Papers

Summer School in Structural Estimation

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Outline

Reduced form and structural are both **useful** for different purposes

- Reduced form is great for getting answers to causal questions.
  - The bread and butter of program evaluations
  - Only one part of a larger picture of most other fields in finance
  - Only useful for understanding economic mechanisms in the presence of assumptions

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- Reduced form is great for getting answers to causal questions.
  - The bread and butter of program evaluations
  - Only one part of a larger picture of most other fields in finance
  - Only useful for understanding economic mechanisms in the presence of assumptions
- Structural is useful for questions involving the words "why" and "how much" but requires a mathematical model.
  - Counterfactual (what-if) questions
  - Impulse responses
  - Economic intuition
- Often, a richer answer to a question involves both methods

I am going to illustrate these points with examples

Five "types" of integration

1. The model incorporates reduced-form shocks
2. Part of the model is simplified via a reduced-form regression to reduce complexity
3. The model extends the external validity of the reduced-form result
4. A reduced-form regression serves as a check of external validity
5. Use a model to address regression selection problems

Type 1: Build the model to incorporate reduced form shocks

- The paper has a clean natural experiment or exogenous shock.
- A model is built to feature this exogenous shock
- Why?
  - quantify unobservable parameters that drive the reduced form exercises
  - observe counterfactuals
  - provide economic intuition by tying the two estimations together

Why not?

- To provide "identification" (Kahn and Whited 2018)
- "Causal" elasticities are often influenced by more than one model parameter.
  - Why we see all of the cross sectional tests that researchers to do uncover "mechanisms."

Two Examples

- Briggs, Cesarini, Lindqvist and Östling (2021)
- Ivanov, Pettit and Whited (2022)

Windfall gains and stock market participation Briggs et al. (2021)

Three research questions:

- What happens to stock market participation after cash windfalls?
- Why are some households not participating in the stock market?
- What are the costs preventing them from doing so?

What is the reduced form methodology?

- A windfall wealth increase from lottery prizes is an exogenous shock to household wealth.
- Random assignment of lottery prizes payment methods differentiates
  - the one-time stock entry cost from
  - the per-period participation cost

,

What do we learn from the reduced form part?

- A 150K USD windfall from lottery wealth increases the probability of stock ownership in post-lottery years by 4%.
- The effect is concentrated in:
  - previous stock market non-participants
  - lump sum prize payments (instead of monthly installments)
- The last item shows that the one-time entry cost (instead of the per-period participation cost) explains household stock market non-participation.

What is the structural methodology?

- The authors use a life-cycle model with costly stock market participation choice and an unexpected lottery prize windfall.
- Estimation method is Simulated Minimum Distance

What question that can be answered by the structural part?

- How big does the entry cost have to be to explain the data.
- The average entry cost for pre-lottery equity market nonparticipants is over 31K USD, ...
- But even this cost cannot reconcile the small amount of participation.
- Estimation of models with behavioral biases also does not help.
- Data on survey of beliefs indicates that belief biases (pessimism) are the likely culprit.

What do we learn from a combination of methods that we could not learn otherwise?

- The reduced form setting of random sized lottery prize provides an exogenous shock to household income
  - for identification of the directional effect of wealth on participation.
  - for identification of the **type** stock market participation cost.
- The structural method makes it possible to quantify the size of the cost.
- Eliminate possible explanations for nonparticipation

Taxes Depress Corporate Borrowing: Evidence from Private Firms Ivanov et al. (2022)

- Research question: How do taxes affect capital structure?
- Reduced-form part uses a staggered difference-in-difference setting to establish
  - Causality
  - Sign and magnitude
- Structural part illustrates
  - Intuition
  - Counterfactual effects on firm value

Newish data on private firms

- Use comprehensive samples of U.S. privately-held firms.
- Staggered diff-in-diff around changes in state corporate income taxes since the late 1980s.
- Distinguish between enactment and effective dates of tax changes.

We obtain directional findings from the reduced form part

- Corporate leverage increases following tax cuts and decreases following tax hikes.
- Firms increase investment following corporate income tax cuts.
- Results are strongest for small, healthy firms but also present in large public firms.

The second part of the paper is structural

- We estimate an equilibrium model of an economy
- Firms are financed by internal profits and external **risky** debt.
- They make debt, hiring, and investment decisions in anticipation of future tax changes.
- Interest expense **is** tax deductible

Where does the reduced-form part fit in?

- We estimate the model using mostly means and variances as moments.
- Then we check to see whether it can replicate the reduced-form tax elasticity.
- This external validity check also makes the model relevant to this particular experiment

What do we learn from the structural part?

- We get intuition for the reduced-form result:
  - Interest tax shields are just one part of a larger picture that includes the level of default thresholds.
  - The **quantitative** effect of taxes on default thresholds can be much larger than the **quantitative** effect on interest tax shields.
- We can look at the effects on firm value:
  - Taxes depress value more than they would in the absence of debt.
  - Loss of interest tax shields.

Type 2: part of the model is simplified via a reduced-form regression to reduce complexity

- Very useful for highly complex models
- Simplify part of the model whose mechanism is
  - too complicated to add to the current model
  - does not affect the results of other parts of the model
- All of the currently very popular demand estimation methods fit in this category.
- The conditional choice probability methods in Hotz and Miller (1993) and the policy function approach in Bajari, Benkard and Levin (2007) are two examples.
  - Kang, Lowery and Wardlaw (2015) use CCP methods
  - Matvos and Seru (2014) use the BBL methods

The costs of closing failed banks: A structural estimation of regulatory incentives

Kang et al. (2015)

- How do regulators choose whether to close a troubled bank?
- Dynamic discrete choice model: close/open
  - an aversion to close banks against
  - higher risk and future deposit-insurance costs from delayed closure
- The difference in the regulator utility from each decision is proportional to the probability of each decision.
- The latter can be estimated via a **logit**.
- With the estimated utility functions, they conduct counterfactuals:
  - Delayed closures are driven by "desire to defer costs, an aversion to closing the largest and smallest troubled banks, and political influence."

Market Power and Monetary Policy Transmission: Evidence from a Structural Estimation Wang, Whited, Wu and Xiao (2022)

- To what extent do market power and regulatory frictions affect the pass-through of policy rates to bank lending decisions?
- This is by nature a structural question.
- The model has to be very complicated
  - Equilibrium between borrowers, lenders, and banks
  - Imperfect competition between banks
  - Dynamic optimization decisions by banks

We simplify the problem by using demand estimation

- Estimate loan and deposit elasticities using the methods in Berry, Levinsohn and Pakes (1995)
- Plug these estimates into the model.
- Markets automatically clear because interest rate choices by banks imply optimal demand from the estimated elasticities.

Type 3: the model is used to extend the external validity of the reduced-forms results

- Assessing the general equilibrium consequences of reduced form estimates
  - Lots of examples in urban and environmental economics
- Predicting the effect of non-compliers in a reduced-form regression

Who Creates New Firms when Local Opportunities Arise? Bernstein, Colonnelli, Malacrino and McQuade (2022)

- Brazilian matched employer-employee data, with rich employee characteristics
- Ask whether changes in *global* commodity prices affect local entrepreneurial activity
- Generate Bartik-style variation in the income of municipalities
- Young potential entrepreneurs respond to these shocks more than older ones
- This strong response is concentrated in municipalities with more developed banking sectors and a skilled population.

The structural part tells us what happens when population composition changes

- This part of the paper extends the results beyond the causal elasticities in the first part.
- Dynamic discrete choice problem between wage employment and entrepreneurship.
- Selection into entrepreneurship depends on the dispersion in a taste parameter that can be disciplined with the data.
- Parameter estimates yield two interesting results.
  - A 10% increase in the fraction of young people increases firm creation by around 2%.
  - If this increase in the young is concentrated in the non-educated, this effect is muted by 30%.

Do the Right Firms Survive Bankruptcy?
Antill (2022)

- Are decisions to liquidate efficient, and does inefficient liquidation reduce creditor recovery?
- What is the question that can be answered by the reduced form part?
  - For compliers who are close to the marginal threshold of liquidation versus emerging, ...
  - the average liquidation reduces creditor recovery by 58 cents on the dollar.
- What is the question that can be answered by the structural part?
  - The structural part extends the conclusion to non-compliers and estimates that overall, 60% of liquidations are inefficient.

Do the Right Firms Survive Bankruptcy?
Antill (2022)

- What is the reduced form methodology?
  - Use randomly assigned judge as an exogenous shock to firm liquidation versus reorganization.
  - The result is a local average treatment effect that only applies to compliers.

- What is the structural methodology?
  - A generalized Roy (1951) selection framework: binary choice between liquidation and reorganization.
  - In a way similar to the Heckman model, it allows for a sample-selection correction to extend the results to non-compliers.

Type 4: Reduced form is used to assess model validity

- Dynamic models provide a plethora of predictions
- Some of these predictions are used to estimate the model
- But others are not and can be compared to actual data predictions
- Formal test of "unused" moment equality in Bazdresch, Kahn and Whited (2018)
- There are many many many examples

Technological innovation and executive pay inequality

Frydman and Papanikolaou (2018)

- Executive pay and the gap between executive and worker pay have grown in the last 50 years
- Estimate a model of technological innovation to help understand these facts
- The model *also* has predictions about the relations between
  - Executive pay and innovation (+)
  - Executive pay and growth opportunities (+)
- Both hold up in reduced form regressions

Corporate Money Demand
Gao, Whited and Zhang (2021)

- Reduced-form regressions of corporate cash on interest rates produce a robust hump shape
- Estimate a model to understand this fact.
- Use mostly mostly means and variances for identification.
- The model can reproduce correlations between output and cash, investment, and debt not targeted in the estimation.

Reputation and investor activism: A structural approach

Johnson and Swem (2021)

- Why do targets settle so frequently with activists who face large costs of proxy fights
- Why do activists initiate so many proxy fights despite the free rider problem?
- Estimate a model of (unobservable) activist reputation by MLE.
- Use the model based reputation measure to predict several outcomes (CARs, 13D filings) in both the model and the data.

Type 5: the model is used to solve a selection problem in a regression

- A Heckman correction is basically a regression paired up with a probit, ...
- which is itself an outcome of a random utility problem.
  - The agent chooses to stay in the sample if their utility exceeds a threshold
  - This is a very simple structural problem
- But the selection model can be much more elaborate and realistic.

How smart is smart money: A two-sided matching model of venture capital Sorensen (2007)

- Empirical fact: start-up companies funded by more experienced venture capitalists are more likely to go public.
- Why?
  - Direct influence of the VC on the company
  - Sorting of better companies with better VCs
- You cannot answer this question with a regression.

The structural part estimates a two-sided matching model

- Each VC can have more than one match, but each company can have only one VC.
- The equilibrium concept is stability: perturbing the matching outcome would make would make any company's valuation worse.
- Estimate the likelihood of an IPO jointly with the matching model using MCMC.
- The structural part allows for separating the the effects of VC influence versus sorting.

Fighting about reduced-form versus structural methods is a waste of time

- Different methods answer different kinds of questions.
- They can be used separately (e.g., Hennessy and Whited 2005; Bennedsen, Nielsen, Pérez-González and Wolfenzon 2007)
- They can be used together.

Outline

Dynamic models need empirical benchmarks!

- What features of the data should one use to estimate and evaluate dynamic models?
- What are the finite sample properties of the simulation estimators used for this purpose?
- How do you test the external validity of dynamic models?

These questions are interesting because dynamic models are inherently testable.

- Dynamic models provide an abundance of quantitative time series and cross sectional predictions.
- This richness allows researchers to discipline dynamic models more than static models.

The usual estimation method relies on arbitrary choices.

- Choose several interesting moments.
- Pick parameters to get model implied moments as close as possible to data moments.
- No guidance as to the choice of moments.

Our solution is to use data features that are common across models.

- The solution to any dynamic model is characterized by

  Value function: given the current state, what is the value of the firm?

  Policy function: given the current state, what are its optimal decisions?

- We use the *empirical* policy function (EPF) as a benchmark for estimation and testing.

Why are EPFs better than moments?

- For any two models that describe the same variables, ...
- Using EPFs to estimate parameters provides a uniform method for comparing models.
- The moments come from simulating data from the policy functions, ...
- So why not use the policy functions directly.

EPF-based estimation is better in finite samples.

- Monte Carlos show simulation estimators have low bias and mean squared error.
- EPF-based estimation has greater power to detect model misspecification.

To make our setting concrete, we consider a simple dynamic capital structure model...

- The firm maximizes distributions to shareholders.
- The firm chooses next period leverage and investment.

The firm uses capital to produce revenue.

constant returns profit function	$z = zK/K$
stochastic productivity shock	$\ln(z') = (1-\rho)\mu + \rho\ln(z) + \sigma\varepsilon',\ \varepsilon' \sim \mathcal{N}(0,1)$
investment	$i = K'/K - (1-\delta)$
investment adjustment costs	γi^2

The firm can issue risk-free, secured debt and hold cash.

leverage/cash	$p \lesseqgtr 0$
collateral constraint	$p' \leq \xi$
taxes	τ

The firm's sources and uses of funds identity defines payments to equity.

- sources minus uses of funds

$$e(p, p', i, z) = z(1 - \tau) - i - \frac{\gamma i^2}{2} - p(1 + r(1 - \tau)) + p'(1 - \delta + i)$$

- If $e > 0$, distributions

- If $e < 0$, proportional cost of equity issuance, λ

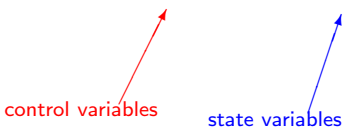
The Bellman equation is standard

$$\pi(p,z) = \max_{p',i} \left\{ e(p,p',i,z) + \beta \mathbb{E}\pi(p',z')(1-\delta+i) \right\}$$

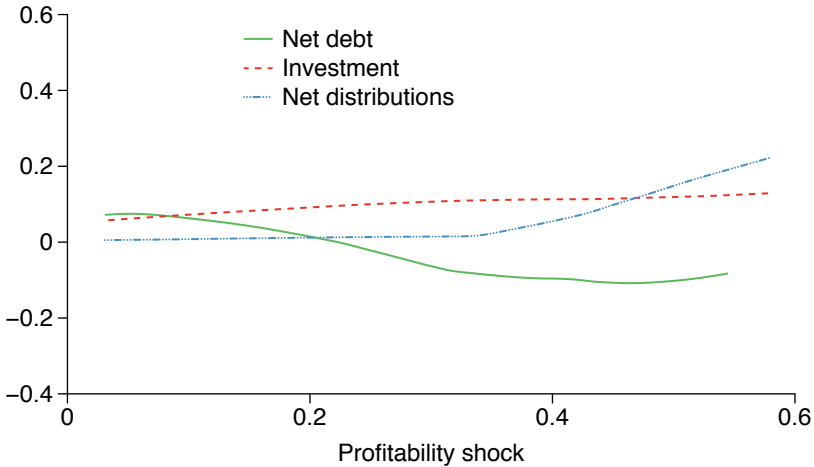
The model has a solution characterized by a value and a policy function.

$$\text{Equity value} = V(\text{profitability, leverage})$$

$$\text{Investment and next period leverage} = G(\text{profitability, leverage})$$



Policy functions



Estimation is necessary to make the parameter values empirically relevant.

- SMM estimation.
- EPF-based estimation.

Identification of SMM requires arbitrary choices.

- You need to pick moments that vary with the underlying parameters.
- You should not cherry-pick moments.
- No guidance as to the choice of moments.

Identification of EPF-based estimation requires few arbitrary choices.

- Use any semiparametric regression technique to estimate the policy functions.
- Polynomial estimator.
- Capture level, slope, variability, curvature

We estimate the model using standard data.

- Compustat data from 1962 to 2012
- The model describes homogeneous firms.
- Remove time and firm fixed effects.
- But **levels** of variables are important.
- Add back sample mean.

Intuitive methods for estimating the parameters:

	Model Step		Data Step
SMM and EPF	Draw from profit shock Compute optimal policies Repeat		Collect data Screen data Remove fixed effects
SMM	Compute moments	$\Longleftrightarrow$ $\Downarrow$ parameters	Compute moments
EPF	Estimate policy functions	$\Longleftrightarrow$ $\Downarrow$ parameters	Estimate policy functions

The estimates are economically different.

Panel A: Parameters

Parameter	Moments-based	EPF-based
μ	-2.203	-2.172
	(0.014)	(0.002)
ρ	0.769	0.619
	(0.013)	(0.048)
σ	0.405	0.561
	(0.012)	(0.023)
δ	0.066	0.067
	(0.001)	(0.001)
γ	11.016	12.777
	(0.316)	(0.145)
ξ	0.444	0.493
	(0.022)	(1.088)
λ	0.236	0.059
	(0.021)	(0.945)
Overidentifying χ^2 p-value (d.f.)	0.000 (1)	0.000 (11)
Out-of-sample χ^2 p-value (d.f.)	0.000 (18)	0.000 (8)

The moments estimation does better at matching moments than the EPF estimation.

Panel B: Moments

	Data	Moments-based		EPF-based	
		Simulated	*t*-statistic	Simulated	*t*-statistic
Mean leverage	0.154	0.156	−6.187	0.215	−3.532
Variance leverage	0.021	0.020	18.722	0.045	−4.772
Mean investment	0.082	0.073	12.756	0.082	0.048
Variance investment	0.003	0.000	40.639	0.000	39.176
Mean distributions	0.006	0.015	−22.771	0.005	−0.212
Variance distributions	0.006	0.001	76.988	0.002	24.983
Mean profits	0.132	0.131	0.236	0.142	−9.729
Variance profits	0.007	0.006	12.321	0.010	−23.840

There are two interesting test stats in that table!

- The first is a standard t-stat on the moment conditions.
- To calculate the t-stats, you need to calculate the moment covariance matrix.

$$\text{var}(g(\boldsymbol{v}_{it}, \theta)) = \frac{1}{nT}\left(1 + \frac{1}{S}\right)(I - G(G'WG)^{-1}G'W)\hat{\Omega}(I - G(G'WG)^{-1}G'W).$$

We also develop an out-of-sample moment condition test.

- Suppose we have a vector of benchmarks, $m^*(\cdot)$, that are not used to estimate the parameter θ. We want to test the null hypothesis that

$$g^*\left(\boldsymbol{v}_{it},\theta\right) = E\left(m^*\left(\boldsymbol{v}_{it}\right) - S^{-1}\sum_{s=1}^{S} m^*\left(\boldsymbol{v}_{it}^s\left(\theta\right)\right)\right) = 0.$$

- We need the variance of these moment conditions, which are given by:

$$\text{avar}(g^*\left(\boldsymbol{v}_{it},\theta\right)) = E\left[\phi_g^*\phi_g^{*\prime}\right],$$

where ϕ_g^* is the influence function for g^*.

- The influence function for $g^*\left(\boldsymbol{v}_{it},\theta\right)$ is given by:

$$\phi_g^* = \phi_m^* - \left(S^{-1}\sum_{s=1}^{S}\left(\partial m^*\left(\boldsymbol{v}_{it}^s\left(\theta\right)\right)/\partial\theta\right)\right)\phi_\theta.$$

Monte Carlo Design

1. Solve model at parameters estimates from polynomial EPF.

2. Simulate 1000 data sets
   - 20 years of data for 3,750 firms.

3. Estimate four parameters using EPF and SMM estimation:
   - depreciation rate δ.
   - equity issuance cost λ.
   - collateral value of capital ξ.
   - adjustment costs ψ.

Simulation estimators recover parameters very well.

	Moments-based		EPF-based	
Parameter	Identity	Clustered	Identity	Clustered
δ (depreciation rate)				
Average % bias	0.123	-0.006	-0.021	-0.001
RMSE %	0.608	0.047	0.059	0.010
$\Pr(t)$	0.605	0.367	0.309	0.348
λ (equity issuance cost)				
Average % bias	0.598	-0.165	1.793	-0.047
RMSE %	3.141	1.477	2.662	0.875
$\Pr(t)$	0.001	0.002	0.001	0.003
ξ (collateral parameter)				
Average % bias	-0.189	-0.299	-0.308	0.035
RMSE %	0.790	0.659	1.997	0.110
$\Pr(t)$	0.117	0.277	0.359	0.019
γ (investment adjustment cost)				
Average % bias	-0.239	0.027	0.052	0.007
RMSE %	1.273	0.106	0.127	0.022
$\Pr(t)$	0.313	0.135	0.115	0.100
Overidentification test rejection rate	0.558	0.048	0.825	0.083
External validity test rejection rate	0.985	0.843	0.668	0.079
Moment t-statistics:				
maximum rejection rate	0.317	0.022	0.354	0.024
median rejection rate	0.132	0.012	0.056	0.010
minimum rejection rate	0.000	0.005	0.000	0.005

Misspecification

- Estimate the same model, but introduce a misspecification.

Data model:	Cost of debt issuance.
Estimation model:	No cost of debt issuance.

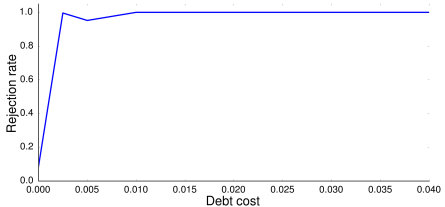
- Simulate 1000 data sets that follow the data model.

- Repeat Monte Carlo exercise using the estimation model.

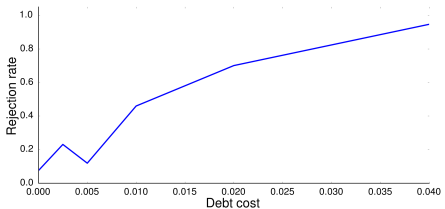
- Count how many times model is rejected by standard χ^2 test.

EPF-based estimation test statistic power

Panel A: Overidentification test

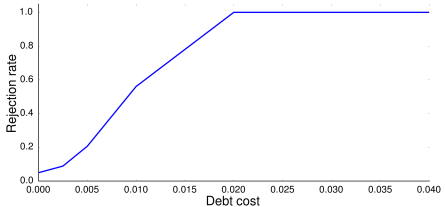


Panel B: Out-of-sample test



Moment-based estimation test statistic power

Panel A: Overidentification test



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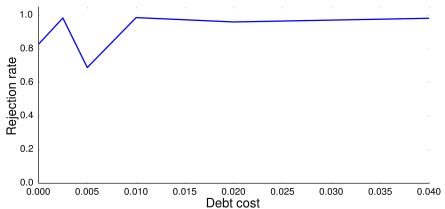


Outline

Debt Dynamics: The Goal

- Formulate a dynamic model of capital structure with endogenous real investment and distributions.
- Can such a model replicate the stylized facts?
- Can the model explain existing "debt anomalies?"

The Anomalies

- Leverage covaries negatively with cash flow and operating income.
  - **?**, **?**, and **?**.
- **?**
  - "The most telling evidence against the static trade-off theory is the strong inverse correlation between profitability and financial leverage... Higher profits mean more dollars for debt service and more taxable income to shield. They should mean higher target debt ratios."

The Anomalies

- Debt Conservatism

$$\tau_c > \tau_c^* = \frac{\tau_i - \tau_d}{1 - \tau_d}$$

in which the latter is the expression for the rate to which the corporate marginal tax rate should be driven in a Miller, "Debt and Taxes" world.

- **?**
  - "Paradoxically, large, liquid, profitable firms with low expected distress costs use debt conservatively."

The Anomalies

- Market Timing
- **?**
  - "The trade-off theory predicts that temporary fluctuations in the market to book ratio or any other variable should have temporary effects."
- Leverage is strongly negatively related to a lagged external finance weighted average market to book ratio:
  - "... a simple and realistic explanation for the results is that capital structure is the cumulative outcome of attempts to time the equity market."

Our Interpretation

- The literature has taken a static model and compared its predictions with data generated by firms making a sequence of dynamic financing decisions.
- However, corporations do not face an infinite repetition of the **?** financing problem.
- The Miller model assumes that
  - The firm is at the debt versus external equity margin.
  - There are no funds already INSIDE the firm.
  - The firm KNOWS it will be distributing in future periods.
  - There is no need for future funding.

Our Approach

- Firm with an infinite horizon
- Stochastic production technology
- Endogenous real investment decision
- Full range of financing options
- Financial distress costs
- Distributions chosen endogenously
- Realistic tax environment
- Costs of equity issuance

The Model: Production and Capital

- Concave, stochastic operating profit function:

$$\pi\left(k, z\right)$$

- The firm invests and and can issue debt, but it can also fall into financial distress.
- Outside distress, firm buys and sells capital for a price of one.
- Sometimes sources fall short of uses of funds.
- The difference is external equity finance, but for each dollar raised, there is a flotation cost $\lambda \geq 0$.

The Model: Debt

- The lender imposes a collateral constraint requiring that the fire-sale value of capital be sufficient to pay the loan.
- If end-of-period internal funds are insufficient to pay debt, a fire sale occurs, with capital sold for $s < 1$.
- The endogenous state variable p' represents the face value of one-period debt.

$$\begin{aligned} p' &> 0 \iff \text{borrowing} \\ p' &< 0 \iff \text{saving} \end{aligned}$$

The Model: Taxation

- Linear tax on interest income τ_i
- Linear tax on corporate distributions: τ_d
- Corporate income tax base

$$y(k,p,z) \equiv \pi(k,z) - \delta k - r\left(\frac{p}{1+r}\right)$$

- Strictly increasing and convex corporate tax function $g\left(y(k,p,z)\right)$, with the marginal corporate tax rate (τ_c) satisfying:

$$\tau_c[y(k,p,z)] \equiv g_1[y(k,p,z)].$$

Fire Sales

- Collateral constraint
$$p' \leq s * k'(1-\delta) + \pi(k', \underline{z}) - g(y(k', p', \underline{z})).$$

- Fire sales. The number of units sold will be
$$n(k', p', z') \equiv \max\left\{0, \frac{p' - [\pi(k', z') - g(y(k', p', z'))]}{s}\right\}.$$

- The firm chooses k' at the start of the period but the actual end of period capital stock, after fire sales, is stochastic.

- Investment is given by
$$i(k, p, k', z) \equiv k' - [k(1-\delta) - n(k, p, z)].$$

Maximization Problem

- Flow to equity

$$\begin{aligned} e(k,p,k',p',z) &\equiv [1+\Phi_i\lambda-\Phi_d\tau_d] \\ &\times \left[\frac{\pi(k,z)-g(y(k,p,z))-p}{\Phi_n+s\Phi_s}-[k'-k(1-\delta)]+\frac{p'}{1+r}\right] \end{aligned}$$

- Bellman equation

$$\begin{aligned} V(k,p,z) &= \max_{(k',p')\in K\times P} e(k,p,k',p',z) \\ &+ \left[\frac{1}{1+r(1-\tau_i)}\right]\int V(k',p',z')\Gamma(z,dz') \end{aligned}$$

Intuition: Optimal Financial Policy

- Fix the state, (k, p, z), and fix the investment program, k'.
- The optimal financing policy is uniquely pinned down by p'.
- Equity issuance or distribution is simply a residual.
- Determine the marginal costs and benefits from a small change in p'.
- At the optimal policy, the marginal costs and benefits must be equal.

The Marginal Cost of Debt

- The cost of servicing increased debt or lower savings balance.

$$MC(k', p', z) \equiv \int \frac{[1 + \Phi_i'\lambda - \Phi_d'\tau_d + \Phi_0'\phi'][1 + r(1 - \tau_c(y(k', p', z')))]}{[1 + r(1 - \tau_i)](\Phi_n' + s\Phi_s')} \Gamma(z, dz').$$

- The economic cost of debt service is high when there is a high probability of a fire sale.

- Debt service is most (least) costly for a firm that expects to be issuing equity (making a distribution) at the margin next period.

The Marginal Cost of Debt

- The MC schedule is upward sloping
- Increasing p' reduces taxable income in every state. Therefore, the expected marginal corporate tax rate is decreasing in the amount of debt issued.
- The expected after-tax return on corporate saving declines in the amount saved, discouraging precautionary saving.
- Raising p' increases the likelihood of a fire sale.
- Raising p' increases the likelihood of resorting to positive equity issuance next period.

The Marginal Benefit of Debt

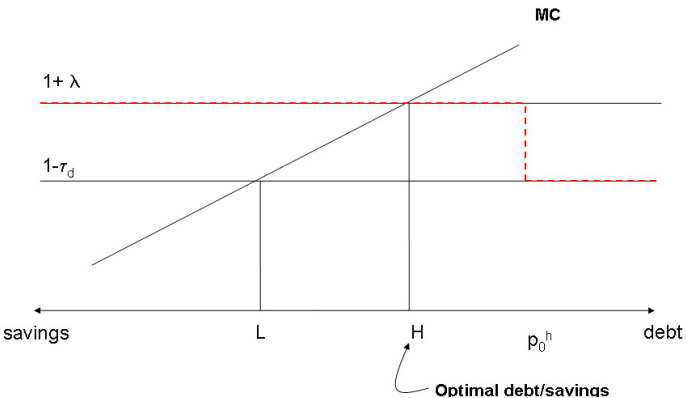
- Gain from increasing debt or reducing saving

$$MB(k, p, k', p', z) \equiv 1 + \Phi_i \lambda - \Phi_d \tau_d$$

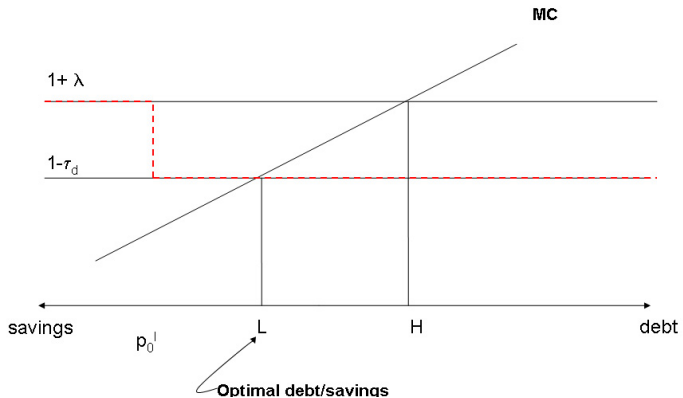
- Denote as p_0 the point at which the firm neither makes distributions nor issues equity.

- As p' is increased the MB schedule jumps down at p_0 from $1 + \lambda$ to $1 - \tau_d$.

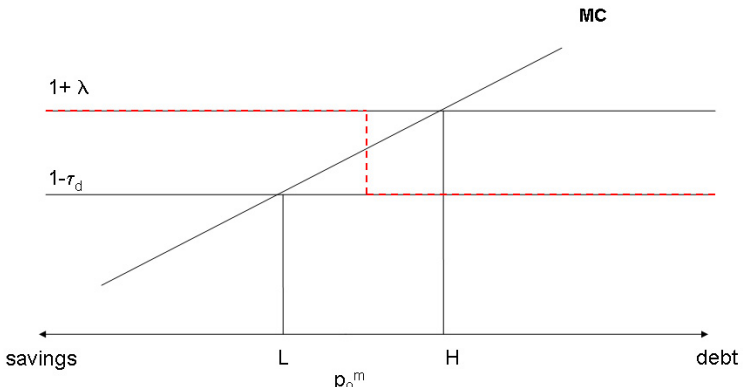
Graphical Interpretation: High Financing Gap



Graphical Interpretation: Low Financing Gap



Graphical Interpretation: Intermediate Financing Gap



Empirical Predictions

- Leverage is predicted to exhibit hysteresis.
- Ceteris paribus, higher lagged debt causes the firm to occupy the high portion of the marginal benefit schedule over a longer stretch.
- With higher lagged debt, more debt must be issued this period before the marginal unit of debt serves to increase distributions rather than to replace external equity.

Empirical Predictions

- Debt conservatism of high liquidity firms
  - Debt issuance serves to finance higher distributions to shareholders, rather than replacing costly external equity.
  - Since high liquidity firms occupy the lower portion of the MB schedule, debt issuance is less attractive.
- The predictions for OLS regression coefficients are less clear, since we have held investment constant.
- So we turn to model estimation via SMM

Moment Matching

	Actual Moments	Simulated Moments
Average Investment/Assets	0.079	0.107
Variance of Investment/Assets	0.006	0.014
Average EBITDA/Assets	0.146	0.165
Average Debt-Assets Ratio (Net of Cash)	0.075	0.127
Average Equity Issuance/Assets	0.042	0.052
Frequency of Equity Issuance	0.099	0.091
Investment-q sensitivity	0.019	0.036
Debt-q sensitivity	-0.080	-0.219
Serial Correlation of Income/Assets	0.583	0.598
Standard Deviation of the shock to Incomes/Assets	0.117	0.120

Parameter Estimates

α	δ	λ	s	σ_ε	ρ	μ_τ	σ_τ	χ^2
0.551	0.100	0.059	0.592	0.123	0.740	-12.267	9.246	4.906
(0.276)	(0.059)	(0.028)	(0.352)	(0.106)	(0.262)	(7.851)	(4.594)	(0.086)

Regression Coefficients

$$\frac{\text{Debt}}{\text{Market Assets}} = -0.045(\text{Tobin's } Q) - 0.754\left(\frac{\text{Cash Flow}}{\text{Book Assets}}\right)$$

$$\frac{\text{Debt}}{\text{Market Assets}} = -0.198(\text{Tobin's } Q) - 1.054\left(\frac{\text{EBITDA}}{\text{Book Assets}}\right)$$

$$\frac{\text{Debt}}{\text{Market Assets}} = -0.191(\text{Tobin's } Q) - 0.841(\text{Weighted } Q) - 1.042\left(\frac{\text{EBITDA}}{\text{Book Assets}}\right)$$

Interpretation

- Leverage varies negatively with lagged liquidity.
  - High liquidity means low zero-distribution point.
  - Debt issuance finances distributions.
  - Debt less attractive.
- Leverage varies negatively with weighted Q.
  - Firms with high productivity shocks simultaneously have high Qs and finance high desired investment with equity.
  - Increased investment raises next period's firm value. Debt hysteresis then implies that the debt to assets ratio falls.

Conclusion

- A dynamic tax-based model with flotation costs produces the following results:
  - There is no target leverage ratio
  - Firms can be savers or heavily levered
  - Leverage is path dependent and exhibits hysteresis
- It explains a number of debt anomalies
  - Leverage is decreasing in lagged liquidity
  - Leverage varies negatively with lagged weighted Q
  - Firms are "debt conservative"

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