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Dynamic Investment Models in Accounting Research

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Dynamic Investment Models in Accounting Research

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ABSTRACT

This monograph presents three variants of the neoclassical investment model and characterizes the firm's optimal investment policy, equity value, and the desirable properties of accrual accounting rules in each setting. Two main questions are considered: (1) What accounting rules result in the most informative financial statements from the perspective of investors seeking to value the firm's equity? and (2) What accounting rules can be efficiently used by shareholders in evaluating the performance of better informed managers? One accounting treatment, referred to as *replacement cost accounting*, achieves efficiency along both dimensions. The notion of replacement cost studied in this monograph corresponds closely to that of fair value, as defined in IFRS 13, in that it is defined as either (i) the current price of the capital goods in a perfectly competitive market, if such a market is available, or (ii) the hypothetical amount that would have to be incurred today to replace the current and future capacity of the capital goods in question. While the replacement cost rule is, in many settings, unique in providing the firm's shareholders with sufficient information for precise equity valuation, the problem of efficient performance measurement is generally less informationally demanding. For example, under certain plausible conditions, the owners can incentivize a better informed manager to make efficient investment decisions using the straight-line depreciation method.

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1

Introduction

What is an investment? The answer to this question depends on whom you ask. Dixit and Pindyck (1994) open their book on investment under uncertainty by formulating the economic perspective that investment is "the act of incurring an immediate cost in the expectation of future rewards." The authors observe that this definition is quite broad: it includes manufacturing firms constructing plants and installing equipment, merchants purchasing goods for future sale, and even a firm shutting down a loss-making plant. Most marketing and research and development (R&D) costs would also constitute investment under this definition. In contrast, the definition of investment activities under the U.S. GAAP is much more narrow — while it does cover the cost of building a new plant or installing equipment, most internally incurred marketing and R&D costs are not considered investments for financial reporting purposes. Similarly, the costs incurred in connection with closing a loss-making plant would be unequivocally treated by accountants as an expense of the *current* period, even though the economic benefits of those costs are the reduced losses of *future* periods.

In practice, firms make (broadly defined) investments on an ongoing basis: they continuously invest in new research and development, open

new and shut down existing factories as demand for their products fluctuates, engage in new marketing campaigns. In the presence of repeated investment, a firm's aggregate cash flow in any given period is difficult to interpret: it combines the benefits from multiple past investment projects with the costs of new ones, which, in turn, will generate benefits in future periods. Such situations are precisely the ones where accrual accounting can be useful in improving the matching between investment costs and benefits. Therefore, dynamic models of investment behavior are a natural setting for studying the desirable properties of accrual accounting rules. This monograph presents three such models and discusses their applications to questions in accounting-based equity valuation and managerial performance measurement.

In characterizing the optimal accounting rules, we focus on two main questions. First, we study the problem of investors who seek to value the firm's equity without observing all of its underlying transactions. Ideally, the firm's financial statements should aggregate information about those past transactions in such a way that the best estimator of the firm's equity value based on the disaggregated data coincides with that based on the aggregate accounting numbers. We refer to the problem of identifying accrual accounting rules with this property as the *equity valuation* perspective. In analyzing this perspective, we ignore any potential agency problems and assume that the firm's managers act in the best interests of its shareholders.

The second perspective considered in this monograph is that of managerial performance measurement. In this setting, we assume that the firm's manager makes investment decisions on behalf of the owners with the goal of maximizing the personal expected utility of consumption. Since the manager is better informed about the state of demand and supply in the firm's input and output markets and the productivity of assets-in-place, the owners cannot verify that manager's decisions are optimal from their perspective. As such, they seek to design performance evaluation schemes that incentivize efficient investment decisions. Our goal is to characterize the set of accounting rules facilitating such goal congruent performance measurement.

While the accounting literature relying on dynamic investment models is relatively new, one can already identify several common

themes in its findings. Perhaps the most consistent result in this growing literature is that *replacement cost accounting* has distinct advantages over other accounting rules from both the perspective of managerial performance measurement (e.g., Rogerson, 2008; Nezlobin *et al.*, 2015; Dutta and Reichelstein, 2010) and equity valuation (Nezlobin, 2012; Livdan and Nezlobin, 2017; Dutta and Nezlobin, 2017a). While different papers focus on different features of the replacement cost information, in this monograph, we proceed with the following unified definition. Under replacement cost accounting, the firm's assets-in-place are carried on the books at either (i) their price in a perfectly competitive market for used capital goods, if such a market is available; or (ii) the *hypothetical* cost of their replacement, accounting for their age, current and expected future physical productivity, and the current price of new capital goods. This notion of replacement cost accounting very closely corresponds to the concept of fair value as defined in IFRS 13 and FASB ASC 820.[1]

In the variants of the neoclassical investment model presented in this monograph, the firm is assumed to purchase its new capital goods in a perfectly competitive market and have some monopoly (pricing) power in its output market. As a consequence, the firm earns economic profits, and the expected net present value of its investment projects is positive. In contrast to the firm's equity value, the replacement cost of its assets-in-place captures neither the net present value of the firm's past investments nor the value of its future investment opportunities. Therefore, the market-to-book ratio under replacement cost accounting will generally exceed one, which makes this treatment more conservative than the notions of mark-to-market or unbiased accounting considered in the earlier accounting studies (e.g., Ohlson and Zhang, 1998; Zhang, 2000b). For similar reasons, the replacement cost of assets-in-place will generally be below their value in use.[2]

[1] According to these pronouncements, an asset's fair value shall be measured as the quoted price for an identical asset in an active market whenever such a price is available (the market approach). Otherwise, fair value can be measured using the *cost approach*, defined as "a valuation technique that reflects the amount that would be required currently to replace the service capacity of an asset."

[2] These relations, however, are not universal and will not hold in all states of nature in the model with irreversible investment presented last in this monograph. If there is no active market for used capital goods (e.g., if the capital goods manufactured

Two prominent results in equity valuation are brought together under replacement cost accounting. First, as is well known in the industrial organization literature, the firm's equity value can be written as the sum of the replacement cost of its assets-in-place and the present value of its future economic profits (e.g., Lindenberg and Ross, 1981; Salinger, 1984; Abel and Eberly, 2011). A seemingly similar result in the accounting literature, known as the residual income valuation formula, states that the firm's equity value is equal to the book value of its assets in place plus the present value of its future residual earnings (e.g., Preinreich, 1936; Edwards and Bell, 1961; Ohlson, 1995; Feltham and Ohlson, 1995). While it turns out that these two decompositions coincide term-wise under replacement cost accounting, it is well known that the residual income valuation formula holds for *any* accounting rule satisfying a basic clean surplus condition.

From the perspective of equity investors, the main advantage of replacement cost accounting is that it is essentially the only rule under which the firm's residual income process tracks the fundamental demand for the firm's output. If investors observe the firm's current financial statements prepared under this rule, it is sufficient for them to predict the future growth in demand for the firm's output to estimate the firm's future residual earnings and, therefore, its equity value. Under alternative accounting rules, the *future* behavior of the residual income process is not only determined by growth in demand but also by the firm's *past* transactions.[3] In other words, alternative accounting rules do not summarize the firm's past transaction data preserving all value-relevant information.

by the firm are too specialized for any alternative use), then it is conceivable that the replacement cost of assets-in-place may exceed their value in use and the firm's equity value, in particular, after a series of unfavorable shocks to demand for the firm's output.

[3]One exception to this statement is "mark-to-market" accounting as defined in, for example, Ohlson and Zhang (1998), i.e., the accounting rule that sets the book value of the firm's assets equal to the market value of its equity. We note, however, that such an accounting treatment is not realistic in our neoclassical setting since it would require the capitalization of the net present value of future, not yet implemented and uncertain, projects.

How close is the replacement cost rule to the actual financial reporting practice? As mentioned above, replacement cost accounting resembles two out of three approaches to fair value measurement under IFRS 13 — the market approach and the cost approach.[4] In not calling for the estimation of the net present values of future benefits of each investment, the replacement cost rule is also consistent with the FASB position that "financial accounting is not designed to measure directly the value of a business enterprise, but the information it provides may be helpful to those who wish to estimate its value," (see SFAC No. 1). However, in contrast to the current practice, the analytical models presented in this monograph suggest that the replacement cost approach should be applied to more broadly defined investment activities, including, for example, research and development and marketing costs.

We consider three closely related dynamic investment models. In the *basic* model studied in Section 2, the firm periodically adjusts its capital stock in response to changing conditions in its product market, purchasing new capital goods when demand for its output improves and selling its existing capital goods when demand deteriorates. This model is perhaps the simplest variant of what is known as the neoclassical investment theory, and it captures one key feature of investment — the mismatch in timing between investment costs and their associated economic benefits. The basic model makes two, very common, simplifying assumptions. First, the useful life of capital goods (assets) is infinite and their productive capacity declines at the same rate, regardless of their age. This assumption is ubiquitous in the finance and economics literature due to its analytical convenience; we will refer to it as that of *geometric productivity*. The second main assumption of the basic model is that the firm can both buy and sell its existing capital goods at prices that reflect their current productive capacity. This assumption will be referred to as investment *reversibility*.

Section 3 studies a *vintage capital* model in which the productivity of the firm's capital goods is allowed to follow any arbitrary pattern. This

[4]Interestingly, IFRS 13 specifically mentions that value in use is not to be considered fair value. The variant of the replacement cost discussed in Section 3 is similar to the newly required treatment for right-of-use assets in the updated lease accounting standards (Topic 842).

section shows that the performance evaluation perspective on optimal accounting rules is generally less demanding than the equity valuation perspective: goal congruent incentives can often be provided by even using simple accounting rules, such as the straight-line method. Section 4 reverts to the assumption of geometric productivity but relaxes the assumption of perfect reversibility. Initially, we focus on the setting in which the firm's investment is fully irreversible, i.e., once the firm's capital goods are installed their exit value drops to zero; we then briefly discuss a setting with costly reversibility of investment. Section 4 demonstrates that, while replacement cost information is useful for equity valuation in both reversible and irreversible investment models, the nature of the relation between the firm's equity value and the replacement cost of its assets is fundamentally different between the two settings. A somewhat cursory discussion of the empirical plausibility of the models presented in this monograph can be found in Section 4.3.

Before proceeding, we should mention two classes of dynamic investment models that are not considered here. First, in the finance literature, it is common to study models in which the firm is a price-taker in its output market but incurs convex capital adjustment costs (see, for instance, Hayashi, 1982).[5] While some results presented in this monograph carry over to such models, we do not explicitly consider adjustment costs and refer the interested reader to the survey by Strebulaev and Whited (2011). Second, multiple papers in the accounting, finance, and economics literature has viewed the firm as a collection of "projects" without imposing a single production function that aggregates capacity across projects (e.g., Berk *et al.*, 1999; Rajan *et al.*, 2007; Kogan and Papanikolaou, 2014; Dutta and Nezlobin, 2017b). While such models are analytically convenient and can be applied to study a broad range of questions in accounting research, discussion of this stream of literature is also beyond the scope of this monograph.

[5] In the accounting literature, a dynamic investment model with capital adjustment costs is studied in Anctil *et al.* (1998).

References

Abel, A. and J. Eberly (1996). "Optimal Investment with Costly Reversibility". *The Review of Economic Studies*. 63(4): 581–593.

Abel, A. and J. Eberly (2011). "How Q and Cash Flow Affect Investment without Frictions: An Analytic Explanation". *Review of Economic Studies*. 78: 1179–1200.

Anctil, R., J. Jordan, and A. Mukherji (1998). "The Asymptotic Optimality of Residual Income Maximization". *Review of Accounting Studies*. 2: 207–229.

Arrow, K. (1964). "Optimal Capital Policy, Cost of Capital and Myopic Decision Rules". *Annals of the Institute of Statistical Mathematics*. 1–2: 21–30.

Baldenius, T., A. Nezlobin, and I. Vaysman (2016). "Managerial Performance Evaluation and Real Options". *The Accounting Review*. 91(3): 741–766.

Benhabib, J. and A. Rustichini (1991). "Vintage Capital, Investment, and Growth". *Journal of Economic Theory*. 55: 323–339.

Berk, J., R. Green, and V. Naik (1999). "Optimal Investment, Growth Options and Security Returns". *Journal of Finance*. 54: 1153–1607.

Berk, J., R. Green, and V. Naik (2004). "Valuation and Return Dynamics of New Ventures". *Review of Financial Studies*. 17: 1–135.

Bernanke, B. (1983). "Irreversibility, Uncertainty, and Cyclical Investment". *Quarterly Journal of Economics*. 98(1): 85–106.

Biddle, G., P. Chen, and G. Zhang (2011). "When Capital Follows Profitability: Non-linear Residual Income Dynamics". *Review of Accounting Studies*. 6(2–3): 229–265.

Dechow, P., A. Hutton, and R. Sloan (1999). "An Empirical Assessment of the Residual Income Valuation Model". *Journal of Accounting and Economics*. 26: 1–34.

DeMarzo, P. and M. Fishman (2007). "Optimal Long-term Financial Contracting". *The Review of Financial Studies*. 20(6): 2079–2128.

Dixit, A. and R. Pindyck (1994). *Investment Under Uncertainty*. Princeton, NJ: Princeton University Press.

Doms, M. and T. Dunne (1998). "Capital Adjustment Patterns in Manufacturing Plants". *Review of Economic Dynamics*. 1: 409–429.

Downs, T. W. (1986). "Using the User Cost". *Journal of Economics and Business*. 38: 297–305.

Dutta, S. (2007). "Dynamic Performance Measurement". *Foundations and Trends in Accounting*. 2(3): 175–240.

Dutta, S. and A. Nezlobin (2017a). "Dynamic Effects of Information Disclosure on Investment Efficiency". *Journal of Accounting Research*. 55(2): 329–369.

Dutta, S. and A. Nezlobin (2017b). "Information Disclosure, Firm Growth, and the Cost of Capital". *Journal of Financial Economics*. 123(2): 415–431.

Dutta, S. and S. Reichelstein (2010). "Decentralized Capacity Management and Internal Pricing". *Review of Accounting Studies*. 15(3): 442–478.

Eberly, J., S. Rebelo, and N. Vincent (2012). "What Explains the Lagged Investment Effect?" *Journal of Monetary Economics*. 59(4): 370–380.

Edwards, E. and P. Bell (1961). *The Theory and Measurement of Business Income*. Berkeley and Los Angeles, CA: University of California Press.

Fazzari, S., G. Hubbard, and B. Petersen (1988). "Finance Constraints and Corporate Investment". *Brookings Papers on Economic Activity*. 1: 141–195.

Feltham, G. and J. Ohlson (1995). "Valuation and Clean Surplus Accounting for Operating and Financing Activities". *Contemporary Accounting Research*. 11(2): 689–731.

Feltham, G. and J. Ohlson (1996). "Uncertainty Resolution and the Theory of Depreciation Measurement". *Journal of Accounting Research*. 34: 209–234.

Fisher, F. and J. McGowan (1983). "On the Misuse of Accounting Rates of Return to Infer Monopoly Profits". *American Economic Review*. 96: 82–97.

Grenadier, S. R. and N. Wang (2005). "Investment Timing, Agency, and Information". *Journal of Financial Economics*. 75: 493–533.

Hao, S., Q. Jin, and G. Zhang (2011). "Investment Growth and the Relation Between Equity Value, Earnings, and Equity Book Value". *The Accounting Review*. 86(2): 605–635.

Hayashi, F. (1982). "Tobin's Marginal q and Average q: A Neoclassical Interpretation". *Econometrica*. 50(1): 213–224.

Islegen, O. and S. Reichelstein (2011). "Carbon Capture by Fossil Fuel Power Plants: An Economic Analysis". *Management Science*. 57(1): 21–39.

Jorgenson, D. (1963). "Capital Theory and Investment Behavior". *American Economic Review Papers and Proceedings*. 53: 247–259.

Kanodia, C. (1980). "Effects of Shareholder Information on Corporate Decisions and Capital Market Equilibrium". *Econometrica*. 48: 923–953.

Kanodia, C. (2006). "Accounting Disclosure and Real Effects". *Foundations and Trends in Accounting*. 1(3): 167–258.

Kogan, L. and D. Papanikolaou (2014). "Growth Opportunities, Technology Shocks, and Asset Prices". *The Journal of Finance*. 69(2): 675–718.

Lewellen, W. and S. Badrinath (1997). "On the Measurement of Tobin's *Q*". *Journal of Financial Economics*. 44: 77–122.

Li, D. (2011). "Financial Constraints, R&D Investment, and Stock Returns". *Review of Financial Studies*. 24(9): 2974–3007.

Lindenberg, E. B. and S. A. Ross (1981). "Tobin's q Ratio and Industrial Organization". *Journal of Business*. 54: 1–32.

Livdan, D. and A. Nezlobin (2017). "Accounting Rules, Equity Valuation, and Growth Options". *Review of Accounting Studies*. 22(3): 1122–1155.

Livdan, D. and A. Nezlobin (2018a). "Goal Congruence and Real Options: Good News About Models with Bad News". Working paper.

Livdan, D. and A. Nezlobin (2018b). "Investment, Tobin's Q, and Vintage Capital: Theory and Evidence". Working Paper.

McNichols, M., M. Rajan, and S. Reichelstein (2014). "Conservatism Correction for the Market-to-Book Ratio and Tobin's q". *Review of Accounting Studies*. 19: 1393–1435.

Nezlobin, A. (2012). "Accrual Accounting, Informational Sufficiency, and Equity Valuation". *Journal of Accounting Research*. 50: 233–273.

Nezlobin, A., M. Rajan, and S. Reichelstein (2012). "Dynamics of Rate of Return Regulation". *Management Science*. 58: 980–995.

Nezlobin, A., M. Rajan, and S. Reichelstein (2016). "Structural Properties of the Price-to-Earnings and Price-to-Book Ratios". *Review of Accounting Studies*. 21(2): 438–472.

Nezlobin, A., S. Reichelstein, and Y. Wang (2015). "Managerial Performance Evaluation for Capacity Investments". *Review of Accounting Studies*. 20(1): 283–318.

Ohlson, J. (1995). "Earnings, Book Values, and Dividends in Equity Valuation". *Contemporary Accounting Research*: 661–687.

Ohlson, J. and X. Zhang (1998). "Accrual Accounting and Equity Valuation". *Journal of Accounting Research*. 36: 85–111.

Preinreich, G. (1936). "The Law of Goodwill". *The Accounting Review*. 11: 317–329.

Rajan, M. and S. Reichelstein (2009). "Depreciation Rules and the Relation Between Marginal and Historical Cost". *Journal of Accounting Research*. 47: 823–867.

Rajan, M., S. Reichelstein, and M. Soliman (2007). "Conservatism, Growth, and Return on Investment". *Review of Accounting Studies*. 12: 325–370.

Reichelstein, S. (1997). "Investment Decisions and Managerial Performance Evaluation". *Review of Accounting Studies*. 2: 157–180.

Reichelstein, S. (2000). "Providing Managerial Incentives: Cash Flows versus Accrual Accounting". *Journal of Accounting Research*. 38(2): 243–269.

Reichelstein, S. and A. Rohlfing-Bastian (2015). "Levelized Product Cost: Concept and Decision Relevance". *The Accounting Review*. 90(4): 1653–1682.

Reichelstein, S. and A. Sahoo (2017). "Relating Product Prices to Long-run Marginal Cost: Evidence from Solar Photovoltaic Modules". *Contemporary Accounting Research*. doi:10.1111/1911-3846.12319.

Rogerson, W. (1997). "Inter-temporal Cost Allocation and Managerial Investment Incentives: A Theory Explaining the Use of Economic Value Added as a Performance Measure". *Journal of Political Economy*. 105: 770–795.

Rogerson, W. (2008). "Inter-temporal Cost Allocation and Investment Decisions". *Journal of Political Economy*. 105: 770–795.

Rogerson, W. (2011). "On the Relationship Between Historic Cost, Forward Looking Cost and Long Run Marginal Cost". *Review of Network Economics*. 10(2): 1–31.

Salinger, M. (1984). "Tobin's q, Unionization, and the Concentration-profit Relationship". *Rand Journal of Economics*. 15: 159–170.

Smith, V. L. (1961). *Investment and Production*. Cambridge, MA: Harvard University Press.

Strebulaev, I. and T. Whited (2011). "Dynamic Models and Structural Estimation in Corporate Finance". *Foundations and Trends in Finance*. 6(1–2): 1–163.

Strulovici, B. and M. Szydlowski (2015). "On the Smoothness of Value Functions and the Existence of Optimal Strategies in Diffusion Models". *Journal of Economic Theory*. 159(Part B): 1016–1055.

Thomadakis, S. (1976). "A Model of Market Power, Valuation, and the Firm's Returns". *The Bell Journal of Economics*. 7(1): 150–162.

Zhang, G. (2000a). "Accounting Information, Capital Investment Decisions, and Equity Valuation: Theory and Implications". *Journal of Accounting Research*. 38(2): 271–295.

Zhang, X. (2000b). "Conservative Accounting and Equity Valuation". *Journal of Accounting and Economics*. 29: 125–149.