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In This Issue . . .

There have been few studies of the relationship between money growth rates across countries. Yet assessing the impact of, say, the U.S. money growth rate on other nations' money growth rates is important because of its implication about the transmission of monetary-induced inflation between countries.

In the first article of this *Review*, "Does U.S. Money Growth Determine Money Growth in Other Nations?" Richard G. Sheehan reviews the potential relationships between two countries' money growth rates under fixed and flexible exchange rate regimes. A standard model suggests that increases in U.S. money growth should have produced increases in foreign money growth under fixed exchange rates. If foreign monetary authorities took full advantage of the insulating properties of flexible exchange rates, however, U.S. and foreign money growth should be independent. Using the Haugh test for independence, Sheehan finds that U.S. and foreign money growth rates generally were related under fixed exchange rates; moreover, money growth in many countries has been independent of U.S. money growth during the floating exchange rate period.

* * *

The recent Tax Reform Act of 1986 has drawn significant criticism for its treatment of capital investment incentives. Many economists have argued that the new tax system will lead eventually to a sharp reduction of productive capital in the United States.

In the second article in this *Review*, "Tax Reform and Investment: How Big an Impact?" Steven M. Fazzari analyzes several major changes in the tax system that affect corporate capital spending incentives. Fazzari considers how investment tax credits, tax depreciation schedules and the corporate tax rate affect the after-tax cost of capital for a variety of asset classes. The recent changes in these aspects of the tax system are discussed in an integrated framework that illustrates their combined effect on the cost of capital. The author concludes that the after-tax cost of capital will rise as a result of tax reform, which will reduce the long-run capital stock in the United States. How big the reduction will be, however, is uncertain. Fazzari shows that, under plausible assumptions, the changes need not be as dramatic as many analysts predict.

Does U.S. Money Growth Determine Money Growth in Other Nations?

Richard G. Sheehan

THE money-inflation relationship has been examined extensively for a variety of economies resulting in a consensus that money growth has had a significant and positive impact on inflation.[1] A related, but little studied issue, is the relationship between money growth rates across countries. This issue is important for assessing the extent to which inflation pressures have been transmitted from country to country.

If, for example, U.S. money growth influences the actions of foreign central banks and, therefore, foreign money growth, it also influences foreign inflation. Thus, rapid U.S. money growth may lead both to a higher U.S. inflation rate and to higher inflation rates around the world. In other words, focusing solely on the U.S. impacts of rapid U.S. money growth could substantially understate its total effects.[2]

In this paper we attempt to ascertain whether U.S. money growth has had identifiable impacts on money growth in other industrial countries. We first consider why U.S. money growth might exert effects on foreign money growth under both fixed and flexible exchange rate regimes. We then present some empirical evidence on the significance of this relationship.

PREVIOUS STUDIES OF MONETARY LINKAGES

Since the money-inflation relationship has been examined in detail elsewhere, this article focuses solely on the link between U.S. and foreign money growth rates. This latter relationship has received comparatively little attention. Feige and Johannes (1982) used causality tests to examine the U.S. money-foreign money relationship during the fixed exchange rate period. They found mixed results; U.S. money growth influenced money growth in Australia, France and Germany but had no impact in Norway or Sweden. Batten and Ott (1985) used a small structural model to examine this relationship during the floating exchange rate period. They found that U.S. money growth influenced money growth rates in Canada, Germany, Japan, the Netherlands and possibly the United Kingdom; money growth rates in France, Italy and Switzerland, however, were unaffected by U.S.

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[1]For example, see Cuddington (1981), DyReyes, Starleaf and Wang (1980), Genberg and Swoboda (1977), Gutierrez-Camara and Huβ (1983), Laidler (1976), Mills and Wood (1978), Mixon, Pratt and Wallace (1980), Pearce (1983), Swoboda (1977) and Wahlroos (1985).

[2]We ignore the possible existence of a direct relationship from U.S. money growth to foreign inflation. For theoretical arguments on the existence of such an effect, see Aukrust (1977) and Bordo and Choudhri (1982).

money growth. In a study spanning both fixed and floating exchange rate periods, Sheehan (1983) found significant cross-country differences, with U.S. money growth (M1) influencing Australian and German money growth but having no discernable impact on money growth in Canada, Italy, Japan and the United Kingdom.[3] Here, we re-examine the U.S. money-foreign money relationship using a common methodology to analyze the fixed vs. floating exchange rate periods, extending the analysis to a broader group of countries and updating the analysis through 1985.

WHY SHOULD U.S. AND FOREIGN MONEY GROWTH BE RELATED? THEORETICAL ISSUES

The theoretical relationship between U.S. and foreign money growth may differ substantially depending upon the exchange rate regime.

Fixed Exchange Rate Regime

For a fixed exchange rate system, traditional models of the monetary approach to the balance of payments predict that if the United States is the reserve currency country, an increase in the U.S. money supply leads to increased money stocks in other open economies.[4]

To see why, consider the sequence of events that typically follows an increase in U.S. money growth. Initially, the increase causes an excess supply of U.S. money and an excess U.S. demand for goods and capital. This excess demand results in simultaneous inflows of goods and services to the United States and outflows of funds from the United States to the foreign economy. Attempts to convert some of these dollars to foreign assets result in a lower exchange rate (the price of the dollar in terms of the foreign currency) in the absence of any intervention by the monetary policymakers. To maintain the exchange rate, the foreign monetary authority, and perhaps the Federal Reserve as well, must purchase dollars with foreign assets. The foreign central bank affects these purchases by increasing its own monetary base and, as a result, its own money stock.[5]

There is a potentially important qualification, however, to this traditional approach to the transmission mechanism from U.S. money growth to foreign money growth under fixed exchange rates. McKinnon (1982) has advanced the so-called currency substitution argument based on desired shifts in asset holdings between U.S. and foreign-denominated assets. Assume preferences shift from holding foreign-denominated assets to holding dollar-denominated assets, perhaps in response to changes in perceived long-run productivity growth. Simply to accommodate these changes and prevent exchange rate changes under fixed exchange rates, the Federal Reserve would have to *increase* the U.S. money stock, or the foreign monetary authority would have to *decrease* the foreign money stock, or some combination of the two. Thus, in this case, the U.S. and foreign money stocks would move generally in opposite directions.[6] Whether this negative currency substitution effect is sufficiently large enough or occurs frequently enough to offset or overcome entirely the traditional positive effect is an empirical question.[7]

Floating Exchange Rate Regime

In the traditional model of floating exchange rates, the foreign economy is insulated from U.S. money growth because the foreign monetary authority is not committed to buying (or selling) dollars at any fixed rate. Floating exchange rates, therefore, enable foreign monetary policymakers to base their policy actions on variables other than the exchange rate. An increase in the U.S. money supply, assuming demand constant, simply leads to an excess supply of dollars, a higher rate of U.S. inflation and downward pressure on the exchange rate. Thus, if monetary policymakers fully take advantage of the insulating properties of floating

[3]For results for individual countries, see Layton (1983) and Pearce (1983).

[4]For example, see Barro (1984), pp. 536–39, Frenkel (1986) or Swoboda (1977). This statement assumes fiscal policy is devoted to other goals. A typical assumption is that monetary policy is better suited to deal with exchange rate fluctuations, while fiscal policy is better suited to other objectives. See Frenkel and Mussa (1981).

[5]The foreign monetary base and money stock would not increase if these purchases were sterilized by foreign monetary authorities. See Batten and Ott (1984) for a detailed discussion of the ability of foreign monetary authorities to sterilize.

[6]In theory, zero correlation also could occur if only the U.S. money or foreign money stock changed. In practice, however, it is generally assumed that both the U.S. and the foreign monetary authority would alter their money stocks.

[7]See the debate by McKinnon and others (1984) and the references cited there for alternative views on the importance of the currency substitution argument.

Table 1

Correlation Coefficients of U.S. and Foreign Money Growth Rates

	Fixed exchange rate	Floating exchange rate
Belgium	.238	.168
Canada[1]		.374
France	.398	.034
Germany	.304	.194
Italy	.139	.138
Japan	.209	.110
Netherlands	.083	.157
Switzerland	−.057	−.103
United Kingdom	.391	.105

[1]The floating exchange rate period for the tests of independence for Canada begin in III/1973 to maintain comparability with the other countries, even though Canada switched to floating exchange rates in III/1970. Beginning the floating rate period earlier for Canada does not alter the results.

exchange rates, changes in the U.S. money growth rate may have permanent impacts on the foreign exchange rate, but no effect on the foreign money growth.

Even during the floating exchange rate period, however, there is considerable evidence that monetary policy actions have attempted, in part, to manipulate the exchange rate.[8] Moreover, many countries have attempted to keep their exchange rate movement within some wider or narrower range in order to achieve some "target rates."[9] Attempts to manage exchange rates, however, lead inevitably to some loss of monetary independence.[10]

MONEY GROWTH DATA

To determine the impact of U.S. on foreign money growth, we focus on the major world traders for which money data are available: Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland and the United Kingdom.[11] Since this group includes the major countries that have adopted floating exchange rates, we can determine whether the switch from fixed to floating exchange rates altered the U.S.-foreign money growth relationship. These countries also have the most active foreign exchange markets; thus, they may have substantial capital mobility as well.

Table 1 compares the correlation coefficients of U.S. money (M1) growth and foreign money (M1) growth for the fixed and floating exchange rate periods.[12] The fixed exchange rate sample period runs from I/1960 to II/1971, while the floating exchange rate period runs from III/1973 to IV/1985. The intervening period is viewed as transitional and thus is not considered in the analysis.[13]

In general, the correlation coefficients suggest that movements in U.S. M1 growth are partially reflected in movements in foreign money growth. In addition, the correlations generally are larger for the fixed exchange rate period than for the floating exchange rate period. For example, the correlation coefficient between U.S. and U.K. money growth rates is .391 during the fixed rate period but declines to .105 under floating ex-

[8]For example, see Batten and Ott (1985) and Wickham (1985). See also Federal Reserve Bank of New York's regular summary of "Foreign Exchange Operations," e.g. (1986).

[9]The International Monetary Fund (IMF) classifies countries by type of exchange rate regime. For example, see IMF (1985). See Heller (1978) for an alternative classification procedure. While the period since 1973 is generally acknowledged to be one of floating exchange rates, in fact, relatively few countries are classified as "floaters." For example, as of December 1983, the IMF classified just nine countries as having independently managed floating exchange rates.

[10]The ability of floating exchange rates to insulate foreign money growth from U.S. money growth, however, may be even less complete than suggested by this discussion, even when foreign monetary authorities allow the exchange rate to fluctuate. As with fixed exchange rates, currency substitution may result in a negative correlation between U.S. and foreign money growth. In addition, capital mobility also may reduce the insulating ability of floating exchange rates.

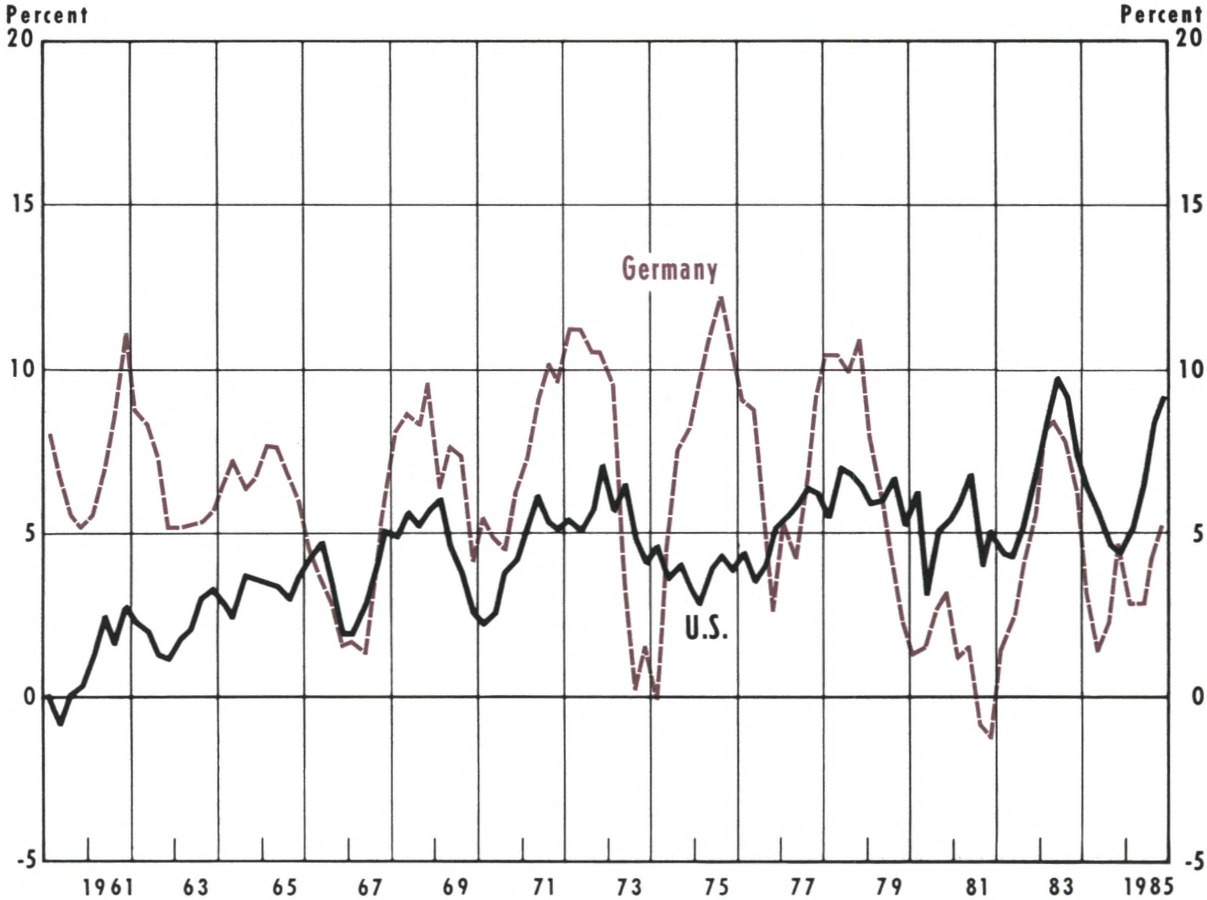
[11]This set of countries is the so-called Group of 10 plus Switzerland. Sweden is excluded due to lack of data.

[12]Given seasonally unadjusted data with trend, we use the second difference, that is: $\Delta(\ln M_t - \ln M_{t-4})$. The change from one year ago removes seasonality, while first differencing the result removes any remaining trend. The sample ends in IV/1984 for Switzerland due to a break in the data and in III/1985 for Italy since that is the most recent available. In addition, Canadian data for the fixed exchange rate period is omitted due to breaks in the data. Other breaks in the data — Canada in IV/1981, France in IV/1977, Germany in I/1968 and the United Kingdom in II/1975 and IV/1980 — appear to be relatively unimportant.

[13]The Smithsonian Agreement in 1971 replaced the Bretton Woods fixed exchange rate system. It was not until 1973, however, when the Smithsonian Agreement broke down, that exchange rates were allowed to fluctuate freely. This practice of omitting the period from III/1971 to II/1973 follows Mixon, Pratt and Wallace (1980). Studies of the floating exchange rate period generally begin after mid-1973. For example, see Batten and Ott (1985). Studies of the fixed exchange rate period generally end before mid-1971. For example, see Feige and Johannes (1982).

Chart 1

Money Growth in the United States and Germany



change rates. This finding is consistent with the ability and willingness of countries to conduct independent monetary policy under floating exchange rates. Differences among foreign countries should also be noted. For some countries including France and the United Kingdom, the correlation is quite strong during the fixed-rate period; for others, such as the Netherlands and Switzerland, the relationship is much weaker.

To further illustrate the relationship between U.S. and foreign money growth rates, charts 1 to 3 present the annualized money (M1) growth rates for Germany, Italy and the United Kingdom relative to U.S. money growth for the period I/1960 through IV/1985. These countries are chosen to reflect a diversity of monetary behavior, both between countries and over time within a country.[14]

For Germany there appears to be a regular association with U.S. money growth throughout the period. In contrast, the Italian money growth rates bear little resemblance to U.S. rates until mid-1981. For the United Kingdom, there appears to be a close relationship with U.S. money growth until 1971. After that, the

[14]Neither the graphs nor the correlations allow us to investigate the causes for the diversity of money growth rates in detail. An examination of the causes of this diversity, while an interesting topic for further research, is tangential to the goal of this paper.

rates diverge substantially. The charts also suggest that the period may be divided into the fixed and floating exchange rate regimes, and there are no other obvious breaks in the data.

ARE U.S. AND FOREIGN MONEY GROWTH INDEPENDENT?: RESULTS USING THE HAUGH TECHNIQUE

The simple correlations and graphical analysis discussed above are generally not sufficient to discover many statistical regularities, in particular, lagged relationships. To find whether such statistical regularity exists requires more refined techniques. To investigate this issue, a statistical technique developed by Haugh (1976) was used to test for independence of U.S. and foreign money growth rates. Although the Haugh technique previously has been used to consider questions of causality, it is used here only to test independence.[15] The direction of causality is *assumed* to run from U.S. to foreign money growth.[16] For example, if U.S. and Belgian money growth are statistically dependent, this result is interpreted as implying that U.S. money growth causes Belgian money growth.

The Haugh procedure ascertains statistical independence between two series based on their cross-correlations. In particular, it considers both the contemporaneous correlation between U.S. and foreign money growth and the correlations between these series across time. For example, the contemporaneous correlation between two series, X and Y, can be defined as $r_{XY}(0)$, while the correlation between X in one period and Y in the following period can be defined as $r_{XY}(1)$ and the correlation between X in one period and Y in the preceding period as $r_{XY}(-1)$. Haugh's test statistic for small samples is

$$N^2 \sum_{k=-m}^{m} (N-|k|)^{-1} \hat{r}_{XY}(k)^2,$$

where N is the number of observations, m is the maximum lag (and lead) length and $\hat{r}$ is the estimated cross-correlation coefficient. Thus, this statistic is based on the cross-correlations from X with Y lagged m periods to X with Y led m periods (or equivalently, Y with X lagged m periods). Haugh has demonstrated that this statistic follows a χ^2 distribution with $2m+1$ degrees of freedom (the number of cross-correlation coefficients calculated).

In the statistical results reported below, we vary m, the maximum lag (and lead) length. In all cases, however, the maximum lag length is relatively short. The rationale for short lags is quite simple. If exchange markets are efficient, any adjustment of foreign to U.S. money growth, either to avoid exchange rate changes or to accommodate currency substitution or mobile capital flows, should occur relatively quickly. This hypothesis implies that longer lags and the corresponding cross-correlations should be insignificant, which is supported by the empirical results.

EMPIRICAL RESULTS

Table 1 presents the significance levels for the Haugh statistic for alternative values of m in both the fixed and floating exchange rate periods.[17] For the fixed exchange rate period and for each value of m, the null hypothesis of independence between U.S. and foreign money growth can be rejected for four of the eight countries using a 10 percent significance level.[18]

[15]For example, see Feige and Johannes (1982).

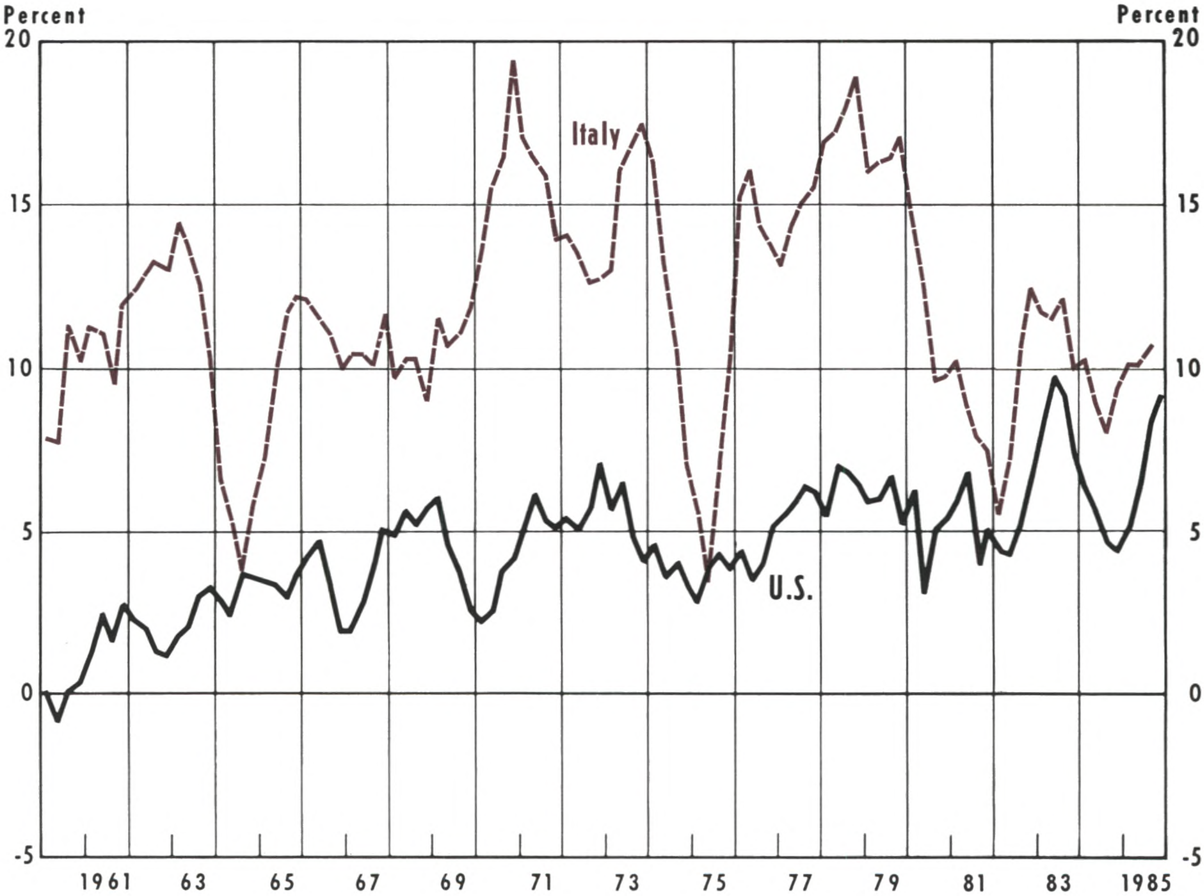
[16]Granger causality relies on time precedence in regression analysis. As Sims (1972) has admitted, it is a sophisticated version of *post hoc, ergo propter hoc.* Simply stated, regressing X on lags of Y is assumed to reveal if Y preceded — and thus "Granger-caused" — X. Zellner (1979) reviews the methodological criticisms of this approach. The Haugh technique tests only for the independence of two series. The direction of causation can then be tested, subject to the timing problems discussed by Zellner. Alternately, the direction of causation can simply be assumed. The assumed lack of causality running from foreign money growth to U.S. money growth should not be troubling for the smaller foreign countries examined. For Germany and Japan, in particular, one might argue that causality may run in both directions. To date, however, there is no evidence in the U.S. reaction function literature to support the hypothesis that U.S. money growth is influenced by any foreign money growth rate.

The Haugh technique is also not without its limitations. In particular, it requires filtered data as discussed below, and the results may be sensitive to the choice of filter employed. See footnote 17. In addition, since the Haugh technique uses cross-correlations rather than regression analysis, it is not possible to hold other factors constant. This limitation is discussed by Schwert (1979).

[17]The Haugh technique requires stationarity in both series. Given seasonally unadjusted data, all variables were converted to log differences, then time series techniques were used to obtain white noise residuals. The filters employed are available upon request. The results are basically unchanged when using Sims' (1972) filter.

[18]Canada had to be dropped from the fixed exchange rate period because of a break in the data. In addition, Canada had fixed exchange rates only for the III/1962 to II/1970 period.

Chart 2
Money Growth in the United States and Italy



The countries rejecting independence vary, however, based on the value of m. The French and Japanese results reject independence for m = 0 but not for higher values; the results for Belgium and the Netherlands, however, cannot reject independence for m = 0 but can for higher values. The null hypothesis of independence of foreign money growth from U.S. money growth cannot be rejected for any value of m only for Italy and Switzerland.

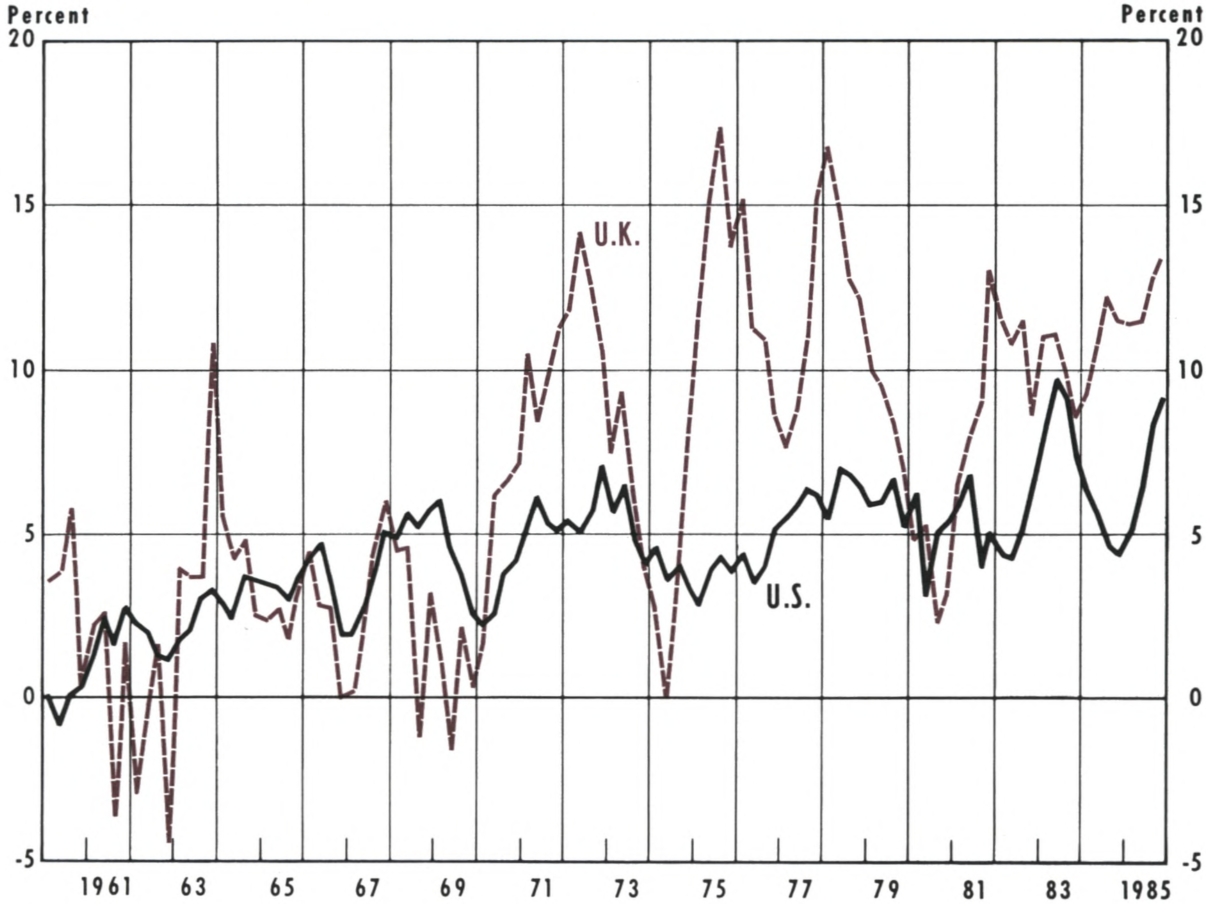
What do these results mean? If foreign money growth responds to U.S. money growth *within* one quarter, the Haugh test should reject independence for m = 0. Higher order values for m may not be able to reject independence, however, because the power of the test declines for higher values of m when the true relationship exists only at short lags.[19] Alternately, if foreign money growth responds with a lag (or with a lead if foreign monetary authorities anticipate U.S. policy actions and change their policy in advance), the contemporaneous correlation would suggest independence, while higher values of m would capture the true dependence.[20] Thus, a rejection of the null hy-

[19]Consider a simple, albeit extreme, example: r(0) = .4, r(i) = 0 for i ≠ 0 and N = 50. For m = 0, the Haugh statistic is significant at the 1 percent level. For m = 2, the Haugh statistic is insignificant even at the 10 percent level.

[20]Consider another simple example: r(1) = .4, r(i) = 0 for i ≠ 1 and N = 50. For m = 0, the Haugh statistic is clearly insignificant. For m = 1, the statistic is significant at the 5 percent level, while for m = 2, it is again insignificant.

Chart 3

Money Growth in the United States and the United Kingdom



pothesis at any value of m should be considered evidence of non-independence.

Using this criterion, foreign money growth "depends" on U.S. money growth at the 10 percent significance level during the fixed-rate period for six of the eight countries considered. In addition, in all cases in which the null hypothesis of independence is rejected, the correlations are positive. These correlations are consistent with the traditional channel of influence from U.S. money growth to foreign money growth. They are not consistent, however, with the currency substitution hypothesis. These results also are generally consistent with Feige and Johannes' (1982) results that U.S. money growth influenced foreign money growth in most countries.

The failure to reject the null hypothesis of independence for Italian and Swiss money growth, however, appears at odds with traditional theory. Two possible explanations exist for this result. First, Italy and Switzerland's rates may, in fact, have been floating during the period. This rationale, however, conflicts with an examination of the exchange rate data and classifications of exchange rate regimes such as the IMF's which suggest that exchange rates were fixed.

Alternately, the insignificant results may be due to the relatively low power of the Haugh test.[21] With a

[21]See Schwert (1979).

Table 2

Tests of Independence of U.S. and Foreign Money Growth Rates

Country	Fixed exchange rate m = 0	Fixed exchange rate m = 1	Fixed exchange rate m = 2	Floating exchange rate m = 0	Floating exchange rate m = 1	Floating exchange rate m = 2
	Haugh Statistic — Significance Levels					
Belgium	.2767	.0329	.0880	.3599	.4303	.4203
Canada[1]				.0029	.0205	.0242
France	.0352	.2118	.2620	.5891	.1741	.4003
Germany	.0175	.0127	.0005	.1521	.3505	.4032
Italy	.2437	.4247	.2674	.3322	.3280	.5399
Japan	.0539	.1664	.2452	.1831	.0310	.0040
Netherlands	.2396	.0585	.0612	.2406	.5715	.7516
Switzerland	.9854	.2627	.4921	.6460	.5944	.8088
United Kingdom	.0013	.0123	.0448	.1183	.4467	.6836

[1]The floating exchange rate period for the tests of independence for Canada begin in III/1973 to maintain comparability with the other countries, even though Canada switched to floating exchange rates in III/1970. Beginning the floating rate period earlier for Canada does not alter the results.

significance level of 10 percent, the probability of rejecting a true null hypothesis is set at 10 percent, while the probability of correctly rejecting a false null hypothesis — the power of the test — generally is unknown. Although Italian and Swiss money growth, in fact, may depend on U.S. money growth, we may be unable to correctly reject the false null hypothesis of independence.[22]

Floating Exchange Rate Period

The floating exchange rate results differ substantially from the fixed- rate results. We can reject the null hypothesis of independence only for Canada and Japan. In both cases, the correlation is positive, again inconsistent with the currency substitution hypothesis. These results are consistent with Batten and Ott's (1985) finding that some countries — including Canada and Japan — have not fully availed themselves of the insulating properties of floating exchange rates.

Using the Haugh test, it is impossible to determine whether this dependence is due to discretionary policy response to U.S. money growth. For example, foreign monetary authorities may change foreign money growth in response to changes in their real interest rate, and their real rate may change in response to U.S. money growth or a host of other factors, including a change in foreign money demand.[23]

Results Using German Money Growth in Place of U.S. Money Growth

To test further the importance of cross-national monetary linkages, we repeated the tests in table 2 for the European economies using German rather than U.S. money growth as the reference point. Under fixed exchange rates, the traditional theory would allow a relationship between, say, German and Swiss money growth only to the extent that both are correlated with U.S. money growth since both are pegged to the dollar.

[22]A third possible explanation of the insignificant Italian and Swiss results is that the positive correlation associated with the traditional channel and the negative impact associated with currency substitution may be offsetting. Of course, it then is necessary to explain why currency substitution should vary systematically with U.S. money growth.

[23]It may be preferable to run the Haugh test not on money growth ($\dot{m}$) but on money growth in excess of money demand growth. Assuming money demand growth can be approximated by income growth ($\dot{y}$), we should examine the relationships of $\dot{m}$-$\dot{y}$ between the United States and foreign countries. Unfortunately, quarterly gross national product data (or gross domestic product data) are unavailable for some or all of the period for Belgium, France, the Netherlands and Switzerland. With one exception, the results for $\dot{m}$-$\dot{y}$ were basically unaltered for the subset of countries with available data. The only exception was the floating exchange rate result for the United Kingdom, which was significant (at $m = 0$) and negative.

Table 3

Tests of Independence of German and Other Nations' Money Growth Rates

	Haugh Statistic — Significance Levels					
	Fixed exchange rate			Floating exchange rate		
Country	m = 0	m = 1	m = 2	m = 0	m = 1	m = 2
Belgium	.3768	.6623	.7872	.1817	.5797	.0911
France	.4576	.5745	.6809	.6969	.6734	.8333
Italy	.9345	.8499	.8934	.8164	.7850	.5034
Netherlands	.4553	.5809	.7392	.0121	.0323	.0677
Switzerland	.2564	.4738	.7659	.0273	.1814	.0736
United Kingdom	.0380	.1340	.0524	.0578	.0992	.0750

The results in table 3 suggest that the null hypothesis of independence can be rejected during the fixed exchange rate period only for Germany and the United Kingdom. This result likely reflects the common impact of U.S. money growth on both German and U.K. money growth, since these two countries were the most closely correlated with U.S. money growth. The correlation again is positive, which again refutes the currency substitution hypothesis. The inability to reject the null hypothesis of independence for other countries reflects their lower correlations with U.S. money growth.

Under floating exchange rates, German money growth may have an impact on other nations' money growth that it would not have had under the Bretton Woods system. Floating exchange rates, in fact, could mean a different system of pegging for some countries rather than truly floating rates. For example, other nations may choose to peg their exchange rate to the deutsche mark rather than the dollar. The current European Monetary System (EMS) formed in 1979 reflects a movement in that direction. To the extent that other nations peg to the mark, the traditional analysis on the relation between the dollar and other currencies would then hold between the mark and those currencies. Clearly, during the floating exchange rate period, based on the results in table 2, any relation between German money growth and other nations' money growth cannot be attributed to common response to U.S. money growth.

The floating exchange results in table 3 indicate that money growth in Belgium, the Netherlands, Switzerland and the United Kingdom have responded to German money growth using the 10 percent level of significance. Given EMS procedures for maintaining exchange rates within narrow bounds, the results should not be too surprising. The only possible surprise is the Swiss and U.K. results, since Switzerland and the United Kingdom are not part of the EMS.[24] The empirical evidence, however, suggests that they have behaved as if they were.

CONCLUSIONS

The results here both support and extend previous results by Batten and Ott (1985), Feige and Johannes (1982) and Sheehan (1983). Feige and Johannes focused exclusively on the fixed exchange rate period. Batten and Ott, using a different methodology, considered only the floating rate period. Here, a common technique was used to consider the impact of U.S. money growth on foreign money growth for both the fixed and floating exchange rate periods. Under fixed exchange rates, U.S. money growth had a significant impact on foreign money growth in most countries, as predicted by the textbook model of fixed exchange rates. There was no evidence of negative correlation implied by the currency substitution hypothesis.

During the floating exchange rate period, the effect of U.S. money growth was less pervasive, influencing

[24]Although Switzerland is not part of the EMS, it has admitted being influenced by the exchange rate with respect to the mark. See Schiltknecht (1983).

only a relatively small number of countries. This finding is consistent with Batten and Ott's results that some countries have not fully availed themselves of the insulating properties of floating exchange rates. Further buttressing these results, when German money growth replaced U.S. money growth, some European countries' money growth rates were shown to be related to German money growth during the floating rate period, a finding consistent with EMS institutional arrangements as well as Batten and Ott's results.

The results presented here should be considered suggestive rather than definitive for two reasons. First, the finding of dependence between U.S. and foreign money growth may be the result of common response to some third variable rather than a deliberate response of foreign central banks to U.S. money growth. And second, the Haugh test has relatively low power. Nevertheless, the results suggest that U.S. money growth had wide-ranging impacts on foreign money growth rates during the fixed exchange rate period and that these impacts have become much narrower during the floating-rate period.

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Tax Reform and Investment: How Big an Impact?

Steven M. Fazzari

THE U.S. Congress has recently passed historic legislation that revises the fundamental structure of U.S. income tax law. Promoters of this legislation hope that the new tax system will encourage more productive use of economic resources and faster economic growth. Economists disagree very little about the general objectives of tax reform. The new law, however, has drawn significant criticism, primarily because of its treatment of capital investment. The new law weakens or eliminates many tax initiatives originally designed to stimulate investment.

This article analyzes the effect of tax reform on investment and the U.S. capital stock. It discusses the channels through which changes in the corporate income tax rate, the investment tax credit and the rules for deducting depreciation expense from taxable income affect the cost of capital and a firm's investment decisions. Furthermore, this article assesses how the increase in corporate taxes affects investment. First, however, the next section presents some capital theory concepts that provide a framework for understanding tax effects on investment.

SOME BASIC CONCEPTS IN CAPITAL THEORY

A firm invests to maintain and expand its stock of productive capital. Most economic models of investment begin with the equation:

$$(1)\ \text{Investment} = \begin{bmatrix}\text{Change in}\\ \text{Desired Capital}\end{bmatrix} + \text{Depreciation.}$$

Over the long run, the amount of depreciation is determined primarily by the size of the capital stock in place. To explain investment, therefore, one must understand how firms choose their desired stock of capital.[1]

We begin by analyzing the investment decisions of a representative firm that maximizes its expected earnings over time to increase the wealth of its shareholders. The firm faces constraints on its choices. Some of these constraints, like the firm's technology, are determined by past investment decisions and the long-term development of the economy; other constraints are market-determined, such as interest rates and the availability of funds to finance investment spending. The tax system imposes another constraint on the firm's behavior. To understand its role in investment decisions, we must first see how firms would make investment decisions in the absence of corporate taxation.

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[1]Equation 1 explains gross investment. Some studies consider the change in desired capital alone, or net investment. The response of investment and the actual capital stock to changes in the desired capital stock will not be immediate; there may be long lags between investment decisions, orders, expenditures and delivery. Estimates of these lags are necessary to predict the timing of investment arising from a change in desired capital. These transitional issues are beyond the scope of this article. The analysis here focuses on the long-run changes in the capital stock caused by the new tax law. For further discussion of short-run adjustments, see Jorgenson's (1971) survey article.

Investment Decisions without Corporate Taxation

When considering capital expenditure, a firm will compare the revenue that the new investment will produce over its useful life with the costs of purchasing and using the new capital. Because capital goods are durable, they contribute to production over a number of years. It would be incorrect, therefore, to charge the full purchase price of a capital good against revenue in the year it is purchased. Rather, the cost of a capital asset over a year is its *opportunity cost;* this is simply what the firm gives up by holding it for a year. In the absence of tax effects, the opportunity cost of an investment has two components: interest expense and depreciation.[2]

Suppose a firm uses its own funds to finance an investment expenditure. The firm gives up the opportunity to earn interest on these funds. If the firm borrows from others to finance its investment, then it must pay interest to its creditor. Whether the firm uses its own funds or borrows from others, some measure of interest expense enters the cost of capital.

Actually, only the *real* interest rate affects the firm's cost of capital. Assume that capital goods prices rise at the same rate as the general price level. If the interest rate were equal to the inflation rate, the firm would not sacrifice any purchasing power by holding capital assets instead of financial assets. Only the portion of interest that exceeds what is necessary to offset expected inflation, real interest, represents a sacrifice for firms that hold capital rather than financial assets. Let i denote the nominal interest rate and π^e denote the expected inflation rate. Then the real expected interest rate can be closely approximated by $i - \pi^e$.

These concepts lead to a natural characterization of the way firms determine their desired capital stock and their corresponding investment decisions. New investment increases a firm's output. Economists call this increment to output during a year the *marginal product of capital* (MPK). The revenue gained from investing in another unit of capital, the value of the marginal product of capital, is $P \times MPK$, where P represents the firm's output price. The opportunity cost of a unit of capital, is its price, P_c, multiplied by the sum of the real interest rate and the depreciation rate $(i - \pi^e + d)$. The insert on the opposite page provides an example calculation of this cost.

If the value of the marginal product of capital, $P \times MPK$, exceeds the opportunity cost of investment, $P_c(i - \pi^e + d)$, the firm can increase its profit by making the investment. On the other hand, if $P \times MPK$ is less than $P_c(i - \pi^e + d)$, the investment is not profitable. To maximize its profits, the firm will invest up to the point at which the revenues and costs from additional capital are equal, or,

$$(2)\quad P \times MPK = P_c(i - \pi^e + d).$$

The firm's desired capital stock is reached when the last unit of capital purchased satisfies equation 2. This is a fundamental result in capital theory. It divides the determinants of a firm's desired capital stock into technical (MPK and d) and market factors (P, P_c, i). Changes in these factors alter a firm's desired capital stock, and, as equation 1 shows, changes in the desired capital stock along with depreciation determine investment.[3]

TAX REFORM AND THE COST OF CAPITAL

Of course, equation 2 is strictly valid only in the absence of corporate taxation. But the analysis underlying it helps to explain how the new tax law will affect capital spending. The changes necessary to incorporate corporate taxation into equation 2 are summarized in the insert on page 18. The key issue considered here is how tax reform has changed the after-tax cost of capital. We shall analyze three changes of particular importance: the repeal of the investment tax credit, the change in depreciation rules and the cut in the corporate tax rate.

Repeal of Investment Tax Credits

In 1963, the *Economic Report of the President* stated that "... it is essential to our employment and growth

[2]Rather than analyzing the cost of holding a capital asset year by year, we could compute the present value of the costs over the life of the asset. This would be subtracted from the present value of the revenues generated by the asset to give the net present value. To maximize its shareholders' wealth, the firm would invest in any project with a positive net present value. This procedure is more complicated than the year-by-year analysis presented in the text. It leads to equivalent results, however, assuming that the firm takes the rate of depreciation and the real rate of interest as constant over the life of the asset.

[3]In general, the marginal product of capital in equation 2 will depend on the input of other factors of production along with the capital input. These other factors, labor in particular, are not considered here. For further discussion of this issue, see the *Economic Report of the President* (1987), pp. 90–93.

Calculating the Cost of Capital: An Example

Consider an example of how the real interest rate and the depreciation rate affect the cost of an investment project. Suppose a firm buys a machine for $100,000 at the beginning of a year. It finances the purchase by borrowing from a bank at a real interest rate of 5 percent. The value of the machine depreciates by 20 percent over the year in real terms. At the end of the year, the firm must pay $5,000 to the bank in interest and it has a machine that is now worth $80,000, rather than $100,000, because of wear and tear and obsolescence. The real cost to the firm of using the machine for a year is $25,000, or 25 percent, of the original investment.

If the firm finances the investment through internal funds then, with a 5 percent real return, it gives up the opportunity to have a financial asset worth $105,000 at the end of the year. Instead, the firm buys the machine, which is worth $80,000 at year-end. The cost of capital is $105,000 − $80,000 = $25,000, the same result obtained when the purchase was financed by borrowing.

This investment will be worthwhile if it generates at least $25,000 in new revenue for the firm after other costs, such as maintenance and insurance, are deducted.

objectives as well as to our international competitive stance that we stimulate more rapid expansion and modernization of America's productive facilities."[4] One policy designed to achieve this goal was the investment tax credit, first instituted in 1962. This tax subsidy allowed firms to reduce their taxes by a percentage of their spending on certain kinds of capital equipment.

To integrate this into the capital theory summarized by equation 2, suppose that the revenues from capital investment are taxed at a rate t and the only allowable deduction for capital costs is the investment tax credit at a rate of k. Then, the after-tax cost of purchasing a unit of capital is the price paid (P_c) minus the investment tax credit amount (kP_c). The after-tax benefit of investment is $(1-t)$ multiplied by the value of the marginal product of capital. This changes equation 2 to

$$(3)\quad P_c \times MPK\,(1-t) = (P_c - kP_c)\,(i - \pi^e + d) = P_c\,(1-k)\,(i - \pi^e + d).$$

The investment tax credit reduces the after-tax cost of capital on the right-hand side of equation 3, increasing the desired capital stock and investment. The new tax bill, by eliminating this subsidy, directly increases a firm's cost of capital, reduces the corporate sector's desired capital stock and depresses investment.

[4]See pages xvi–xvii of the report.

Depreciation Rules: Some Theory

As capital wears out over time, its value declines, imposing a cost on the firm that should be deducted from its taxable income. A problem arises, however, when this concept is put into practice: how should depreciation costs be determined for tax purposes? From an economic perspective, depreciation is the change in the market value of a capital asset. But market value would be costly for firms to measure and the IRS to verify. As an alternative, the tax code provides schedules prescribing the percentage of an asset's purchase price that can be deducted from each year's taxable income. Changes in these rules lead to changes in the after-tax cost of capital faced by firms.

While all depreciation schedules allow deductions that eventually equal the total historical cost of an asset, the earlier these deductions occur, the more valuable they are. Thus, the after-tax cost of capital is reduced by depreciation schedules that concentrate deductions over a shorter period. Also, "accelerated" depreciation, which permits firms to write off a greater proportion of the asset's cost early in its life, reduces the cost of capital relative to "straight line" methods that divide the deductions evenly over the asset's service life.[5] To evaluate the importance of changing

[5]See Ott (1984) for a discussion of depreciation methods and an analysis of the effects of changes in the depreciation rules that occurred in 1981 and 1982.

The Effect of Corporate Taxes on the Desired Capital Stock Equation

In the absence of corporate taxation, firms choose their capital stock to satisfy equation 2:

$$P \times MPK = P_c (i - \pi^e + d).$$

With a proportional tax on corporate income at rate t and an investment tax credit at rate k, the equation becomes:

$$P \times MPK (1-t) = P_c (1-k) (i - \pi^e + d).$$

Including tax deductions for depreciation allowances with a present value of z gives:

$$P \times MPK (1-t) = P_c (1 - k - tz) (i - \pi^e + d).$$

Finally, recognizing the tax deductibility of nominal interest expenses gives:

$$P \times MPK (1-t) = P_c (1-k-tz) (i-\pi^e+d-tLi),$$

where L is the firm's marginal proportion of investment financed by debt. Rearranging this equation yields:

$$(P/P_c) \times MPK = \frac{(1 - k - tz)}{(1-t)} (i - \pi^e + d - tLi).$$

The right side of this equation gives the tax-adjusted cost of capital in equation 6. The calculations in table 2 are based on this formula. See the text for further explanation.

depreciation rules, one must compare the present values of the tax saving over time under the old and new tax laws. An example of how these present values are computed is given in the insert on page 20.

Consider how the deductibility of depreciation affects the cost of capital. The tax saving will equal the present value of depreciation deductions per dollar of investment (z), multiplied by the corporate income tax rate (t) and the cost of a unit of capital (P_c). Thus, the tax deductibility of depreciation reduces the after-tax cost of a unit of capital by tzP_c. This changes the equation that determines the desired capital stock to

$$(4)\quad P \times MPK (1-t) = (P_c - kP_c - tzP_c) (i - \pi^e + d) = P_c (1-k-tz) (i - \pi^e + d).$$

The right-hand side of equation 4 represents the effective cost of capital after accounting for the investment tax credit and depreciation deductions. A reduction in z, the present value of depreciation deductions, increases the cost of capital.

Changes in Depreciation Rules Due to Tax Reform

The tax acts of 1981 and 1982 instituted the Accelerated Cost Recovery System (ACRS) that increased the tax benefit from depreciation deductions and reduced the cost of capital. The new tax law changes these rules.

The figures in table 1 compare the present values of depreciation allowances for several representative asset classes over a range of pre-tax interest rates. For equipment purchases, the new tax law changes the present value of depreciation deductions in several ways. First, the service lives for some assets were lengthened. For example, cars and light trucks had their tax service lives extended from three to five years. This reduces the present value of their depreciation allowance, as shown in table 1, because it extends the time between a capital purchase and the tax saving. For many other assets, however, tax service lives were unchanged. Office, computing and accounting equipment, for example, kept its five-year depreciation period. On average, equipment service lives were extended to 6.0 years from their 4.6-year average under ACRS.[6]

On the other hand, the new law allows a more accelerated depreciation schedule (firms may use a 200 percent, rather than a 150 percent, declining balance depreciation method). This allows a greater proportion of the total deduction in the earlier years. By itself, this change would increase the present value of

[6]The average service life estimates used in this article are weighted averages over the different classes of assets. The weights reflect the proportion of total assets in each class. The author thanks Joel Prakken of Laurence H. Meyer and Associates for providing these estimates.

Table 1
Present Value of Depreciation Allowances Per Dollar of Investment

	Pre-Tax Interest Rate					
	5 percent		10 percent		15 percent	
Asset Class	Previous law	New law	Previous law	New law	Previous law	New law
Cars and light trucks	.971	.947	.943	.900	.918	.857
Office, computing and accounting equipment	.948	.947	.901	.900	.858	.857
Communications equipment	.948	.923	.901	.857	.858	.800
Equipment average	.952	.935	.908	.877	.868	.827
Business structures	.815	.626	.682	.431	.583	.319

NOTE: The present value is computed by discounting the depreciation allowances for each asset at the after-tax interest rate. Thus, the discount rate is 1 − 0.46 times the interest rate shown for the old law and 1 − 0.34 times the interest rate for the new law. Further details about the depreciation flows are given in the appendix.

depreciation deductions, thus partly offsetting the negative impact of extending service lives.

Finally, by reducing the corporate tax rate, the new tax law increases the after-tax discount rate firms use to calculate the present value of their depreciation deductions at a *given* nominal interest rate. By itself, this reduces the present value of a particular sequence of depreciation deductions.

As table 1 shows, on net these changes cause the present value of depreciation allowances to decline under the new tax law. The effects for equipment are modest on average.

The new law has a much more significant impact on business structures. The ACRS system adopted in 1981 allowed firms to depreciate business structures over 19 years with an accelerated method (175 percent declining balance). The new law requires straight line depreciation over 31.5 years. As the bottom row of table 1 shows, this significantly reduces the present value of depreciation allowances for structures.

Changes in the Corporate Tax Rate

The new tax law cuts the top corporate income tax rate from 46 percent to 34 percent. By itself, it might seem that this would stimulate investment, because it allows firms to keep a larger proportion of the profits earned from new capital. The analysis that led to equations 2 through 4 shows that this may not be the case. Although a cut in the corporate income tax rate increases the after-tax revenues gained from new investment, it also decreases the value of tax deductions generated by capital costs. Thus, the net effect on investment of a lower corporate tax rate is ambiguous. It depends on the extent to which capital costs are tax-deductible.

Let us consider this point in more detail. The cost of capital per dollar of investment is reduced by the corporate tax rate times the present value of depreciation allowances (tz). The lower the corporate tax rate, the lower the value of this deduction, and the higher the after-tax cost of capital. Thus, considering this channel alone, lowering the corporate tax rate actually *reduces* the incentive to invest.

Another primary component of capital cost is real interest earnings foregone by investing in fixed capital. In the absence of corporate taxation, this cost was essentially the same whether firms financed their investment with internal funds or external borrowing. This is no longer true when we introduce the corporate income tax. Nominal interest paid on debt is tax-deductible, but foregone interest on internal funds is not. This gives debt financing a tax advantage over internal financing.[7] The tax saving from interest deductions is the corporate tax rate (t), multiplied by the proportion of the investment financed with debt (L), multiplied by the nominal interest rate (i). This amount is subtracted from the real interest rate in the

[7]See Brealey and Myers (1984) for a clear summary of this idea.

The Present Value of Depreciation Deductions

To correctly evaluate the cost of a capital asset, a firm must take into account the tax savings that result from depreciation deductions. These savings, however, occur over time after the asset is purchased. The further in the future a tax deduction occurs, the lower its "present value," because the firm loses the opportunity to earn interest on the tax saving.

Suppose a firm buys a computer for $100,000 in 1987. The new tax law allows the firm to write off this cost over five years. The deductions for each year are given in the first column of the accompanying table. The $20,000 deduction the firm gets in 1987 is worth the same amount as any other cost it incurs in 1987, so it is not discounted.

The firm will obtain a $32,000 deduction in 1988. The present value of this deduction is the amount of money the firm would need in 1987 to get $32,000 in 1988. Assume the pre-tax interest rate is 10 percent and the corporate tax rate is 34 percent, as specified in the new tax law. Then, the after-tax interest rate is 6.6 percent = (1 − .34) × 10 percent. The amount of money needed in 1987 to have $32,000 after tax in 1988 is $32,000/1.066 = $30,019. This is the present, or "discounted" value of a $32,000 depreciation deduction in 1987. The divisor 1.066 is called the "discount factor."

The longer the firm must wait for depreciation deductions, the greater the discount factor, and the lower the present value. For example, the $19,200 depreciation in 1989 from the hypothetical computer purchase is discounted by $(1.066)^2 = 1.136$. Applying this method to all the depreciation deductions yields a total present value of $89,965 in depreciation deductions from a $100,000 purchase, or about 90 cents for every dollar spent. All the figures in the following table are computed using this approach.

Present Value of Depreciation Deductions from a $100,000 Computer Purchase under the New Tax Law

Year	Depreciation Deduction	Discount Factor	Present Value of Deduction
1987	$ 20,000	1.000	$ 20,000
1988	32,000	1.066	30,019
1989	19,200	1.136	16,901
1990	14,400	1.211	11,891
1991	14,400	1.291	11,154
Total	$100,000		$ 89,965

capital cost in equation 4, which now becomes:

$$(5)\ P \times MPK\,(1-t) = P_c(1-k-tz)\,(i - \pi^e + d - tLi).$$

As noted previously, the corporate income tax rate also affects the revenue side of the investment decision. The effective value of the marginal product is $(1-t)\,P \times MPK$. A lower corporate tax rate stimulates investment through this channel; with lower taxes, firms keep a larger proportion of the revenues generated by new investment.

In summary, reducing the corporate tax rate increases the benefits from new capital investment by raising the left side of equation 5. At the same time, lower corporate tax rates reduce the value of tax deductions for depreciation and interest expense. This increases the costs of new capital on the right side of equation 5. Therefore, this theory cannot predict whether the lower corporate tax rate will stimulate or depress investment. To obtain a more definite result, we must look at the net effects of changes in the tax law.

Table 2
The Effects of Tax Reform on the After-Tax Cost of Capital

Investment Category	Base Case (Old Tax Law)	Base With Repeal of Investment Tax Credit	Base With Revised Depreciation	Base With 34 Percent Corporate Tax Rate	New Tax Law
Cars and light trucks	36.1%	39.4%	37.5%	36.2%	39.9%
Office, computing and accounting equipment	29.6	34.3	29.6	29.5	33.6
Communications equipment	15.6	18.0	16.1	15.7	18.2
Equipment average	17.1	19.5	17.5	17.2	19.6
Business structures	13.2	13.2	15.4	12.5	13.9

NOTE: These calculations assume a 10 percent nominal interest rate and a 4 percent expected inflation rate. The cost-of-capital formula and additional assumptions are given in the appendix.

Net Effects of Tax Changes on the Cost of Capital

To fully assess the impact of tax reform on the cost of capital, we need a way of combining all the changes into a single measure. The basis for this is the theory summarized in equation 5. By putting all the terms affected by the tax system on the right side of the equation, we obtain:

$$(6)\quad (P/P_c) \times MPK = \frac{(1-k-tz)}{(1-t)}(i - \pi^e + d - tLi).$$

The right side of this equation is the tax-adjusted cost of capital per dollar of investment spending. Some representative calculations of this cost are shown in table 2.[8] The differences among the cost of capital estimates for different asset classes are primarily due to different rates of economic depreciation.

The first column of table 2 gives cost of capital estimates based on assumptions that reflect the old tax law. The second column shows the effect of eliminating the investment tax credit, while retaining all other assumptions of the base case. This has a significant impact on the after-tax cost of capital for equipment. The average equipment cost of capital rises by 2.4 percentage points with the repeal of the investment tax credit. The credit does not apply to structures.[9]

On the other hand, the third column shows that the effect of changing the depreciation rules is more pronounced for the after-tax cost of business structures. The present value of depreciation deductions declines much more for structures than for equipment under the new tax law. Compared with the base case of the old tax law, the change in tax depreciation rules raises the after-tax cost of capital by only 0.4 percentage points for equipment, on the average, while raising the cost of capital by 2.2 percentage points for business structures.

The fourth column shows the effect of lowering the corporate tax rate from 46 percent to 34 percent. This causes a substantial reduction in the cost of capital for business structures, but leaves the equipment figures virtually unchanged. The analysis in the previous section explains this result. Theoretically, the net effect of

[8]The basic reference for the tax-adjusted cost of capital measure is Hall and Jorgenson (1967). Further details of the calculation are given in the appendix. To make the comparisons shown in table 2, one must make assumptions about the future course of nominal interest rates and expected inflation. The calculations in table 2 assume a nominal interest rate of 10 percent and expected inflation of 4 percent. These assumptions are the same for the old and new tax laws to focus on the results of tax changes alone. Some economists have argued that the tax reform will change interest rates and inflation. This issue is considered later in the article. Also, these calculations do not consider the effects of changes in personal taxes on capital income. See Henderson (1986) for further discussion of this issue.

[9]In econometric analysis that uses National Income and Product Accounts (NIPA) data, the investment tax credit for structures is often not set at zero. This is because the NIPA data for structures include asset classes, drilling rigs and air-conditioning equipment, for example, which were eligible for the credit. This is not important, however, for the illustrative calculations in table 2.

a lower corporate tax rate on the cost of capital is ambiguous. The direction of change depends on the value of tax deductions for depreciation. The depreciation deductions for equipment per dollar of investment are much more valuable than those for business structures, because equipment write-offs are faster. Thus, lowering the corporate tax rate reduces the value of equipment depreciation allowances more than business structures allowances. On the other hand, the benefit of lower corporate taxes — from the reduced proportion of revenues paid in taxes — is the same for both equipment and structures. Thus, lower corporate tax rates benefit structures much more than equipment, as the fourth column of table 2 shows.

The aspects of the tax reform bill that affect the cost of capital have drawn significant criticism because some analysts view them as anti-growth. The results presented in table 2 provide some support for this view. The last column shows the net effect of the new tax law. All the cost of capital estimates rise relative to the old law. For equipment, the repeal of the investment tax credit has the most important effect, and some asset classes face higher costs due to changes in the depreciation rules.

For business structures, the change in depreciation has a significant impact by itself, but this is offset to a large degree by the benefits of a lower corporate tax rate. The comparatively moderate increase in the cost of capital for business structures is somewhat surprising in light of the strong criticism the new tax treatment of structures has drawn. This is probably because most analyses focus on the more obvious effect of less generous structure depreciation. But it is important not to ignore the important impact of lower corporate tax rates.[10]

THE IMPACT OF TAX REFORM ON INVESTMENT AND THE CAPITAL STOCK

How large an effect will changes in the cost of capital have on U.S. investment and the capital stock? This is not an easy question to answer. Economists have not resolved important technical questions about the sensitivity of the desired capital stock to changes in the after-tax cost of capital. Furthermore, many economists have argued that tax reform will lower the real interest rate. The calculations presented in table 2 assume that real interest rates do not change under the new tax law.

The Link between Investment and the Cost of Capital

Economists generally agree that the new tax law will increase the cost of capital. The effect of this increase on investment and the desired capital stock depends on the economy's production technology. The key parameter is called the "elasticity of substitution" between capital and other factors of production. This measures the sensitivity of firms' demand for capital to changes in the cost of capital. An increase in the cost of capital induces firms to substitute other factors of production for capital. This lowers the desired capital stock, and according to equation 1, investment falls. The higher the elasticity of substitution, the bigger the reduction in the long-run capital stock.

Let c_o and c_n represent the cost of capital under the old and new tax laws, respectively. The theory predicts that the long-run percentage change in the capital stock is given by:

$$(7)\ \text{Percent Change in Capital} = 100 \times [(c_o/c_n)^s - 1],$$

where s is the elasticity of substitution. The assumptions used to derive equation 7 are discussed in the appendix. The higher s is, the greater the long-run reduction in the capital stock will be as a result of tax reform.

The elasticity of substitution is determined by the economy's technology. Although not directly observable, it can be estimated, and a wide range of estimates of s can be found in the economics literature. Some researchers have concluded that the elasticity of substitution is close to unity.[11] If this is true, the size of the desired capital stock would be very sensitive to changes in the cost of capital. Thus, even the modest increase in the cost of capital shown in table 2 could have a significant long-run impact on the capital stock.

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[10]Of course, this point is relevant only for profitable firms that invest in structures. Firms that invest only to obtain tax losses from fat depreciation allowances will be hurt by the new depreciation rules, but, since they pay no tax, will not be helped by lower tax rates.

[11]If the elasticity of substitution is equal to one, the economy's technology can be represented by a Cobb-Douglas production function. Jorgenson (1971) finds empirical support for this case. Also see Chirinko and Eisner (1982) for further discussion.

With s equal to 1.0 in equation 7 and the cost of capital figures from table 2 we obtain the following results:

$$\text{Percent Change in Equipment} = 100 \times [(17.1\%/19.6\%) - 1] = -12.8\%$$

$$\text{Percent Change in Structures} = 100 \times [(13.2\%/13.9\%) - 1] = -5.0\%.$$

These dramatic results support the views of tax reform critics. A 12.8 percent drop in the stock of U.S. capital equipment would cause a significant reduction in the economy's productive potential with a correspondingly negative impact on future national output and employment.[12]

Other researchers have found that the desired capital stock is much less sensitive to changes in the cost of capital. For example, in an extensive survey of predictions from large econometric models, Chirinko and Eisner (1982) found estimates of s as low as 0.55 for equipment and 0.16 for structures. Such low values change the predicted effects of tax reform significantly:

$$\text{Percent Change in Equipment} = 100 \times [(17.1\%/19.6\%)^{0.55} - 1] = -7.2\%$$

$$\text{Percent Change in Structures} = 100 \times [(13.2\%/13.9\%)^{0.16} - 1] = -0.8\%.$$

These results suggest that tax reform could have a more moderate effect on equipment and virtually no effect on structures.

Tax Reform, Interest Rates and Investment

The analysis up to this point has assumed that the interest rate would not be affected by tax reform. Yet, there are widespread predictions that tax reform will *decrease* interest rates. The tax reform bill cuts marginal personal tax rates sharply, especially for high-income individuals. Thus, the after-tax returns to saving rise, which stimulates saving and lower real interest rates. Furthermore, reduced capital spending lowers the demand for financing. This also pushes real interest rates lower. One recent study, for example, predicts that the new tax law will cause a 1.3 percentage-point decline in the corporate bond yield and a 0.5 percentage-point decline in the inflation rate. Under these circumstances, the real interest rate would decrease 0.8 percentage points.[13]

The effects of lower interest rates are explored in table 3. The first column reproduces results given earlier for the percentage changes in the capital stock assuming no changes in real interest rates due to the new tax law. Figures are given for both the high elasticity of substitution case (s=1) and the low elasticity case (s = 0.55 for equipment and s = 0.16 for structures). The columns show the effects of a range of assumptions about the decline in the interest rate induced by tax reform.

These figures show that even modest reductions in real interest rates from the new tax law can substantially mitigate the negative impact of tax reform on investment. The effects on the stock of producers' durable equipment are moderate, especially with the lower elasticity of substitution estimate. Surprisingly, the calculations show that the desired stock of business structures may even rise with real interest rate reductions in the middle of the relevant range. Thus, the dramatic reductions in the capital stock and investment predicted by some critics of the new tax law represent a worst case, where the elasticity of substitution is high and the real rate of interest does not fall in response to tax changes.

The Effects of Increasing Corporate Tax Burdens

The analysis to this point has used conventional capital theoretic concepts to evaluate the impact of tax reform on investment incentives. Tax policy affects investment decisions by changing the costs and benefits of individual investment projects. A firm can obtain financing for any profitable project at the prevailing cost of capital. Thus, the reduction of a firm's internal funds available to finance investment caused

[12]Some economists have argued that, although investment and the capital stock will fall as a result of tax reform, the projects that are undertaken will be more efficient. Eliminating special tax breaks for certain kinds of investment will encourage firms to carry out more productive projects rather than projects that generate the biggest tax savings. Thus, the fall in investment may benefit the economy by reducing wasteful investment. A complete analysis of this issue is outside the scope of this article. See Batten and Ott (1985), Henderson (1986), and the *Economic Report of the President* (1987), pp. 86–93, for further discussion.

[13]These estimates are from Prakken (1986), p. 30. Some economists have argued that the fall in long-term interest rates during 1986 was due, at least in part, to expectations that the new tax law would reduce interest rates.

Table 3

Percentage Changes in the Desired Capital Stock Due to Tax Reform

	Real Interest Rate Reduction (percentage points)				
Investment Category	**0.0**	**0.5**	**0.8**	**1.0**	**1.5**
High Elasticity Case					
Equipment (s = 1.00)	−12.8	−10.5	−9.0	−8.1	− 5.5
Structures (s = 1.00)	− 5.0	− 0.8	2.3	4.8	10.9
Low Elasticity Case					
Equipment (s = 0.55)	− 7.2	− 5.9	−5.1	−4.5	− 3.1
Structures (s = 0.16)	− 0.8	− 0.1	0.4	0.7	1.7

NOTE: The variable s represents the elasticity of substitution assumed in each calculation. See the text for further discussion.

by the new tax law does not directly affect investment. Firms offset the decline in internal cash flow by borrowing the necessary funds in external capital markets.[14] The economics literature, however, has identified reasons why this view may not be valid.

The assumption that all desired investment can be financed at the market interest rate ignores the problem of communicating information from borrower to lender. It is costly for lenders to evaluate the prospective returns of various investment projects because they do not have extensive knowledge of the particular situations facing potential borrowers. While borrowers will provide some relevant information, they have an incentive to present an optimistic view of their circumstances. Thus, lenders may be willing to finance some investment projects only at interest rates so high that these projects become unprofitable. Furthermore, as various studies have shown, when capital market information is costly, some firms may not be able to obtain external financing even at high interest rates.[15] In this case, the new tax law could reduce investment because firms would not be able to offset the loss of internal funds by borrowing.

Furthermore, even if lenders are willing to provide funds at favorable market interest rates, firms themselves may be reluctant to use credit markets to recover investment finance lost under the new tax law. Firms are concerned about their debt-equity ratios and their credit ratings. Thus, they may choose to curtail capital expenditures rather than increase borrowing. New equity issues are a potential source of funds, but the historical evidence shows that little new investment is financed through new share issue.[16]

How big an impact will tax reform have on investment through this channel? The investment equation 1 can be modified to address this question:

$$(8)\ \text{Investment} = \text{Depreciation} + \begin{pmatrix}\text{Change in}\\ \text{Desired}\\ \text{Capital}\end{pmatrix} + \left(b \times \begin{matrix}\text{Cash}\\ \text{Flow}\end{matrix}\right).$$

The parameter b represents the size of the effect of internal cash flow on investment. Estimation of b from

[14]An immediate objection that might be raised against this view is that firms must pay interest on external funds, so borrowing appears more costly than internal finance. This is true on the firm's income statement. But in economic terms, the firm also gives up the opportunity to earn interest on internal funds when they are spent on capital accumulation.

[15]This situation is called "credit rationing" in the economics literature. Stiglitz and Weiss (1981) present a theoretical model that explains this possibility. This idea is linked to investment theoretically by Greenwald, Stiglitz, and Weiss (1984) and empirically by Fazzari and Athey (1987).

[16]In a detailed study of 12 large companies over 10 years, Donaldson and Lorsch (1983), p. 52, show that only 0.5 percent of new funds raised resulted from equity issues. They also find a strong preference for internal investment financing, rather than debt financing. Common and preferred stock issues accounted for only 3.9 percent of the sources of funds for 799 industrial firms reported on the Value Line database in 1984. Greenwald, Stiglitz and Weiss (1984) provide a theoretical explanation, based on capital market signaling, for why firms avoid equity finance.

historical data shows that cash flow has been positively related to equipment investment over the last three decades; cash flow had no significant effect, however, on business structures investment. The details of the estimation are presented in the appendix.

These estimates provide one way to predict the effect of increasing corporate taxes while reducing personal taxes. Suppose, in the absence of tax changes, that real equipment investment would grow from mid-1986 through 1988 at a 5 percent annual rate. Now suppose that the new tax act will increase corporate taxes by $25.2 billion in 1987 and $23.9 billion in 1988.[17] Then, the estimates of equation 8 predict a 2.8 percentage-point reduction in equipment investment for 1987 and a 2.1 percentage-point reduction in 1988, relative to the benchmark 5 percent real growth trend. While not especially large relative to historical variations in equipment investment, these changes are still substantial.[18]

There is an important qualification to these predictions. The calculations are based on the assumption that firms absorb the whole tax increase in reduced cash flow rather than increasing before-tax markups to recover part of the tax increase through higher prices. This assumption becomes less realistic as the forecast horizon expands further into the future and firms revise their pricing policies to reflect the new tax system. This eventually could reduce or even eliminate the effect of higher taxes on corporate cash flow.

CONCLUDING REMARKS

How big an impact will tax reform have on investment? The analysis presented here shows a rather wide range of possibilities. Capital theory implies that the new tax law will increase the cost of capital, especially for producers' durable equipment investment, tending to reduce investment and lower the U.S. capital stock. The size of this effect, however, is uncertain. Under some assumptions, the rising cost of capital leads to a dramatic 13 percent long-run fall in the stock of equipment. Different assumptions, however, lead to much smaller changes. Moreover, lower interest rates caused by tax changes will likely offset some of the rise in after-tax capital costs due to changes in tax rules.

The 1987 *Economic Report of the President* predicts that "a somewhat higher overall marginal tax rate on capital income will modestly reduce the economy's long-run capital intensity" (p. 79). The analysis presented in this article supports this view. A middle-of-the-road forecast indicates that the new tax law alone will cause a moderate decline in equipment investment, chiefly due to the repeal of the investment tax credit. The effects on business structure investment will likely be small, at least for structure investment motivated by economic profits as opposed to tax benefits (see footnote 10). The rollback of generous depreciation treatment for structures increases their after-tax cost, but the lower corporate tax rate and the potential for lower real interest rates largely offset the depreciation rule change.

[17]The 5 percent annual growth rate was the actual growth rate of real producers' durable equipment investment from the second quarter of 1985 through the second quarter of 1986. It gives a benchmark for equipment investment growth in the absence of tax reform. The estimated changes in corporate taxes were obtained from the congressional conference committee report on the Tax Reform Act of 1986. See Bureau of National Affairs, Inc. (1986).

[18]The standard deviation of the producers' real durable equipment growth rate from 1970 through 1985 was 9.9 percentage points.

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Technical Appendix

A. Present Value of Depreciation Allowances

The tax service life for cars and light trucks under the old tax law was three years. It has been lengthened to five years under the tax reform act. The tax service lives for office, computing and accounting equipment, and communications equipment were five years under the old law. Tax reform did not change the depreciation period for office, computing and accounting equipment, but it extended the service life for communications equipment to seven years. The tax service lives are based on the Asset Depreciation Range system. See Ott (1984) for further details.

Depreciation allowances for equipment were computed using a 150 percent declining balance method under the old tax law and a 200 percent declining balance under the new law. A switch to straight-line depreciation to maximize the deduction is also assumed. These methods are discussed in detail in Ott (1984). The half-year convention was used that treats all purchases within a year as if they occur at midyear.

To compute the present value, depreciation deductions were discounted at an after-tax rate obtained by multiplying the nominal interest rate by one minus the appropriate marginal corporate tax rate.

B. Cost of Capital

The cost of capital calculations in the text are based on the Hall and Jorgenson (1967) formula. The cost of capital, often called the implicit capital rental rate, is given by the formula:

$$c = 100 \times \frac{1 - k - tz(1 - 0.5 \times k)}{1\text{-}t}\left[(1 - tL)\,i - \pi^e + d\right],$$

where

k = investment tax credit rate,
t = corporate tax rate,
z = present value of a one dollar depreciation allowance,
L = leverage ratio (debt as a proportion of assets),
i = nominal interest rate,
d = economic depreciation rate, and
π^e = expected inflation rate.

A leverage ratio of 0.306, based on data from the Washington University Macro Model (WUMM), was used in all the calculations.

The capital stock calculations given in the text are based on a constant elasticity of substitution aggregate production function. With this technology, the desired capital stock is proportional to c^{-s} where c is the cost of capital defined above and s is the elasticity of substitution. These calculations assume that the level of output and the ratio of the price of investment goods to the price of output are constant.

C. Estimated Effect of Cash Flow Changes on Investment

The estimated reductions in equipment investment due to lower corporate cash flow caused by tax reform are based on the regression equation:

$$INVE_t = \underset{(0.0153)}{0.0994}\,K_{t-1} + 0.0174\,f\left(\frac{P_tY_t}{E_tC_t} - \frac{P_{t-1}Y_{t-1}}{E_{t-1}C_{t-1}}\right)$$

$$+ \underset{(0.0380)}{0.2081}\,IFIN_t + \underset{(0.0538)}{0.0953}\,IFIN_{t-1} + \underset{(0.0534)}{0.0136}\,IFIN_{t-2},$$

where

$INVE_t$ = producers' durable equipment investment at time t in 1982 dollars,
K_{t-1} = lagged stock of equipment (as calculated for WUMM),

P_t = implicit price deflator for private non-farm output,

E_t = implicit price deflator for producers' durable equipment,

Y_t = real private, non-farm output, and

$IFIN_t$: internal finance, defined as after-tax corporate profits plus depreciation allowances minus corporate dividends, deflated by E_t.

Standard errors of the estimated coefficients appear beneath the estimates. The f(•) function represents a 14-quarter, third-degree polynomial distributed lag. The equation was estimated with a correction for first order autocorrelation of the residuals, with quarterly data from the third quarter of 1956 through the second quarter of 1986.