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Time to build capital: Revisiting investment-cash-flow sensitivities

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ABSTRACT

A large body of empirical work has established the significance of cash flow in explaining investment dynamics. This finding is further taken as evidence of capital market imperfections. We show, using a perfect capital markets model, that time-to-build for capital projects creates an investment-cash-flow sensitivity as found in empirical studies that may not be indicative of capital market frictions. The result is due to mis-specification present in empirical investment-q equations under time-to-build investment. In addition, time aggregation error can give rise to cash-flow effects independently of the time-to-build effect. Importantly, both errors arise independently of potential measurement error in q. Evidence from a large panel of U.K. manufacturing firms confirms the validity of the time-to-build investment channel.

1. Introduction

Investment in fixed capital is one of the most important and volatile components of aggregate activity. Understanding investment dynamics is central to the study of aggregate fluctuations. In the neoclassical theory of firm investment with adjustment costs, the firm's market value and investment respond simultaneously to signals about future profitability as encoded in Tobin's q. In this theory, Tobin's q, defined as the expected value of the firm relative to its capital stock becomes a summary statistic for investment. Nevertheless, despite its theoretical appeal the empirical performance of the q theory has been rather disappointing. In contrast to the predictions of the theory, various measures of internal funds such as profits or cash flow are significant in explaining corporate investment and the responsiveness of investment to fundamentals is weak. This sensitivity of investment to internal funds is further taken as evidence of capital market imperfections that disturb the firm's investment schedule from the frictionless neo-classical benchmark. This paper uses a neoclassical investment-q model with time-to-build and time-to-plan features for capital and revisits this evidence. We provide a new explanation for the emergence of cash-flow effects in empirical investment-q equations that relies on an important technological aspect of capital production.

Time-to-build and time-to-plan are key technological features of investment. A variety of survey (Montgomery, 1995; Koeva, 2000) and firm level (Koeva, 2001; Del Boca et al., 2008) evidence suggests that these technological constraints are important at the firm level. This evidence indicates that the time required for the installation of new equipment and structures ranges from 3 to 4 quarters for equipment and 2 to 3 years for non-residential structures. But as we demonstrate in this paper, the typical investment-q equation that serves as the benchmark for evaluating the capital market imperfections hypothesis, is usually not robust to the presence of time-to-build investment. When time is required to build new capital q is

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no longer a sufficient statistic for investment. This result arises because under time-to-build an additional state variable significantly affects optimal investment decisions. Investment consists of new and partially finished projects that have not yet become productive capital. In addition to q the sum of current expenditures on existing incomplete projects belongs to the right hand side of the investment regression. In other words, when the firm decides—on the basis of new information about future investment opportunities—how many new projects to initiate, past projects already under way influence that decision, i.e. they constitute a state variable for this decision. The perfect capital markets model we use allows us to characterize this state variable analytically and show how it induces specification error in the typical investment-q equation. More importantly, we show this state variable is strongly correlated with cash flow and thus when not included among the right-hand-side variables of the regression, induces a positive investment-cash-flow sensitivity that is nevertheless not indicative of capital market imperfections.

We use the model to calibrate and simulate an industry to the aggregate U.S. manufacturing sector. The specification error we identify renders q an insufficient summary statistic is the primary driver of cash-flow effects in our simulated investment-q regressions. Our results closely corroborate findings recently reported in Eberly et al. (2008) although (as explained below), in contrast to theirs, our findings are free of measurement error in q. Nevertheless as we demonstrate, measurement error magnifies the specification error we identify. Further, our model provides an explanation for the emergence of lagged investment effects in empirical investment-q regressions, in addition to cash-flow effects. The importance of lagged investment effects is a largely overlooked empirical regularity, since most of empirical work focuses almost exclusively on the role of cash flow. But as Eberly et al. (2008) note: "Both cash-flow and lagged-investment effects have been found in virtually every investment regression specification and data sample." In our study—as in Eberly et al. (2008)—we show that the lagged investment rate is an important determinant of current investment because it proxies for an omitted state variable. In Eberly et al. (2008) simulations, lagged investment proxies for a regime-switching component in a firms' demand schedule. In the present model with time-to-build, lagged investment has a different structural interpretation, capturing time-to-build effects for the construction of capital.

We further investigate whether our model can reproduce cross sectional differences in investment-cash-flow sensitivities reported in the majority of empirical studies that test for capital market imperfections (see for e.g. Fazzari et al., 1988; Gilchrist and Himmelberg, 1995, and the survey by Hubbard, 1998). These studies find that firms which are thought *a priori* to be more vulnerable to imperfections in capital markets, e.g. small, young, with no dividends payout firms, exhibit higher investment-cash-flow sensitivities compared to firms that are thought to have ample access to external finance, e.g. large, old, dividend distributing firms. We show that the model is capable of reproducing this empirical regularity as long as the former group of (constrained) firms have longer time-to-build investment schedules compared to the latter group of (unconstrained) firms. For this purpose we bring to light evidence from large samples of U.S. (Compustat) and U.K. (Datastream) manufacturing firms that strongly suggests constrained firms to have longer time-to-build investment schedules compared to unconstrained firms.

The presence of mis-specification under time-to-build begs the question of whether and how we can mitigate it when undertaking empirical work within the q framework. We show that we can approximate the omitted state variable with two readily available variables, namely the lagged investment rate and the growth rate of the capital stock. We evaluate the usefulness of this approximation for empirical work in our simulated environment and find that it performs almost as well as its theoretical counterpart, nearly eliminating the cash-flow effect from the investment regression. We then test the predictions of the theoretical model in a large panel of U.K. manufacturing firms and find results that are remarkably consistent with the proposed time-to-build channel. When we include the two variables above as right-hand-side regressors in the empirical investment-q equations we find a significant improvement in the fit of the regression equations. More importantly, the inclusion of these controls nearly eliminates both the cash-flow sensitivity of investment and the cross sectional difference in the cash-flow coefficients. Finally, *independently* of the time-to-build effect above we show that a cash-flow effect can emerge in an investment-q equation when researchers estimate an investment-q regression using annual data—a practice followed in the majority of studies—that are aggregated from more frequent factor input decisions. This time or temporal aggregation error has been highlighted in the context of capital and labor adjustment cost estimates by Hall (2004) but as far as we know the implications in an investment-q framework have not been explored.

Recent work by Erickson and Whited (2000), Gomes (2001), Cooper and Ejarque (2003), Alti (2003), Cummins et al. (2006), Abel and Eberly (2003), also cast doubt on the validity of investment-cash-flow sensitivities as an indicator of capital market imperfections. Erickson and Whited (2000), Gomes (2001) and Cummins et al. (2006) stress that cash-flow effects may arise because Tobin's q is measured with error. Cooper and Ejarque (2003) emphasize market power that creates a divergence between average and marginal q while in Alti (2003) Tobin's q is a noisy measure of fundamentals and cash flow is highly informative about long-run profitability. Finally, in Abel and Eberly (2003) cash-flow effects arise as a result of specification error induced by changes in the user cost of capital. Yet, our contribution is rather different from all the above. First, in time-to-build, we provide a new and important channel for the emergence of significant cash-flow effects in investment-q regressions. Importantly, this channel receives considerable support from the data. Second, in contrast to the studies above our findings do not involve any mis-measurement between average and marginal q and thus are not driven by measurement error.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 discusses the solution and calibration. In Section 4 results from the simulated version of the model are presented. Section 5 concludes.