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Plant and Equipment Investment

4.1 Introduction

In this chapter the equation explaining plant and equipment investment will be discussed. Forecasting plant and equipment investment is greatly facilitated by the use of the OBE-SEC survey of expected investment expenditures, and the work in this chapter relies heavily on this survey. In Section 4.2 the survey will be briefly described and the series that has been used for the work here will be explained. In Section 4.3 the final equation will be derived, and in Section 4.4 the results of estimating the equation will be presented. The possible effects of monetary policy on investment expenditures and expectations will then be briefly discussed in Section 4.5.

4.2 The OBE-SEC Survey of Expected Investment Expenditures

The OBE-SEC survey is conducted in January-February, April-May, July-August, and October-November of each year, and at each of these times firms are asked to estimate their plant and equipment investment expenditures for the next one to four quarters ahead. These expectations are then adjusted when necessary for "systematic tendencies" and published in the March, June, September, and December issues of the *Survey of Current Business*. The usefulness of these expectations for predicting plant and equipment investment is well known, and the data have been widely used.¹

In the March issue of the *Survey of Current Business*, data on expectations are available for the first and second quarters and for the second half of the year; in the June issue data are available for the second, third, and fourth quarters; in the September issue data are available for the third and fourth quarters; and in the December issue data are available for the fourth, first, and second quarters.² There are thus two expectations published for the first quarter, three for the second quarter, two for the third quarter, three for the fourth quarter, and one for the third and fourth quarters

¹ See, for example, Eisner [11], Evans and Klein [13], Friend and Taubman [23], and Jorgenson [29].

² The data are, of course, available somewhat before the issues are actually published.

combined. Since continuous series are needed for purposes of estimation, only two expectation series are available for use in this regard, the one-quarter-ahead expectation series and the two-quarter-ahead expectation series.

In the last few years the OBE-SEC has been expanding the survey, and in 1969 for the first time they began collection of three-quarter-ahead expectations for the first and third quarters.³ (As mentioned above, three-quarter-ahead expectations were already being collected for the second and fourth quarters.) In the future one should thus be able to construct a continuous series on three-quarter-ahead expectations, but for present purposes only two continuous series could be constructed. It should be noted, however, that for present purposes the three-quarter-ahead expectations that are available can be used as proxies for the two-quarter-ahead expectations. The use of these expectations for this purpose is discussed in Chapter 13, where the sensitivity of the model to errors made in forecasting the exogenous variables is examined. It should also be noted that four-quarter-ahead expectations of the fourth quarter will be available in the future. Since the March issue already publishes expectations for the second half of the year and since collection of three-quarter-ahead expectations for the third quarter has begun, this implies that four-quarter-ahead expectations of the fourth quarter will be available. Collection of expectations for the second half of the year has also begun to be made in the October-November survey, which means that four-quarter-ahead expectations for the second half of the year will also be available.⁴ In short, the OBE-SEC expectations survey should be even more useful in the future than it has been in the past, but for purposes of estimation in this chapter, attention will have to be concentrated on the one-quarter-ahead and two-quarter-ahead expectation series.

Comparing the two expectations, the one-quarter-ahead expectation should be more accurate than the two-quarter-ahead expectation, since it is made three months later. For the one-quarter-ahead expectation, firms should have had a chance to revise their two-quarter-ahead expectation in the light of more recent developments. For forecasting purposes, however, the two-quarter-ahead expectation has the advantage of being available three months earlier, and for this reason most of the emphasis in this study has been placed on the two-quarter-ahead expectation series. The one-quarter-ahead expectation series has been used only for some of the work in Chapter 13.

It should perhaps be mentioned, although it does not directly affect the work in this study, that at the beginning of 1970 the OBE-SEC revised the

³ Wimsatt and Woodward [47], p. 19, fn. 1.

⁴ *Ibid.*

expectation series in what seems to be an undesirable way. In the February 1970 issue of the *Survey of Current Business* [47], they issued "revised" estimates of the one-quarter-ahead and two-quarter-ahead expectation series. The revised estimates were obtained by first taking the raw data and regressing over the entire sample period (for each industry) the ratio of actual expenditures to expected expenditures on seasonal dummy variables, time, and time-squared. These estimates were then used (when significant) to obtain the "corrected" expected expenditure numbers. The corrected expenditure numbers were then seasonally adjusted.

There are a number of things wrong with this procedure, not the least of which is the use of time and time-squared in the regressions. By using these variables, the OBE-SEC is beginning to estimate a realizations function (assuming that time and time-squared are picking up some of the cyclical pattern of the economy), and it is not the stated intention of the survey to present expected expenditure numbers that have been fed through a cyclical realizations function. Also, it seems unlikely that the estimates of the coefficients of time and time-squared in the regressions will remain constant over time. The use of the entire sample period to estimate the regressions is also a questionable procedure, since in actual forecasting situations data are available only up to the initial quarter being forecast. The revised estimates published in the February 1970 issue are not numbers that could have been obtained at the time the expected expenditure numbers were first published.

The revised expected expenditure numbers were not used in this study. Rather, the numbers that were first published in the *Survey of Current Business* were used. These numbers were adjusted for "systematic tendencies" (mostly seasonal tendencies) at the time they were published, but these adjustments are less questionable than the ones described above, and they obviously were based only on data that were actually available at the time the numbers were being published. The numbers that have been used are presented in Appendix A.

The revised numbers were in fact used to estimate equations like the ones below, and the results were distinctly inferior to the results presented below. In particular, the use of the one-quarter-ahead expectation series led to poorer results than the use of the two-quarter-ahead expectation series, which does not seem reasonable and which is not consistent with the results below.

With respect to the future use of the OBE-SEC series, it should prove to be possible, if necessary, to use the OBE-SEC raw data each quarter to construct expected expenditure numbers that are similar to those that were constructed in the past. From personal correspondence with the OBE,

however, it appears that the time and time-squared regressions are not going to be mechanically extrapolated into the future in adjusting the raw data. In practice, therefore, the new published numbers may actually be adjusted in a way that is closer to the way the "unrevised" numbers were adjusted than to the way the revised numbers were adjusted.

4.3 A Simple Realizations Function

Given that the OBE-SEC expectation series is to be used in the explanation of plant and equipment investment, the question arises as to what other variables, if any, should be included in the equation. The following is a simple model relating actual investment expenditures to expected investment expenditures.

It seems likely that firms have some flexibility in changing their investment expenditures from what they had originally expected them to be as the economic situation changes from what it was originally expected to be. Let GNP_t^e denote the level of gross national product expected by the firms for quarter t , the expectations being made at the same time the plant and equipment investment expectations are made, and let GNP_t continue to denote the actual level of gross national product during quarter t . The equation explaining actual plant and equipment investment is then postulated to be (using the two-quarter-ahead expectation variable):

$$IP_t = a_0 + a_1(GNP_t - GNP_t^e) + a_2 PE2_t + u_t. \quad (4.1)$$

IP_t is the actual investment during quarter t , $PE2_t$ is the two-quarter-ahead expectation for quarter t , and u_t is an error term. The coefficient a_1 in equation (4.1) is expected to be positive: if GNP is larger than expected for a given quarter, this should have a positive effect on actual investment for that quarter, and conversely if GNP is smaller than expected. The coefficient a_2 in equation (4.1) should perhaps be constrained to be one; but it makes no difference in the following analysis whether this is done or not.

Data are available on IP_t , GNP_t , and $PE2_t$ in (4.1), but data are not directly available on GNP_t^e . Consequently, a further assumption is necessary in order to eliminate GNP_t^e from the equation. As a rough approximation it is postulated that

$$PE2_t = b_0 + b_1 GNP_t^e, \quad (4.2)$$

i.e., that the expected amount of plant and equipment investment for quarter t is a function of the expected level of gross national product for quarter t . (Remember that the expectations of investment and GNP have been assumed to be made at the same time.) This is admittedly a crude hypothesis,

since expected plant and equipment investment is also likely to be a function of monetary variables and of expected levels of GNP for quarters beyond t . Given the highly aggregative nature of the data, however, the hypothesis may be adequate for present purposes.

Equation (4.2) can be solved for GNP_t^e and substituted into equation (4.1) to eliminate GNP_t^e from (4.1). This yields:

$$IP_t = \left(a_0 + \frac{a_1 b_0}{b_1} \right) + a_1 GNP_t + \left(a_2 - \frac{a_1}{b_1} \right) PE2_t + u_t. \quad (4.3)$$

Equation (4.3) states that actual investment in quarter t is a function of GNP in quarter t and of the amount of investment expected for quarter t . Due to the likelihood that many relevant variables have been omitted from the analysis, the error term in equation (4.3) is likely to be serially correlated.

4.4 The Equation Estimates

Equation (4.3) was taken as the basic equation relating expected expenditures to actual expenditures, and the following equation was estimated using the two-quarter-ahead expectation variable:

$$\begin{aligned} IP_t = & - 8.50 + .063 \widehat{GNP}_t + .687 PE2_t \\ (4.86) & \quad (8.87) \quad (8.34) \\ & \hat{r} = .689 \\ & \quad (6.72) \\ & SE = 1.011 \\ & R\Delta^2 = .633 \\ & 50 \text{ observ.} \end{aligned} \quad (4.4)$$

$$[1, IP_{t-1}, GNP_{t-1}, CD_{t-1}, CD_{t-2}, CN_{t-1}, CN_{t-2}, CS_{t-1}, CS_{t-2}, V_{t-1}, V_{t-2}, G_t, MOOD_{t-2}, PE2_t, PE2_{t-1}].$$

IP_t is the amount of nonresidential fixed investment during quarter t seasonally adjusted at annual rates in billions of current dollars, and $PE2_t$ is the two-quarter-ahead expectation of plant and equipment investment for quarter t seasonally adjusted at annual rates in billions of current dollars.⁵ Both the

⁵ Actually, the IP_t and $PE2_t$ series do not refer to the same thing. IP_t , which is the estimate of fixed nonresidential investment for the national income accounts, includes agricultural investment and certain equipment and construction outlays charged to current expense that the $PE2_t$ series does not. For 1968 IP was 88.8 billion dollars, while the actual P (plant and equipment investment corresponding to the PE2 series) was 67.76 billion dollars.

It turned out that the results using IP_t were better than the results obtained by treating P_t and $IP_t - P_t$ as separate variables, and so it was decided not to disaggregate IP_t any further. The results of treating P_t and $IP_t - P_t$ as separate variables will not be reported here.

expectation variable and the GNP variable are highly significant in equation (4.4), and the fit is fairly good. Because of the significance of the GNP variable, firms do appear to have some flexibility in changing their expected investment expenditures in light of current short-run developments. As expected, there is a rather large amount of positive serial correlation of the residuals in equation (4.4).

In an attempt to test for a more complicated lag structure, lagged GNP and then lagged investment were added to equation (4.4). The results were:

$$\begin{aligned}
 IP_t = & -9.31 - .073 \widehat{GNP}_t + .143 GNP_{t-1} + .630 PE2_t \\
 (4.54) & \quad (1.31) \quad (2.48) \quad (6.52) \\
 \hat{r} = & .695 \\
 & (6.84) \\
 SE = & 1.159 \\
 R\Delta^2 = & .528 \\
 & 50 \text{ observ.} \\
 & \text{[variables same as for (4.4) plus } GNP_{t-2}\text{].}
 \end{aligned}
 \tag{4.5}$$

$$\begin{aligned}
 IP_t = & -6.47 + .045 \widehat{GNP}_t + .217 IP_{t-1} + .590 PE2_t \\
 (4.30) & \quad (5.12) \quad (1.95) \quad (5.56) \\
 \hat{r} = & .582 \\
 & (5.06) \\
 SE = & 1.013 \\
 R\Delta^2 = & .640 \\
 & 50 \text{ observ.} \\
 & \text{[variables same as for (4.4) plus } IP_{t-2}\text{].}
 \end{aligned}
 \tag{4.6}$$

Equation (4.5) is clearly not an improvement over equation (4.4), since the current GNP variable is no longer significant in the equation and the fit has not been improved.⁶ In equation (4.6) the lagged investment variable is nearly significant, but the fit has not been noticeably improved (the standard error of the regression has actually risen slightly). Since the theoretical justification of including IP_{t-1} in the equation is to begin with somewhat

⁶ Notice that the (unadjusted) R -squared actually decreased when GNP_{t-1} was added to the equation, a situation which can happen when using two-stage least squares techniques. Since GNP_{t-1} dominated GNP_t in equation (4.5), an equation like (4.4) was estimated with GNP_{t-1} replacing GNP_t to see if the use of GNP_{t-1} led to better results. The fit of the resulting equation ($R\Delta^2 = .620$) was slightly worse than the fit of equation (4.4).

weak, equation (4.6) was dropped from further consideration.⁷ Equation (4.4) was thus taken to be the basic equation determining plant and equipment investment expenditures.

To see how the results compared, an equation like (4.4) was also estimated using the one-quarter-ahead expectation variable:

$$\begin{aligned}
 IP_t &= -6.36 + .046 \widehat{GNP}_t + .874 PEI_t \\
 &\quad (5.59) \quad (7.76) \quad (12.65) \\
 \hat{r} &= .572 \\
 &\quad (4.94) \\
 SE &= .873 \\
 RA^2 &= .727 \\
 &50 \text{ observ.}
 \end{aligned} \tag{4.7}$$

$$[1, IP_{t-1}, GNP_{t-1}, CD_{t-1}, CD_{t-2}, CN_{t-1}, CN_{t-2}, CS_{t-1}, CS_{t-2}, V_{t-1}, V_{t-2}, G_t, MOOD_{t-2}, PEI_t, PEI_{t-1}].$$

PEI_t is the one-quarter-ahead expectation of plant and equipment investment for quarter t seasonally adjusted at annual rates in billions of current dollars. The fit of this equation is better than the fit of equation (4.4), which uses the two-quarter-ahead expectation variable; the coefficient estimate of the expectation variable is larger; and the coefficient estimate of the income variable is smaller (but is still highly significant). All of these results are as expected. Firms still appear to have some flexibility in changing their expected investment expenditures, but not as much as for the longer (6-month) adjustment period implied by equation (4.4). Equation (4.7) was taken to be the basic equation determining plant and equipment investment for some of the work in Chapter 13, but otherwise the equation has not been considered in the work below.

4.5 The Effect of Monetary Policy on Investment

So far little mention has been made of the possible effect of monetary policy on investment expenditures. To the extent that monetary policy (as reflected, say, through interest rates) affects investment expectations, this is reflected

⁷ Presumably IP_{t-1} should be picking up the effect of lagged values of GNP and PE2, but the effect of lagged values of GNP from at least quarter $t-2$ on back should already be reflected in the $PE2_t$ variable, and there is little reason for believing that lagged values of PE2 have much effect on IP_t .

through the $PE2_t$ variable in equation (4.4). Equation (4.4) thus incorporates some of the effects of monetary policy on IP_t because of the inclusion of the $PE2_t$ variable. Since data on $PE2_t$ are available about 5 months ahead of the forecast period and since proxies for $PE2_t$ are available up to about a year ahead, it does not appear to be too important to specify more directly the effects of monetary policy on IP_t .

There is still the question, however, whether short-term credit conditions affect the relationship between $PE2_t$ and IP_t specified in equation (4.4). It may be, for example, that tight credit conditions cause less investment to be realized, other things being equal, than do loose credit conditions. In an effort to test for this, a number of short-term interest rates and other measures of short-term credit conditions were tried in equations like (4.4). None of these variables proved to be significant, however, and no evidence could be found that the relationship between $PE2_t$ and IP_t in (4.4) is affected by short-term credit conditions.

It should also be mentioned that in the initial phases of this study an equation explaining $PE2_t$ was developed. $PE2_t$ was taken to be a function of a lagged capital stock variable, of lagged values of GNP, and of lagged values of the (long-term) corporate bond rate. The coefficients were all significant and of the expected signs, and in particular the corporate bond rate had a significantly negative effect on $PE2_t$. This equation could have been used in the model to forecast values of $PE2_t$ for those quarters in which data for $PE2_t$ were not available. Experimentation with this equation indicated, however, that using the proxies for $PE2_t$ that are available from the OBE-SEC survey and then using extrapolated values for the remaining values gave better results than using the estimated $PE2_t$ equation to forecast the values of $PE2_t$. The estimated $PE2_t$ equation did not appear to be good enough to warrant its inclusion in the model, and so it was decided to treat $PE2_t$ as a completely exogenous variable. Since the corporate bond rate entered the $PE2_t$ equation with an average lag of only about three quarters, it would also have been necessary for the four-quarter-ahead forecasts and beyond to forecast the bond rate exogenously or else explain it within the model. It appeared to be at least as accurate in this case to forecast $PE2_t$ directly. For a policy model, of course, it would not have been appropriate to drop the $PE2_t$ equation. For forecasting purposes, however, the results achieved in this study indicated that little accuracy is likely to be lost by not incorporating the effects of monetary policy directly in the model.