NOLCF deduction availability increases government revenue.

Now consider the effect of limiting the availability of NOLCF deductions on total tax revenue. Total tax revenue as a function of optimal investment is:

$$TR(k^*) = \tau R(k^*)\left[(1-p)2 + p(1-\gamma|z|)\right] \tag{4}$$

Differentiating with respect to γ gives:

$$\frac{\partial TR(k^*)}{\partial\gamma} = \tau\frac{\partial R(k^*)}{\partial k^*}\frac{\partial k^*}{\partial\gamma}\left[(1-p)2 + p(1-\gamma|z|)\right] - \tau R(k^*)p|z| \tag{5}$$

The term $\frac{\partial R(k^*)}{\partial k^*}\frac{\partial k^*}{\partial\gamma} \equiv \mu$ is marginal firm revenue induced by increasing γ. Setting (5) to zero and solving for the government-revenue-maximizing NOLCF deductability γ^* gives:

$$\gamma^* = \frac{\mu(2-p) - p|z|R(k^*)}{\mu p|z|}. \tag{6}$$

[1] This deduction is usually limited by the magnitude of positive revenues in the period, but this restriction is omitted from the simple model without loss of generality.

First, notice that if the right-hand-side of (6) is greater than or equal to one, then the government and the firm are both worse off if the government limits the deductability of NOLCFs. Second, γ^* is unambiguously decreasing in the probability of losses, p, the magnitude of the adverse shock, $|z|$, and the magnitude of potential losses $|z|R(k^*)$. Finally, γ^* is increasing in marginal revenue induced by NOLCF deduction allowance as long as $\frac{(2-p)}{p|z|} > 1$, which relates expected gains to expected losses. Of course, if $\frac{(2-p)}{p|z|} < 1$, the firm's expected value is negative for any level of investment, and the firm should not produce.

2.2 Benchmark Model

Suppose now that firms choose over capital and loss carryforwards to maximize an infinite stream of equity payments discounted geometrically at rate $\frac{1}{1+r}$. Firms own capital k and experience productivity risk. In any period, the firm's total factor productivity is determined by a random shock that follows a first-order autoregressive process,

$$z' = \bar{\rho} + \rho z + \epsilon \tag{7}$$

$$\epsilon \sim \mathcal{N}(0, \sigma_\epsilon^2). \tag{8}$$

The specification of productivity allows for negative income shocks, which play a critical role in understanding NOLCFs. Production experiences decreasing returns to scale, and the firm's income function can be written as zk^θ. Capital depreciates at rate δ, and investment, $k' - (1-\delta)k$, is chosen in the period before capital becomes productive. If firms change their capital stocks, they incur quadratic adjustment costs: $\frac{\gamma}{2}(k' - (1-\delta)k)^2$.

Firms pay proportional taxes τ on positive corporate income. If corporate income is negative, the firm incurs a loss of that magnitude and can carry the loss forward to deduct it from taxable income in a future period. In reality, before the 2017 tax reform, the U.S. corporate tax code allowed firms to carry losses forward for up to 18 years and back for 3 years, but the dimensionality required to account for this feature makes the model intractable. Instead, the model assumes only carryforwards and no such expiration for NOLCFs.

The Bellman equation describing firm optimization is:

$$V(k,c,z) = \max_{k',c'} \left\{ e(k,c,k',c',z) + \frac{1}{1+r} E_{z'|z} \left[V(k',c',z') \right] \right\} \tag{9}$$

$$s.t. \qquad \begin{cases} c - c' \in [0, \min\left\{zk^{\theta}, c\right\}], & \textit{if} \quad zk^{\theta} \geq 0 \\ c' = c + \mid zk^{\theta} \mid, & \textit{if} \quad zk^{\theta} < 0 \end{cases} \tag{10}$$

where

$$e(k,k',c,c') = zk^{\theta} - \tau(y - (c - c')) - (k' - (1-\delta)k) - \frac{\gamma}{2}(k' - (1-\delta)k)^2, \tag{11}$$

$$y = \max\{zk^{\theta}, 0\}. \tag{12}$$

The loss carryforward constraint (10) describes feasible NOLCF exhaustion in the case of positive income and NOLCF accumulation in the case of negative income. The first condition of (10) ensures that losses deducted $(c-c')$ from positive income do not exceed the lesser of current income and losses carried into the current period. The condition $c - c' \leq zk^{\theta}$ implies that the deduction is not refundable, while $c - c' \leq c$ is a non-negativity constraint on c', ensuring that firms can not use NOLCFs as a borrowing mechanism. Constraint (10) also implies $c \geq c'$ in profitable periods so that firms can not choose to pay taxes in excess of the tax bill and incur NOLCFs for use in a future period. Such a constraint, however, is an arbitrary feature of the tax system and open to further evaluation.[2] The taxable income equation (12) restricts taxation to positive

[2] This would never be optimal with linear taxes, though it might be desirable under nonlinear taxation.

income levels, giving rise to the study of asymmetric corporate taxation.

For a given set of parameters, moments of the model correspond to the steady-state distribution over the state space. Specifically, let $\Lambda_t(k, c, z)$ be any distribution over the state space at time t, and let $\Gamma(\cdot)$ be the transition function determined by the productivity shock's Markov process and optimal decision rule over the state space, such that:

$$\Lambda_{t+1}(k, c, z) = \Gamma(\Lambda_t(k, c, z)). \tag{13}$$

Then the steady-state distribution is represented by the fixed point of Γ:

$$\Lambda(k, c, z) = \Gamma(\Lambda(k, c, z)). \tag{14}$$

3 Estimation

3.1 Data and Methodology

Data moments are derived from the WRDS COMPUSTAT data set. The time period is 2000-2016, which includes roughly as many years before the start of the Great Recession as after. Inactive firms, firms with missing data, and firms with total assets below \$10 million are excluded from the data set. Also, because of differing financial structures, regulated, financial, and quasi-private firms with SIC code between 4900-4999, 6000-6999, and greater than 9000 are removed from the data set. The remaining data provides 66,910 observations. The top and bottom 1% of estimated values are windsorized, and standard errors are determined using a bootstrapping procedure. Histograms corresponding to the moments estimated from the bootstrapping procedure are provided in the appendix.

The goal of the estimation procedure is to find the vector of structural parameters, $\beta = \{\theta, \delta, \gamma, \tau, \bar{\rho}, \rho, \sigma_\epsilon^2\}$ such that the model-generated moments closely match the corresponding data moments. With the exception of the corporate tax rate τ, estimating this set of parameters is standard in the structural corporate finance literature. Including the corporate tax rate as an estimated parameter ameliorates some of the discrepancies between various tax deductions and incentives in the real world and the deductions explicitly modeled. The only remaining parameter is the interest rate, which is set to $r = 0.04$.

Parameters of the structural model are estimated using simulated method of moments. Let $M(x)$ be a vector of moments of the data, x, and let $m(\beta)$ be the corresponding model moment vector as a function of the parameter set β. Finally, let W be a positive semi-definite matrix corresponding to the inverse of the covariance matrix of the moments. The estimated parameter vector, $\hat{\beta}$, is the solution to the optimization problem:

$$\hat{\beta} = \underset{\beta}{\operatorname{argmin}}(m(\beta) - M(x))'W(m(\beta) - M(x)). \tag{15}$$

To increase the likelihood of finding a global optimum, simulated annealing is used to solve (15). Model variables and the data analogs are summarized in Table 1.

The productivity shock process is discretized into 11 states using the method described in Adda and Cooper (2003). For a given set of parameters, the model moments are computed by solving the firm's problem, then applying the law of large numbers to approximate the invariant distribution corresponding to the state space. The resulting distribution differs from the common Monte Carlo approach to estimating model moments. Many applications of the Monte Carlo process in the literature solve the agent's problem by optimizing over discrete points in the choice space. The decision rule corresponding to a discretized choice space gives exact grid points in the state space, reducing the computational cost of Monte Carlo simulation. However, because the model in this paper is solved by optimizing over a continuous choice space, which generally provides solutions between grid points, multi-dimensional interpolation would be required in every iteration of a Monte Carlo simulation. The computational requirement for this approach

Variable	Model Calculation	Compustat Name and Derivation
Capital	k	'Assets - Total'
Income	zk^{θ}	'Pretax Income'
Investment	$k' - (1-\delta)k$	'Capital Expend Property, Plant and Equipment Schd V'
Equity	$e(k, c, k', c', z)$	'Sale of Common and Preferred Stock' minus 'Purchase of Common and Preferred Stock'
Tax	$\tau(y - (c - c'))$	'Income Taxes - Federal'
NOLCF	c	'Tax Loss Carry Forward'

Table 1: Model and Data Variables

is prohibitive and reduces the precision of the model moments. Instead, the invariant distribution is approximated, and statistics dependent on the simulation sample size are replaced by the asymptotic equivalent.

3.2 Identification

Choice of moments to be matched reflects the ability of the moment to help infer the parameters of the model. Accordingly, moments of income, investment, equity, and taxes are included. With the exception of correlation and positive shares, all moments reflect the variable relative to the firm's capital stock. While it would be ideal to include NOLCFs as a targeted moment, that variable in the COMPUSTAT data is known to suffer from significant measurement error.[3] Instead, values corresponding to NOLCFs are reported in the appendix as untargeted moments.

The discrete distribution approach to measuring model moments complicates serial correlation calculation, which is sometimes used to capture the persistence of the shock process.[4] Instead, the frequencies of positive income and positive taxes are introduced to help infer the distributional properties of the shock process. In particular, the stochastic process characterizing the productivity shock determines the frequency of positive income,

[3]See, for example, Heitzman and Lester (2018).

[4]Cooper and Haltiwanger (2006) and Hennessy and Whited (2005), for example.

so including that moment helps determine the parameters of the AR1 process.

Mean income is another moment often included to capture features of the income process. While total income in the data is positive (i.e., the sum over all income data points), average income-to-asset ratio (i.e., *mean income* in the context of the moment names) is negative. Including this moment skews parameter values in the estimated model in a way that understates total income, so mean income is omitted as a targeted variable. Mean income and the variance of income are, however, reported as untargeted moments, and the variance of income in the model is a close match to the data.

3.3 Results

	Model Moment	Data Moment	S.E.
Mean Investment	0.0516	0.0580	0.0003
Mean Equity	0.0519	0.0488	0.0007
Mean Tax	0.0114	0.0099	0.0001
Variance of Investment	0.0051	0.0046	0.0001
Variance of Equity	0.0349	0.0267	0.0004
Variance of Taxes	0.0003	0.0003	0.0000
Positive Tax Share	0.4958	0.4975	0.0023
Positive Income Share	0.6364	0.6156	0.0019
Correlation of Taxes and Income	0.7624	0.5231	0.0212

Table 2: Targeted Model and Data Moments

Targeted model moments and corresponding data moments with standard errors are reported in Table 2. Parameter estimates and corresponding standard errors are reported in Table 3. With the exception of correlation of taxes and income, all model moments are close to the corresponding data moments. The U.S. corporate tax code allows for several types of deductions that are excluded from this model, including debt interest and taxes paid to lower levels of government. To that extent, it makes sense that the model overstates correlation of taxes and income, relative to the value measured in the data.

	Parameter Estimates	S.E
θ	0.7492	0.0091
δ	0.0350	0.0004
γ	0.4402	0.0095
τ	0.0998	0.0012
$\bar{\rho}$	0.1795	0.0129
ρ	0.2386	0.0171
σ_ϵ^2	0.2333	0.0245

Table 3: Parameter Estimates

Estimates of the model parameters are consistent with existing estimates in the literature. In a model that includes taxes, corporate debt, and external financing costs, DeAngelo, DeAngelo, and Whited (2011) estimate the curvature parameter to be $\theta = 0.7880$, which is close to the value estimated in this paper. Cooper and Haltiwanger (2006) estimate a similar dynamic firm model with alternative specifications of the capital adjustment cost function. In the version of the model that has convex adjustment costs, they find an adjustment cost parameter $\gamma = 0.455$, which is close to the value in this estimation. Bazdresch, Kahn, and Whited (2017) estimate a standard dynamic corporate finance model and find a depreciation rate of $\delta = 0.0449$ using a moments-based estimator, which is close to the value estimated for this model. The specification of the profitability shock in that paper assumes log-normal distribution. Such a specification for this model yielded similar parameter values but a poorer fit to the data. By contrast, the profitability shock in this paper is normally distributed with a positive mean. Finally, the implied federal tax rate is roughly 10%. Although this value seems low relative to the statutory tax rates, several other real-world deductions and tax credits explain the difference and account for the lower model rate.

A firm's current and future tax outlays decrease as its NOLCF stock increases. Consequently, a firm's value increases with its NOLCF stock. Figure 1 shows how NOLCFs improve the valuation of a firm with average assets. Mathematically, the graph shows $100 \times \left(\frac{V(\bar{k},c,z_i)}{V(\bar{k},0,z_i)} - 1\right)$, where $\bar{k}$ is the mean capital stock, i corresponds to the productivity

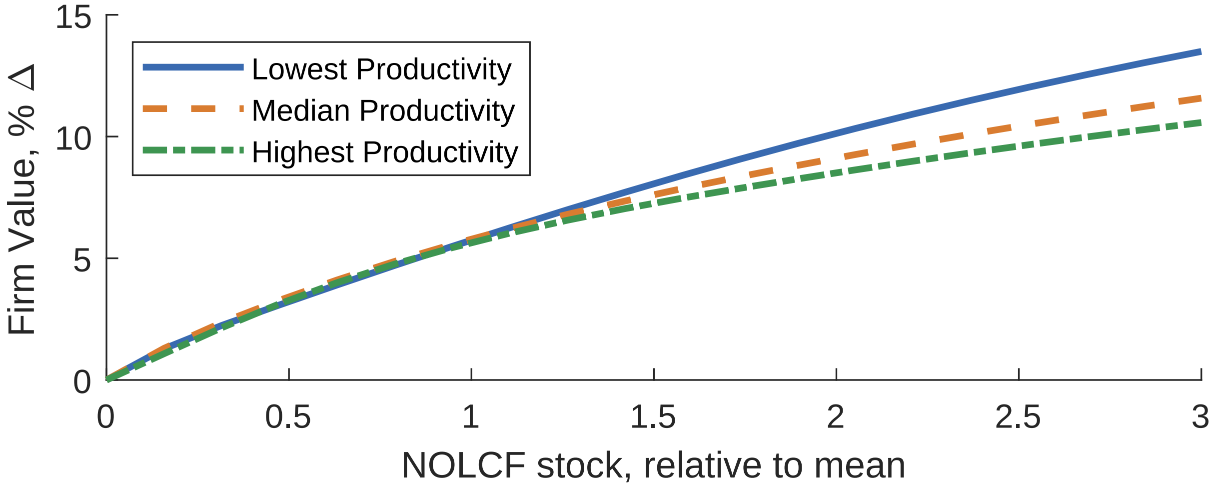


Figure 1: Contribution of NOLCF stock to firm valuation.

shock, and values of c are normalized by the mean. This graph suggests that an average NOLCF stock comprises roughly 6% of the value of a firm with average assets.[5] Further, the contribution of NOLCFs to a firm's value is robust to variations in the productivity of the firm.

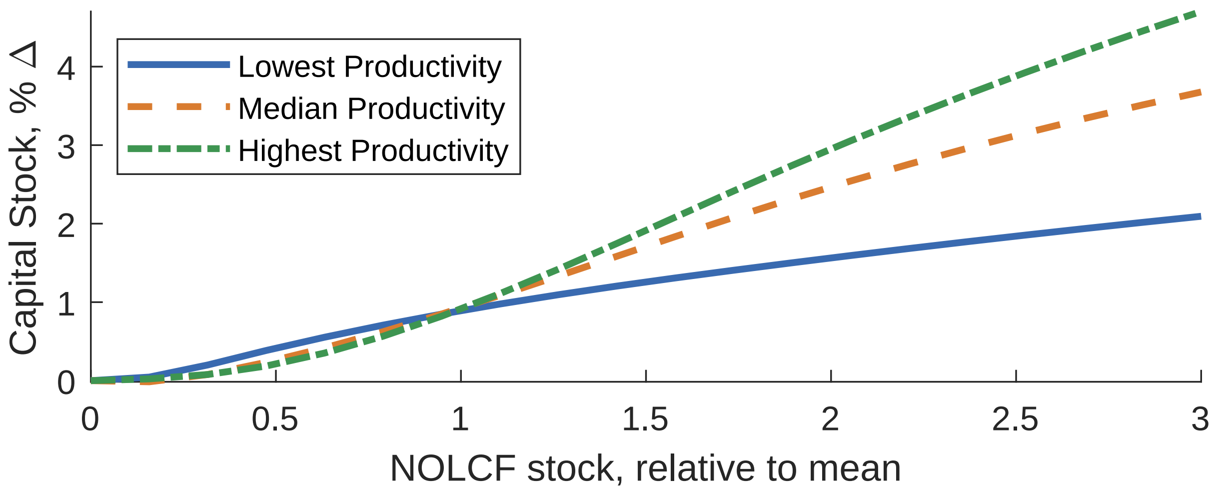


Figure 2: Capital expansion induced by NOLCF stock.

A higher NOLCF stock reduces a firm's near-term marginal tax rate, which raises the firm's expected return to capital. Accordingly, Figure 2 shows, for a firm with average

[5] Note that the calculation of average NOLCF stock includes a large share of firms with zero NOLCFs.

capital stock, how much capital expansion is induced by a change in the firm's stock of NOLCFs. Mathematically, the graph shows $100 \times \left(\frac{k^*(\bar{k},c,z_i)}{k^*(\bar{k},0,z_i)} - 1\right)$, which is similar to Figure 1 with the value function switched out for the capital policy function. The results show that a firm with the average capital stock, the average NOLCF stock, and any productivity shock in the range of model values will increase its capital stock by roughly 1%. However, firms with higher productivity will increase investment significantly more than firms with low productivity as the stock of NOLCFs rises. This happens because higher productivity firms have larger expected after-tax profits than low productivity firms as the stock of NOLCFs increases. This effect is compounded by the persistence of productivity shocks.

4 Policy Evaluation

Given the estimated parameter values, the model provides a framework for counterfactual policy evaluation. The most common policy actions with regards to NOLCFs involve limiting their usage or moving the window of availability (i.e., allowing carrybacks or extending the expiration of carryforwards). Since changing the window of availability in the model involves a change to the dimensionality of the firm optimization problem, the first part of this section studies the consequences of limiting NOLCFs. The effectiveness of NOLCF policy directly corresponds to the magnitude of the corporate tax rate. To that extent, this section also evaluates the effects of changes in the corporate tax rate on model moments. Finally, because the policy changes have important and interesting effects in the transition, this section concludes by evaluating the dynamics of the corporate tax reform of 2017.

4.1 NOLCF Accumulation Caps

A common proposal restricting NOLCFs involves placing a cap on total losses carried forward. As of 2017, two states - New Hampshire and Pennsylvania cap NOLCF accumulations at \$10 million and \$5 million, respectively.[6] To evaluate the effects of absolute limits on NOLCFs, the model is solved at discrete points along a continuum of cap values between zero (the most restrictive case) and the lowest value such that the cap is no longer binding for any firm (the baseline case). Mathematically, if NOLCF accumulation has a cap of $\bar{c}$, the NOLCF constraint (10) becomes:

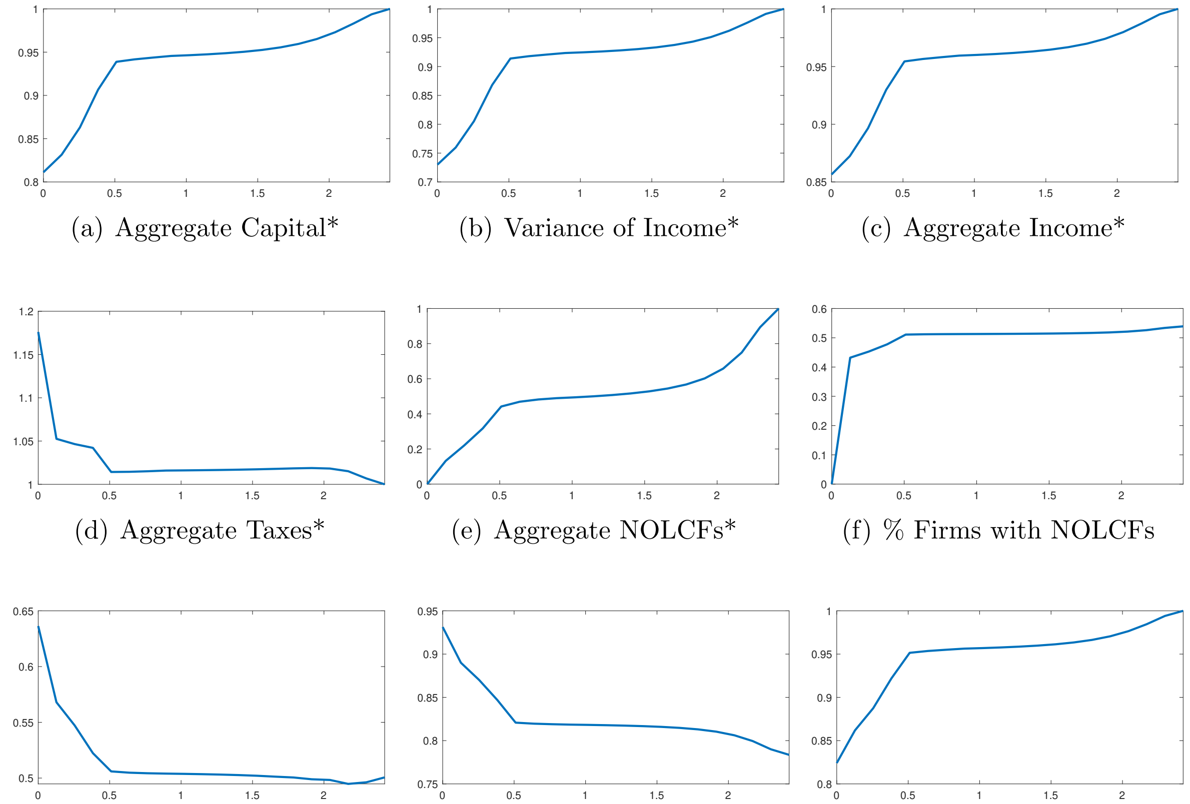
$$\begin{cases} c - c' \in [0, \min\left\{zk^{\theta}, c\right\}], & \textit{if} \qquad zk^{\theta} \geq 0 \\ c' = \min\left\{\bar{c}, c + \mid zk^{\theta} \mid\right\}, & \textit{if} \qquad zk^{\theta} < 0. \end{cases} \tag{16}$$

Figure 3 shows how the model moments respond to changes in the NOLCF cap. The x-axis represents values of the cap scaled to units of the mean NOLCF stock. The graphs of certain moments have kinks that result from the discrete nature of the productivity shock in the quantitative model.

The simplified theoretical model presented in Section 2.1 shows how investment can be discouraged by restricting NOLCF deductibility. Without the availability of NOLCF deductions, firms with higher capital experience higher variances of income, subsequently resulting in higher tax bills for the same expected profits and reducing the marginal value of investment. The same effect can be seen in Figure 3(a), as eliminating NOLCF deductions can reduce capital accumulation by nearly 20%. Further, as shown in Figure 3(b), reductions in capital reduce the variance of income, as it declines by more than 25% in the limiting case. Most outcomes in the model are proportional to capital, so the effect of policy on several model moments materialize through its effect on capital. In particular, NOLCF restriction reduces aggregate income almost proportionally to the decline in

[6] https://taxfoundation.org/net-operating-loss-carryforward-carryback-2017/

Effects of Implementing NOLCF Accumulation Cap



(a) Aggregate Capital* (b) Variance of Income* (c) Aggregate Income*

(d) Aggregate Taxes* (e) Aggregate NOLCFs* (f) % Firms with NOLCFs

(g) % Firms with Taxes (h) Correlation Taxes and Income (i) Aggregate Value*

Figure 3: Response of model moments to limiting NOLCF accumulation. (*) denotes share of baseline value.

capital, as shown in Figure 3(c). Total taxes rise modestly as NOLCF deductibility becomes more restricted, as shown in Figure 3(d). This finding suggests that eliminating restrictions on NOLCF deductibility is not likely to induce enough investment to offset government revenue lost from increasing the deduction, as the simplified model in Section 2.1 proposed as a possibility. As the NOLCF cap gets smaller, firms can accumulate fewer losses, so aggregate NOLCFs decline, as shown in Figure 3(e). Firms also exhaust their stocks of carried losses faster, so the share of firms with any NOLCFs declines to zero as the policy becomes more restrictive, as shown in Figure 3(f). With NOLCF deductibility, some firms are able to offset their entire taxable income with carried losses, so restricting the deduction causes the share of firms with positive tax bills to rise, as shown in Figure 3(g). By fully eliminating NOLCF deductibility, tax bills are a constant fraction of positive income, so the correlation of taxes and income rises as the policy becomes more restrictive, as shown in Figure 3(h). Finally, Figure 3(i) shows how firm valuations decline more than 15% in the limiting case, as firms hold less capital and pay higher average taxes per unit of capital.

4.2 NOLCF Operating Income Restriction

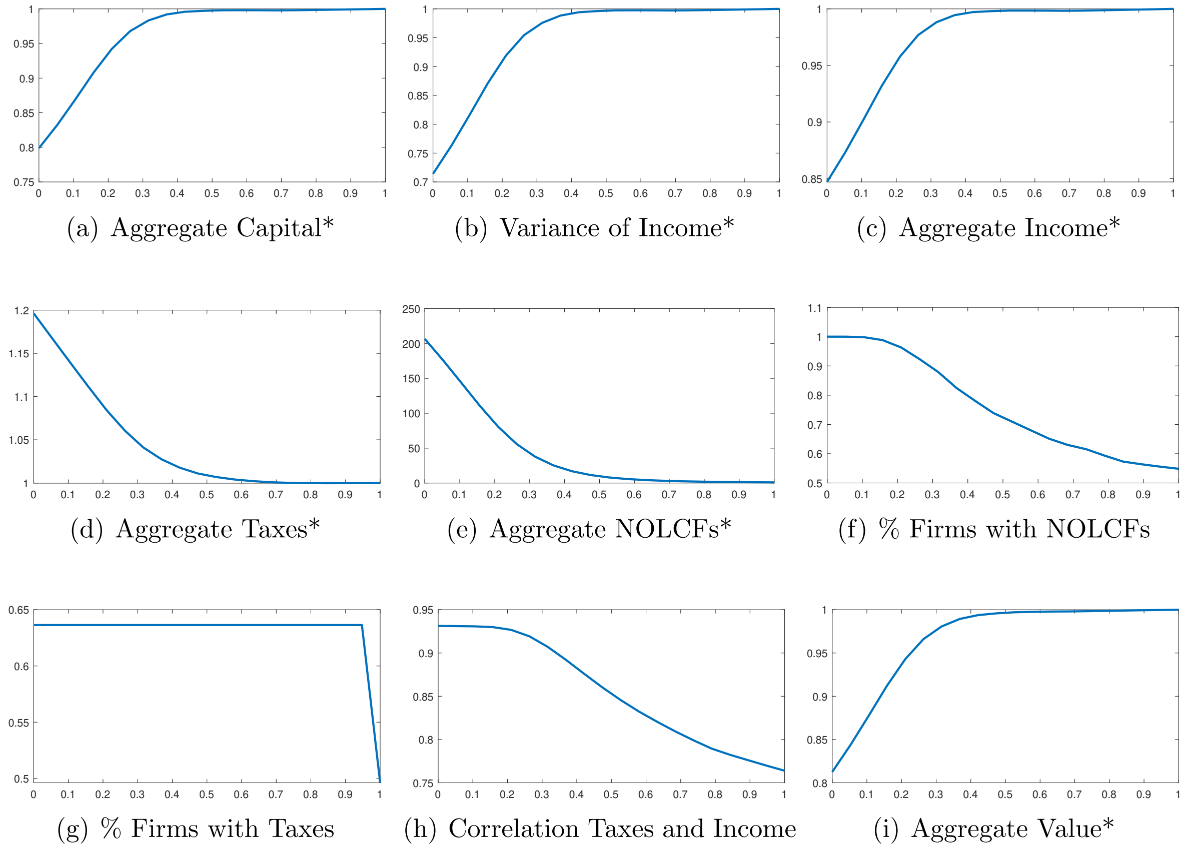
Another common way to restrict NOLCFs is to limit the magnitude of its deduction in any period to a share of operating income. In other words, this restriction forces firms to pay some taxes in every period in which they are profitable. The U.S. corporate tax reform of 2017 limited NOLCF deductions to 80% of operating income. As another example of this implementation, in 2017, Louisiana restricted NOLCF deductions to 72% of operating income. Since operating income in the model corresponds to the value zk^{θ}, (10) becomes:

$$\begin{cases} c - c' \in [0, \min\left\{\alpha z k^{\theta}, c\right\}], & \textit{if} \quad zk^{\theta} \geq 0 \\ c' = c + \mid zk^{\theta} \mid, & \textit{if} \quad zk^{\theta} < 0, \end{cases} \tag{17}$$

where α is the share of operating income that can be offset with carried losses.

Figure 4 shows how the operating income restriction affects several moments of the model as the cap changes from 0% to 100% of operating income. Specifically, the x-axes correspond to values of α in (17). Both this policy and the absolute cap have the same behavioral effect in the limit, where NOLCFs deductions are entirely eliminated. One important difference between the two policies is that the operating income cap simply reduces the exhaustion rate of the carried losses. For operating income caps as low as 70%, the policy has almost no long-term effect, and investment is not materially distorted until the operating income share declines to around 40%, as shown in Figure 4(a). As

Effects of Implementing Operating Income Restriction



(a) Aggregate Capital* (b) Variance of Income* (c) Aggregate Income*

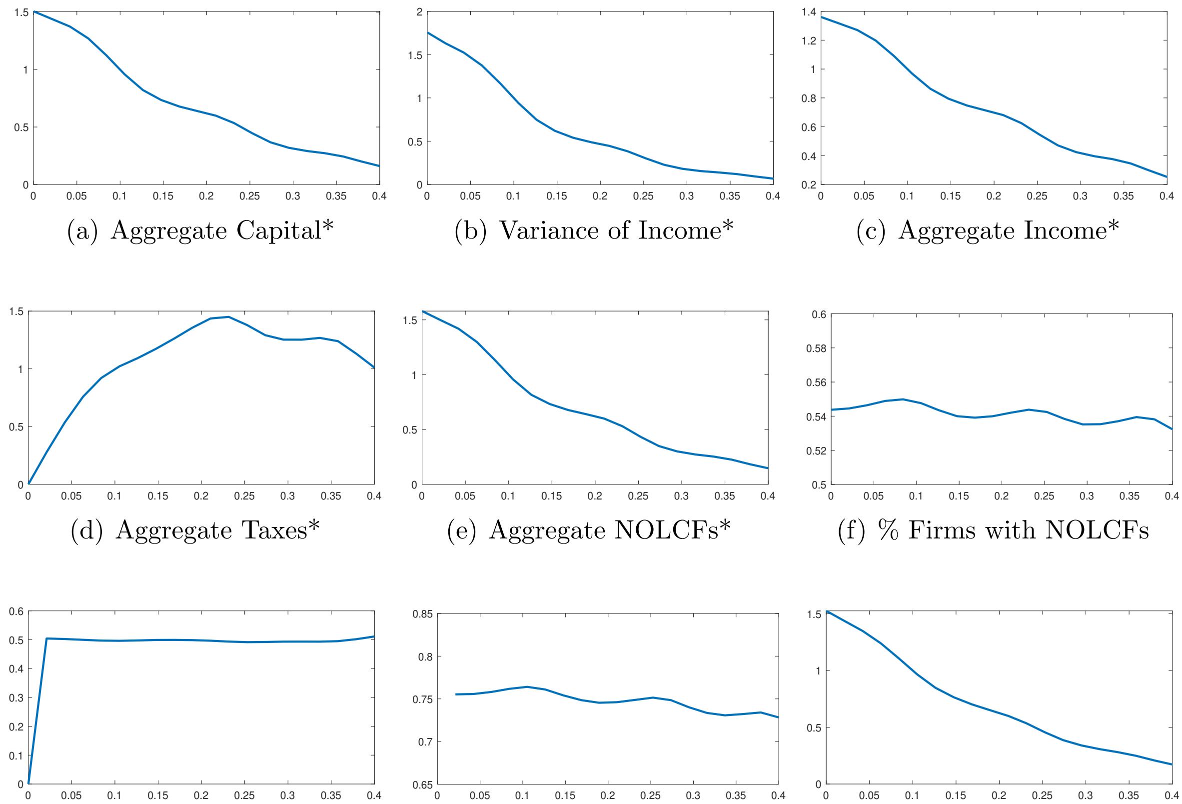
(d) Aggregate Taxes* (e) Aggregate NOLCFs* (f) % Firms with NOLCFs

(g) % Firms with Taxes (h) Correlation Taxes and Income (i) Aggregate Value*

Figure 4: Response of model moments to restricting NOLCF deductions to a share of operating income. (*) denotes share of baseline value.

in the previous counterfactual, Figure 4(b) and Figure 4(c) show how the variance of income and total income decline with reductions in capital. Again, reducing restrictions on NOLCF deductibility does not generate enough investment to increase tax revenue, as in the previous counterfactual. As long as expected profits are positive, some fraction of firms will always have exhausted their NOLCFs in the absence of any restrictions. As the operating income cap becomes increasingly restrictive, the exhaustion rate of carried losses declines, and NOLCF's build up, as shown in Figure 4(e). Conceptually, if the exhaustion rate becomes smaller than the rate at which firms accumulate NOLCFs, then all firms never fully exhaust their NOLCF stocks. This can be seen for very low values of α in Figure 4(f), as the share of firms with NOLCFs reaches 100%. The percentage of firms with positive tax bills quickly converges to the share of points in the productivity grid that have a positive value, as shown in Figure 4(g). As in the case of NOLCF accumulation caps, Figure 4(h) shows how the correlation of taxes and income rises with the restrictiveness of the operating income share, as taxes become a constant share of positive income in the limiting case. Finally, Figure 4(i) shows how firms' valuations are almost entirely unaffected for restrictions in excess of 50%, suggesting that the restrictions placed by both the federal government and the State of Louisiana are unlikely to have any long-term effect on corporate valuation.

Effects of Corporate Tax Rate Changes



(a) Aggregate Capital* (b) Variance of Income* (c) Aggregate Income*

(d) Aggregate Taxes* (e) Aggregate NOLCFs* (f) % Firms with NOLCFs

(g) % Firms with Taxes (h) Correlation Taxes and Income (i) Aggregate Value*

Figure 5: Response of model moments to changes in the corporate tax rate. (*) denotes percentage of baseline.

4.3 Alternative Tax Rates

Because NOLCF policy only matters to the extent that corporate income is taxed, this section studies the effects of alternative corporate tax rates on the model's key variables. These effects are shown in Figure 5, which shows the model moments at various tax rates.[7] As shown in Figure 5(a), the corporate tax rate has a highly distortionary effect on capital choice, which causes corresponding changes in the variance of income, as in Figure 5(b), aggregate income, as in 5(c), and aggregate valuation, as in Figure 5(i), which is discussed in greater detail below. Figure 5(d) shows how reductions in the corporate tax rate *can* induce increases in investment that offset the direct government revenue loss resulting from a lower tax rate. However, this only begins to happen at tax levels that are in excess of twice the baseline tax rate. Finally, some model moments are mostly unaffected by the tax rate, such as the share of firms with some NOLCFs, as in Figure 5(f), the share of firms with taxes (for positive tax rates), as in Figure 5(g), and the correlation of taxes and income, as in Figure 5(h).

The 2017 tax reform reduced the statutory corporate tax rate by 40%. Applying a reduction of that magnitude to the model's corporate tax rate, which is approximately 10%, reduces the model's corporate tax rate to approximately 6%. This 40% reduction in the corporate tax rate results in a 27.2% reduction in corporate tax revenue and a 24.2% increase in total NOLCFs. The disproportionate decline in tax revenue results from a 28.9% increase in capital induced by the corporate tax reduction, which improves corporate income by 21.1%. The 40% corporate tax reduction also increases corporate valuation by 25.7%.

When the corporate tax rate declines, so does the value of NOLCFs to a firm. To measure this effect as it relates to the 2017 tax reform, the model is solved at the baseline tax rate and again at a 40% tax reduction. Figure 6 shows the resulting change in

[7] Recall that the baseline tax rate is roughly 10%.

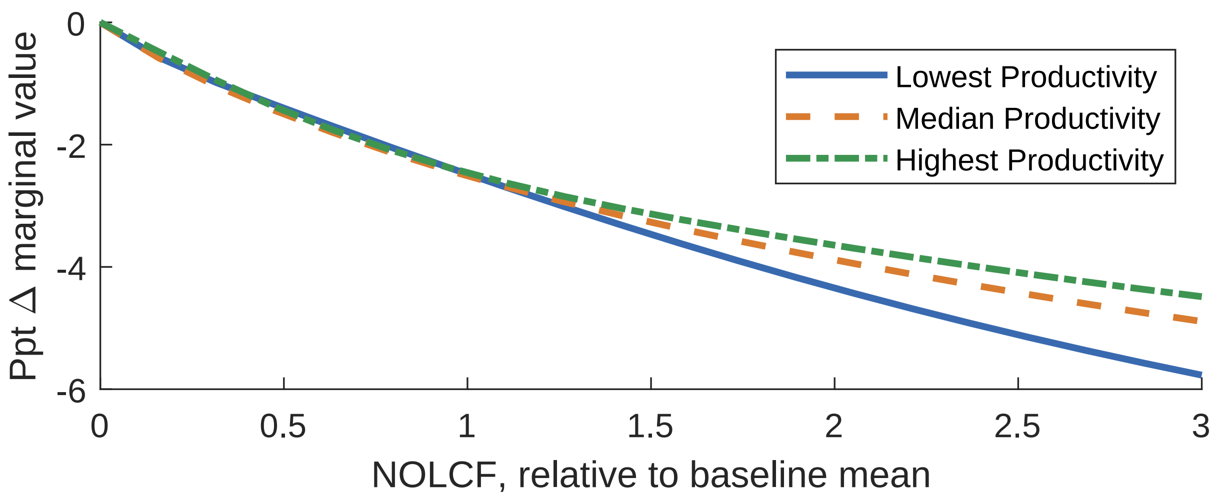


Figure 6: Effect of 40% tax reduction on marginal NOLCF valuation.

the contribution of NOLCFs to corporate valuation over a continuum of NOLCF stocks following the reform. Mathematically, this graph shows $100 \times \left(\frac{\tilde{V}(\bar{k},c,z_i)}{\tilde{V}(\bar{k},0,z_i)} - \frac{V(\bar{k},c,z_i)}{V(\bar{k},0,z_i)} \right)$, where $\tilde{V}$ is the value of the firm after the tax reduction, and $\bar{k}$ is the mean capital stock in the baseline. This graph can be compared to Figure 1, where Figure 6 shows how much each curve declines after a 40% tax reduction. Again, the domain is normalized to units of the mean NOLCF stock in the baseline case. The results show that the decline in the contribution of NOLCFs to the valuation of the firm is roughly proportional to the decline in the corporate tax rate. For example, Figure 1 shows how the average NOLCF stock improves valuation by roughly 6%. Figure 6 shows how a 40% corporate tax reduction reduces the contribution of the average NOLCF to corporate valuation by approximately 2.5 percentage points - roughly a 40% decline. This specific relationship is shown for a continuum of tax rate reductions in Figure 7. For a firm with mean assets, Figure 7 shows the decline in the marginal contribution of the mean NOLCF stock to firm valuation for a continuum of tax reductions. For example, for a firm with mean assets in the baseline case, the mean NOLCF stock improves valuation by approximately 6%, but the same firm with an 80% tax reduction would only experience rouhgly 1% improvement in valuation from having the mean NOLCF stock.

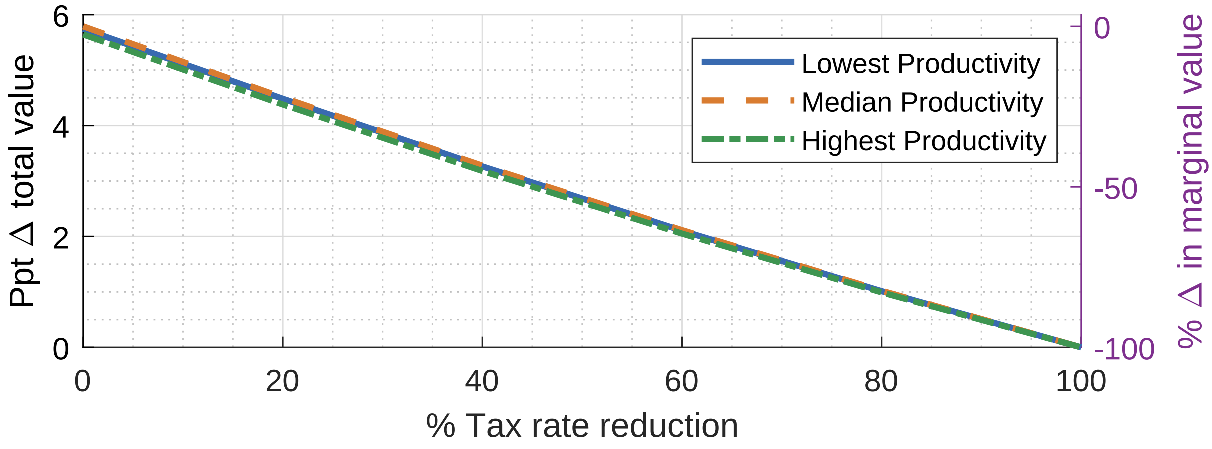


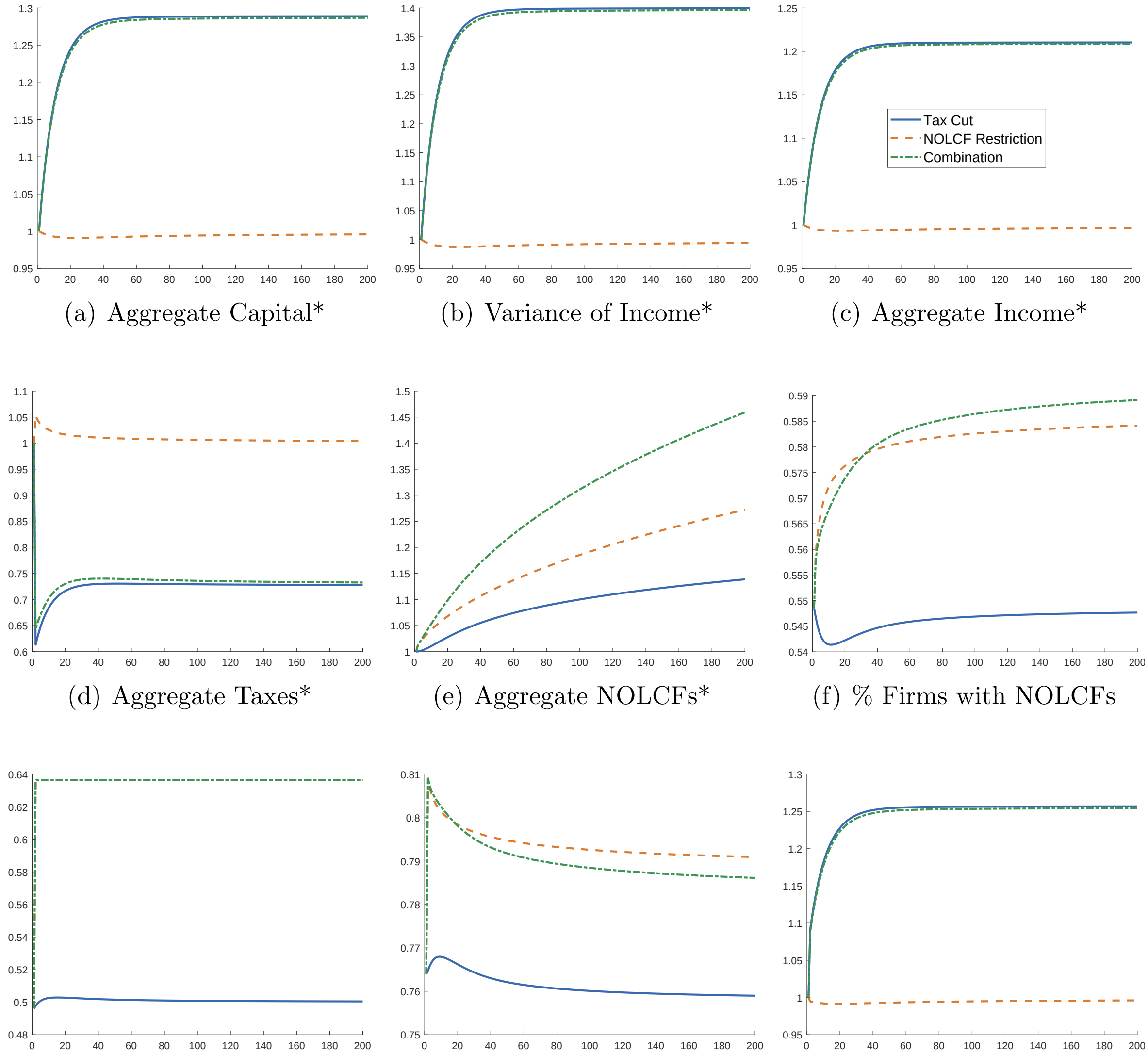
Figure 7: Effect of tax reductions on marginal NOLCF valuation.

4.4 Transitory Effects of the 2017 Tax Reform

The previous sections explained how changes in the tax rate or restrictions on carried losses affect key model moments in the long-run. This part builds on that intuition to understand how the 2017 tax reform affects these moments along the transition path. Recall that the tax reform reduced the tax rate by 40% and limited NOLCF deductibility to 80% of operating income. To separately evaluate the impact of the tax reduction and the NOLCF restriction, the transition path is solved once for each policy change and once with the combined reform. Figure 8 summarizes the results of the policy simulation over 200 periods, where the first point is the baseline value.

As with the steady-state results, capital accumulation drives several results along the transition. Investment rises rapidly following a corporate tax cut, and much of this accumulation happens in the first 30 years, as shown in Figure 8(a). Rising capital over this period causes increases in the variance of income, as in Figure 8(b), aggregate income, as in 8(c), and aggregate value as in 8(i). The effect of the NOLCF restriction on these moments is small, and the effect eventually washes out, as shown in the steady-state

Effects of the 2017 Tax Reform over the Transition



(a) Aggregate Capital* (b) Variance of Income* (c) Aggregate Income*

(d) Aggregate Taxes* (e) Aggregate NOLCFs* (f) % Firms with NOLCFs

(g) % Firms with Taxes (h) Correlation Taxes and Income (i) Aggregate Value*

Figure 8: Individual and combined effects of the 2017 tax cut and NOLCF restriction over a 200-period transition path. (*) denotes share of baseline value.

results. Of particular interest is the effect of the reform on tax revenue. Figure 8(d) shows that the 40% tax reduction immediately causes a nearly proportional decline in tax revenue, but tax revenue subsequently rises more than 10 percentage points as firms accumulate more capital. As mentioned above, the restriction on NOLCF deductibility slows the exhaustion rate of NOLCFs but has no long-term consequence on tax revenue.

Figure 8(d) shows, however, that the NOLCF restriction dampens the total short-term effect of the reform by shifting the timing of taxes towards the near term. Figure 8(e) shows how both policies cause an increase in NOLCF stocks. NOLCF stocks rise in the case of restricting NOLCF deductions because of the reduction in the exhaustion rate of these deductions. In the case of a tax cut, however, the lower corporate tax rate encourages capital accumulation, which increases the variance of income. This in turn drives up the magnitude of losses in periods when they are incurred, relative to the rise in gains, causing a rise in NOLCF stocks as well. Immediately after the tax cut, positive gains grow larger, and NOLCF stocks are low relative to the long-run stock. Accordingly, Figure 8(f) shows that the fraction of firms with NOLCFs temporarily declines before returning to the initial value. A reduction in the deductibility of NOLCFs, however, causes the share of firms with NOLCFs to rise significantly throughout the transition path, leading to a rise in the combined effect of the policies. The tax cut initially increases the share of firms that pay taxes, since the initial stock of NOLCFs is low relative to the long-run stock, as in Figure 8(g). The NOLCF restriction, however, forces profitable firms to pay taxes in every period of positive profits. Accordingly, the share of tax-paying firms immediately switches to the fraction of productivity grid points that are positive. These mechanisms also affect the correlation of taxes and income, as in Figure 8(h). While NOLCFs build up, the correlation of taxes and income is initially higher. As firms accumulate NOLCFs, however, this value steadily declines.

5 Conclusion

NOLCFs allow firms to smooth tax payments over time, dampening a natural asymmetry of corporate income tax implementation. Their availability is an important public financing instrument often found at the center of fiscal policy discourse. Understanding the role of NOLCFs within the firm helps guide fiscal policy implementation and valuation of these carried losses. This paper integrated NOLCFs into the state space of a standard corporate finance model to address these fiscal policy and corporate finance issues.

This paper presented a simple theoretical model to provide intuition regarding the fiscal policy effects of NOLCF deduction allowance. The paper then extended the simple model to include several of the salient features and dynamics of optimal firm decisions and NOLCF policy. Structural parameters of the extended model were estimated using simulated method of moments. This procedure produced baseline model moments that closely matched several of the moments chosen for estimation.

The baseline model provided an ideal framework for NOLCF policy evaluation. In particular, policy evaluation included capping NOLCFs, which is policy in two U.S. states, and limiting annual NOLCF deductions to a share of taxable income, which is a policy recently implemented by the U.S. federal government and one state government. The results showed that binding caps have real economic consequences and affect tax revenue. While the 80% limit introduced in the 2017 U.S. federal tax reform was shown to have no long-term effects and generate no additional long-term revenue, analysis of the transition path showed short-run consequences of the reform. Changes to the tax rate were also evaluated and shown to have large effects on capital accumulation, which drives several variables in the model. While a tax reduction improves the total value of the firm, the marginal contribution of NOLCFs to the valuation of a firm was shown to decline by approximately as much as the percentage reduction in the corporate tax rate.

This paper presents a framework for analyzing NOLCFs in a standard corporate finance model. The model could be modified or extended to evaluate several interesting questions. For example, NOLCF deductability is often credited for reducing the volatility of business cycles because of its role as an automatic stabilizer. This model provides an ideal framework for evaluating the possible stabilization benefits of NOLCF policy.

Another interesting application of this framework would involve evaluation of alternative tax functions. In particular, with progressive income taxation, a firm may not wish to exhaust NOLCFs immediately. In fact, a firm facing a convex tax function may actually want to prepay taxes to smooth payments over time, resulting in potentially interesting incentives and behavior. To that extent, this model also provides a starting point for future research.

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Appendix

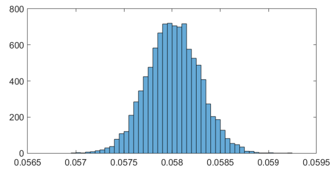
Untargeted Moments

	Model Moment	Data Moment	S.E.
Mean Income	0.1166	-0.0260	0.0009
Mean NOLCF	1.2454	0.6589	0.0070
Variance of Income	0.0597	0.0522	0.0006
Positive NOLCF Share	0.5493	0.7428	0.0020

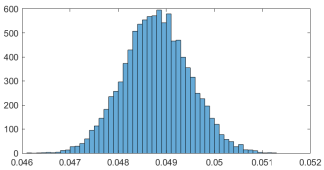
Table 4: Untargeted Model and Data Moments

Bootstrapped Moment Histograms

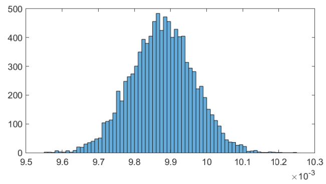
Histograms of Bootstrapped Moments



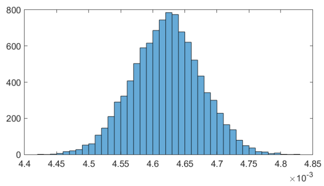
(a) Mean Investment



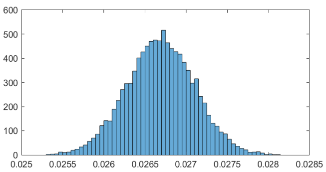
(b) Mean Equity



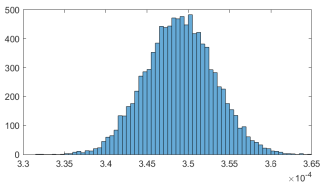
(c) Mean Tax



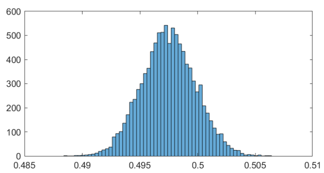
(d) Variance of Investment



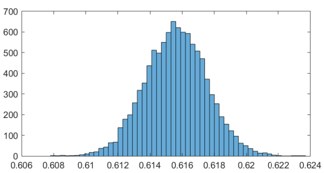
(e) Variance of Equity



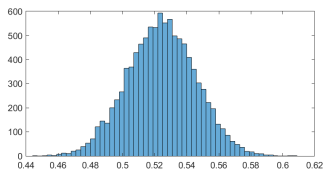
(f) Variance of Taxes



(g) % Firms with Taxes



(h) % Firms with Positive Income



(i) Correlation Taxes and Income

Figure 9: Histograms of bootstrapped moments.