CAPITAL SUBSTITUTION IN GOVERNMENT COST-SHARE PROGRAMS:

MODELING INVESTMENT BEHAVIOR

J. E. de Steiguer
Research Forester, USDA Forest Service, Southeastern Forest Experiment Station, North Carolina State University, Raleigh, North Carolina

ABSTRACT

Government reforestation cost-share programs, such as FIP and ACP, have been criticized on the basis that the government payments simply substitute for private investment capital. To provide insight into this problem, an econometric model of reforestation investment behavior was developed to separate the effect of the programs from market responses. The analysis indicated that government cost-share programs have induced the private cash outlays for reforestation that they were designed to induce. The difficulties of investment behavior modeling are discussed.

Presented at the Southern Forest Economics Workshop, April 1, 1982, Charleston, South Carolina.
"Always study your residuals," Paul Samuelson has advised "the scientific forecaster." But the econometrician working in the field of investment might well scream, "Which residuals?"

Robert Eisner (1969)

Since the 1930's, federal and state programs have assisted private landowners in the reforestation of nonindustrial private forests (NIPFs). Of particular interest here are the federal cost-share programs such as the Agricultural Conservation Program (ACP), the Forest Incentives Program (FIP), and several state programs such as the Forest Development Program (FDP) of North Carolina. In cost-share programs, the government carries up to 75 percent of the initial cost of reforestation and the landowner bears the remainder.

An examination of past reforestation acreage figures, coupled with a knowledge of the level of cost-share funding, will lead an observer to conclude that these programs have resulted in the increased planting of seedlings. Despite the apparent success of cost-share programs in terms of increased plantings, however, these incentives have been subjected to substantial criticism (Georgia-Pacific Corporation 1981), and their overall effectiveness has been questioned.

One specific criticism directed toward cost-share programs is the so-called "capital substitution problem." Proponents of this argument maintain that cost-share monies have simply replaced private capital. The capital substitution problem has been examined and discussed by others (Yoho and James 1958, Gregersen and others 1975) but the results are inconclusive as to the net impact of cost-share programs (Mills 1976).
Here, I try to ascertain whether cost-share payments have increased private investment in reforestation or simply replaced private capital which would have been invested in place of government payments. This characterization of the problem presupposes a functional relationship between private investment capital (I), the level of government cost-share payments (G), and other economic variables (Z) which influence the investment decision. Otherwise stated,

\[ I = f(G,Z). \] \hfill (1)

By definition, cost-share programs induce investment. The NIPF landowner must expend a certain amount of capital in order to obtain the cost-share monies. Thus, the question that we really want to examine is: "Do government cost-share programs induce at least as much otherwise unlikely private investment as they, by virtue of the cost-share rate, are designed to induce?" I examined the ACP, FIP, and state programs during 1964 through 1979 in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee and Texas. Cost-share rates varied by program, state, and year. For all observations, the cost-share ratio, weighted by the number of government dollars shared, was found to be 73 percent government to 27 percent private capital. Thus, for each dollar of government money expended, we would fully expect to see 36.9¢ of additional private capital invested. This fact gives us some basis on which to evaluate the problem of capital substitution. If we take into account the effect of all market factors on private investment, did each dollar of cost-share money beget at least 37¢ of private investment in addition to the investment that would have occurred without public money? If not, we can assume that some degree of capital substitution has occurred. Stated more rigorously, the argument is:
\[
\text{if } \frac{\delta I}{\delta G} \geq .369,
\]

then no capital substitution is evident.

As described, the problem and its solution are intertwined with the general problem of determining the factors that influence behavior of private investment in reforestation. The purpose here is to formulate and to estimate an econometric model of reforestation investment behavior with special emphasis on the role of government cost-share payments. This investigation differs from previous efforts because the focus is upon the behavior, rather than attitudes, of investors.

**Investment Modeling**

Economics literature includes substantial numbers of articles on modeling of investment behavior. In a review of econometric studies of such behavior, Jorgenson (1971) identified two general problems for the economics researcher: 1) ascertaining the determinants of investment and 2) characterizing the time structure of the investment process.

Forest economists, and the forestry community in general, have traditionally viewed the management of forest growing stock as an act of personal savings and investment (Duerr 1960). By planting trees, we assume that the landowner is willing to forego consumption today so that he can consume at some higher level in the future. To the many NIPF owners, reforestation may simply be an act of consumption which yields some current satisfaction. Anticipated returns on the investment may have little to do with the decision to plant. However, let us proceed under the traditional view that reforestation is an investment.

In a book on personal savings El-Mokadem (1973) sets forth a general model for personal savings and investment via financial assets in the United Kingdom. The model may be stated as:
\[ I = f(W, R, E) \]  \hspace{1cm} (3)

where

\( I \) = the investment in some financial asset,
\( W \) = a measure of the total personal wealth of society,
\( R \) = the expected rate of return on the asset in question, and
\( E \) = expectations regarding interest rates (i.e., alternative rate of return).

Models of this type are to a degree ad hoc, especially with regard to the formulation of expectations concerning certain variables such as interest rates (Griliches 1967). Nevertheless, the following theoretical bases for the model are given:

1. The general theoretical framework is based upon the work of Friedman. That is, the demand for any financial asset is determined by its characteristics subject to a wealth constraint.
2. The model is Keynesian in that it emphasizes the importance of interest rates in determining the demand for an asset.

El-Mokadem found that the measurement of total personal wealth proved to be impossible, and thus he used personal income as an index of wealth. With this qualification in mind, the model provided a satisfactory explanation of personal investment in financial assets for the UK.

Reforestation Investment Model

The UK model provides the basis for the present model of NIPF reforestation investment behavior and the latter may be stated as:

\[ I = f(Y, G, P^*, r^*) \]  \hspace{1cm} (4)

The response variable, \( I \), represents the total dollars of private capital invested in tree planting; \( Y \) is total dollars of personal income; \( G \) represents the total dollars of government cost-share money available for
assistance in tree planting; \( P^* \) is an index of expectations concerning sawtimber stumpage prices; and \( r^* \) is an index of expectations regarding interest rates. Relating this formulation to the UK model, the present variables \( I, Y, \) and \( r^* \) correspond, respectively, to \( I, Y, \) and \( E \) in the UK model. The variables \( G \) and \( P^* \) represent \( R \) evident in the UK model and, thus, they are measures of the asset's financial characteristics. In other words, they reflect the anticipated rate of return on the asset. A comment on the inclusion of \( G \) is in order. Infusion of government cost-share money into the market will offset reforestation costs and, thereby, increase the rate of return on forestry investments for many landowners.

\( P^* \) and \( r^* \) both represent indices of expectations. Specifying expectations is, inherently, a difficult task. Many possible approaches have been suggested, but perhaps the most common (Kmenta 1971) and conceptually pleasing is that of imposing a geometrically distributed lag on the variables in question. For \( P^* \) and \( r^* \) we would write this as:

\[
P_t^* = \sum_{n=0}^{\infty} \lambda^n P_{t-n} \tag{5}
\]

\[
r_t^* = \sum_{n=0}^{\infty} \lambda^n r_{t-n} \tag{6}
\]

where

\( P = \) sawtimber stumpage prices,

\( r = \) alternative rate of return,

\( t = \) time period, and

\( \lambda = \) a weight whose value is between 0 and 1.
Quite simply, the lag structure says that people's expectations regarding $P^*$ and $r^*$ are based upon current and past observations of the magnitudes of those variables. And, furthermore, the most recently observed values are the most important in helping to form expectations.

I assume the functional form of (4) to be linear, as did El-Mokadem, add subscripts to denote observations for the $i$th state in the $t$th year, and an error term $\mu$. Also, the variable $G$ is lagged one period to allow for the delay in the allocation of funding and the actual investment in planting by the landowners. Thus, the model may be written as:

$$
I_{it} = \alpha_0 + \alpha_1 Y_{it} + \alpha_2 G_{it-1} + \alpha_3 (P_{it} + \lambda P_{it-1} + \lambda^2 P_{it-2} + ...) \\
+ \alpha_4 (r_{it} + \lambda r_{it-1} + \lambda^2 r_{it-2} + ...) + \mu_{it}. \tag{7}
$$

The model, as stated above, presents some problems in estimation due to the infinite string of regressors on $P$ and $r$. However, Koyck (1954) developed a means for eliminating the infinite number of regressors while still retaining an implied geometrically distributed lag structure. This is accomplished mathematically by lagging (7) by one period and multiplying through by $\lambda$:

$$
\lambda I_{it-1} = \lambda \alpha_0 + \lambda \alpha_1 Y_{it-1} + \lambda \alpha_2 G_{it-2} + \lambda \alpha_3 (P_{it-1} + \lambda P_{it-2} + ...) \\
+ \lambda \alpha_4 (r_{it-1} + \lambda r_{it-2} + ...) + \lambda \mu_{it-1}. \tag{8}
$$

The Koyck transformation is completed by subtracting (8) from (7):

$$
I_{it} = \alpha_0 (1 - \lambda) + \alpha_1 Y_{it} - \lambda \alpha_1 Y_{it-1} + \alpha_2 G_{it-1} - \lambda \alpha_2 G_{it-2} \\
+ \alpha_3 P_{it} + \alpha_4 r_{it} + \lambda I_{it-1} + (\mu_{it} - \lambda \mu_{it-1}). \tag{9}
$$
Equation (9) can be simplified to:

\[ I_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 Y_{it-1} + \beta_3 G_{it-1} + \beta_4 G_{it-2} + \beta_5 P_{it} \]

\[ + \beta_6 r_{it} + \beta_7 I_{it-1} + \xi_{it} \]  

(10)

where \[ \alpha_1 = \beta_1 \]  

\[ \alpha_2 = \beta_3 \]  

\[ \alpha_3 = \beta_5 \]  

\[ \alpha_4 = \beta_6 \]  

\[ \lambda = \beta_7 \]  

The Koyck transformation successfully eliminates the infinite number of regressors but, in the process, raises two new problems of parameter estimation. First, present on the right side of the equation is a lagged value of \( I \) which is an endogenous variable. Second, serial correlation, if not already present, has been introduced into the error term. Johnston (1972) has suggested a means for handling these problems, and his estimation procedure has been made available through the Statistical Analysis System (SAS 1979). The procedure involves the ordinary least squares estimation of the lagged endogenous variable by means of instrumental variables, lagging the predicted value by one period, and then estimating the parameters by a manner similar to the method of Cochrane-Orcutt for time-series regression models that have autocorrelated errors. This procedure was followed to estimate the parameters of equation (7).

The expected signs of regression coefficients are positive for personal income and stumpage price expectations, negative for interest rate expectations, and positive for government cost-share payments.
Data

The model parameters were estimated by means of pooled cross-sectional and time-series observations. The data included the years 1964 through 1979, for Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Texas. Thus, the model is not based on a particular state, and is meant only to explain aggregate behavior.

All data were obtained in nominal, rather than real, terms. Personal income was obtained from the U.S. Statistical Abstracts, sawtimber stumpage prices from reports of USDA Forest Service timber sales as reported in Forest Farmer magazine. Total government cost-share payments represent the funding for the ACP and FIP programs, and for the state programs of North Carolina and Mississippi, and were collected from government documents and by personal communication. The cost-share payments were for tree planting only. Interest rates were represented by the rates on 3-month U.S. treasury bills.

The dependent variable, I, is the total out-of-pocket expenditure by NIPF investors for tree planting. Since these did not exist, they had to be calculated. An approximation of private investment was computed as follows:

1. Total cost-share allotments and cost-share percentages for each government program, by state and year were collected. Private investment was assumed to be the private cost-share portion associated with these allotments.

2. Total reforestation acreage figures were obtained by state and year from the USDA Forest Service (1980). ACP, FIP, and state program cost-share acreages were deducted from the total acreages. These residual acreage figures were assumed to have been accomplished at the total expense of NIPF landowners, and were converted to
current dollars based on the average planting costs associated with the ACP, FIP, and state programs.

3. The private investment estimates obtained from 1 and 2 above, were summed to obtain an approximation of I.

Parameter Estimates

Using the data and procedures mentioned, the parameters of the investment model were estimated as:

\[ I_{it} = \$1,354,504 + .0011Y_{it} + .3275G_{it-1} - 5050P^*_{it} - 115,050r^*_{it} \]

\[ (303,104) \quad (.0001) \quad (.1089) \quad (2693) \quad (32,472) \]

\[ R^2 = .9818 \quad \lambda = .34 \quad (11) \]

The signs were correct and the standard errors indicated significance for all terms except \( P^* \). Therefore, that variable was dropped, and the model re-estimated:

\[ I_{it} = \$1,457,547 + .0011Y_{it} + .3563G_{it-1} - 136,062r^*_{it} \]

\[ (275,335) \quad (.0001) \quad (.1117) \quad (28,743) \]

\[ R^2 = .9772 \quad \lambda = .99 \quad (12) \]

The partial derivative of I with respect to G, which is of special interest, has a positive value of .3563, and the standard error indicates statistical significance.

Conclusion and Discussion

This study was one of the first attempts to develop and estimate a macroeconomic model of the NIPF reforestation investment behavior. As such, the results are tentative and still subject to peer review and scrutiny. By now, the reader should have gained some appreciation for the difficulty
in formulating models of personal savings and investment, especially with regard to the expression of people's expectations regarding certain variables such as stumpage prices and interest rates. Also not to be denied are the problems of insufficient data. Nevertheless, this area of research is of paramount importance to forestry, and we must press forward. Both the Office of Management and Budget and the General Accounting Office have said that we must be able to give evidence of the effectiveness of the programs we think are needed to improve forest management (Satterfield 1981, GAO 1981). This, of course, means that the forestry community should improve its ability to analyze the impact of government programs on timber production on NIPF lands. This study is a step toward that goal.

The model presented in this study was able to account for virtually all of the variation in the dependent variable, private investment in tree planting. This is evident by the very high coefficient of determination. Increases in personal income were found to have a significant, positive impact on investment. Increasing alternative rates of return (T-bill rates), when a geometrically distributed lag was imposed, had a negative effect on investment. Importantly, increases in government cost-share payments had a positive impact on investment. The reader will recall, however, that not only the sign, but the magnitude of the partial derivative of I with respect to G is of interest. At the beginning of this paper, it was indicated that this partial derivative should have a value of approximately .369 or greater in order to indicate that no capital substitution was evident. The model estimation yielded a value of .356, which is slightly less than, but approximately equal to the hurdle value. Some readers may want to quibble about the difference between the two values (-.013) and point to this as evidence of capital substitution. However, given the fact that the parameter is estimated within certain bounds of probability, it is sufficient to say
that the two values are about equal.

In conclusion, we can say that government cost-share programs have induced the amount of private investment that they were designed to induce. Capital substitution does not appear to be a valid criticism of these programs.

Literature Cited


