Dynamic Models and Structural Estimation in Corporate Finance

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Dynamic Models and Structural Estimation in Corporate Finance*

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Abstract

We review the last two decades of research in dynamic corporate finance, focusing on capital structure and the financing of investment. We first cover continuous time contingent claims models, starting with real options models, and working through static and dynamic capital structure models. We then move on to corporate financing models based on discrete-time dynamic investment problems. We cover the basic model with no financing, as well as more elaborate models that include features such as costly external finance, cash holding, and both safe and risky debt. For all the models, we offer a minimalist, simplified presentation with a great deal of intuition. Throughout, we

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show how these models can answer questions concerning the effects of financial constraints on investment, the level of corporate leverage, the speed of adjustment of leverage to its target, and market timing, among others. Finally, we review and explain structural estimation of corporate finance models.

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1

Introduction

Over the last 20 years, research on dynamic corporate finance has witnessed dramatic growth in both theoretical and empirical directions. Several interrelated factors have led to this advancement. First, although it has long been recognized that most financial decisions involve inherently dynamic interactions (e.g. Lintner, 1956), the development of methods necessary to tackle a number of important dynamic issues has lagged. However, advances in stochastic dynamic optimization techniques, contingent claims asset pricing analysis, game theory, and dynamic investment modeling have opened avenues for the fruitful study of dynamic problems in corporate finance. Second, there has been contemporaneous development in structural empirical methods. Third, researchers have gained access to more and significantly higher-quality data, as well as to dramatically better computing power, which makes analyzing such data possible in a reasonable amount of time. These resources have allowed researchers to take dynamic models and empirical methods seriously and, more importantly, to ask more demanding questions from the data and methods. Fourth, it is gradually becoming clearer that static models and the intuition they imply often fail to explain even simple, first-order stylized facts. In contrast, a dynamic paradigm allows the formalization and exploration of new questions that are either irrelevant or impossible to address in a traditional set-up.

Given this background, the goal of this survey is threefold. First, we wish to explain the models and techniques used in this literature as simply as possible, with the goal of making the literature more accessible. Many of the published papers in dynamic corporate finance contain models with many details. Although detail adds to the realism and rigor of the research, the unintended consequence is that the models appear to be black boxes with many indistinguishable moving internal parts. In reality, the intuition behind the models used in this literature is simple, and our goal is to reveal this simplicity. As such, we do not claim to offer a full-blown and complete overview of dynamic theoretical and empirical models in dynamic corporate finance. We also do not claim to be rigorous, precise, or generic. Rather, we offer an intuitive presentation with much less mathematical formalism than has been used in the papers we survey. For technical details and formal proofs of many results, we refer readers to the appropriate studies.

Our second goal is to introduce the reader to the main strands of this literature. Thus, our paper can be viewed in part as a literature review and in part as a tutorial. We spend a great deal of time on dynamic capital structure and on corporate investment, both of which have been the home of much, though certainly not all, of the work in dynamic corporate finance. Looking at these areas via the lens of a dynamic model helps us understand questions that would be impossible to tackle in a static framework. For example, the optimal *timing* of investment projects, equity issuance, and debt refinancing is inherently dynamic, as is the *speed* of adjustment of a leverage ratio to its target. Taking dynamics seriously also helps shed new light on questions that can be examined in static frameworks. Important examples include the detection of financial constraints, the corporate diversification discount, the low-leverage puzzle, the effects of agency on leverage and investment, and the anomalous negative sensitivity of leverage to income, which stands in the face of static capital structure theories that predict higher leverage for high-income firms.

One particular advantage of using dynamic models is that they can often provide *quantitative*, rather than simply qualitative implications.

This distinction is especially important in areas such as capital structure, in which the relative magnitudes of the costs and benefits of leverage have been the center of much of the research agenda. Throughout this monograph we delineate the similarities and differences between the different classes of dynamic models that we review.

Our third goal is to explain how to estimate dynamic models. Once again, our intent is not to provide a rigorous econometric treatment but a practical, "hands-on" guide to three specific methodologies that have been used in the literature: generalized method of moments, simulated method of moments, and maximum simulated likelihood. We also provide a concise guide to the extant structural estimation literature in corporate finance.

Space constraints necessitate several compromises. We do not cover recent developments in dynamic principal agent models. We also omit discussion of the relatively widely used class of dynamic models based on two to three time periods. We also leave out the large amount of closely related literature on dynamic models of credit spreads.

The rest of the paper proceeds as follows. Section 2 provides an overview of dynamic corporate finance models based on techniques developed in the continuous time contingent claims literature. We start with real options and then move on to static and dynamic capital structure models. We conclude this section by surveying the rest of the literature based on this class of models. Section 3 covers a separate strand of the literature that stems from a completely different formal base — discrete time investment models. Here, we cover the basic model without financing, and then move through the literature by expanding this basic model one feature at a time. Again, we conclude this section with a broad overview of the literature. Section 4 then reviews the relatively small number of different econometric techniques that have been used to estimate these models, as well as the studies that have used them. We close with a brief overview of directions for future research. Because we are reviewing highly diverse sets of models, we need to use a great deal of notation. We therefore define all of the symbols that we use in Table 1.1.

Table 1.1. Symbol and definitions.

Symbol	Definition
Section 2	
X_t	Project or firm cash flows
μ	The instantaneous growth rate of cash flows
σ	The instantaneous volatility of cash flows
$dW_t^{\mathbb{Q}}$	A standard Brownian motion process under the risk-neutral measure
I	The cost (amount) of investment
r	The risk-free interest rate
$V(\cdot)$	Firm value
$A(\cdot)$	The date-0 value of an Arrow-Debreu security
ξ_1, ξ_2	Roots of the fundamental quadratic equation
S_t	The value of equity
D_t	The value of debt
X_D	The default threshold
c	The coupon rate of perpetual debt
γ	A multiplicative constant defining the default threshold
α	Deadweight default costs
F	The unlevered firm value
TB	The present value of the tax benefits of debt
DC	The present value of default costs
$L(\cdot)$	The market leverage ratio
QML$(\cdot)$	Quasi-market leverage ratio
X_{R}	Refinancing threshold
T_X	Time that X is reached for the first time
$R(\cdot)$	Value of the debt payoff at refinancing
ω	Premium associated with the right to recall debt
q	The proportional cost of issuing debt
π_t	Realized cash flow
ϵ_t	Temporary component of realized cash flow
λ	Intensity of a Poisson process
$\phi(\cdot)$	Poisson density
T_{s}	Time of arrival of a temporary shock
T_{r}	Time of reversal of a temporary shock
Section 3	
$e(\cdot)$	Cash flows to equity holders
k	Capital stock
z	Productivity/demand shock
$\pi(\cdot)$	Profit function
$\psi(\cdot)$	Investment adjustment cost function
I	Investment
$V(\cdot)$	Equity or firm value
r	Risk free interest rate
$\mathbb{E}_t$	Expectations operator conditional on information known at time t
δ	Rate of capital depreciation
χ	Shadow value of capital
ε	Innovation to the $AR(1)$ process for z

(*Continued*)

Table 1.1. (*Continued*)

Symbol	Definition
σ_ε	Standard deviation of ε
ρ	Serial correlation of the $AR(1)$ process for z
$g(z' \mid z)$	Transition function for z
θ	Profit function curvature
$h(\cdot)$	Policy function
ψ_0, ψ_1	Fixed and quadratic investment adjustment cost parameters
$\eta(\cdot)$	External financing/equity issuance costs
η_0, η_1	Fixed and linear issuance cost parameters
p	Cash
b	Debt
s	Fraction of debt that can be collateralized
τ	Corporate tax rate on profits and interest
ζ	Lagrange multiplier
$\tilde{r}$	Interest rate on risky debt
Section 4	
x	Real data vector
$M(x)$	Vector of real data moments
y	Simulated data vector
$m(y,\beta)$	Vector of simulated moments
β	Parameter vector to be estimated
W	Weight matrix
$Q(x,y,\beta)$	SMM objective function
N	Number of observations in x
S	Ratio of the dimension of y to x
u_i	Random effect
$f(\cdot)$	Generic symbol for a density

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