Investment and Time to Plan: A Comparison of Structures vs. Equipment in a Panel of Italian Firms

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Summary

"Time to build" models of investment expenditures play an important role in many traditional and modern theories of the business cycle, especially for explaining the dynamic propagation of shocks. We estimate the structural parameters of a time-to-build model using firm-level investment data on equipment and structures. For equipment expenditures, we find no evidence of time-to-build effects beyond one period. For structures, by contrast, there is clear evidence of time to build in the range of 2-3 years. The contrast between equipment and structures is intuitively reasonable and consistent with previous results. The estimates for structures also indicate that initial-period expenditures are low, and increase as projects near completion. These results provide empirical support for including "time to plan" effects for investment in structures. More generally, these results suggest a potential source of specification error for Q models of investment and production-based asset pricing models that ignore the time required to plan, build and install new capital.

Keywords: Investment expenditures, Panel data, Italian firms, Time to build

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1 Introduction

Tobin's Q theory of investment observes that the ratio of the marginal value of capital to its marginal cost (Tobin's Q) ought to be unity for a value-maximizing firm. Deviations from one are explained by capital adjustment costs, and give rise to an equilibrium relationship between investment and Q. The theory assumes that capital is the sole endogenous state variable. Empirically, this is a strong assumption. In the presence of multiple capital types and/or time to plan, build and install capital (TTB), the model no longer predicts a simple relation between investment and Q. In our view, failure to account for these added margins is a leading explanation for the empirical shortcomings of the Tobin's Q model.

The Q theory generalizes to accommodate multiple capital types and TTB (Wildasin, 1984; Altug, 1989). But empirical estimates of models designed to accommodate both features of the data – especially TTB – are surprisingly scant.[2] Allowing *both* features simultaneously is useful because it sharpens identification. In particular, if TTB is important, the magnitude of its effects ought to be larger and statistically easier to recognize for structures than for equipment. Since equipment and structures are treated symmetrically in the model, there is no reason to expect spurious findings for one over the other. Hence, if the predicted contrast in the magnitude of TTB is supported by the data, then it is harder to attribute the results to spurious factors.

Our paper uses panel data on Italian firms to estimate a model that allows for two capital types (equipment and structure), each with its own time to plan and build. These data are well-suited to our purposes because they report stocks and expenditures for equipment and structure separately. We investigate the multi-factor TTB model derived in Altug (1993). Our empirical implementation follows the vector autoregressive approach of Abel and Blanchard (1986), as modified for panel data and

[2]Papers that directly or indirectly estimate investment models with TTB include Altug (1989), Oliner, Rudebush, and Sichel (1995), Peeters (1998), Christiano and Vigfusson (1999), and Koeva (2001).

multiple capital inputs by Gilchrist and Himmelberg (1995, 1998) and Bontempi, Del Boca, Franzosi, Galeotti, and Rota (2004), respectively.

We find strong evidence of time to build effects for structures. Our estimates of the structural parameters for time to build indicate that investment projects for structures require 2-3 years from their initial planning to their final completion. For equipment, by contrast, we cannot reject a model in which all investment becomes productive within a period of one year. These findings are broadly consistent with evidence obtained from data at the project level (Montgomery, 1995b; Koeva, 2000), firm level (Koeva, 2001), and aggregate macroeconomic data (Altug, 1993; Zhou, 1997).

The estimates for structures also indicate that expenditures are low initially, and increase as projects near completion. These results provide empirical support for including "time to plan" effects for the structures component of investment, and thus provide firm-level evidence complementary to the macroeconomic evidence documented in Christiano and Todd (1996), Bernanke, Gertler, and Gilchrist (1999), and Christiano and Vigfusson (2001).

Our findings are interesting for the following reasons. First, our results shed light on well-known evidence of specification error in existing estimates of investment models. For one, investment is characteristically persistent, and existing research shows this persistence is not easily explained. Empirical investigations of the Q model, for example, typically report residual correlation in the error term. This finding is consistent with (unmodeled) multiple capital types or TTB. Second, time to plan and build also has important implications for models of production-based asset pricing (of which Tobin's Q model is a special case).[3] In particular, it can explain why investment appears "insufficiently" sensitive to asset prices (e.g., interest rates or equity prices, including Q ratios). The relative insensitivity to current price changes arises because the current flow of investment reflects not only expenditures for new projects, but

[3]Cochrane (1991) and Gomes, Yaron, and Zhang (2003).

also the completion of existing projects, the decisions for which were based on the expectations of costs and benefits formed in earlier periods.

Finally, modern business cycle models have difficulty accounting for the persistence of output. Our evidence should be of value to research on business cycles because TTB is one commonly cited source of persistence and cycles. Recent work by Christiano and Todd (1996), Bernanke, Gertler and Gilchrist (1999), and Christiano and Vigfusson (2001) finds that allowing for "time to plan" (where initial periods are characterized by low expenditures) is important for explaining the "hump-shaped" response of investment expenditures to shocks. In related work, however, Rouwenhorst (1991) argues that TTB plays only a secondary role in the propagation of shocks in the calibration experiments in Kydland and Prescott (1982) (which assumed capital takes four quarters to install, one fourth in each quarter). Further evidence is reported by Cogley and Nason (1995), who argue that the quantitative role of TTB for shock propagation is small. The results in the current paper suggest that these results may be reconciled by the choice of calibration values. The above studies tend to assume the time to plan and build is 3 to 4 quarters. By contrast, empirical work increasingly suggests longer construction periods. Altug (1989) and Koeva (2000), for example, suggest TTB on the order of 7 to 12 quarters. This is consistent with our findings. Our evidence suggests that TTB is on the order of 12 quarters for structures (at least in Italy), versus less than a year for equipment expenditures. It remains an open question whether these larger values would be enough to produce interesting shock propagation in business cycles models like those calibrated, for example, by Cogley and Nason (1995).

The paper is organized as follows. Section 2 provides a brief overview of the research on time to build. In Section 2 we lay out the model of optimal investment decisions in heterogeneous capital under time to build. Section 3 describes the data set. In Section 4 we discuss the estimation methodology and present the empirical results. In Section 5 we interpret the structural parameters. Section 6 concludes.

2 The Investment Model with Heterogenous Capital Under Time-to-Build

When relating flows to stocks of capital goods, the standard assumption in the investment literature is that one unit of investment at time t yields an additional unit of capital stock in the same period. An alternative that is sometimes considered assumes that a unit of investment adds to the stock only in period $t+1$. This case, which implies that investment becomes productive with a lag, is usually referred to as one-period delivery lag. Of course, longer lags are possible, but with annual data that is the case most often entertained.

The time-to-build model postulates that it takes a number of periods (greater than one) for an investment project to be completed. Following Altug (1993), let P_t denote the real size of a capital project initiated in period t. Each project takes τ periods to complete; additions to time t capital stock equal projects started in period $t-\tau$. Thus: $K_{it} = (1-\delta) K_{it-1} + P_{it-\tau}$ (δ is the i-th firm's capital depreciation rate). Let ϕ_h denote the proportion of the value of a project that is put in place h periods after the start, with $\phi_h \geq 0$ $(h = 0, 1, \ldots, \tau)$ and $\sum_h \phi_h = 1$. Finally, letting I_t be the value put in place during period t from all projects under way at that time, we have: $I_t = \sum_{h=0}^{\tau} \phi_h P_{t-h}$. Because different capital goods are likely to be characterized by different completion patterns, it is important to consider optimal investment decisions with many capital inputs.

We embed the TTB hypothesis in a model of optimal investment decisions in individual capital goods. Consider a firm which, at time $t = 0$, decides the optimal size of projects in the various capital inputs in order to maximize the expected present value of the future stream of profits:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \Pi \left(K_{1,it}, \ldots K_{J,it}, \theta_{it} \right) - \sum_{j=1}^{J} \left[c^j \left(I_{j,it}, K_{j,it}, \xi_{j,it} \right) - p_{j,t} I_{j,it} \right] \right\} \quad (1)$$