FEDERAL RESERVE BANK
OF SAN FRANCISCO

ECONOMIC REVIEW

SPRING 1982

measurement and policy

The Federal Reserve Bank of San Francisco's **Economic Review** is published quarterly by the Bank's Research and Public Information Department under the supervision of Michael W. Keran, Senior Vice President. The publication is edited by William Burke, with the assistance of Karen Rusk (editorial) and William Rosenthal (graphics). Opinions expressed in the **Economic Review** do not necessarily reflect the views of the management of the Federal Reserve Bank of San Francisco, or of the Board of Governors of the Federal Reserve System.

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Measurement and Policy

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Measurement and Policy

Proper analysis of public-policy issues depends heavily on proper measurement of the economic quantities involved. This issue of the *Economic Review* demonstrates this obvious truth with examples taken from several widely different fields. One article analyzes the shift adjustments taken to improve the measurement of the monetary aggregates. A second article discusses ways of improving the measurement of "redlining" in bank lending practices. A third article proposes a change in the pricing mechanism for irrigation water, as a means of improving resource allocation in California's Central Valley.

Barbara Bennett argues that changes in the public's demand for various types of financial instruments have altered the meaning of the monetary aggregates, making observed growth in these aggregates harder to interpret. The growth in M1, in particular, has slowed considerably over the past few years. Yet with the proliferation of higher-yielding substitutes for the traditional M1-type transaction instruments, slower *observed* growth may not necessarily be associated with a slowdown in the economy.

The Federal Reserve has sought ways to minimize the effects of recent financial innovations and regulatory changes upon the meaning of the monetary aggregates and their relationship to economic activity. As Bennett notes, one part of the effort has centered around the redefinition of the monetary aggregates in 1980. In addition, the Federal Reserve has come to place greater emphasis in its policy deliberations on broader aggregates, whose growth rates and relationships to economic activity are affected less by shifts of funds among financial instruments. Again, the Federal Reserve has attempted to cope with the problem of measuring and interpreting money growth by adjusting observed growth rates of the aggregates to account for distortions caused by shifts of funds among financial instruments. The obvious case is the Fed's treatment of "other checkable deposit growth" that occurred after the nationwide introduction of NOW accounts at the end of 1980.

But Bennett continues, "We have not seen the last of the sweeping changes recently taking place in the U.S. financial system." Money-market funds continue to grow rapidly. Increasing numbers of brokerage firms and depository institutions are announcing deposit-sweeping services, while larger numbers of banks and thrift institutions are offering retail repurchase agreements and loophole accounts. In addition, the pressure to deregulate deposit-interest rates continues to mount, and regulatory authorities have met that pressure by creating short-term accounts designed to permit depository institutions to compete more effectively with money-market funds.

Because of these developments, Bennett argues, "Observed M1 growth may continue to give somewhat misleading policy signals." To the extent that distortions in M1 growth can be traced specifically to the growth in certain financial instruments, shift adjustments may be useful. But she cautions that many of these changes cannot be quantified with even the same degree of certainty as the NOW account shifts.

Alane Sullivan and Randall Pozdena consider the measurement problems involved in implementing anti-discriminatory housing credit policy under the Community Reinvestment Act (CRA). The act was designed to encourage financial institutions to "help meet the credit needs of the local communities in which they are chartered." To meet that policy goal, the CRA directs each supervisory agency to take into account a financial institution's CRA record when ruling on branch, merger or other applications. However, the affirmative orientation of the CRA represents a significant departure from standard bank-regulation procedures, which were designed primarily to insure the safety and soundness of the banking system.

The CRA has its origins in long-standing allegations by community groups that financial institutions discriminate against certain neighborhoods in credit decisions. The practice called neighborhood "redlining" allegedly contributes to, and even causes, the decline of inner-city neighborhoods. However, in view of analytical limitations, as well as Congressional intent, the authors believe the CRA's anti-redlining provisions should center on detection of *irrational* redlining, or arbitrary geographic discrimination that is contrary to sound business judgment.

With this in mind, Sullivan and Pozdena measured the usefulness of various analytical techniques and data sources in detecting the arbitrary use of property location in mortgage-lending decisions. They found that simple index techniques were unreliable, because they ignored the complexity of the economic decisions involved in the mortgage market. (These measures failed to account for the sound business reasons or demand factors which may be the cause of disparities in loan volumes among neighborhoods.) They also found problems with the "market model" approach used in more sophisticated studies, because of the difficulty of defining an individual lender's role in such a complex context. "The most reliable technique for evaluating charges of geographic discrimination appears to be loan applications analysis, which permits the scrutiny of a credit supplier's individual lending decisions."

The authors argue that effective CRA enforcement may require substantive changes in the methodology used by regulators in evaluating allegations of redlining. "In the absence of quantitative evaluation techniques, CRA assessments today largely depend on the judgment of CRA examiners. Since the detection of CRA violations is considered an important regulatory responsibility, decisions should be accurate and consistently applied, given their far-reaching consequences. The use of formal, objective methods of evaluation can make a positive contribution to both of these goals. Among the methods that probably should be considered are those which analyze loan application records.

Turning to the area of rural development, Yvonne Levy argues for a new approach to solving the potential shortfall of water supplies in Southern California. Most proposed solutions to the problem have called for an expansion of supplies for prospective water-short areas, primarily the construction of new dams and canals to bring more water from Northern to Southern California. But Levy argues for an alternative approach. "If water were priced higher, final users would have a greater incentive to conserve, the projected demand would be lower, and some or all of the proposed new water facilities would not be required."

Levy notes that, in practice, the U.S. Bureau of Reclamation charged on average about $5 per acre-foot of Central Valley Project (CVP) irrigation water in 1981. She argues, however, that this represented a substantial subsidy to California farmers because the Bureau's charge should have reflected costs that would have been incurred by an investor-owned utility.

With adjustments made for imputed property taxes, amortization, and interest cost, the Central Valley Project would have incurred an average unit cost of almost $24 per acre-foot of irrigation water in 1981, calculated on a historical accounting basis. The calculations would yield a $48 acre-foot charge if they took into account the replacement cost of the CVP capital plant. And if efficiency of resource allocation were the only criterion, the Bureau would price all irrigation water on the basis of long-run incremental cost—the cost of delivering an additional acre-foot of water from the next scheduled block of new capacity. This approach, indeed, would yield a $324 acre-foot charge for CVP irrigation water.

Levy argues that very high subsidies for Federal irrigation water have had major consequences. "The consumption of water and the size of the Federal irrigation system have expanded beyond the point where the net return to the last unit of water, in terms of agricultural revenue, is equal to the cost of supplying that extra unit. This suggests that more resources have been devoted to the construction of the Federal irrigation system in California than are warranted by agricultural benefits." She calls for increased emphasis on pricing reform to improve the efficiency of water usage, through the use of more efficient irrigation methods and shifts to less water-intensive crops. "Indeed, Congress logically should give more attention to the role of the price mechanism in reducing the projected growth of irrigation water demand not only in California, but throughout the West."

"Shift-Adjustments" to the Monetary Aggregates

Barbara A. Bennett*

The actions of the Federal Reserve System, as the nation's central bank, have a major impact on economic activity and the level of prices. The impact of these actions, however, cannot be observed apart from the effect of other influences such as fiscal policy decisions. As a result, the Fed must rely on intermediate measures such as the money supply or interest rates to gauge the effectiveness of its policy actions. To be useful as an intermediate target, such a measure should, first, be related to economic activity (GNP) in a stable and predictable manner, and second, be susceptible to Federal Reserve control.

Since the mid-1970s, the Federal Reserve has used the money supply as its intermediate target by setting—and striving to meet—annual growth rate targets for several monetary aggregates, including M1, M2, M3 and a measure of bank credit. M1 comprises currency, demand deposits, other interest-bearing checkable deposits and travellers' cheques. M2 includes M1, savings deposits, small denomination time certificates, noninstitutional money market mutual fund shares, overnight repurchase agreements and overnight eurodollar deposits held by U.S. residents. M3 comprises M2, term repurchase agreements, institutional money market fund shares and large denomination certificates of deposit.

Despite this wide array of measures of the money supply, the public and the Federal Reserve have, in practice, tended to focus on the narrower aggregates. These measures have the most stable and predictable relationship to economic activity historically, and they are most closely under the control of the central bank. Recent changes in U.S. financial markets, however, may be changing the nature of that relationship, making the impact of monetary policy decisions temporarily harder to gauge than in the past. The virtual revolution in cash management techniques of the past decade has permitted businesses and households to transact a greater volume of transactions with a given level of transaction balances than was true previously. Innovations involving the increased use of automation in bill collection (such as automated lockboxes) and in funds transfer (such as automatic investment of idle funds) have increased the rate of turnover of transaction balances and reduced the demand for narrowly defined money relative to income or spending. Furthermore, the growing acceptance of new high-yielding and highly liquid instruments, such as money market mutual funds and retail repurchase agreements, has profoundly affected the ways the public chooses to hold its wealth and accommodate its transaction needs. Likewise, regulatory and legislative changes allowing depository institutions to pay interest on transaction balances that are held in ATS (automatic transfer from savings) and NOW (negotiable order of withdrawal) accounts have led to substantial shifts of funds into these interest-bearing accounts from traditional demand and savings deposits.

Changes in the public's demand for various types of financial instruments have altered the meaning of the monetary aggregates, making observed growth in these aggregates harder to interpret. The growth in M1, in particular, has slowed considerably over the past few years; yet, with the proliferation of higher-yielding substitutes for the traditional M1-type transaction instruments, slower *observed* growth may not necessarily be associated with a slowdown in the economy.

The Federal Reserve System has sought ways to minimize the effects of recent innovations and regulatory changes upon the meaning of the monetary aggregates and their relationship to economic activity. One part of this effort has centered around the redefinition of the monetary aggregates announced in early 1980. By including ATS and NOW ac-

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counts in the narrow definition of money and by acknowledging the potential transaction characteristics of money market funds and overnight RPs and eurodollars, the redefined aggregates correspond more closely than did the old measures to the new ways in which the public has chosen to hold its transaction balances and liquid assets. This redefinition has helped to reduce the distortion in observed growth rates caused by shifts of funds among financial instruments which are now viewed as close substitutes but which, for whatever reasons, were formerly classified as components of different aggregates.

The Federal Reserve has also come to place greater emphasis in its policy deliberations on broader aggregates whose growth rates and relationships to economic activity are affected less by shifts of funds among financial instruments. As recently as 1980, the most prominent measure of the money supply—then termed M1-A—included only currency and demand deposits. Today, the policy focus has shifted to M1-B—which includes ATS and NOW accounts as well as traditional demand deposits and currency—and, to a certain extent, to M2. Reflecting this change of emphasis, M1-A is now no longer published and M1-B has been renamed M1. In 1981 the Federal Open Market Committee (FOMC) appeared, at times, to give considerable weight to M2 growth. Some Committee members argued at that time that at least some of the surprisingly sluggish growth of (shift-adjusted) M1 may have been due to the public's ability to reduce its holdings of traditional transaction balances by shifting funds to the higher-yielding substitutes (such as money market funds) included in M2.[1]

The Federal Reserve System also has attempted to cope with the problem of measuring and interpreting money growth by adjusting observed growth rates (or growth-rate targets) of the aggregates to account for distortions that are caused by shifts of funds among financial instruments resulting from readily identified changes in law. The Fed's treatment of the growth in other checkable deposits that occurred after the nationwide introduction of NOW accounts at the end of 1980 is an example of this approach. Shifts of funds into NOW accounts from sources other than demand deposits "artificially" boosted M1 growth at that time. To compensate, the Fed began using a "shift-adjusted" measure of M1 in its policy deliberations. Although until now the Fed has used this approach to accommodate specific regulatory changes, similar shift-adjustments to account for other types of financial change may become possible and desirable in the future. For example, the explosive growth of money market funds in 1981 may have "artificially" reduced M1 growth, thus increasing the desirability of a shift-adjustment to account for that distortion. Likewise, the growing acceptance of deposit-sweeping arrangements, whereby excess balances in transaction accounts are automatically "swept" into money funds, may also distort future M1 growth and encourage consideration of a shift-adjustment.

This paper analyzes the shift-adjustment technique, both as it has been used to compensate for the distorting effects of rapid NOW account growth during a transition period and as it might be used to compensate for the distorting effects of changes in the demand for other financial instruments. The first section presents the rationale for adjusting M1 to compensate for growth in NOW balances. The second section examines the alternative approach of adjusting the growth rate target for M1. Since the shift-adjustment technique is essentially a "sources-and-uses" concept, the third section provides an interpretation of the technique from a money demand context. The fourth section describes the methodology used to calculate the published measure of shift-adjusted M1, and the fifth section analyzes the sensitivity of that measure to alternative assumptions about the sources of growth in NOW balances. The sixth section examines the merits of using the shift-adjustment technique to compensate for other changes in financial markets, and develops a shift-adjusted measure of M1 that would incorporate the impact of growth in money market funds. The paper concludes with a discussion of potential uses and limitations of the shift-adjustment technique in the future.

I. Rationale for Shift-Adjusted Measure

The nationwide introduction of NOW accounts at the end of 1980 distorted the observed growth rates of the narrow monetary aggregates, which were identified then as M1-A and M1-B. (As noted earlier, M1-A is no longer published and M1-B has been renamed M1.) By causing funds to shift to NOW accounts from both transaction and nontransaction accounts, this development altered the growth rates of M1-A and M1-B relative to the rates that would otherwise have prevailed. As a result, the growth rates of the Fed's yardsticks—M1-A and M1-B—were distorted by these shifts of funds. Because the extent of the distortion was not directly observable, analysts lost some ability to measure the impact of monetary policy on economic activity. As early as July 1980, the Federal Reserve acknowledged this problem, when in his monetary policy report to Congress Chairman Volcker stated that:

> The introduction of negotiable order of withdrawal (NOW) accounts on a nationwide basis in January will accelerate the shift from regular demand deposits into interest-earning transactions balances, thereby depressing M1-A growth next year. On the other hand, M1-B probably will be boosted somewhat next year by shifts from savings deposits and other interest-bearing assets into NOW accounts. The range for M1-B thus may have to accommodate a period of abnormal growth as the public adjusts to the availability of a new instrument.[2]

The extent to which M1-B was boosted and M1-A depressed depended on first, the rate of growth in NOW balances and second, the sources of that growth. Had NOW balances grown only slightly, the distortions in growth would likewise have been minimal. However, the rapid growth in NOW balances that actually occurred during 1981, from $28.1 billion to $77.0 billion, meant a distortion in the growth of one or both of the narrow (M1-A and M1-B) aggregates from these shifts of funds.

Conceivably, this distortion could have occurred in the growth rate of only one of the two aggregates —M1-A, if the growth in NOW balances had come entirely from demand deposits, or M1-B, if that growth had come entirely from savings deposits and other non-M1 assets. In fact, however, NOW growth affected both aggregates. M1-A growth was affected to a greater extent because NOWs have the transaction features of checking accounts—plus 5¼ percent interest. However, NOWs were generally offered in connection with high minimum-balance requirements and offered almost the same rates of return as savings accounts, and thus distorted M1-B growth also by inducing depositors to combine checking and savings funds to open accounts.

Faced with potential distortions in the M1-B growth rate, then, the Federal Open Market Committee announced an annual growth target for that aggregate which abstacted from any shifts of funds related to the introduction of NOW accounts on a nationwide basis. The target growth range was set, in other words, as if NOW accounts had not been introduced at the end of 1980. In order to evaluate M1-B growth against its growth target, then, the observed growth of this aggregate required an adjustment to account for shifts related to NOW growth. The adjustment, in essence, involved subtracting from observed growth that proportion of the growth in NOW balances which came from transfers of funds from savings accounts and other nontransaction accounts.

II. Adjustments to Growth Rate Targets

As an alternative to adjusting the *actual* growth rate of M1, the Federal Reserve could have adjusted the growth rate *target* for that aggregate in such a way that observed growth could then be compared directly to the target. These two approaches are equivalent, in theory. The Federal Reserve, in fact, had employed this second approach earlier to account for shifts of funds that were caused by the introduction of Automatic Transfer from Savings (ATS) accounts. In 1979, following the late-1978 debut of ATS accounts, the FOMC chose to lower the target range for old M1, thereby widening the difference between the midpoints of the annual targets for old M1 and M2—old M1 comprised only currency and demand deposits, while old M2 added small denomination time and savings deposits and

other checkable deposits. By widening the spread between the growth rate targets, the FOMC was able to compensate for the divergence in the observed growth rates caused by shifts of funds from demand deposits (included in M1) to ATS accounts (included in the non-M1 component of old M2).

Likewise, in 1980, the Federal Reserve adjusted the growth rate targets of the aggregates to accommodate shifts of funds into ATS accounts. At the beginning of the year, the FOMC set the spread between the midpoints of the targets ranges for M1-A and M1-B at 1/2 percentage point, on the assumption that shifts into ATS accounts would slow over the course of the year. However, with the passage of the Depository Institutions Deregulation and Monetary Control Act (March 1980), which permanently authorized ATS accounts and authorized NOW accounts on a nationwide basis as of year-end, commercial banks began to promote ATS accounts more vigorously in order to get a "head-start" on the NOW account competition. (To the depositor, ATS and NOW accounts are virtually indistinguishable.) As a result, the growth of ATS balances accelerated as depositors shifted funds from checking and interest-earning assets. Hence, M1-B grew more rapidly than it would have otherwise, while M1-A grew more slowly. In light of these shifts, Chairman Volcker stated in the Board's February 1981 Policy Report to Congress that the 1980 growth targets for M1-A and M1-B should have been adjusted to take account of these shifts: "If the FOMC's [target] ranges are adjusted for current estimates of the actual impact of shifting into ATS and NOW accounts, the [observed] increases in both narrow aggregates are close to the upper bounds of the FOMC's ranges for 1980."[3]

Although the two ways of compensating for distortions in aggregate growth are equivalent in theory, adjustments to the observed growth rates may be preferable in practice, since less information about the nature of the shifts of funds is required *a priori* than is needed for adjustments to the targets. Also, given the potentially greater impact on money growth rates anticipated from the nationwide introduction of NOW accounts, the Fed decided to adjust the observed growth rates in 1981. Raising the M1 growth rate target at a time when the Federal Reserve was anxious to demonstrate its commitment to a gradual reduction in money supply growth might have confused the general public. Furthermore, it might have been more confusing to change publicly announced growth rate targets as new information on NOW sources became available than to change the shift-adjustment of the levels of the monetary aggregates.

III. Interpretation of Shift-Adjustment

The theoretical concept of a shift-adjustment—whether to the observed growth rate or to the target growth rate—has never been particularly well-defined in Federal Reserve publications. It has generally been described as a means of abstracting from, or compensating for, shifts of funds which temporarily produce an "abnormal" rate of growth in a given aggregate. But what is "abnormal?" Abnormal growth is not merely any deviation from an aggregate's trend rate of growth, since that deviation may be due to changes in the levels of interest rates or income which influence the demand for money. Instead, abnormal growth is growth that cannot be accounted for once adjustments are made for such changes in income and interest rates. How, then, should the shift-adjustment technique be interpreted? Essentially, it has been used to quantify *shifts* in the *level* of the money demand function that are caused by the introduction of new instruments and other legislative and regulatory changes.

The shift-adjustment technique is based on an analysis of the shifts of funds among financial instruments that apparently arise from shifts in the money demand function—i.e., from shifts of funds into (or out of) a given monetary aggregate. Implicit in this approach is the assumption that the introduction of a new instrument (such as NOWs) does not change the way the monetary aggregate responds to changes in income growth or the level of interest rates. Of course, shifts of funds into a new instrument frequently alter the composition of the aggregate and, possibly, alter the income- and interest *elasticities* of the demand for that aggregate as well as the *level* of money demanded. To the extent, then, that these shifts change elasticities, the use of a shift-adjustment will not fully capture the change

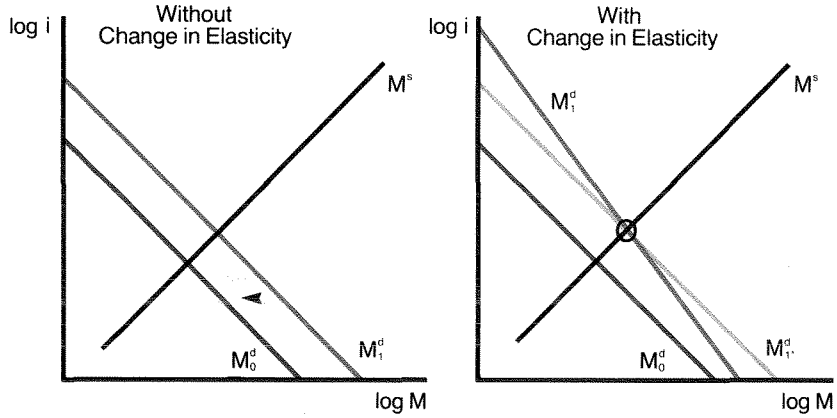
in the relation between the aggregate and the economic variables of ultimate concern—income, prices, employment, etc.

This inability to measure fully the nature of the shift in money demand may not represent a serious shortcoming of the shift-adjustment technique in the short-run, however. Initially, while the public rearranges its portfolio of financial assets in response to the availability of a new instrument, the effect on money growth of changes in elasticities (the slope of the money demand curve) is likely to be much less pronounced than the effect of changes in the level of money demanded (the intercept of the money demand curve). As a result, shift-adjusted measures may be useful temporary measures of money growth even if the income- and interest elasticities of money demand have changed. The Federal Reserve has, in fact, used shift-adjustments as merely temporary yardsticks. The Fed stopped calculating shift-adjusted M1, for example, when the shifts of funds were apparently over. Once the public has rearranged its portfolio, of course, shift-adjustments are no longer necessary. This is because either the level of measured money demand has changed and the aggregate's long-term growth rate has not been affected, or else the elasticities have changed and the shift-adjustment is incapable of capturing the change in the long-term money growth rate. (In the latter case, the long-term growth rate target must be changed to reflect the new relationship between money growth and income and interest rates.)

The shift-adjustment to M1 that was associated with the nationwide introduction of NOW accounts illustrates the way in which shift-adjustments attempt to cope with shifts in the slope as well as in the intercept of the money demand curve. Clearly, the introduction of NOWs increased the demand for M1, causing the level of the money demand curve to shift outward. Whether that shift was also characterized by changes in either the income- or interest-elasticities of money demand depended on the way that both the suppliers and demanders of NOW-account services responded to their availability. Prior to the introduction of interest-bearing transaction accounts, of course, depository institutions could not pay explicit interest on transaction balances. Although they were able to evade this restriction by offering free services to their customers, the yield on transaction balances tended to be low and unresponsive to changes in market interest rates. By allowing depository institutions to pay up to 5¼ percent explicit interest, then, NOWs (and ATS) undoubtedly raised the average yield on transaction

Chart 1

Alternative Assumptions About NOW Accounts' Effect on the Demand for Money (M1)



M^s = money supply curve
M_0^d = initial money demand curve
M_1^d = new money demand curve after NOWs
$M_{1'}^d$ = assumed new money demand curve for shift-adjustment

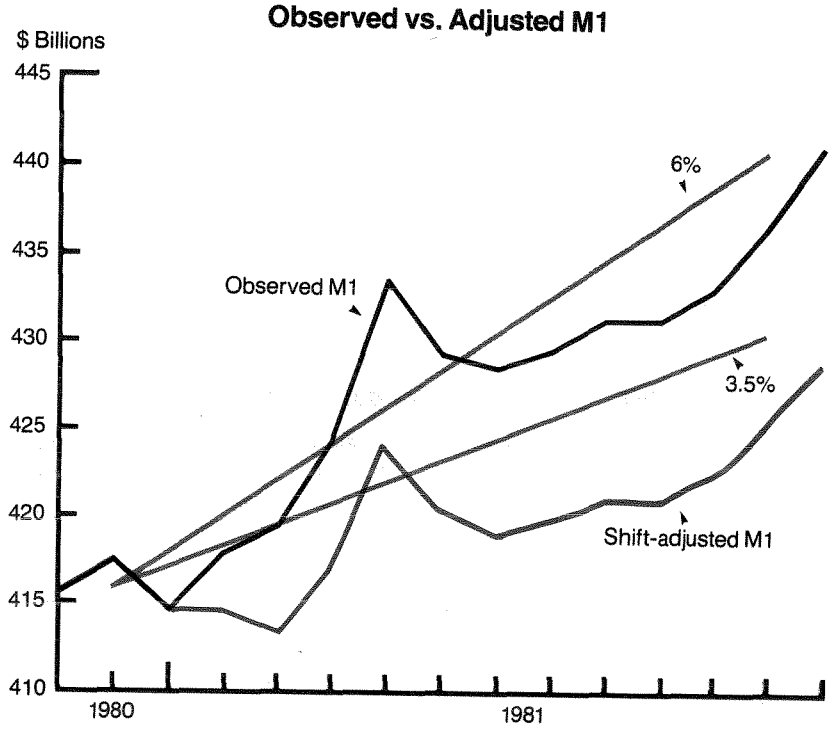
balances substantially.

A one-time upward adjustment in yield would increase the demand for M1, but would not affect the income- and interest-elasticities. As illustrated in Panel A of Chart 1, the money demand curve has shifted to the right, parallel to the old demand curve. In this case, a shift-adjustment to M1 would produce an M1 measure that would, in effect, return the demand curve to its original position, as indicated by the arrow. The Federal Reserve would then be able to use the old relation between the M1 aggregate and income and interest rates to judge whether its policies were appropriate.

The results are not so straightforward if NOW accounts did, in fact, change the income- and interest-elasticities of money demand. This situation may have arisen for two reasons. First, the introduction of NOW accounts changed the composition of M1 by raising the proportion of household deposits contained in M1 relative to the proportion of business deposits. Since the demand for household deposits may respond somewhat differently to changes in income and interest rates than would the demand for business deposits, this change in composition could have changed the slope of the demand for M1. Second, because depository institutions are now permitted to pay up to 5¼ percent on transaction balances, they have more flexibility (and possibly more incentive) to vary the yield in accordance with changes in market rates. Of course, given current levels of market rates, most institutions are offering the ceiling rate; however, they are still able to vary the average yield (and have done so on occasion) on NOWs by changing other features such as minimum balance requirements. The possibility that the yield on transaction balances now varies more than before with changes in market rates may mean a decline in the elasticity of the demand for money. Panel B of Chart 1 depicts this new, steeper slope. Since the shift-adjustment technique cannot measure this change in slope, shift-adjusted M1 will treat the new demand curve as if it were parallel to the old curve at the new equilibrium point. The lightest colored line and the circle indicate that the shift-adjustment accurately measures the impact of monetary policy at only one point on the new demand curve.

Chart 2

Observed vs. Adjusted M1



To the extent that the introduction of NOW accounts altered the income- and interest-elasticities of the demand for M1, then, distortions in the measurement of money growth could have arisen. However, the post-NOW rearrangement of the public's portfolio of financial assets apparently happened very rapidly, thereby temporarily swamping the effects of any changes in demand elasticities that might also have occurred. Distortions in shift-adjusted M1, as a result, were probably minimal. Problems with such distortions might have been more serious, however, if the public's portfolio adjustment had not occurred so rapidly and if NOW accounts had been allowed to yield higher and more flexible rates—since this clearly would have caused major changes in the income- or interest-elasticities of money demand. Similarly, distortions in shift-adjusted measures are likely to be more pronounced when we consider some of the other, higher-yielding substitutes for traditional transaction accounts, such as money market funds (Section VI).

IV. Calculation of Shift-Adjusted M1

The calculated NOW-account distortion in the M1 growth rate was quite substantial during 1981, particularly during the first four months of the year, when the difference between the actual and shift-adjusted measures widened by several billion dollars each consecutive month. (See Chart 2 and Table 1). The spread widened at a much slower pace in the latter half of the year, however, which suggests a weakening of the shifts of funds creating such a divergence.

As noted earlier, the calculation of shift-adjusted M1 involves a subtraction from the observed M1 level of the increment in ATS and NOW balances, or "other checkable deposits" (OCD), which originally came from accounts not included in M1. Though conceptually simple, the arithmetic involved in the Federal Reserve's calculation of shift-adjusted M1 was actually quite complicated because of seasonal adjustment factors. The basic calculation can be described somewhat more simply (Table 2). As a first step, the Fed estimates the level to which OCD balances would have grown assuming normal, trend growth in such accounts, but without the nationwide introduction of NOWs. According to these estimates, the trend growth rate was $200 million per month during the first half of 1981 and $300 million per month in the latter half of the year. Growth in NOW balances in the Northeast, where NOWs had been available prior to 1981, would be included in this trend since, presumably, such growth was not affected by the change in the law. Likewise, some of the growth in ATS balances was included in trend growth since ATS accounts had been introduced by commercial banks in 1978. (Still, the ATS trend was harder to measure because banks began promoting such accounts more aggressively in late 1980 and early 1981 as an alternative to the newly authorized NOW accounts.)

The above-trend growth in OCD—the growth attributable to the introduction of NOWs—then could be obtained by subtracting the trend level from the observed growth of OCD. The amount of growth in OCD balances that can be attributed to

Table 1
Monthly Levels of M1 and Shift-Adjusted M1
(Billions of Dollars, Seasonally Adjusted)

Month	M1	Shift-Adjusted M1	Difference	Change in ATS/NOW Balances
Jan.	417.9	414.4	3.5	15.1
Feb.	419.4	413.4	6.0	10.1
Mar.	424.4	416.8	7.6	6.2
April	433.3	423.6	9.7	7.0
May	429.2	420.1	9.1	−1.3
June	428.4	418.8	9.6	1.5
July	429.4	419.5	9.9	1.4
Aug.	431.1	420.9	10.2	1.4
Sept.	431.2	420.7	10.5	1.7
Oct.	432.9	422.2	10.7	0.4
Nov.	436.4	425.0	11.4	3.1
Dec.	440.9	428.7	12.2	2.3

Table 2
Calculation of Shift-Adjusted M1
(Billions of Dollars, Seasonally Adjusted)

Calculation	January 1981	February 1981
1) Observed level of OCD	43.2	53.3
2) Less trend level of OCD	28.3	28.5
3) Yields above-trend growth in OCD (cumulative)	14.9	24.8
4) Less previous month's above-trend level	0.0	14.9
5) Yields current month's above-trend growth	14.9	9.9
6) Times fraction of growth associated with shifts from nontransaction sources	.225	.275
7) Yields OCD from nontransaction sources	3.4	2.7
8) Cumulative nontransaction OCD	3.4	6.1
9) Observed level of M1	417.9	419.4
10) Less cumulative nontransaction OCD (from line 8)	3.4	6.1
11) Yields shift-adjusted M1	414.5	413.3

Figures in this table may not agree precisely with Table 1 figures, due to slight differences in the calculation of seasonally adjusted totals.

shifts of funds from savings and other non-M1 deposits, then, is obtained by multiplying the above-trend growth in OCD by the fraction of that growth assumed to come from nontransaction sources—estimated at .225 during January and .275 in subsequent months. Shift-adjusted M1 is obtained, finally, by subtracting from observed M1 the cumulative amount of OCD estimated to have come from nontransaction sources. Alternatively, shift-adjusted M1 could be calculated by adding its individual components: currency, demand deposits, travellers' cheques, cumulative trend OCD and cumulative OCD estimated to have come from demand deposits.

V. Importance of Assumptions

These calculations reveal that the magnitude of the shift-adjustment depends on several factors—the growth in OCD balances outstanding, the assumed trend growth in those balances, the proportion of the above-trend growth attributable to shifts from non-M1 sources and, finally, the duration of the stock adjustment process. Only one factor—the overall growth in OCD balances—actually can be observed, and the other three factors can only be estimated from indirect evidence. As a result, the shift-adjusted measure of M1 could be subject to error, possibly providing the FOMC with misleading signals about the impact of its policy decisions.

Estimates of the trend growth in ATS/NOW balances and the proportion of above-trend growth associated with shifts from savings and other nontransaction sources were based on econometric evidence and on surveys of depository institutions and households. The econometric evidence came from several regressions which related the monthly changes in NOW balances at individual banks to reported changes in other deposit categories. The underlying hypothesis was that, with the diversion of funds to NOWs from other deposit categories (either within each institution or intraregionally), institutions with substantial growth in NOW balances would report a smaller increase in other deposit categories than would institutions with smaller NOW increases. In each regression, the change in NOW balances was the independent variable, while the changes in the other deposit categories—demand, personal savings, nonpersonal savings, personal time and nonpersonal time deposits—were each treated in separate regressions as dependent variables. Each equation took the form:

$\Delta DC/Z = -\beta_1(\Delta N/Z)+\beta_2+u$, where

ΔDC = change in outstanding balance of each specific deposit category

ΔN = change in NOW balances;

Z = bank size;

β_2 = constant representing effects of "other factors"; and

u = error term.

A statistically significant coefficient on the NOW account variable in each equation could be interpreted loosely as the proportion of NOW growth coming from each deposit category. However, only the regressions for demand deposits and personal

savings deposits yielded statistically significant results—approximately 80 percent of NOW growth in January outside of the Northeast came from demand deposits, while nearly 20 percent of that growth came from savings deposits (adjusted for the relative market shares of banks and savings and loan associations).

This approach has some advantages for estimating the proportion of NOW growth attributable to shifts from savings. By using a cross section of institutions and a cross section of regions, we need not specifically include general influences on deposit levels (such as interest rates and economic activity) in the regressions, since most of those influences presumably do not vary across institutions. However, to the extent that any omitted variables are correlated with specific variables, the regression results may be biased. For example, institutions that report large changes in demand and NOW balances may also have more "sophisticated" depositors who behave differently from depositors in general. These depositors are likely to shift checking balances into NOWs and at the same time continue to shift passbook savings balances into higher-yielding instruments. Because these shifts of savings will appear to be correlated with NOW growth, the savings deposit regression will tend to overstate the NOW effect.

In addition to regression data, the Federal Reserve obtained estimates of the sources of NOW growth from a number of surveys of depository institutions and households. Depository institutions were asked to provide data on the percentages of the total inflows to their *new* NOW accounts that came from their own checking and other types of accounts. Likewise, consumers were asked what proportions of their NOW balances were transferred from various types of assets.

Like the regression results, these surveys had a number of weaknesses. The first was simply the quality of the responses, particularly from the banks —many of the respondents may have provided only rough estimates. Furthermore, the original source of each NOW deposit may not have been the account from which funds were actually transferred, because this transaction would represent only one in a chain of related portfolio-balance transactions. And the surveys, by addressing only the new accounts, would not have captured any shifts to existing accounts. However, the agreement between survey and regression results lends added credence to the estimates.

Nonetheless, small errors in estimating the sources of NOW account growth could have significantly distorted the shift-adjusted measure of M1. Table 3 shows the sensitivity of this measure to alternative assumptions about the proportion of NOW growth attributable to one-time shifts from savings.

The growth rate of the shift-adjusted measure of M1 varies widely, depending on the estimate of the proportion of OCD growth associated with shifts of funds from savings and other non-transaction accounts. If 17 percent of the above-trend growth in OCD balances had come from nontransaction sources, instead of 27.5 percent as assumed, "effective" M1 in 1981 would have grown 4.2 percent instead of 3.2 percent—in the lower half of the target range instead of below the lower bound of the range. (See Chart 3). The disparity in the estimated effective growth rates was even larger during the early months of the year because of the rapid growth in OCD balances at that time.

Table 3
Shift-Adjusted M1 Under Alternative Shift Assumptions
(Billions of Dollars, Seasonally Adjusted)

Shift Assumption (Percent from savings)	January Level	January Annual Rate*	February Level	February Annual Rate*	December Level	December Annual Rate*
0	$417.9	6.6%	$419.4	5.5%	$440.9	6.1%
17	415.4	−0.6	415.2	−0.6	433.1	4.2
22.5 (Jan.)						
27.5 (after Jan.)	414.5	−3.2	413.4	−3.2	428.7	3.2
50	410.5	−14.7	407.0	−24.8	417.9	0.6

*Growth since December 1980 at simple annual rate

Another source of possible distortion is the assumption regarding the duration of the stock adjustment process. Instead of extending throughout 1981 as assumed, the process may have been substantially over by June—as Table 1 possibly suggests. Thus, if the Fed had stopped adjusting M1 at the end of May, the calculated growth rate for the full year would have been nearly 4 percent, instead of 3.2 percent.

Given the sensitivity of the shift-adjusted measure of M1 to alternative assumptions about the sources of OCD growth and the duration of the stock adjustment process, the success of the Federal Reserve's efforts to obtain a truly reliable measure of effective money growth cannot be determined with any degree of precision. Depending on the assumptions one uses in calculating shift-adjusted M1, monetary policy in 1981 could be viewed as having been either moderately expansionary or fairly contractionary. Clearly, then, the Fed's measurement problems did not disappear once shift-adjusted M1 had been calculated.

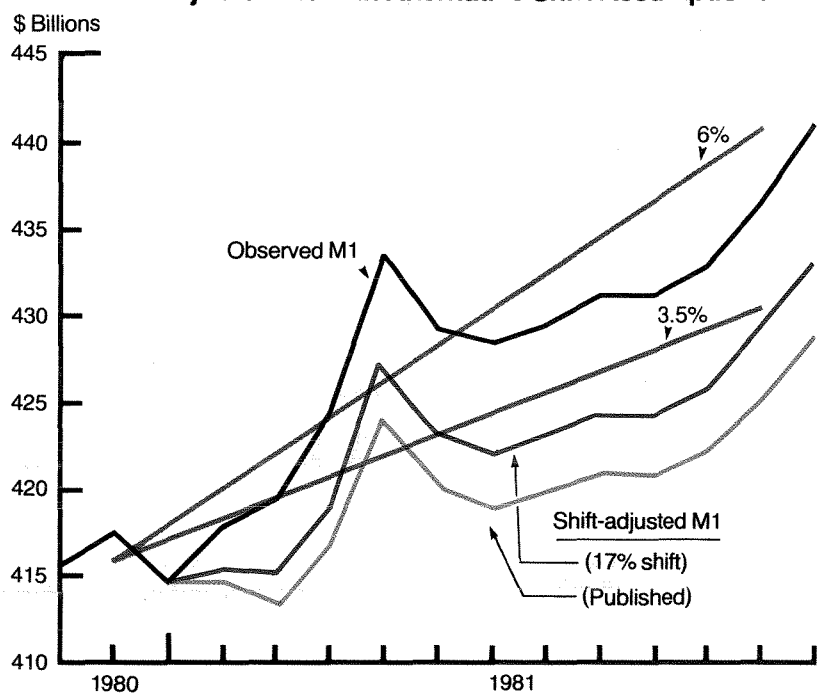
VI. Adjustments for Other Shifts

Although the Fed has used shift-adjustments primarily to account for shifts of funds engendered by regulatory and legislative changes such as the introduction of ATS accounts (1978) and NOW accounts (late 1980), the rationale for using a shift-adjusted measure of money growth applies equally well to shifts of funds that are related to other types of financial change. In fact, shift-adjustments for regulatory changes probably address just a small part of the whole money measurement problem. After all, it is the sweeping changes in financial markets that create the pressure for legislative and regulatory remedies. For example, the pressure for payment of interest on transaction balances and for deregulation of deposit rate ceilings generally would be less pronounced if financial markets were unable to offer depositors nondeposit alternatives.

Money market mutual funds, deposit-sweeping arrangements, retail repurchase agreements, and loophole accounts—all changes occurring largely

Chart 3

Adjusted M1 with Alternative Shift Assumptions



outside the regulatory framework—may have contributed significantly to the current problem of interpreting money growth. Money market mutual funds (MMFs), which are included in the M2 aggregate, are technically open-end short-term investment pools. They invest in a variety of highly liquid money market instruments such as Treasury bills, large negotiable certificates of deposit and commercial paper. However, minimum initial investment requirements are generally low ($1,000 to $2,500), and shareholders may write checks against their accounts and/or transfer funds to third parties by wire, so that MMFs may be viewed as partial substitutes for the transaction accounts included in M1. Deposit-sweeping arrangements also may create money measurement problems, since they permit depositors to keep their transaction account balances to a minimum, while automatically transferring idle funds to a highly liquid and higher yielding instrument (usually MMFs).

With retail repurchase agreements and loophole accounts, banks and thrift institutions have created alternatives to traditional transaction deposits as well. Retail repurchase agreements (RPs) are essentially short-term investments in denominations of less than $100,000—minimum investment requirements are usually in the $1,000 to $2,500 range—with maturities as short as one day or as long as 89 days. In order to compete with MMFs, banks and savings and loan associations frequently offer retail RPs in connection with a checking or NOW account, permitting the depositor to order transfers of funds between the two accounts by telephone. Loophole accounts also permit depositors to earn market interest rates on funds that might otherwise have been held in a transaction account. They offer a line of credit which can be drawn on by check, in connection with instruments such as the six-month money market certificate, and thus grant depositors access to funds before the stated maturity date.

The current proliferation of high-yielding short-term instruments with low minimum investment requirements may be reducing the demand for M1-type balances. In the past, small savers did not have many alternatives to low-yielding accounts, even during periods of high interest rates, and thus had little incentive to reduce holdings of M1-type balances. Now, however, they do have such an incentive. First, the public may be able to use these new instruments—MMFs and loophole accounts especially—as substitutes for demand deposits and other checkable deposits. Second, these new instruments yield market rates far in excess of ATS and NOW rates, and thus induce depositors to limit their

Chart 4

Noninstitutional Money Market Fund Assets

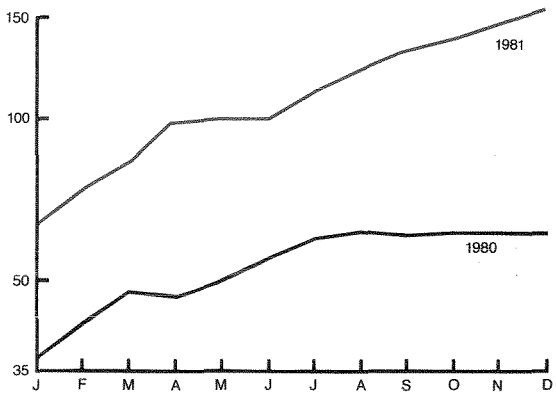
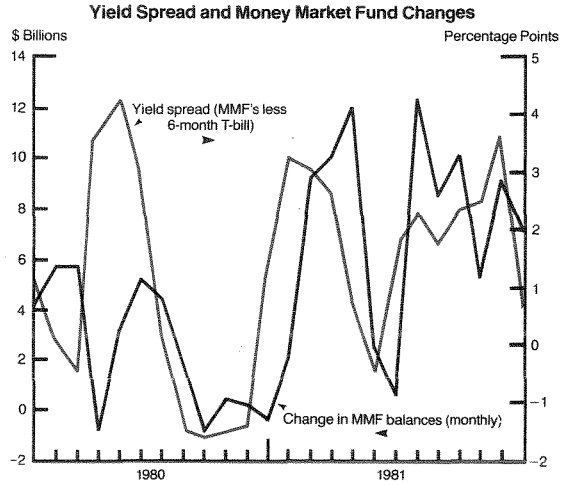


Chart 5

Yield Spread and Money Market Fund Changes



holdings of all types of transaction balances. As a result, M1 growth may give misleading policy signals, particularly during the stock adjustment period when the growth in these new instruments is very rapid. Shift-adjustments to compensate for these shifts out of M1 thus may be appropriate.

The phenomenal growth in money market funds (from $75.8 billion to $184.5 billion in 1981) in particular may reflect this adjustment in the public's stock of assets. Of course, one could argue that this growth was *only* a normal response to high interest rates, which induced the public to shift funds into MMFs (as one of several options) from lower-yielding assets. The 1980–81 experience does not support this argument, however. Although interest-rate patterns were similar in both years, MMF balances grew much more rapidly in 1981 than in 1980. (Chart 4). Furthermore, the response to changes in the spread between MMF yields and the six-month T-bill rate was much more dramatic in 1981 than in 1980 (Chart 5).

Instead, some sort of stock adjustment apparently increased the MMF growth rate substantially. Some of this growth may have come from stocks of demand and other transaction balances, causing observed M1 to grow more slowly (after the NOW-account adjustment) than if MMFs had not been available. In fact, according to one source, MMFs reduced M1 demand by more than $12 billion by September 1981.[4] Therefore, just as the Fed adjusted M1 growth *downward* to account for NOW-induced shifts of funds from interest-earning assets, so it should have made an *upward* adjustment to account for MMF-induced shifts of funds out of M1.

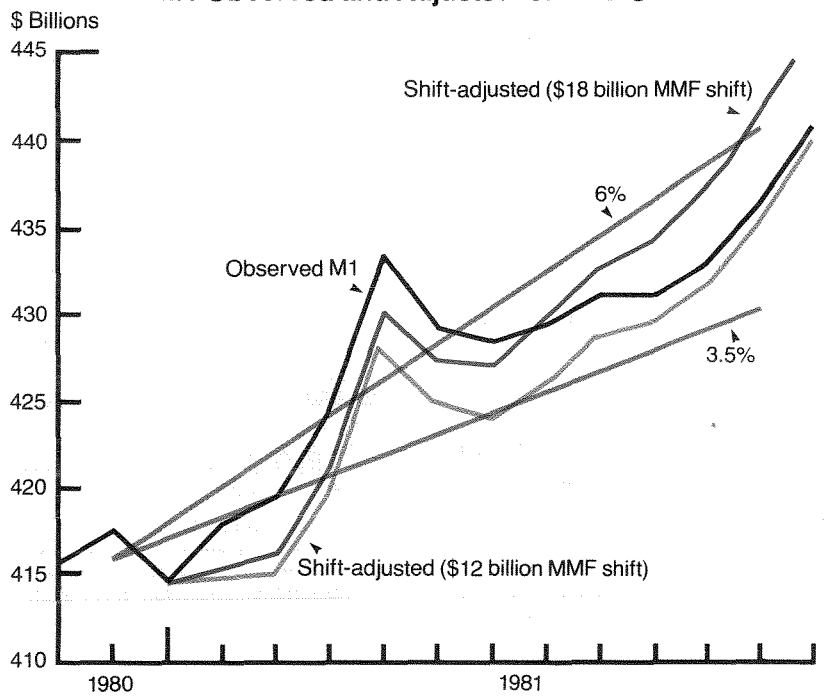
Table 4
Shift-Adjusted M1 Under Alternative MMF-Shift Assumptions (Billions of Dollars)

Shift Assumption	Year-End Level of M1* (adjusted)	Annual Growth Rate Over 1981
$ 0	$428.7	3.2%
12	440.7	6.0
18	446.7	7.5

*This measure of M1 also incorporates the Federal Reserve estimate of the NOW shift-adjustment.

Chart 6

M1 Observed and Adjusted for MMF Shifts



Various measures of M1 can be calculated, depending on whatever assumption is made about the percentage of noninstitutional MMFs (coming from a reduction in M1-type balances (see Table 4). Incidentally, we exclude institution-only MMFs because such funds are generally regarded as substitutes for direct money-market investments. For this reason, institution-only MMFs are included only in M3, while other MMFs are included in M2. Shareholders of institution-only funds generally have other options for earning market rates on transaction balances, and these funds thus may not attract balances held for transaction purposes. Noninstitutional MMFs, by contrast, tend to be close substitutes for small-denomination deposit instruments and, because of the lack of options their shareholders have for earning market rates, such MMFs are more likely to attract demand and other transaction balances.

With a $12-billion reduction in M1-type balances resulting from MMF growth, the adjusted M1 measure would have grown at a 6.0-percent annual rate, even after the NOW shift adjustment. But the $12-billion shift assumption referred only to the first nine months of 1981, and moreover, simulation results showed the MMF impact increasing steadily over that period.[5] Therefore, we could assume up to an $18 billion shift from transaction accounts into MMFs. In that case, shift-adjusted M1 would have grown at a 7.5 percent rate—more than the 6.1-percent growth in observed M1, offsetting the downward NOW adjustment (see Chart 6). Relative to its target range, then, M1 growth may actually have been somewhat expansionary in 1981. However, this result seems contrary to the sluggish economic growth observed in 1981. Furthermore, this apparent inconsistency illustrates the difficulties inherent in measuring demand shifts when the instrument involved, unlike a NOW account, pays market interest rates.

VII. Conclusion

We have not seen the last of the sweeping changes recently taking place in the U.S. financial system. Money market funds continue to grow rapidly. Increasing numbers of brokerage firms and depository institutions are announcing deposit-sweeping services, while larger numbers of banks and thrift institutions are offering retail repurchase agreements and loophole accounts. The pressure to deregulate deposit interest rates continues to mount. Furthermore, the Depository Institutions Deregulation Committee (DIDC) has created a new market rate 91-day account and is currently considering the creation of other, more liquid accounts to permit depository institutions to compete more effectively with MMFs.

Thus, observed M1 growth may continue to give somewhat misleading policy signals. To the extent that distortions in M1 growth can be traced specifically to the growth in certain financial instruments, shift-adjustments may be useful. Many of these changes, however, cannot be quantified with even the same degree of certainty as the NOW-account shift. We have insufficient data to make shift-adjustments for certain innovations, such as deposit-sweeping arrangements. Furthermore, many of these new instruments pay market rates (unlike NOW accounts), so that shifts of funds become harder to classify, either as shifts in the demand for money or as changes in the quantity of money demanded due to interest rate changes. As a result, the ability of shift-adjustments to compensate for these changes and to reduce uncertainty about the effective growth rate of money may be somewhat limited, compared to what could be achieved with the NOW shift-adjustment.

FOOTNOTES

1. See, for example, the minutes of the August 18, October 5–6 and November 17, 1981, meetings of the Federal Open Market Committee.

2. **Federal Reserve Bulletin**, July 1980, p. 535.

3. **Federal Reserve Bulletin**, March 1981, p. 199

4. Michael Dotsey, Steven Englander and John C. Partlan, "Money Market Mutual Funds and Monetary Control," **Federal Reserve Bank of New York Quarterly Review**, Winter 1981–82, Volume 6 No. 4, pp. 9-17.

5. **Ibid.**, p. 17

Enforcing Anti-Redlining Policy Under the Community Reinvestment Act

Alane K. Sullivan and Randall J. Pozdena*

On October 12, 1977, President Carter signed into law the Community Reinvestment Act (CRA) as Title VIII of the Housing and Community Development Act of 1977. The act was designed to encourage financial institutions "to help meet the credit needs of the local communities in which they are chartered." To meet that intent, the CRA directs each federal financial supervisory agency to take into account an institution's CRA record when ruling on branch, merger, or other applications.

The affirmative orientation of the CRA represents a significant departure from earlier bank regulation, which had been designed primarily to ensure the safety and soundness of the banking system. Regulators examine banks' financial structure and portfolio quality, for example, to monitor their overall soundness and thereby to minimize the incidence of bank failure and the disruptions to financial markets that might ensue. Similarly, they regulate competitive structure in banking markets—through chartering, branching, and merger regulation—presumably with the intention of preserving vigorous rivalry without promoting "overbanking" of individual markets.

Bankers and economists may not all agree that such regulation is necessary (or even desirable) to achieve the goal of a stable banking system. Nonetheless, such regulation does not usually call into question the basic ability of a competitive banking market to make socially appropriate allocative decisions. The passage of the CRA, on the other hand, indicates that Congress questioned the ability of the market to produce desirable patterns of credit use. Moreover, by linking the CRA to the regulatory approval of merger and other applications, Congress has made the future development of banking markets contingent on current patterns of credit service to the community.

This paper traces the origins of the Community Reinvestment Act and examines its aims and the extent to which those aims are being met by the current enforcement process. Section I sets forth the legislative history of the CRA. Sections II and III describe the law in more detail with specific focus on its enforcement. Section IV examines the problem of detecting noncompliance with the anti-redlining provisions of the CRA, with special attention to the agencies' evaluation methodologies and the community group and academic studies of the "redlining" phenomenon. Section V presents our conclusions and discusses the policy implications of a possible alternative evaluation method to those currently used to enforce the Act.

I. Legislative History and Intent of the CRA

The CRA had its origins in long-standing allegations by community groups that financial institutions discriminate against certain neighborhoods in credit decisions. The practice, called neighborhood "redlining", allegedly contributes to and even causes the decline of inner city neighborhoods.

Anti-discrimination and anti-redlining legislation was already in place at the time the CRA was formulated, but community groups saw this earlier legislation as ineffective in structure and application. The Home Mortgage Disclosure Act (1975), for example, required financial institutions to disclose data on the volume of mortgage loans on a census tract or zip code basis. Such disclosure of geographic lending patterns was intended to provide an overt mechanism for detecting redlining—but provided no mechanism for imposing govern-

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mental sanctions should such behavior be detected. Similarly, the Equal Credit Opportunity Act (1974) prohibited discrimination in credit transactions on the basis of race, color, religion, national origin, sex, marital status, or age, but did not address the problem of "geographic discrimination" involved in redlining. Dissatisfaction with the thrust and implementation of existing legislation led citizens' groups to increase lobbying and legal pressure on Congress and the regulatory agencies.

The response was an anti-redlining bill (Senate bill 406), which would have required the federal regulatory agencies to encourage financial institutions to "help meet the credit needs of the local communities." Although banks already were required to serve the "convenience and needs" of their communities,[1] the sponsors of the bill felt that "convenience and needs" had focused traditionally on the provision of deposit facilities. The passage of the CRA would ensure that, in practice, the "convenience and needs" consideration also included credit services. The bill's proponents clearly felt that the "semiexclusive franchise" that government granted financial institutions obligated those institutions to pursue "community" as well as private entrepreneurial goals. More specifically, the draft bill emphasized that a financial institution's first obligation was to the credit needs of its "primary savings service area"—defined as an area from which 50 percent of the institution's deposits were derived. Thus institutions could not "export" credit from the community from which deposits were drawn without attending first to that area's credit demands.

Many saw in these proposals an unrealistic view of the role of financial institutions and a challenge to the traditional market mechanism of allocating credit. As a result, Congress modified the initial bill substantially, removing, for example, the very specific focus on the "primary savings service area" and leaving "community" undefined. In addition, it deleted reporting requirements and inserted a prohibition against the imposition of any additional administration burdens on affected financial institutions. Furthermore, the bill's sponsors argued repeatedly in committee discussions that the bill was not an attempt to allocate credit.

Thus, the final bill which became the Community Reinvestment Act avoided the direct condemnation of "exportation" of credit, because Congress clearly wished to avoid allocating credit or doing anything that might inadvertently sacrifice the safety and soundness of the banking system. At the same time, however, the law retained the idea of "serving the needs of the community," with an emphasis on low- and moderate-income neighborhoods. The reconciliation of these two potentially contradictory aims was left to the regulatory agencies.[2]

II. Regulatory Implementation

Congress gave the financial regulatory agencies the task of drafting regulations which both reflected Congressional intent and provided specific compliance guidelines for financial institutions. The agencies involved—the Federal Reserve Board of Governors, the Federal Deposit Insurance Corporation (FDIC), the Federal Home Loan Bank Board (FHLBB), and the Comptroller of the Currency (OCC)—completed the assigned task by October 1978. The following discussion covers the Federal Reserve's Regulation BB, which is the same in all major respects as the regulations promulgated by the other agencies.

Regulation BB reflects the apparent Congressional intent that the concept of "community" employed in CRA regulations be flexible enough to accommodate the myriad markets and service needs which banks confront. Regulation BB, in fact, leaves the definition of geographic market and service orientation up to individual banks. The banks must prepare a Community Reinvestment Statement and make it readily available to the public. The statement includes: 1) a clear definition of market area, without arbitrary exclusions of low- and moderate-income areas; 2) a list of the types of credit services offered; and 3) a copy of the public CRA notice, a description of consumers' rights under the CRA. In addition, each bank must maintain a file of all comments received with regard to its community lending practices and must include in the file its replies to complaints and comments.

The evaluation process is based not only on com-

pliance with these procedural requirements, but also on a bank's behavioral compliance—whether the bank's actual lending activity meets the "credit needs of the community." Here, Regulation BB provides only general guidance for compliance, by listing twelve factors the Federal Reserve will consider when making its CRA evaluation. These include:

a. Activities conducted to ascertain a community's credit needs, including the extent of the bank's efforts to communicate with community members regarding the credit services it provides;
b. Extent of the bank's marketing and special credit-related programs to make community members aware of the credit services it offers;
c. Extent of participation by the board of directors in formulating bank policies and reviewing its performance with respect to CRA purposes;
d. Any practices intended to discourage applications for types of credit set forth in the bank's CRA statement(s);
e. Geographic distribution of the bank's credit extensions, credit applications, and credit denials;
f. Evidence of prohibited discriminatory or other illegal credit practices;
g. Record of providing financial services, including opening and closing of offices;
h. Participation, including investments, in local community development and redevelopment projects or programs;
i. Origination of residential mortgage loans, housing rehabilitation loans, home improvement loans, and small business or small farm loans within the bank's community, or the purchase of such loans originated in its community;
j. Participation in government-insured, guaranteed, or subsidized loan programs for housing, small businesses, or small farms;
k. Ability to meet various community credit needs, based on the bank's financial condition and size, legal impediments, local economic conditions, and other factors; and,
l. Other factors that, in the Board's judgment, reasonably bear upon the extent to which a bank is helping to meet the entire community's credit needs.[3]

III. Legal Aspects of the CRA

The CRA legal process follows the pattern of civil rights and equal employment opportunity litigation, wherein the law provides a quick means for establishing the legal standing of a citizen or group. Specifically, a party establishes a *prima facie* case by establishing the basis for a protest under the CRA provisions, subject to the acknowledgement of its validity by the regulator involved. The financial institution then must furnish documentation to show that there are no grounds for the protest. As long as the protest is substantive, the burden of proof lies primarily with the institution to demonstrate its compliance with the requirements and the intent of the CRA.

A legitimate protest does not require demonstration of *intent* to discriminate against a particular neighborhood. Rather, a bank practice can be called into question if it has the *effect* of discriminating against a certain neighborhood. In order to continue such a practice, the bank must show that it is necessary to the business and that another, nondiscriminatory practice cannot be substituted.[4]

Denial of merger or branch applications is the most severe penalty imposed for noncompliance with the CRA. However, the Federal Reserve (and the other agencies) have the authority to condition approval of an application on changes in the applicant's mode of doing business. The Act apparently is influential though somewhat vague in content, since financial institutions and protest groups often reach agreements independently. Most interested parties agree that an accurate, objective measurement method would add a great deal to the current understanding and enforcement of the CRA.

IV. Problem of Detecting Noncompliance

The original legislation provided very little guidance for detecting noncompliance. The regulations formulated by the regulatory agencies set forth general guidelines for assessing lenders' behavior. However, the agencies still had to devise an evaluation method which would yield an accurate detection of undesirable behavior, as is described below.

Regulatory Process

The regulatory agencies are involved in CRA enforcement on two levels. First, the regular examination process involves routine evaluations of CRA compliance. Secondly, as the law states, the agencies must evaluate CRA performance every time a financial institution applies to branch, merge, or otherwise expand its operations. In 1980, for example, the Federal Reserve processed 917 applications with CRA implications. Often, in these cases, the CRA record is determined by studying the bank's most recent examination report. These analyses are expanded, however, when a protest arises.

Examiners conduct a CRA compliance exam as one part of the overall examination which they regularly make at financial institutions. The twelve items listed in Regulation BB serve as a guide to the examiner in determining whether the institution is complying with CRA procedural requirements. In addition, the examiner must study the bank's lending record and its public relations policy as well as many other factors to determine the degree of behavioral compliance. From the observations made and from contact with community groups, the examiner then makes a final judgment regarding the institution's overall record. A rating of 1 or 2, on a scale of 1 to 5, means that the institution's CRA record is above average, while a 3 represents a "less than satisfactory" record. Standardized examination procedures include a weighting scheme designed to cover all twelve assessment factors of Reg BB, but examiners still have some latitude in assessing performance. The agencies, therefore, admittedly rely on the subjective analysis of experienced staff members.

The regulatory agencies have developed a joint evaluation handbook as well as rigorous training programs, but many observers remain uneasy about the regulatory methods of evaluation and enforcement.[5] Even the examination handbook acknowledges the lack of a standardized evaluation technique, when it notes that "the examiner is expected to adjust the CRA procedures on a case-by-case basis to accommodate institutions that vary in size, expertise, and locale."[6] In fact, a financial institution can attempt to serve its community's needs in myriad ways, and somehow the examiner must determine whether the institution's effort is adequate.

Resolution of a protest also involves evaluation of CRA compliance. The protest process begins when a group claims that an institution has failed to serve a community's credit needs. The group then submits a protest to the appropriate regulatory agency asking that the institution's application to expand be delayed until after examination of its CRA record. When the Federal Reserve is involved, the Board first determines whether the protest is nonsubstantive on its face or whether it warrants a detailed investigation—and in the latter case, it conducts a thorough analysis of the bank's CRA performance.

In practice, the Federal Reserve first attempts to create a constructive dialogue between the protesters and the bank to clarify the issues. Often a case is then dismissed due to a prior misunderstanding of the law or because of poor communication. At other times, the two parties reach an agreement on their own and the group drops the protest. However, sometimes a thorough investigation is necessary, and in such cases, the Board may hold a public meeting where both sides may present their views.

The Federal Reserve's analysis entails the evaluation of the statements of the two parties and some investigative research. The agency studies the bank's marketing programs, along with other factors which may reflect the affirmative action it has taken to serve community credit needs. To detect whether actual lending behavior is in compliance with the CRA, it also examines data available as a

result of the Home Mortgage Disclosure Act (HMDA data), often along with real estate transfer records and bank loan applications to account (at least partially) for loan demand. Other relevant data include information on neighborhood characteristics, compiled from such information sources as U.S. Census data and city planning records. Using all of these sources, the Board's Research staff recommends whether the protest is substantive—and whether the bank's application to expand its operations should be approved, approved subject to certain conditions, or denied. The Board's decision is based on some objective analysis coupled with a subjective judgment of the bank's behavior and management attitudes. Precedents are set on a case by case basis.

One possible way of handling a protest case is "conditioned approval," whereby the application is approved subject to certain requirements. For example, the Federal Home Loan Bank Board approved the application of Midwest Federal Savings and Loan Association, Minot, North Dakota, to establish a new branch—provided that the Association change its delineation of its local community and withdraw its policy of refusing to make mobile home loans on American Indian reservations unless the policy could be shown to have a firm economic basis.

On other occasions, a bank and a protesting group have privately agreed on conditions, leading the community group to drop its charges. Landmark Bancshares Corporation of Clayton, Missouri, for example, upon protest of its application to acquire Ladue Bank and Trust Company, made an agreement with the Missouri Association of Community Organizations for Reform Now (ACORN). The agreement, which led ACORN to drop charges, included a commitment of $1 million for home improvement loans and mortgage loans to the Wellston, Missouri community at below market rates. Clearly, in cases such as these, conditioned approval and private agreement raise concerns about credit allocation, an activity not intended by Congress. The Federal Reserve Bank of St. Louis, reflecting the Federal Reserve System's opinion, held, in the Landmark Bancshares case, that "since the Board of Governors has stated that neither the Bank Holding Company Act nor the Community Reinvestment Act requires that the Board impose commitments to allocate credit, the Reserve Bank does not endorse any term of the agreement between applicant and protestant which may have such a result."[7]

As these examples show, the costs involved in lodging a protest are usually relatively low. On the other hand, the protest process can be costly to the institution involved. First, conditioned approval or private agreements can result in significant financial commitments. Second, the application to expand must be delayed until the CRA issue is resolved. The bank must not only pay the costs incurred in public meetings (legal fees, etc.) but also those resulting from substantial delays in expansion plans, including the costs of affected competitive positions. In addition, protesters need not be community groups, but can even include competing banks, which sometimes file CRA protests, presumably with the hope of delaying or preventing competitors' expansion plans.

In view of the high costs of an inaccurate decision to all parties involved, the regulatory agencies should attempt to devise the best possible methods of detecting CRA violations and to encourage the use of the best methods by protesters. In essence, regulators have relied on a two-part approach. First, regulators focus considerable attention on what could be called affirmative marketing efforts. In this regard, the law is designed to ensure that the demand for loans is not adversely affected by a lack of knowledge about availability. Since marketing efforts such as advertising, community meetings and discussions with realtors can enhance the flow of information between potential loan applicants and lenders, the monitoring of such efforts under the CRA probably improves the efficiency of the marketplace. It is probably impossible to measure the optimum level of market information, so it is reasonable to use only general criteria to form judgments on a bank's performance in this area.

A second important part of the CRA enforcement process involves the examination of actual lending activity to determine evidence (if any) of discrimination. Here, detailed objective analysis is desirable, despite the difficulty of developing a good evaluation method for detecting noncompliance.

The remainder of the paper, therefore, addresses the problems associated with those CRA enforcement procedures which focus on possible discriminatory lending patterns, or redlining.

Definition of Redlining

Part of the trouble in this area stems from the lack of a generally accepted definition of redlining. Before choosing a method for detecting violations, it is essential to decide on a correct legal definition of redlining and determine what type of behavior would be deemed unacceptable. From the beginning, differences of opinion arose over the intent of the CRA, and these differences naturally carried over into the debate over the definition of redlining. Community groups and other CRA proponents, being concerned about urban "disinvestment," criticized as redlining any lending behavior resulting in an uneven distribution of loans across neighborhoods, regardless of the reason for this pattern. In their view, lending policies that create uneven distributions of mortgage credit have the *effect* of discriminating. Many also argued that banks have an obligation to make every effort to serve their communities, even if this means lower profits than could be earned elsewhere. By refusing to lend in a neighborhood, for whatever reason, community groups claim banks otherwise would create an externality effect: deterioration of the community.

Under the community groups' definition, successful CRA enforcement would mean a more equal distribution of loans across neighborhoods. Evaluation methods devised under this approach simply involve the examination of loan distribution patterns for inequalities, as discussed below. However, in its final form, the CRA falls far short of mandating credit allocation or affirmative urban renewal efforts if they are unprofitable. Instead, the law seems to recognize that there may be sound business reasons for an uneven pattern of loans—partly reflecting differences in demand across neighborhoods, but also lenders' recognition of higher risks in certain areas. In the economic literature, this type of lender behavior is referred to as "rational" redlining. Lenders who operate efficiently will make loans to minimize risk and maximize profit, subject to regulations regarding the overall quality of loan portfolios. We assume here that the law was not meant to outlaw rational redlining—but rather irrational practices whereby a lender avoids lending in a certain area despite the fact that the activity would yield a normal balance between risk and return. Under irrational redlining a property's location remains a significant explanatory factor for a given lending pattern, even after adjustment for all the factors which might explain the pattern on the basis of sound business judgment.

This does not mean that a lender who uses a property's location as a decision criterion *necessarily* has discriminatory (irrational) *intent*. To make economically sensible decisions, lenders must use the available information to evaluate individual requests for funds. At times, the cost of obtaining this information is prohibitively high, so that lenders may attempt to economize on information costs by using proxies for certain variables. If these proxies have statistically significant results, the quality of the lending decision is probably enhanced. However, the law prohibits the use of certain variables (such as zip code), assuming that their use would have discriminatory *effects*. This practice may be rational in a purely private decision-making process, but since the law outlaws it in a social context, we must include such variables in our definition of irrational redlining.

The use of the CRA's anti-redlining provisions to address *irrational* redlining gives us the basis for choosing an appropriate evaluation method. Detection of irrational redlining requires an understanding of the factors necessary to make a sound business decision. We will narrow our focus to the factors that affect risk and return in the mortgage market, since it is the behavior of lenders in this market that has drawn the most criticism from CRA proponents. After discussing these factors, we will examine the evaluation methods devised to detect redlining by interested parties (community groups, academicians and regulators) to determine whether they account for the rational business reasons affecting lending decisions.

Demand for Mortgages

Outcomes in the mortgage market (as elsewhere) result from the interaction of demand and supply forces. Although the CRA directs its attention to supply side (i.e., lender) behavior, it is also necessary to specify demand behavior to extract evidence on supply behavior from the available data on mortgage activity.

According to a number of studies,[8] the desired stock of household debt is determined as an element of a broader decision concerning the consumption of housing and non-housing goods and services. In the most general models, household wealth, current income, prevailing interest rates, and market housing prices are found to determine the demand for housing and mortgage debt. (Here wealth is defined as the present value of lifetime earnings plus the stock of savings.)

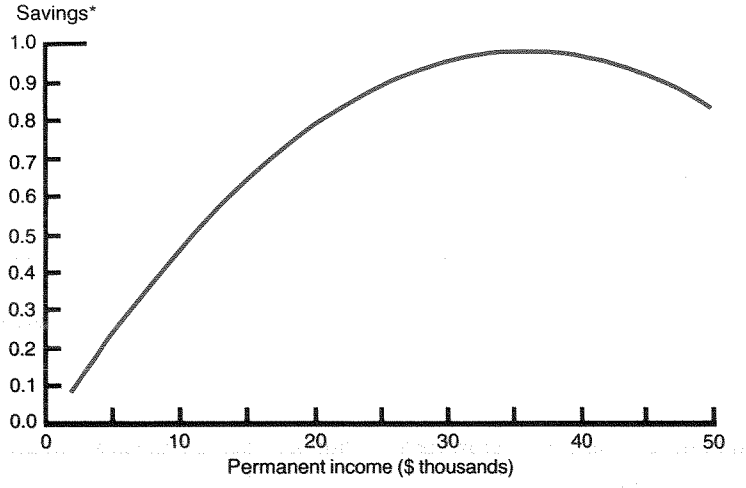
This relatively straightforward assumption is complicated, however, by certain imperfections in the credit and housing markets. First, the progressiveness of income tax rates and the tax deductibility of mortgage interest reduce the after-tax cost of indebtedness to wealthier households. Second, the lifetime earnings portion of household wealth is fairly illiquid; households are typically not able to borrow against their future income. Coupled with the convention of minimum downpayment requirements, this fact may make initial savings—and not simply total household wealth—independently important to housing and mortgage demand. A household with a lower level of initial savings would display a lower effective demand for housing than an equally wealthy household with a higher initial level of savings.

In addition, the household's current income position (rather than its wealth alone) may be an important independent factor influencing its housing ownership decision. With conventional mortgage instruments, the borrower can encounter cash-flow problems if the monthly loan payment is large relative to current nominal income. Lower current income is likely to result in lower demand for housing, everything else being equal.

Finally, the variability of income may play a role in the demand for housing and mortgage debt—the more variable its income, the greater the risk that a household will be unable to meet mortgage payments in the normal manner. Because of the high legal and other costs of meeting (or avoiding) loan delinquencies and defaults, a household with a variable income may have a lower effective demand for debt and for housing than a similarly situated family with a stable income.

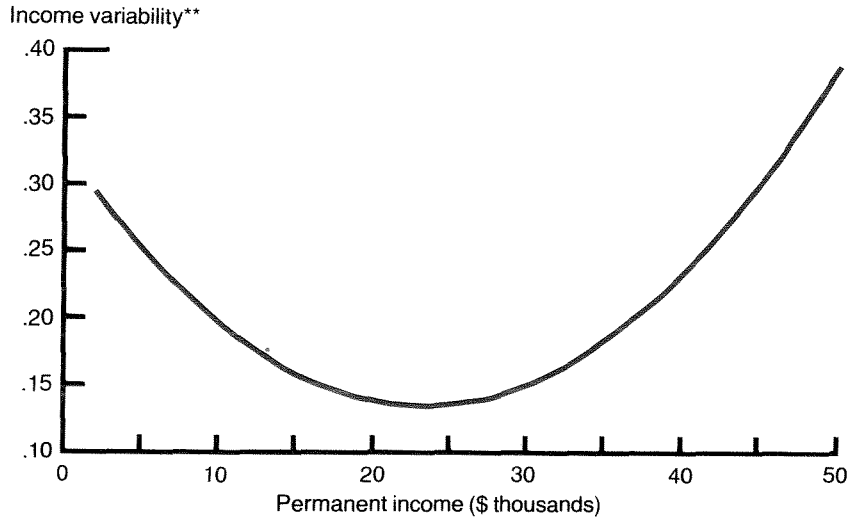
These demand variables would suggest the weak-

Chart 1



*Savings is a dichotomous variable where O=households without savings greater than two months' income and 1=all other households. The relationship estimated here represents the probability of a household at various permanent income levels having savings greater than two months' income.[10]

Chart 2



**Income variability is defined as the standard deviation of each household's income from its nine-year-average trend values.[10]

ness of wealth alone (or its reasonable proxy, permanent income) as an accurate predictor of the demand for mortgages. Indeed, data on family economic characteristics[9] suggest that savings as a proportion of wealth tends to increase as wealth increases over much of its range (see Chart 1). Moreover, poorer households also tend to have more variable incomes than all but the wealthiest households (see Chart 2).

These nonlinear relationships suggest that mortgage demand on the part of less wealthy households should be less than their wealth alone would predict. Therefore, we would expect to find poorer households demanding fewer mortgages than richer households, even after adjustment for income and wealth. Since neighborhoods tend to be relatively homogeneous with respect to household wealth, an uneven pattern of mortgage lending across neighborhoods may be explained, in part, by these differences in mortgage demand.

Mortgage Supply

In addition to these demand-side influences, a number of factors relating to the applicant and the property will necessarily influence lenders' willingness to supply credit. One major factor is the lender's general inability to obtain security for the loan by attaching the borrower's future income; thus, the loan must be secured by the property itself. Factors bearing on the likelihood and cost of foreclosure and liquidation will thus influence the lender's willingness to supply credit. The borrower's ability to handle the cash-flow burdens of a mortgage, of course, would be paramount in a bank's assessment of the risk of foreclosure. Thus, the borrower's current income, liquid asset position and income stability are all considered by lenders in this regard.

The lender's perceptions about the "quality" of the real assets securing a loan also will affect the lender's willingness to make a real estate loan. In obtaining a secured loan, the borrower in effect obtains an option to hand over the security (the house) to the lender and abandon the loan. As option theory suggests, the more uncertain the future value of the security (the house), the more valuable this option becomes. Thus, lenders should charge more or demand more security (by offering a lower loan-to-value ratio, for example) for a loan on a property with an uncertain future value. Such uncertainty typically will arise due to the lender's assessment of the remaining economic life of the house. This assessment, in turn, may be a function of the house's current level of upkeep and of the maintenance of nearby properties.

Consequently, we would expect fewer loans to be supplied to those loan applicants with lower

incomes, with lower savings/loan ratios, or with intentions to buy homes with uncertain future value, all else being equal. The greater income variability of poorer households (see Chart 2) should also have consequences for mortgage supply. Lenders would be willing to supply less mortgage money at any given mortgage rate to variable-income households because of potentially greater delinquency and default risks.

Resultant Lending Patterns

An accurate evaluation method for detecting noncompliance with the CRA, or "irrational" redlining, thus would necessarily incorporate variables such as those discussed above. No available data set would permit us to prove this point directly or to test directly all the implications of our model on the demand and supply of mortgages. However, some of these variables are important to household financial decisions through their influence on the pattern of home ownership.[11]

Since households of various wealth levels tend to be concentrated geographically, these conclusions about demand and supply factors may translate into unevenness in the observed number, value, or price of mortgage loans across neighborhoods. In particular, households in poor neighborhoods are likely to receive less mortgage money than households in well-to-do neighborhoods. In fact, a comparison of lending outcomes between inner city and suburban neighborhoods probably would reveal a pattern of fewer loans and lower dollar loan values in the typical American inner city because of its general pattern of household characteristics. The uneven distribution can, therefore, often result from rational behavior on the part of both lender and potential loan applicant. However, the evaluation methods used traditionally by community groups generally have led them to equate such uneven distributions with redlining.

Community Group Studies

Because of their limited resources, community groups have tended to use the simplest analytical procedures when providing evidence to support their protests against financial institutions. Typically, their analysis of residential lending patterns consists of construction of simple indices—such as loans per census tract—to depict the geographic pattern of mortgage lending. The type of indices has depended upon the type of data available.

Prior to the passage of the HMDA, these groups obtained their data from manual reviews of public registers of real estate transactions—as seen, for example, in the New York Public Interest Research Group report on redlining in Brooklyn. The report compared total value of Brooklyn mortgages made by certain Brooklyn savings banks to these lenders' total assets and total mortgage-loan volume. The resultant ratios were small, and the report's authors thus inferred that the lenders were redlining Brooklyn neighborhoods.[12]

The passage of the HMDA considerably facilitated this simple index analysis, because it required each financial institution to disclose the number and value of all mortgage and home improvement loans made, by type and by neighborhood (using census tracts or zip codes to represent neighborhoods).[13] The HMDA provided much of the data used by community groups to stimulate Congressional interest in the CRA. For example, in her March 1979 testimony, Gale Cincotta of National Peoples' Action used such data to show that three major cities received a smaller share of urban financial institutions' loans than did their suburbs and non-metropolitan areas.[14] Ms. Cincotta used this example of asymmetry between urban and suburban lending patterns as evidence of the existence of redlining and of the need for the CRA.

The Buckeye-Woodland Community Congress (BWCC) in Ohio also used HMDA data and simple index analysis to establish its standing in a CRA protest. When AmeriTrust, a Cleveland bank holding company, proposed to acquire a new bank early in 1980, BWCC alleged that AmeriTrust had a poor record of real estate lending in predominantly black

areas of the community. These accusations were based on simple indices developed from HMDA data, real estate transfer data, and deposit data.[15]

Although simple index analysis has been very effective in attracting policy-makers' attention, it suffers from serious analytical problems. Clearly, simple index analysis does not address the problem of irrational redlining. It compares only *outcomes* across neighborhoods, and thus cannot show if a lender is arbitrarily discriminating against a given neighborhood. Data on geographic lending patterns alone cannot show whether the outcome is a result of demand or supply factors or, if the latter, whether the behavior is rational or irrational (discriminatory). In addition, these indices give no consideration to the impact of risk variables on lenders' behavior. Without controlling for other factors that legitimately influence mortgage demand and supply, it is not possible to use such indicators to prove discriminatory lending practices. Furthermore, HMDA data do not correct for population or size differences among neighborhoods, and their use would be inappropriate even to coarsely screen for CRA violations. Indeed, redlining behavior could be occurring in those markets where the simple index measures might imply the opposite.

Some groups have recognized the severe limitations of the simple index approach and have tried to overcome them—for example, by using additional data to compensate for differences in demand.[16] Some have used real estate transfer activity and other variables as proxies for mortgage demand. However, these variables have limited value as well, since it is doubtful that they adequately control for demand factors in a neighborhood.[17]

Therefore, simple index analysis is clearly incapable of proving the existence of irrational redlining, despite its frequent use in CRA protests. To isolate lending patterns that involve something more than economically "rational" behavior—namely, to identify discriminatory and irrational redlining—analysts must adjust for the factors expected to influence rational lending behavior. Academic researchers, in their search for better measurement methods, have come to employ one of two approaches: 1) market models or 2) applications analysis.[18]

Market models

In the market model approach, researchers have recognized the joint involvement of demand and supply factors in the process that determines observed mortgage activity. Demand for mortgages is typically assumed to have the form

$M_d = M_d (i, P, X)$

where M_d is the demand for mortgages, i is the mortgage interest rate and other loan terms, P is the price of housing, and X is a set of variables influencing the scale of demand (such as the borrower's demographic and financial characteristics). The mortgage supply relationship takes the general form

$M_s = M_s (i, B, R)$

where i is the terms of the mortgage, B is a set of borrower characteristics related to creditworthiness, and R is a set of characteristics of the property. Then, in equilibrium,

$M_d = M_s = M_{observed}$

and the model can be solved for the relationship between observed mortgage activity ($M_{observed}$) and borrower and property characteristics:

(1) $M_{observed} = f (P, X, B, R)$.

This "reduced form" relationship is typically estimated with regression analysis, using data on the number or value of mortgages made in various census tracts or neighborhoods in a certain period as measures of M. The borrower and property characteristics are the average characteristics of the occupants and properties in those tracts.

Within this general framework, analysts have attempted to obtain evidence of redlining in several ways. Under one approach, certain characteristics of the borrower (such as race) or the property (such as the age of housing in the census tract) would be considered irrelevant to the banking decision. Thus if these variables are statistically significant in explaining observed mortgage activity, the analysts conclude that redlining is involved.

Hutchinson, Ostas and Reed,[19] for example, found the number of mortgages made in a cross-section of 120 census tracts in Toledo, Ohio, to be negatively related to average housing age. They

took these findings as evidence of redlining.

The difficulty with this approach, of course, is that the underlying assumption may be faulty. The age of the house may be irrelevant in and of itself, but it may be related to a variable overlooked by analysts but used by the lender, such as uncertainty about the property's future value. Similarly, the race of the borrower may capture the effect of an excluded variable, such as the borrower's initial savings position or income variability. By law, of course, the lender should not use variables such as these, but they may be statistically significant in a retrospective analysis.

A second approach is to estimate equation (1) to predict mortgage volumes for allegedly redlined areas on the basis of data from purportedly nonredlined areas. If the predicted volume for the allegedly redlined areas exceeds the actual volume, the analysts consider this evidence of redlining. Using this approach, Richardson and Gordon found study areas in West Oakland, California not to be "mortgage deficient" relative to surrounding areas, while Schafer found evidence that certain areas in New York City were "redlined."[20]

With this approach, however, valid comparisons may not be possible because not enough legitimate factors influencing mortgage volumes have been included in the prediction relationship. Richardson and Gordon, for example, point out the need for cautious conclusions about "mortgage deficiencies," because allegedly redlined and nonredlined areas typically differ dramatically in borrower and property characteristics.

Market model redlining studies also involve a number of general problems. First, the complexity of the mortgage market makes it extremely hazardous to rely on simplified model representations of this type. To our knowledge, for example, no market model study has incorporated household wealth, initial savings, and income variability in the specification of mortgage demand (mainly for a lack of data). Yet Michigan Panel Survey data suggest that these variables are significant in the prediction of home ownership because of their relevance to either demand or supply.[21] Similarly, data are probably not available to characterize adequately the risk characteristics of the properties, so that the supply relationships are also misspecified. As mortgage market theory suggests these are likely to be important determinants of the pattern of mortgage demand and, hence, of observed mortgage flows. The omission of such basic variables makes the results of such studies highly tentative.

In addition, market model studies focus only on a portion of the mortgage market (typically institutional mortgage lending), often excluding the activity of mortgage bankers and other non-bank lenders. The exclusion from these studies of private mortgage sources, which now represent an increasingly important component of mortgage supply, may negate any findings of redlining behavior, since lenders may specialize in certain kinds of loans and perhaps neighborhoods as well.

For these reasons, market models have not resolved and are unlikely to resolve the debate about redlining. Moreover, the difficulties encountered in verifying allegations of redlining for the market as a whole are multiplied severalfold when a specific lender's behavior is involved, since the market model must then explain the market shares of various lenders as well as aggregate mortgage activity. Yet, the behavior of individual lenders is what the CRA is meant to address. Conceptually, market models are far superior to the simple index analysis practiced by community analysts and some regulatory agencies. However, market models have not been consistently successful in detecting "redlining." Indeed, their generally ambiguous findings suggest that the "strong" superficial evidence of redlining indicated by simple index analysis is much more difficult to verify in a more appropriate modelling context.

Applications Analysis

Because of the difficulties encountered with market models, some academic analysts have tried to simplify the problem by focusing only on the lender's loan evaluation process. If lenders reject loan applications involving properties in certain locations more frequently than similar applications elsewhere, this could be taken as an indication of possible redlining behavior.

In essence, such studies are pure supply studies; "demand" is given since an application has been filed.[22] This alleviates the problem of modelling the demand process. In addition, inferences about *individual* mortgage suppliers can potentially be made by focusing on the applications process of the specific lender.

The typical applications analysis model involves estimation of a mortgage decision relationship of the form

$$\text{Prob(MD)} = f(i, B, R)$$

where MD is the mortgage decision made concerning the application (such as "denial" of the application), and Prob = f(...) is a function describing the probability of that decision as a function of i, the terms of the loan request, B, the characteristics of the applicant, and R, the characteristics of the property, (including location). This model indicates the presence of irrational redlining if all characteristics of the applicant and the property relevant to a wise business decision are included and the property's location is still independently important.

The most thorough study of this type was conducted by Schafer and Ladd for the Department of Housing and Urban Development.[23] Since such studies require detailed data on individual mortgage applications, the researchers were limited to an analysis of mortgage markets in New York and California, where state laws require certain institutional lenders to provide information in applications registers.[24] The authors obtained information on allegedly redlined areas, and then tested whether such property locations were independently important in explaining mortgage decisions.

The results of the study are mixed; the location of a property in an allegedly redlined area increases the probability of adverse treatment by the lender in some but not all of the cities studied. More surprisingly, there are statistically significant cases where "nonredlined" areas appear to receive less favorable consideration than "redlined" areas. Indeed, in California, there are only six cases in which an adverse mortgage decision is statistically more likely for central city properties than for suburban properties; yet there are twenty-one cases where the reverse is true. Similar, though less pronounced ambiguities arise from the New York data.

The authors conclude from their results that "some neighborhoods appear to be redlined and others do not." An alternative explanation, however, is the omission of some locally important variable(s) from the model specification. The applications data provide relatively good information on the applicant's financial position (such as some savings and net worth data), but they lack most information that might bear on the market's perception of the riskiness of the specific property (with the exception of age of house). The data thus had to be augmented with census and other data, which might have been insufficient to the task; indeed, the analyst really needs all of the data available to the lender to discern accurately the "unbiasedness" of the loan decision process. Nevertheless, applications analysis, by virtue of narrower focus, has greater practical potential than market modelling or index analysis for CRA evaluation.

Use of Applications Analysis

Most of the regulatory agencies have access to the loan application register (LAR) maintained by each institution. The LAR is a record of loans made, including details related to the applicant, the property and the loan terms. This record must be maintained for 25 months for every loan made by each institution.[25]

The Federal Home Loan Bank Board conducted a pilot study of such data in 1978 to detect discrimination in the overall lending practices of savings and loan associations.[26] Discrimination was defined as the arbitrary use of applicants' age, race, sex, or marital status, or property location, to make decisions regarding appraised value, loan acceptance or

denial, or mortgage terms. Violations of CRA would have been found if property location alone had made a difference in lending decisions, but discrimination was not evident after controlling for applicant and property risk variables.[27] The pilot study demonstrates the agencies' concern about finding appropriate objective measurements of CRA compliance. It also suggests that detailed studies of individual applications reveal more information than simple index models and can explain much "suspect" activity.

V. Conclusions and Policy Implications

This paper has focused on some of the analytical challenges posed by the Community Reinvestment Act. Proponents of the CRA had many policy aims in mind—including the regulation of credit flows to stimulate redevelopment of deteriorated urban areas. But in view of analytical limitations as well as Congressional intent in the ultimate CRA legislation, we believe that enforcement of the CRA's anti-redlining provisions should center on detection of *irrational* redlining, or arbitrary geographic discrimination. Indeed, the debate surrounding the passage of the CRA makes it clear that geographic credit allocation was not Congressional intent in the Act's final form.

With this in mind, we have attempted to assess the usefulness of various analytical techniques and data sources in detecting the arbitrary use of property location in mortgage lending decisions. We found that the simple index techniques commonly used by community groups are likely to be unreliable, because they ignore the complexity of the economic decisions involved in the mortgage market. These measures simply do not account for the sound business reasons or demand factors which may be the reason for disparities in loan volumes among neighborhoods. We also found that the market model approaches used in more sophisticated studies were also inappropriate, due to the difficulty of defining an individual lender's role in such a complex context. A more reliable technique for evaluating charges of geographic discrimination may be loan applications analysis, because it focuses on individual lending decisions, while at the same time drawing on a more complete set of data than the simple index techniques.

These conclusions suggest that effective CRA enforcement may require substantive changes in the methodology used by regulators to assess a lender's CRA performance and to evaluate allegations of redlining. In the absence of quantitative evaluation techniques, CRA assessments today largely depend on the judgment of CRA examiners. Since the detection of CRA violations is considered an important regulatory responsibility, decisions should be accurate, and consistently applied, given their far-reaching consequences. The use of formal, objective methods of evaluation can make a positive contribution to both of these goals. Among the methods that probably should be considered are those which analyze loan application records.

At the present time, regulators must conduct thorough analyses of CRA compliance when a protestant alleges the existence of redlining and also during routine examinations. With a loan application register readily available for analysis, regulators could address complaints more quickly and accurately. The burden of the analysis would rest with the regulatory agencies, which have the appropriate staff and resources for the task. This should serve the desire of Congress to keep enforcement costs to a minimum. Also, it should save protestants from the time-consuming, unreliable use of simple index methods, and should reduce the burden of the existing CRA process on affected institutions.

However, the loan application register has drawbacks also. The need to maintain the necessary standard-format applications data files would impose a non-trivial compliance burden on affected institutions. (There is now no standard format nor standard method of analysis, and lending institutions must only maintain a file of loan applications and make these records accessible to regulators.) The costs of maintaining the loan registers would be high, especially since relatively few banks are faced with protests or allegations of poor performance. In addition, unless institutions were also required to maintain records of all requests for lending information (in addition to formal applications), this method would not detect "pre-screening" forms of

lending discrimination.

Given the serious problems associated with existing evaluation methods, and given the high costs of a more accurate, (but still imperfect) alternative method, regulators might do well not to try to detect redlining per se, but rather to concentrate on encouraging the affirmative marketing efforts of financial institutions. Assuring the free flow of information to all market participants should increase competitive pressures on lenders who discriminate, making them less able to continue such practices in the long run.

If the efforts to detect redlining are to continue, however, improvements in evaluation methods may be necessary. At the very least, analysts should conduct a more thorough study of the costs and benefits of alternative evaluation methods than we have attempted here. Our analysis indicates that the current method has severe limitations, and that a more accurate method would involve incorporating all the information lenders receive in loan applications. Although the substantial investment of time and capital necessary to maintain these data may exceed the explicit costs of current compliance regulations, an accurate cost/benefit analysis would also have to consider the high, hidden costs incurred under existing protest procedures—such as concessions made in private agreements, penalties incurred through conditioned approvals, legal fees, and costs of jeopardized competitive positions. When these hidden costs are taken into account, it is not obvious that loan applications analysis would be too costly to implement. Indeed, if CRA enforcement and elimination of discriminatory lending practices continue to be desirable legislative goals, a review of the current evaluation method clearly would be in order.

FOOTNOTES

1. Whenever a bank applies to expand its operations, the regulatory agency does an analysis of the competitive effects of the proposed activity and an analysis of how the expansion meets the "convenience and needs" of the community. Banks must, therefore, include in their applications descriptions of how the expansion will benefit customers by improving services in their communities.

2. For further details, see U.S. Senate, **Hearings before the Committee on Banking, Housing and Urban Affairs on S. 406**, "Community Credit Needs," March 23–25, 1977, 95(1), and Consumer Bankers Association, **A Compliance Guide for the Community Reinvestment Act: Background and Implications**.

3. Board of Governors of the Federal Reserve System, Regulation BB (12 CFR 228), effective November 6, 1978.

4. For a thorough discussion of the effects test as it applies to consumer credit legislation, see Sarah E. Burns, "Credit Scoring and the ECOA: Applying the Effects Test," **Yale Law Journal**, 88(7), June 1979; pp. 1450–1486.

5. The General Accounting Office, for example, in a recent study of the enforcement of several consumer credit laws, was critical of the agencies' monitoring of substantive compliance or compliance with the "basic principles of the law." The GAO complained that few detailed analyses were conducted on the data available. Although the study refrains from drawing conclusions on CRA enforcement (since CRA was new at the time), we can probably apply the agency's findings to CRA as well. Comptroller General of the United States, **Report to the Congress: Examinations of Financial Institutions Do Not Assure Compliance With Consumer Credit Laws**, U.S. Government Printing Office, January 2, 1981.

6. Comptroller of the Currency, Federal Deposit Insurance Corporation, Federal Home Loan Bank Board and Federal Reserve Board, **Community Reinvestment Act Examination Procedures**, November 1978, p. 5.

7. Federal Reserve Bank of St. Louis, news release, November 30, 1979.

8. See Diewert, W. E. "Intertemporal Consumer Theory and the Demand for Durables," **Econometrica**, May 1974, pp. 497–516; Dunkelberg, W. L., and Stafford, F. P., "Debt in the Consumer Portfolio: Evidence from a Panel Study," **American Economic Review**, September 1971, pp. 598–613; Hess, A. C., "A Comparison of Automobile Demand Equations," **Econometrica**, April 1977, pp. 683–701; Mishkin, F. S., "Illiquidity, Consumer Durable Expenditures, and Monetary Policy," **American Economic Review**, September 1976, pp. 642–54; and Sandmo, A., "The Effect of Uncertainty on Saving Decisions," **Review of Economic Studies**, July 1970, pp. 353–360.

9. The data are from continual follow-up surveys of 5,000 American families in each of the nine years 1968-1976 conducted by the Survey Research Center of the University of Michigan (the Michigan Panel Survey). Our sample, however, involves only families in which the married couple which headed the household remained together over all the years of the survey.

10. The equations for the charts took the forms $s = a + bY + cY^2$ (for Chart 1) and $I = a + bY + cY^2$ (for Chart 2), where S = the savings variable as described, I = income variability, and Y = permanent income. Source of the data used is described in footnote 9.

11. The importance of the factors presented in the theoretical discussion was demonstrated in a regression of home-

ownership on various homeowner attributes (Michigan Panel Survey data). For example, level of permanent income and level of savings show a statistically significant relationship to home ownership. Increased income variability, on the other hand, reduces the probability of home ownership for the families in the sample. Because of the obvious relationship between home ownership and mortgage indebtedness, the findings suggest that these same variables would affect the pattern of mortgage indebtedness, although we cannot distinguish whether the factors are supply or demand related.

12. New York Public Interest Research Group, "Take the Money and Run," New York, 1976.

13. The HMDA was amended in 1980 and now requires disclosure of the number and value of mortgage loans made by census tract only. Zip code can no longer be used as a designation of neighborhood.

14. See **Hearings**, footnote 2, pp. 132–147.

15. Federal Reserve Bulletin, "Bank Holding Company and Bank Merger Orders issued by the Board of Governors," March 1980, pp. 238–242.

16. The Department of Housing and Urban Development, in its CRA guidebook, **Assessing Community Credit Needs** (August 1979, p. 13), recommends that community groups use census tract data, coupled with HMDA data, to help determine demand as well as to explain possible discrepancies in loan volumes between two dissimilar census tracts.

17. With regard to the use of real estate transfer records to compensate for demand, evidently there is not always a one-to-one relationship between mortgages and transfers of real estate. The use of private or mortgage bank financing, the practice of assuming existing mortgages, and other factors will make this link a loose one. It is also very possible that real estate transfers are a reflection of the mortgage market, not vice versa—people may demand fewer homes because they have difficulty finding mortgages.

18. The survey method of analysis has also been tried (for instance, a study of redlining in Rochester, N.Y. by George Benston). Because this method has not been used widely and does not seem to improve upon the market models and applications analysis, we do not discuss it in the text.

19. Peter M. Hutchinson, James R. Ostas, J. David Reed, "A Survey and Comparison of Redlining Influences in Urban Mortgage Lending Markets," **AREUEA Journal**, 5, Winter 1977, pp. 463–472.

20. Harry W. Richardson and Peter Gordon, "Measuring Mortgage Deficiency and Its Determinants," **The Annals of Regional Science**, November 1979, 13:3, pp. 25–34; and Robert Schafer, **Mortgage Lending Decisions: Criteria and Constraints**, Cambridge, Mass. 1978.

21. See footnote 11.

22. Of course these studies assume that no pre-screening is taking place prior to the actual application process.

23. Robert Schafer and Helen Ladd, **Equal Credit Opportunity Accessibility to Mortgage Funds by Women and by Minorities**, Volume 1–3, U.S. Department of Housing and Urban Development, U.S. Government Printing Office, Washington, D.C., 1980.

24. In California, only state-chartered savings and loan associations were involved. In New York, data were obtained from savings and loan associations, commercial banks and mutual savings banks.

25. The Federal Reserve Bank does not require regular reports on this subject, but the other three agencies must collect such data on a regular basis as a result of a federal lawsuit.

26. A. Thomas King, "The Loan Application Register: A Tool for Examiners," **Federal Home Loan Bank Board Journal**, August 1980, pp. 8–13.

27. One exception was the higher rate of denials among Blacks and Hispanics. However, even if this conclusion is valid, it is a violation of the Equal Credit Opportunity Act rather than CRA, and hence is not addressed in this paper. Furthermore, we cannot say whether this finding is conclusive evidence of discrimination, since race could be correlated with certain risk factors not compensated for in the study.

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Pricing Federal Irrigation Water: A California Case Study

Yvonne Levy*

Forecasts of California water supply and demand to the year 2000 suggest that overall supplies will be ample. But according to the same studies, the state's total water supplies are distributed so unevenly geographically that a chronic shortage could develop in certain areas by the late 1980's.[1] Southern California—which currently accounts for two-thirds of the state's total water consumption—is particularly vulnerable to a potential shortfall. Despite an increase in projected demand, that area by the mid-1980's will lose over one-half of the 1.2 million acre-feet of surface water it currently receives annually from the Colorado River.[2]

Most proposed solutions to the problem have called for an expansion of supplies for prospective water-short areas, primarily by the construction of new dams and canals to bring more water from Northern to Southern California. Recently, the most intense debate has centered on the Peripheral Canal, a proposed addition to the State Water Project which would cross the Delta formed by the Sacramento and San Joaquin rivers at the head of San Francisco Bay and bring more water to Southern California. (An overwhelming negative vote from Northern California voters caused the plan to be rejected in the June 1982 election.) But programs to expand the Central Valley Project—the huge Federally-owned water system—also have created considerable controversy.

An alternative approach—an economic approach—would solve the problem through pricing reform, as a means of reducing the projected growth of demand.[3] According to this view, the projected supply-demand imbalance reflects the assumed continuation of inefficient pricing practices followed by Federal, state and local agencies (utilities) in pricing water at all stages of distribution. If water were priced higher, final-users would have a greater incentive to conserve, the projected demand would be lower, and some or all of the proposed new water facilities would not be required. The present article follows this approach in analyzing the pricing of surface irrigation water supplied from the Central Valley Project (CVP) and sold at wholesale by the U.S. Bureau of Reclamation (Bureau).

Agriculture accounts for about 85 percent of the total water consumed annually in California. The Central Valley Project is the single largest supplier, accounting for nearly 40 percent of total irrigation water, with the State Water Project and groundwater sources accounting for the remainder. The pricing practices followed by the U.S. Bureau of Reclamation in pricing irrigation water at wholesale thus significantly influence the general level of water prices ultimately faced by the important agricultural sector.

Economic theory suggests that resources would be allocated most efficiently if the Bureau based its rates for CVP irrigation water on the "long-run incremental cost" of supplying that water. This concept refers to the cost of delivering an additional unit (acre-foot) of water, taking into account the need to add more fixed factors, namely new plant facilities. Pricing all CVP irrigation water on the basis of the cost of the last increment would be the most efficient method of allocating scarce resources, because customers would then be aware of the cost of the resources required to bring them additional water.

In this paper an estimate of long-run incremental cost based on the cost of building the next scheduled block of capacity—namely, the proposed Auburn-Folsom South Unit—is developed. This estimated long-run incremental cost is far higher than the "replacement average cost"—the average cost of irrigation water from the existing plant (including both old and new facilities), when this plant is valued at its current replacement cost, i.e., the

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opportunity cost to society of the resources that are currently tied up in supplying water. The differential is even greater between incremental cost and "historical average cost"—the average unit cost of water from the existing plant, with the latter valued on a historical (original) cost basis. Most regulatory commissions use the historical pricing method for investor-owned utilities under their jurisdiction.

Yet today, the Bureau of Reclamation is realizing an average price for Central Valley Project irrigation water that does not even recover full historical average cost let alone the replacement average cost. In implementing reclamation law, which calls for such practices as basing rates on farmers' ability to pay and not charging interest on public funds invested in the CVP irrigation system, the Bureau is requiring taxpayers and electrical users to pay a substantial subsidy per acre-foot of Federal irrigation water supplied. The subsidy is even greater when the realized average price is measured against the "true" average cost—average cost on a replacement cost basis.

The purpose of this study is to describe and measure how Bureau prices for Central Valley Project irrigation water deviate from the efficiency model and to discuss the implications of higher relative water prices for the California agriculture sector's demand for Federal irrigation water.

Section I discusses the economic-efficiency argument for pricing on the basis of long-run incremental cost. As noted there, water utilities traditionally have followed other pricing methods because their operations presumably have been characterized by decreasing long-run replacement average costs owing to economies of scale. Under such conditions, pricing on the basis of incremental cost would fail to recover average cost valued on a replacement cost basis, and thus would result in a loss. But as Section II indicates in the case of the Central Valley Project, long-run incremental cost today actually is far higher than the average cost of CVP irrigation water, even when average cost is measured on a replacement basis. This suggests that water provision is no longer a decreasing cost industry. In Section III, we show that the prices realized by the Bureau do not cover the actual costs of supplying that water, partly because of the Bureau's failure to recover full historical cost, and partly because of the failure of the utility industry's historical accounting methods to reflect inflation over time. In Sections IV and V, we discuss some of the implications of higher Federal irrigation water prices for the demand for water, and also for the future development of the CVP irrigation system.

I. Rationale for Different Pricing Methods

Social objectives related to the development of the arid West and the creation of a prosperous farm sector have traditionally guided the Bureau of Reclamation in its pricing of irrigation water[4] (see Box). To foster these objectives, Federal reclamation law has limited the agricultural sector's repayment responsibility to its "ability to pay," a concept described later. But in the course of fostering such objectives, the Bureau not only has failed to recover the full historical average cost for irrigation water but has not even consistently utilized the traditional average-cost pricing method prescribed by utility regulatory commissions for private investor-owned utilities.

Under this standard historical average-cost method, the utility first determines its revenue requirement for a particular function, for example, electrical power or irrigation water.[5] This refers to the total costs that must be recovered through rates during a given period to compensate the utility for all the expenses incurred in supplying the product, including a return on invested capital.[6] Under present statutes, total revenues must exactly equal total costs, a requirement known as the budgetary constraint. Dividing total costs by the number of units expected to be sold in a given period yields the average unit cost—and thus the price—of the product. However, the "ability to pay" doctrine has led the Bureau to set its price below the level implied by this type of computation.

In economic theory, the value of the resources embodied in each unit of output is determined on the basis of the replacement cost of the plant employed. As we shall see, utility commissions have used economic theory as the rationale for pricing on the basis of average cost. But they have prescribed an accounting method for measuring average cost which understates the true replacement average cost.

But even if the Bureau had priced its water according to the true economic definition of average cost, that method still would not have been the most efficient in allocating resources. Theory also demonstrates that for efficient resource allocation the price per unit should be equal not to average cost but rather to incremental cost. Incremental cost is the change in total cost resulting from an additional unit of output—that is, the cost of producing one more unit of a good or service, or alternatively, the cost that would be saved by producing one less unit.

A fundamental precept of economics states that optimum efficiency is achieved when the prices of goods and services are equal to their marginal cost of production. Under such conditions, resources would be channelled into their most efficient uses.[7] This is because each price would reflect the value of the resources required to supply each particular good or service, and because consumers therefore would be provided with the proper price signals to make the choices that would yield society the most efficient use of resources. If price were less than marginal cost, consumers would be induced to consume an additional unit, even if the benefits were less than the marginal commitment of society's resources to produce that unit.

An important point is the distinction between short and long-run, which is based on whether or not plant size is fixed. Short-run calculations show how a firm's costs will vary in response to variations in output within the limits of a given amount of fixed plant. Long-run calculations show how costs vary during a planning period long enough to permit adjustment of the scale of productive (or distribution) facilities.

Water pricing decisions thus depend upon whether or not the scale of plant is to be increased. If new plant is scheduled during the planning period encompassed in the rate calculation, long-run incremental (marginal) cost is the appropriate basis for efficient pricing, i.e., price per unit should be equal to long-run incremental cost.[8] Long-run incremental cost equals the cost of water produced by the next block of new storage and conveyance facilities scheduled to be added. Under that approach, the price per unit thus reflects only the cost of water produced from new productive facilities—in contrast to the regulators' favored method of average cost pricing, which also reflects the cost of water from older facilities.

Regulatory agencies traditionally have not followed the incremental precept in establishing utility rates because of their assumption, in their rate setting, that utility operations are characterized by decreasing long-run average costs. Decreasing long-run costs are the result of increasing returns to scale, which mean that a larger plant has lower unit costs than a relatively smaller plant. Average production costs decline for the individual firm with any increase in the size of its plant (of one or more facilities). Economies of scale are internal to the operation of the individual firm, in contrast to external economies which arise out of the growth of the entire industry.[9]

Most importantly, economies of scale are defined for a particular point in time. At any given time, a firm would be operating in an output range associated with decreasing long-run average cost if expansion to a larger-scale plant (or system) built from scratch entailed lower average costs than a smaller plant also built at that time.

With increasing returns to scale, the long-run incremental cost associated with a given supply of water is less than its long-run average cost. Hence, if selling prices were established on the basis of incremental cost (the cost of the last unit), average cost would not be recovered, and the result would be a loss. But this "loss," as measured by economists, exists because of the specific manner in which average cost is defined, with reference to the *replacement* cost of fixed plant. In practice, incremental cost pricing could yield accounting profits because regulators traditionally have valued plant at historic (original) purchase prices. However, in an industry characterized by decreasing returns to scale and increasing average costs —the CVP case —incremental costs exceed average costs and thus incremental cost pricing would result in a profit in an *economic* as well as accounting sense.

Chart 1-A shows the characteristics of decreasing long-run average cost that originally led governments to grant utilities monopoly status and to institute average-cost pricing.[10] The demand schedule D, which shows the quantity that will be demanded by customers at each price, intersects the long-run average cost schedule (LRAC) at an output level where further expansion in plant size (scale) will

reduce average unit cost, i.e., before the least-cost size.

To achieve the most efficient allocation of resources possible under regulated-monopoly conditions, the utility would have to follow incremental-cost pricing. Under that method, the price (P_{ic}) would be determined by the cost of production of the last unit, that is, by the intersection of the demand schedule (D) and the long-run incremental-cost curve (LRIC). But setting the unit price at P_{ic} would generate losses for the firm (or agency) under conditions of decreasing long-run average costs, in that the cost of the last unit of output would be less than the average replacement cost per unit. These losses would be represented by the area, $(P_1\text{-}P_{ic}) \times Q_{ic}$.

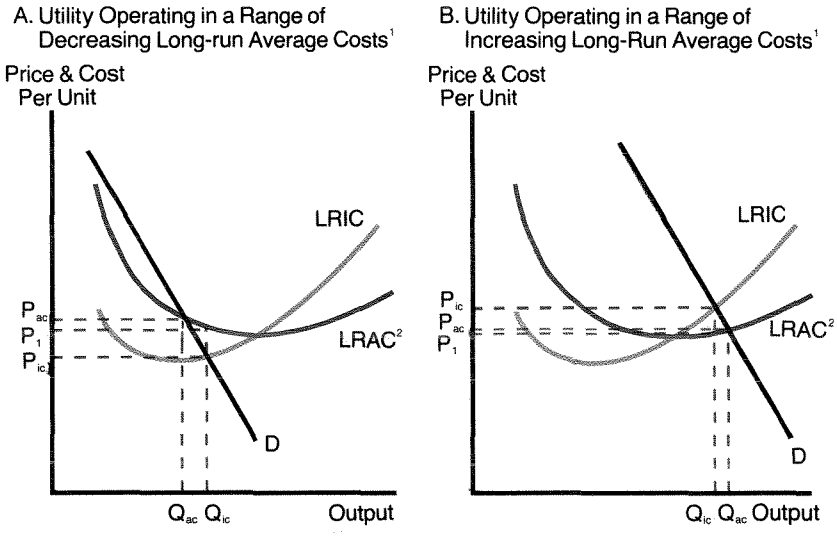
To avoid the necessity for public subsidies to offset these losses, rate-setting commissions originally selected average-cost pricing, incorporating in the average cost a rate of return on invested capital. Under this method, the maximum price per unit is set at (P_{ac}), the intersection of the demand schedule (D) and the long-run average cost curve (LRAC). Under conditions of true decreasing long-run average cost, this method of pricing results in a higher unit price and lower level of output than would result from the more efficient incremental cost method. This is because long-run average cost is above long-run incremental cost under such conditions.

Chart 1-B illustrates the price and output combinations that would result under alternative pricing methods if the utility were operating in a range of increasing long-run average costs due to the exhaustion of economies of scale. This situation characterizes most utility systems today; for example, the CVP is operating in an output range where further expansion in size raises the average unit production cost, that is, where the incremental unit cost is above the average cost, measured on a replacement basis. Under such conditions, pricing on the basis of long-run incremental cost results in a price (P_{ic}) and output level (Q_{ic}). That price would yield a profit beyond the return incorporated in average cost, in that the cost of the last unit of output would be more than the average cost per unit. The *excess profit* would be represented by the area, $(P_{ic} - P_1) \times Q_{ic}$.

To avoid excess profits, regulators could follow the replacement average-cost method, which would result in price (P_{ac}) and output level (Q_{ac}). But average-cost pricing, even under conditions of true increasing long-run average costs, results in an

Chart 1

Pricing Alternatives in a Regulated Monopoly Situation



[1]Describes behavior of costs at a given point in time.
[2]Based on plant valued at current prices, i.e., prices prevailing at the given point in time to which the cost schedules apply.

under-pricing of the product and a correspondingly greater and uneconomic amount of resources devoted to its production. The use of historical rather than replacement average cost results in a still lower price and greater uneconomic amount of resources devoted to its production.

II. Central Valley Project's Long-Run Incremental Cost

Congress has authorized a number of facilities to expand the Central Valley Project, some of which face an uncertain future due to environmentalist opposition and uncertain funding. For that reason, it is difficult to identify for analysis the next large block of capacity likely to be added to the system. The most likely candidate is the proposed Auburn-Folsom South Unit, located between Sacramento and Stockton. The project would consist of the Auburn Dam, the Folsom South Canal and several smaller structures, including the Sugar Pine Dam and Reservoir, the County Line Dam and Reservoir and associated conduits.[11] In addition to generating as much as 450,000 kilowatts of electric power annually, the project when fully operational would supply about 440,000 acre-feet of water for irrigation and 300,000 acre-feet for municipal and industrial uses in the southern Sacramento and northern San Joaquin Valley areas.[12]

To date, only the foundation of the Auburn Dam and some sections of the Folsom South Canal have been completed. Congress has authorized (obligated) nearly $2.2 billion for construction, including about $1.2 billion for irrigation purposes, but the actions of environmentalists and the failure of Congress to appropriate allocated funds have halted further construction.[13]

The project's long-run incremental cost would equal the annual cost of adding an acre-foot of water per year over the project's life. To compute this unit

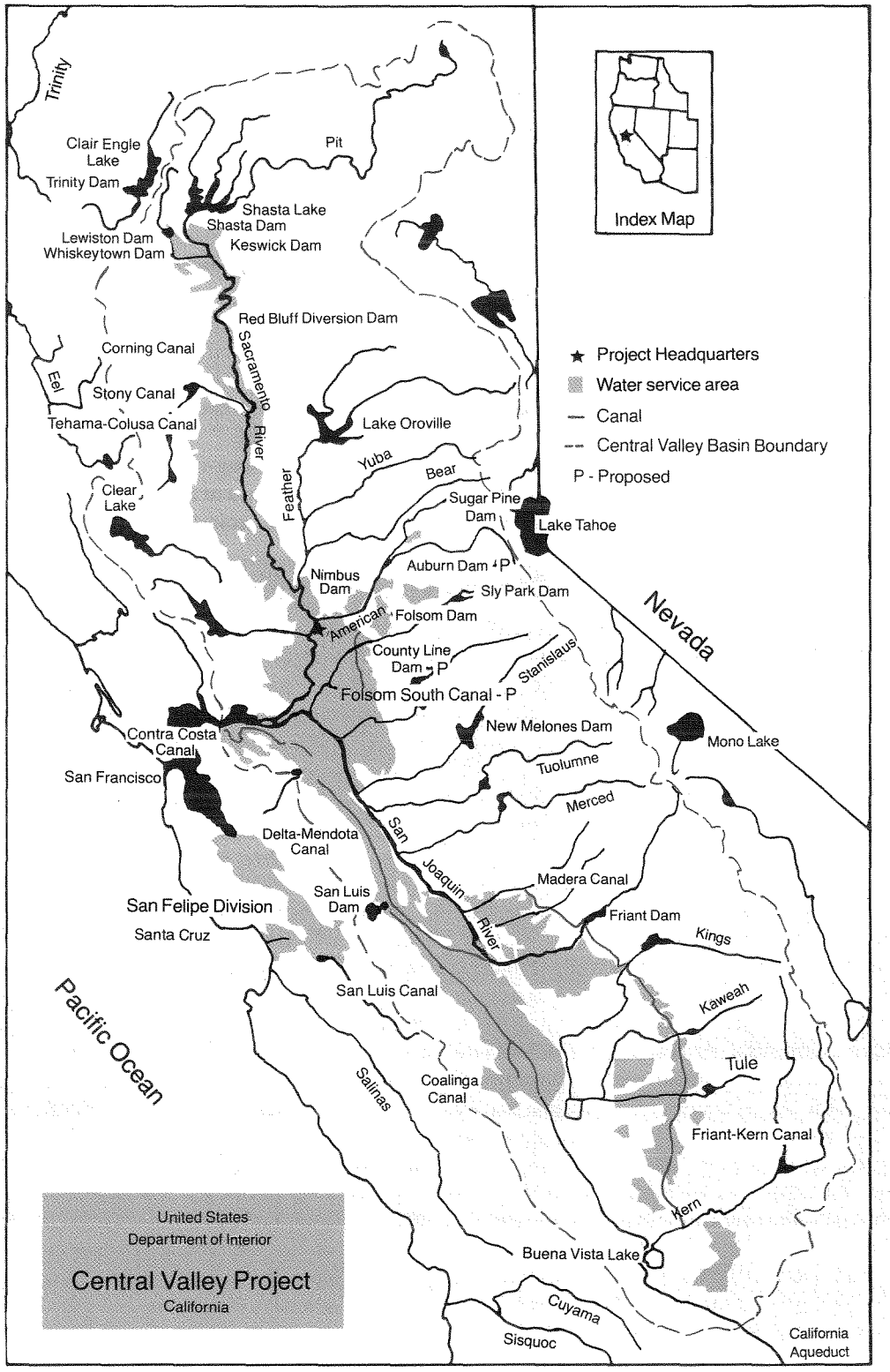
The Central Valley Project

In 1935, Congress authorized construction of the Central Valley Project (CVP) under the provisions of the Reclamation Act of 1902. That earlier legislation had two major objectives: 1) to permit the Federal government to develop the water storage and conveyance facilities necessary to bring arid Western lands under cultivation and 2) to promote widespread land ownership and a family-farm system of production. To encourage the latter objective, Congress restricted the sale of Federal irrigation water to farms 160 acres or less and required landowners to reside on their property.

Congress authorized the Central Valley Project to further implement those objectives. Its purpose was to bring surplus water from the Sacramento River in northern California to the San Joaquin Valley in the south, and thereby bring semi-arid land under cultivation. That need in turn arose from the uneven distribution of natural precipitation, both geographically and among seasons.

The vast Central Valley Basin extends for nearly 500 miles from the Cascade Range in the north to the Tulare Basin in the south, and encompasses more than one-third of California's total land area. In this area, precipitation normally ranges from an extreme of over 150 inches annually in the north to mere traces in the southeastern deserts. More than four-fifths of the State's precipitation falls in the northern one-third of the state, so that the central and southern two-thirds would have been semi-arid or arid without the importation of some of the north's surplus water. Moreover, nearly all of the precipitation occurs during the winter months. Water storage facilities therefore were necessary to redistribute surplus water from the winter to the summer months.

Initially, the Central Valley Project was devoted almost solely to meeting irrigation demands. But as the population of California grew, the project was expanded into a multi-purpose facility, capable of providing water not only for irrigation purposes but also municipal and industrial use, as well as hydroelectric power, flood control, recreation, and fish and wildlife benefits. Today, the completed system consists of 13 major Federal dams, plus numerous pumping and conveyance facilities and hydroelectric generating plants, all of which function as an integrated unit. In the provision of water, the system acts as a wholesaler, selling to water districts and private water companies, which in turn distribute the water at retail to end-users.


Trinity
Clair Engle Lake
Trinity Dam
Pit
Shasta Lake
Shasta Dam
Keswick Dam
Lewiston Dam
Whiskeytown Dam
Red Bluff Diversion Dam
Corning Canal
Eel
Stony Canal
Tehama-Colusa Canal
Sacramento River
Lake Oroville
Yuba
Bear
Feather
Clear Lake
Sugar Pine Dam
Lake Tahoe
Nimbus Dam
Auburn Dam - P
Sly Park Dam
American
Folsom Dam
County Line Dam - P
Stanislaus
Folsom South Canal - P
Nevada
New Melones Dam
Mono Lake
Contra Costa Canal
San Francisco
Tuolumne
Merced
Delta-Mendota Canal
San Joaquin River
Madera Canal
San Luis Dam
San Felipe Division
Santa Cruz
Friant Dam
Kings
San Luis Canal
Kaweah
Pacific Ocean
Tule
Salinas
Coalinga Canal
Friant-Kern Canal
Kern
Buena Vista Lake
Cuyama
Sisquoc
California Aqueduct
Index Map
Project Headquarters
Water service area
Canal
Central Valley Basin Boundary
P - Proposed
United States
Department of Interior
Central Valley Project
California

cost, we estimate the future stream of annual costs in constant dollars—in this case, in 1981 dollars. We then determine the present value of this future stream of costs by discounting at an appropriate real rate of interest. Multiplying the present value by the real rate of interest yields the annual cost of investing resources in this project rather than using them elsewhere in the economy. Finally, dividing this annual cost by the project's expected annual output yields an estimate of long-run incremental cost (see Appendix A).[14]

For discounting purposes, we have used the real rate of return before taxes, i.e., a nominal rate of interest minus the current rate of inflation. Also, we have determined that rate on an opportunity-cost basis—one that assures the general taxpayer a rate of return on invested capital equal to that earned on average in a private-utility sector financed solely through long-term debt. This assumes little difference in risk between the Federal and private-utility sectors, since the latter is regulated to ensure a reasonable rate of return.

Specifically, we have selected a real discount rate of 10 percent—the real rate prescribed by the Office of Management and Budget for evaluating Federal projects.[15] The rate is also consistent with a 16 percent current nominal interest rate for new utility bonds, minus an inflation rate of 6 percent. Employing these assumptions, we estimate the long-run incremental cost of irrigation water from the proposed Auburn-Folsom South Unit project to be around $324/acre-foot.[16]

If it followed efficiency criteria, the Bureau would price *all* CVP irrigation water on the basis of incremental cost. In establishing rates for any given future period, the Bureau would set the unit price equal to the long-run incremental cost of the appropriate block of scheduled capacity. That practice would make wholesale customers aware of the economic value of the resources required to supply additional increments. Instead, in 1981, the Bureau realized an average price of slightly over $5/acre-foot for CVP irrigation water—in contrast to the $324/acre-foot price called for under purely economic criteria. This suggests that far more resources are devoted to the Federal supply of irrigation water than are warranted by the value of the agricultural commodities produced.

III. Differential Between Long-Run Incremental and Average Cost

Three basic reasons can be found for the huge differential between the estimated long-run incremental cost and the latest realized average price of CVP irrigation water. First, the Bureau has not followed the traditional utility pricing model, so that its average realized price is far below the full average cost determined on an historical accounting basis. Second, the traditional utility model fails to reflect replacement cost. Third, the long-run incremental cost of irrigation water would be higher than "true" (economic) average cost, measured by average replacement cost.

Traditionally, a utility determines the capital costs to be recovered through revenues on the basis of its historical (original) cost of plant and equipment. These capital charges include such items as depreciation, interest, and property taxes. During periods of rapid inflation, when the cost of new equipment rises far beyond the original cost of similar equipment acquired in the past, this historical accounting method yields a much lower estimate of average cost than the replacement cost method. Yet the Bureau does not even recover average cost determined under the historical accounting method. The reasons are: 1) reclamation law does not require the Bureau to recover interest on Federal funds invested in irrigation projects; 2) reclamation law limits the repayment responsibility of farmers to their "ability to pay"; 3) the Bureau supplies water under long-term contracts at fixed rates which are not adjusted upward to reflect the blending in of new higher-cost capacity; 4) the Bureau pays no property tax as would a private utility and 5) by periodically extending the assumed lifetime of the plant, the Bureau has reduced the amortization charged on past investments.

1. Interest subsidy: The Reclamation Act of 1902 required beneficiaries to repay the construction costs of Federal irrigation projects, but did not require payment of interest.[17] Congress has retained that interest subsidy ever since.

Some critics claim that an "opportunity" interest rate should be recovered on these Congressional appropriations, in the form of the prevailing aver-

age yield on long-term Treasury bonds at the time the debt is incurred.[18] The author would go even further and use the average rate paid by private utilities for new bond issues. In other words, the appropriate comparison should be between the Federal and private utility sectors, and not between the Federal utility sector and the Federal government sector in general. On that basis, the public would earn as great a return on funds invested in the Federal utility sector as it could earn from purchasing private-utility bonds. Over the 1948-81 period, the average yield on Aaa public utility bonds ranged from 2.6 to 15.6 percent.

2. *Ability to pay:* In a series of laws passed in 1914 and 1926, Congress extended the repayment period on irrigation projects from 10 to 40 years,[19] to help provide relief to hard-pressed farmers during recession periods. Then, in the Reclamation Act of 1936, Congress extended the repayment period to 50 years and introduced the "ability to pay" concept. Under that provision, farmers are required to repay only that portion of irrigation water costs they can afford. Their ability to pay (payment capacity) is measured as a residual equal to the net increase in revenues attributable to project water.

Table 1
Reconciliation of Realized and Imputed Unit Price for Central Valley Irrigation Water Under the (Historical) Average Cost Method
(Dollars per acre/foot)

Fiscal Year[1]	Unit Price As Realized[2]	Actual Operation & Maintenance[4]	Imputed Costs[3]		Imputed Interest-Subsidized Unit Price[5]	Imputed Interest	Imputed Full-Cost Unit Price[6]
			Taxes	Amortization			
1948–1960	2.83	2.40	4.43	3.08	9.91	3.96	13.87
1961	3.48	3.72	5.02	4.19	12.93	5.48	18.41
1962	1.93	1.78	2.37	2.02	6.17	2.59	8.76
1963	2.37	1.95	3.29	2.75	7.99	4.18	12.17
1964	3.32	1.12	4.56	3.87	9.55	5.96	15.51
1965	2.14	2.29	2.93	2.50	7.72	3.78	11.50
1966	3.33	3.89	4.24	3.47	11.60	5.16	16.76
1967	1.88	1.52	3.31	2.59	7.42	3.78	11.20
1968	7.87	.77	12.85	9.89	23.51	19.68	43.19
1969	2.47	3.22	5.78	4.20	13.20	8.21	21.41
1970	4.16	3.38	5.38	3.99	12.75	7.71	20.46
1971	3.47	3.22	5.37	3.76	12.35	7.20	19.55
1972	4.46	3.53	5.62	3.94	13.09	7.37	20.46
1973	3.29	2.57	4.51	3.40	10.48	6.84	17.32
1974	3.70	2.33	3.71	2.86	8.90	5.67	14.57
1975	4.20	2.79	4.32	3.20	10.31	7.03	17.34
1976	6.84	4.60	5.56	4.13	14.29	9.14	23.43
1977	5.41	9.83	17.35	13.11	40.29	29.73	70.02
1978	4.02	3.83	3.90	3.99	11.72	8.92	20.64
1979	5.83	3.84	2.69	3.48	10.01	7.62	17.63
1980	4.55	3.91	2.84	3.67	10.42	9.66	20.08
1981	5.09	3.99	3.26	4.21	11.46	12.31	23.77

[1] Fiscal year ending June 30 until 1976, and ending September 30 for later years.
[2] Derived for any given period by dividing revenues from water sales to irrigation districts, under 9-c water-service type contracts, as reported by total sales to those districts. The recovery of costs associated with CVP-financed distribution systems under 9-d repayment type contracts is excluded from this analysis. For derivation see Appendix B, Table 1.
[3] For derivation of the various imputed-cost components, see Appendix B, Table 2. Note that 1968 and 1977 were drought years, i.e., years when water deliveries fell considerably, raising capital costs per unit. Also, in 1968 there was a large new investment in irrigation capacity.
[4] As reported by the Bureau of Reclamation. The Bureau is required by law to recover operation and maintenance costs incurred in supplying irrigation water from the Central Valley Project. Yet in some years, the realized price did not even cover operation and maintenance costs.
[5] Excludes interest.
[6] Derived on the basis of the average-cost pricing method, with costs determined on the basis of the original (historical) value of plant and equipment, in keeping with traditional regulated utility practice. For derivation see Appendix B, Table 2 and technical notes.

More specifically, the Bureau determines payment capacity by comparing the estimated gross income from a representative small farm in a given irrigation district under two different sets of dry and irrigated farming conditions. From the increase in gross income attributable to project water, the Bureau subtracts the increase in non-water costs required to increase farm yields. These include operating (variable) and capital (fixed) costs, plus a projected rate of profit (return on investment) sufficient to encourage the farmer to increase farm yields.[20] The Bureau then charges the irrigation district the cost of service or ability-to-pay price, whichever is *lower*. If the cost of service, excluding interest, exceeds payment capacity, the remaining costs are recovered from the sale of electric power and municipal and industrial water. The Bureau thus can legally shift a substantial portion of the costs of supplying irrigation water to other beneficiaries of Federal water, beyond the costs shifted through the initial cost-allocation process.[21]

3. Fixed-rate contracts: In contracts negotiated before 1975, the Bureau established water rates for each service area on an individual basis. That is, it charged either an ability-to-pay price or a cost-of-service figure for a service area's share of total CVP costs, whichever was lower.[22] The Bureau also followed a standard practice of granting irrigation districts 40-year fixed rate contracts. But because of this practice, the price realized during the life of the contract failed to recover increased operational, maintenance and new-facility costs.

In 1975, the Bureau introduced several modifications in its pricing policies for *new* contracts. It began to utilize an average-cost pricing method, by dividing total system costs for a given period by the number of units expected to be sold. It also introduced adjustment clauses into its contracts to reflect changes in costs. But these provisions called for rate adjustments every five years to reflect only operation and maintenance costs, and every ten years to reflect added capital costs. Finally, the first adjust-

Table 2
Imputed Costs (Cumulative) as a Percent of Realized Unit Price[1]

Fiscal Year	Unit Price As Realized	Operation and Maintenance[2]	Including Taxes	Including Amortization	Including Interest
1948–1960	100.00	84.9	241.3	350.2	490.1
1961	100.00	107.0	251.4	371.7	529.4
1962	100.00	92.0	214.6	319.0	452.7
1963	100.00	81.9	220.8	336.5	512.5
1964	100.00	33.8	170.9	287.5	466.7
1965	100.00	107.0	244.2	361.0	538.1
1966	100.00	116.5	244.0	348.0	502.7
1967	100.00	80.7	257.0	395.2	596.5
1968	100.00	9.8	173.0	298.7	548.7
1969	100.00	130.1	363.9	533.8	865.9
1970	100.00	81.2	210.7	306.7	492.4
1971	100.00	92.6	247.2	355.6	562.7
1972	100.00	79.1	205.2	293.6	459.0
1973	100.00	78.2	215.2	318.6	526.5
1974	100.00	62.9	163.2	240.5	394.0
1975	100.00	66.4	169.0	245.1	412.5
1976	100.00	67.2	148.6	208.9	342.5
1977	100.00	181.6	502.3	744.4	1293.9
1978	100.00	95.4	192.4	291.8	513.9
1979	100.00	65.8	112.0	171.6	302.2
1980	100.00	86.1	148.5	229.0	441.4
1981	100.00	78.4	142.4	225.1	467.0

[1] The imputed unit costs were calculated under the (historical) average-cost accounting method. In this table, each imputed cost item is cumulatively added and expressed as a percent of realized price. For example, in 1981, the addition of imputed taxes and amortization to operation and maintenance costs equalled $11.46/acre-foot. This figure was 225 percent of the realized unit price, or 125 percent higher.

[2] In some years, the Bureau of Reclamation realized a price greater than the cost of operation and maintenance alone. The imputed price reflecting only that one cost would have been lower than the realized price.

ment was delayed until long after the initial delivery of water. In 1981, the Bureau introduced further reforms in this process, but the basic system still had the same drawbacks as before.

4. Taxes: The Bureau of Reclamation pays no local property taxes on lands occupied by the Central Valley Project. In contrast, private water utilities in California over the 1960-77 period paid annual property taxes averaging about 2.6 percent of their total plant investment. Their property tax burden then dropped to an average of 1.7 percent of capital investment during the 1978-81 period as a result of the passage of Proposition 13.

5. Amortization: The Bureau is required by law to repay each dollar borrowed for investment in Federal irrigation facilities within 50 years after the first delivery of water, but it has not repaid such borrowings on a systematic basis. With its low rates, in fact, the agency frequently has failed to recover even its annual operation and maintenance costs, as required by law. And with its inadequate revenues, the Bureau actually has extended the repayment life for *all* CVP irrigation facilities each time new facilities have been added to the system.[23]

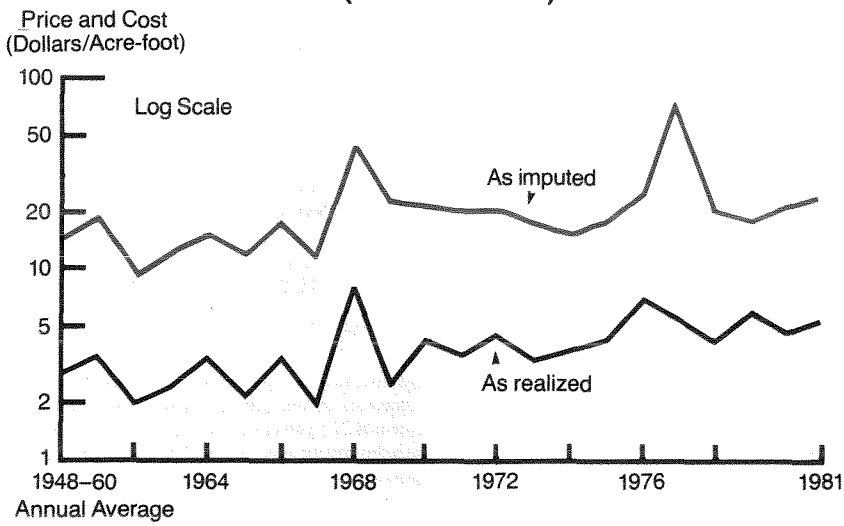
The author has reestimated CVP irrigation costs for the 1949-81 period on the basis of the methodology employed by privately-owned utilities.[24] The adjustments for the "full cost" unit price, calculated under the historical average cost methodology, included the addition of an imputed property tax and interest return on invested capital, as well as the recalculation of amortization of Congressional appropriations for the irrigation function. All these costs were determined on the basis of capital investments valued at original prices. The author adopted Bureau estimates of operation and maintenance costs, and of the irrigation share of total CVP investment (Tables 1 and 2).

With adjustments made for imputed property taxes, amortization and interest costs, the Central Valley Project actually incurred an average unit cost of at least $23.77 per acre-foot of irrigation water in 1981, calculated on an historical accounting basis, instead of the $5.09 per acre-foot actually realized (Table 1). Had rates been raised to reflect this full average cost, the price for CVP irrigation water in 1981 would have been 367 percent higher than the amount actually charged (Table 2).

In any given year, the difference between the imputed historic full-cost unit price and the price actually realized represents the total subsidy paid by the general taxpayer and electrical power users for each acre-foot of irrigation water delivered. (In this case, we used cost figures derived from plant and equipment valued at original purchase prices.) Multiplying this subsidy by total acre-feet delivered, we

Chart 2

Central Valley Project Irrigation Water Costs Under the Historical Average Cost Method, 1948–81 (Current Dollars)



obtain a total annual subsidy of $77 million for 1981, and of $966 million cumulative for the entire 1948-81 period (Table 3).

The interest subsidy is by far the largest single contributor to the overall subsidy. In 1981, the subsidy amounted to $51 million, or 66 percent of the total subsidy. Over the entire 1948-81 period it amounted to about $484 million or 50 percent of the total subsidy.

Both the average realized and imputed price rose over the post-World War II period (Table 4 and Chart 2). Because of the use of the historical-cost approach, both realized and imputed prices (especially the latter) trended downward over time in constant dollars however (Table 4 and Chart 3). Nevertheless, had the Bureau charged the higher imputed price rather than the realized price, farmers would have been encouraged to reduce their consumption of irrigation water. Instead, irrigators increased their annual deliveries of water from an annual average of 0.78 million acre-feet during the 1948-60 period to 4.12 million acre-feet by 1981 (Appendix B, Table 1).

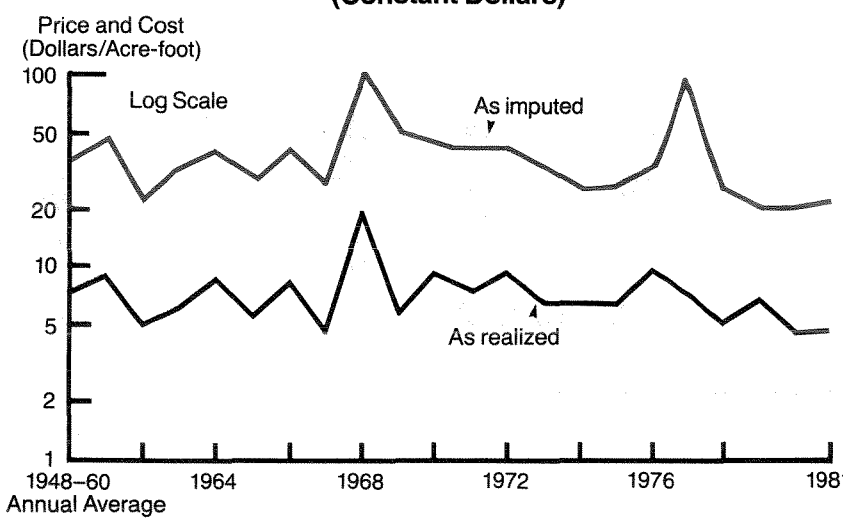
The average-cost figure of $24/acre-foot, as calculated by the traditional private-utility accounting method, is still only a fraction of the estimated long-run incremental cost of $324/acre-foot. This does not necessarily mean that the Central Valley

Table 3
Estimated Annual Subsidy to Users of Central Valley Project Irrigation Water (Historical Accounting Method)

	Subsidy ($ Millions)		
Fiscal Year	Interest[1]	Other[2]	Total[3]
Total, 1948–1960	36.96	66.24	103.20
1961	5.39	9.28	14.67
1962	5.28	8.64	13.92
1963	9.03	12.13	21.16
1964	9.79	10.24	20.03
1965	9.86	14.53	24.39
1966	9.72	15.58	25.30
1967	9.55	14.01	23.56
1968	19.70	15.66	35.36
1969	19.42	25.37	44.79
1970	19.49	21.68	41.17
1971	19.41	23.95	43.36
1972	19.06	22.31	41.37
1973	22.63	23.79	46.42
1974	22.62	20.69	43.31
1975	27.87	24.16	52.03
1976	28.96	23.61	52.57
1977	31.43	36.86	68.29
1978	31.18	26.93	58.11
1979	30.80	16.88	47.68
1980	42.32	25.71	68.03
1981	50.69	26.23	76.92
Total, 1948–1981	481.16	484.48	965.64

[1] Derived by multiplying the imputed interest per acre-foot by the number of acre-feet sold.
[2] Derived by subtracting the realized price from the interest-subsidized imputed price and multiplying by the total acre-feet of water sold.
[3] Derived by subtracting the realized price from the full-cost imputed price (historical accounting basis) and multiplying by the total acre-feet of water sold.
Source: Computed by the author.

Chart 3
Central Valley Project Irrigation Water Costs Under the Historical Average Cost Method, 1948–81 (Constant Dollars)



Project faces decreasing returns to scale and increasing long-run average costs. Those theoretical concepts depict cost and output alternatives facing a firm (or agency) at a moment of time under the assumption of constant technology and factor prices (Chart 1-B). A firm would be operating in an output range associated with increasing long-run average costs if expansion to a larger scale plant (or system) built from scratch today entailed higher average costs than a smaller plant built today. In that case, long-run incremental cost would be above average cost, with both determined on the basis of plant and equipment valued at today's prices. This contrasts with the traditional private-utility practice of determining average cost. Under that method, long-run incremental cost would be above average cost simply because of the failure of the utility industry's average-cost methodology to reflect the effects of inflation on equipment prices.

To determine whether the CVP may in fact be facing increasing long-run average costs due to the exhaustion of economies of scale, we have estimated the average cost of irrigation water with capital costs valued at current replacement prices rather than historical prices. Under the replacement accounting method, we have valued the entire plant in 1981 dollars, and have then compared the incremental cost of water from new plant with the average cost from the existing system, both valued at today's prices (Table 5).

The aggregate value of annual plant investment in 1981 dollars, $1.7 billion, represents the replacement value of the entire system. After calculating that value, we next calculated the average or unit cost of irrigation water from this sytem by dividing the total annual cost (capital, operation and maintenance, and taxes) by the number of acre-feet delivered.[25] This procedure yielded a $48/acre-foot average replacement cost for irrigation water, and a

Table 4
Constant Dollar Realized and Imputed Unit Prices
(Dollars per acre-foot)

	Current Dollar Unit Price				Constant Dollar Unit Price[3]		
Fiscal Year	Unit Price As Realized	Imputed Interest-Subsidized Unit Price	Imputed Full-Cost Unit Price[1]	Producer Price Index[2]	Unit Price As Realized	Imputed Interest-Subsidized Unit Price	Imputed Full-Cost Unit Price[1]
1948–1960	2.83	9.91	13.87	38.82	7.28	25.53	35.72
1961	3.48	12.93	18.41	39.18	8.88	32.99	46.99
1962	1.93	6.17	8.76	39.08	4.95	15.79	22.41
1963	2.37	7.99	12.17	39.15	6.07	20.41	31.09
1964	3.32	9.55	15.51	39.13	8.49	24.42	39.63
1965	2.14	7.72	11.50	39.46	5.42	19.56	29.15
1966	3.33	11.60	16.76	40.55	8.22	28.62	41.33
1967	1.88	7.42	11.20	41.44	4.53	17.91	27.03
1968	7.87	23.51	43.19	42.23	18.64	55.67	102.28
1969	2.47	13.20	21.41	43.56	5.68	30.31	49.16
1970	4.16	12.75	20.46	45.35	9.17	28.11	45.13
1971	3.47	12.35	19.55	46.67	7.44	26.46	41.88
1972	4.46	13.09	20.46	48.02	9.29	27.26	42.62
1973	3.29	10.48	17.32	50.60	6.50	20.71	34.23
1974	3.70	8.90	14.57	56.82	6.51	15.66	25.65
1975	4.20	10.31	17.34	65.41	6.43	15.76	26.52
1976	6.84	14.29	23.43	70.20	9.74	20.35	33.37
1977	5.41	40.29	70.02	74.44	7.27	54.12	94.06
1978	4.02	11.72	20.64	79.96	5.02	14.66	25.81
1979	5.83	10.01	17.63	88.04	6.63	11.37	20.02
1980	4.55	10.42	20.08	100.00	4.55	10.42	20.08
1981	5.09	11.46	23.77	109.23	4.66	10.49	21.76

[1] Calculated on the basis of the historical average-cost accounting method.

[2] Producer price index, all finished goods, 1980=100.

[3] Dollars per acre/foot in constant dollars; derived by dividing current dollar prices by producer price index.

total 1981 subsidy of nearly $175 million.[26] The difference between this figure and the much higher incremental cost suggests that the Central Valley Project is operating in an output range of increasing long-run average cost, reflecting decreasing returns to scale.

Economists would argue that, for efficient allocation of resources, the Bureau of Reclamation should price all CVP irrigation water on the basis of long-run incremental cost, estimated here at about $324/acre-foot. A second-best option would be for the Bureau to price water at least on the basis of the estimated $48/acre-foot replacement average cost. Only that approach would permit recovery of the true cost to society of the resources tied up in supplying water. Recovery of the estimated $24/acre-foot historical average cost, although an improvement over current Bureau practice, would not recover this "true" average cost.

IV. Impact of Higher Water Prices

Would higher prices for CVP irrigation water lead to a reduction in the quantity demanded? Some analysts argue in the negative, because of agriculture's essential need for water. They maintain that a given amount of water is required to produce a given yield for any crop, that the amount is dictated by soil and climatic conditions, and that it is invariant to higher water prices. Thus, because of the limited technical substitutability between water and other productive inputs,[27] demand for irrigation water is price inelastic, i.e., relatively unresponsive to a higher (or lower) price.[28] Proponents of this

Table 5
Imputed Unit Price of Central Valley Irrigation Water, Replacement Average Cost Method

Fiscal Year	Investment in Irrigation Plant[1] ($ Millions)	Conversion Factor[2]	Investment in Irrigation Plant ($ Millions, 1981 Dollars)
1948–1960	178.74	2.73	487.96
1961	26.73	2.30	61.47
1962	.41	2.30	.94
1963	90.82	2.29	207.98
1964	21.83	2.28	49.77
1965	6.62	2.26	14.96
1966	1.66	2.22	3.69
1967	1.19	2.16	2.57
1968	166.96	2.09	348.95
1969	2.15	2.03	4.36
1970	6.17	1.96	12.09
1971	4.83	1.88	9.08
1972	1.48	1.82	2.69
1973	53.12	1.79	95.08
1974	6.13	1.67	10.24
1975	64.31	1.44	92.61
1976	20.48	1.36	27.85
1977	38.69	1.30	50.30
1978	5.89	1.22	7.16
1979	4.07	1.14	4.64
1980	100.06	1.07	107.06
1981	64.24	1.00	64.24
	866.57		1,665.69

Replacement Cost Per Acre-Foot (1981 Dollars) = (Capital Cost[3] + Operation & Maintenance Cost + Property Taxes)/Acre-Feet of Irrigation Water Delivered
= ($166.57 m. + $16.45 m. + $13.43 m.)/4.12 m.
= $47.69

[1] Excluding distribution-system investment from canalside to farmgate under CVP, 9-c water service contracts.

[2] Calculated by dividing the 1981 implicit price deflator for producer durable equipment by the actual deflator for each year.

[3] Capital cost of the entire project (1981 dollars) multiplied by a 10-percent real interest rate.

Source: Annual Investment Data: U.S. Bureau of Reclamation, Mid-Pacific Regional Office, Sacramento. Computation by author.

thesis consequently maintain that resorting to higher prices to allocate available supplies would be ineffective.

Examination of the literature shows that the elasticity of demand for irrigation water varies according to the price range being considered.[29] That is, the responsiveness of quantity demanded to a given percentage change in price varies along a given demand schedule. Early studies covering the 1950's and early 1960's supported the argument for inelastic demand.[30]

But those results were biased by the absence of a wide range of observable prices over which to test the demand responsiveness. More recent studies, based either on observed water-use and price combinations or on linear-programming estimation techniques replicating the cost-minimizing behavior of California farmers, show that water demand is price elastic at a price of over $20 per acre-foot. One of the latest studies, which utilizes an even more advanced programming model of Central Valley agriculture, shows an elasticity coefficient of −1.5 for a price range of $25-35/acre-foot.[31] For prices above $35/acre-foot, the elasticity coefficient then drops to −0.5.[32]

In summary, at water prices prevailing currently, agricultural water demand is not very price responsive, but it should respond substantially at higher prices. Indeed, given a demand of 3.8 million acre-feet at a price of $25/acre-foot, and given an elasticity coefficient of −1.5, a ten-percent price increase would reduce the quantity demanded by 570,000 acre-feet. This would be sufficient to eliminate the need for the proposed Auburn-Folsom project.

To maximize profit from any given crop on a given parcel of land, a farmer will purchase and apply additional units of water until its marginal revenue product equals its price.[33] The "marginal revenue product" refers to the net addition to total revenue resulting from the last increment of water, after subtraction of all other non-water operating (variable) and capital (fixed) costs.[34]

Farmers might react in three different ways to sharply higher prices of CVP irrigation water.[35]

Table 6
Indicators of Impact of Higher Water Price on the California Agricultural Sector

Leading Crops (1980)[1]	Value of Production ($ Thousands)	California as Percent of Total Domestic Production	Water Cost as Percent of Total Production Cost[2]
Cotton	1,389,342	28.2	2.72
Grapes	1,215,585	91.6	1.49
Hay	723,316	5.9	4.81
Tomatoes	490,310	79.2	0.78
Almonds	473,340	95.0	1.29
Rice	423,612	24.3	1.55
Lettuce	382,563	74.4	0.96
Wheat	357,945	3.6	4.82
Oranges	224,548	18.9	2.72
Strawberries	201,266	75.3	4.31
Sugar Beets	182,930	24.8	2.76
Peaches	176,438	66.4	0.34
Walnuts	168,300	95.0	1.39
Potatoes	157,590	6.2	2.26
Corn, for Grain	151,268	0.5	3.24

[1] Crop ranking based on value of production, 1980.

[2] Water cost excludes cost of application. Total production costs include all variable and fixed cultural and harvest costs (including water application), imputed rent on land and return to management. The latter two returns are actually part of profits and should not be included in costs, but were included here because of lack of relevant data.

Source: California Department of Food and Agriculture, *California Agriculture Statistical Review*, 1980. Giannini Foundation of Agriculture Economics, *Agricultural Water Use and Costs in California*, Information Series 80-2, Bulletin 1896.

First, if a given crop still represents the most profitable opportunity on a given parcel of land, the farmer might continue to grow the same crop but cut back water usage to the point where its marginal revenue product equals the higher price. This cutback would be accompanied by some reduction in crop output or introduction of more efficient irrigation methods. Alternatively, the farmer might shift to another crop that yields a higher net return per acre-foot of water, which could mean a shift away from low-valued field crops to higher-valued specialty crops. Or again, the farmer might simply withdraw land from irrigation, if irrigated crops fail to yield a positive profit or if they yield less profit than dry-land farming. In summary, if the price of water is raised, farmers may react by reducing output, changing the input mix (for example, using more capital intensive irrigation methods), and/or shifting cropping patterns.

The elasticity of demand for irrigation water varies significantly, depending on type of crop. Price elasticity increases, in general, the greater is the substitutability of other factor inputs for water, and the greater is the water share of total production costs. But elasticity varies inversely with the ability of farmers to pass on higher water costs to consumers in the form of higher food and fiber prices.

For all 15 of California's major crops, water currently comprises a small percentage of total production costs (Table 6). This reflects the low level of current water prices, and suggests why the price elasticity of demand at current ranges is generally low. Nevertheless, the data also show considerable variability in the importance of water costs among various products.

For certain field crops—especially, hay, wheat and corn—water costs comprise a relatively large proportion of total production costs. This factor alone suggests that any given increase in water prices would affect those products significantly. On the other hand, water comprises a relatively small percentage of total costs for tomatoes, peaches, lettuce, grapes and nuts. In reaction to higher water prices, farmers thus might tend to switch away from field crops to specialty crops such as those.

California farmers also account for a relatively small share of total domestic production of field crops. For corn, wheat and hay, for example, their shares of the national market amount to only 0.5, 3.6 and 5.9 percent, respectively (Table 6). This suggests a relatively elastic demand for water, due to farmers' inability to influence the price of the final product and thereby pass on higher water costs to consumers.

V. Summary and Conclusions

If efficiency of resource allocation were the only criterion, the Bureau of Reclamation would price all irrigation water from the Central Valley Project on the basis of long-run incremental cost—the cost of delivering an additional acre-foot of water from the next scheduled block of new capacity. This approach would be the most efficient because it would make customers aware of the cost of the resources required to bring them additional water. But this approach also would return huge annual profits to the Bureau of Reclamation or to the U.S. Treasury. This is because long-run incremental cost is far higher than the system's average cost of irrigation water, determined as economists would measure average cost on the basis of replacement value of plant. In addition, a switchover to strict incremental cost pricing could cause a major shrinkage in both water usage and the size of California's agricultural sector.

The second-best option from an efficiency standpoint would be pricing of irrigation water on the basis of average cost, determined on a replacement cost basis. This method would at least recover the cost of the resources already embodied in the system, valued at today's prices. It would also enable the Bureau to generate sufficient revenue to perpetuate the existing capacity. A case also could be made for the Bureau to include all cost elements that would be incurred by a debt-financed private investor-owned utility—annual operation and maintenance costs, plus interest expense and property taxes (opportunity-cost basis), plus steady amortization of capital borrowed from the U.S. Treasury.

Pricing on this basis would at least make customers aware of the resources already expended in the system, and would provide farmers with a strong incentive to reduce water consumption. In fact, empirical studies suggest that agricultural demand is elastic above a retail price of around $20 per acre-foot.

When Congress passed the Reclamation Act of 1902, it clearly intended beneficiaries of Federal water projects to repay their original construction costs as well as operating costs. It provided a subsidy, however, by not requiring repayment of interest on capital invested, and later increased that subsidy through the ability to pay concept and other measures. In some years indeed, irrigation water rates have even failed to recover operation and maintenance costs, despite the legal requirement to do so. Moreoever, had the Bureau priced irrigation water to reflect all costs measured on a replacement accounting basis, the average realized price by 1981 would have been nearly ten times as high as the price actually realized.

By charging highly subsidized rates for Federal irrigation water, the Bureau has spurred the growth of consumption beyond the growth that would otherwise have occurred had it priced water to reflect the true average cost of service. Had it priced water on the basis of long-run incremental cost, the amount of resources devoted to the construction of Federal irrigation projects in California would have been still smaller. Instead, the consumption of water and the size of the Federal irrigation system have expanded beyond the point where the net return to the last unit of water, in terms of agricultural revenue, is equal to the cost of supplying that extra unit. This suggests that more resources have been devoted to the construction of the Federal irrigation system in California than are warranted by agricultural benefits.

The social objectives that justified the earlier granting of subsidies—namely, the development of the arid West—may no longer be appropriate. Today's environment is dominated by intense competition for water among competing users—households, energy producers, and farmers. To some observers, the correct policy issue remains the perennial one—what size farms should get the subsidy? Should the 160-acre limit be enforced or expanded? Others would argue, however, that there should be no water subsidy at all. In this view, the focus should be on pricing reform, to improve the efficiency of water usage through the use of more efficient irrigation methods and shifts to less water intensive crops. Indeed, Congress logically should give more attention to the role of the price mechanism in reducing the projected growth of irrigation water demand, not only in California but throughout the West.

Appendix A: Calculation of Incremental Cost of Irrigation Water, Proposed Auburn - Folsom South Unit

The following technical note describes the methodology and assumptions employed by the author to estimate the incremental cost of irrigation water from the proposed Auburn-Folsom South Unit. The incremental cost of irrigation water from this project includes the capital costs (depreciation and interest), taxes, and operation and maintenance expenses to be recovered over the project's life. Each of these costs is expressed as a stream over time and then discounted to determine present value. (However, the present value of the capital costs can be shown to be equal to the initial construction costs). The *annual* cost is then equal to the real interest rate multiplied by this present value. We add these annual costs and then divide by the expected average annual output in acre-feet.

The real interest rate is used to discount capital costs. Taxes and operation and maintenace costs are discounted by the nominal interest rate, because they are assumed to reflect inflation in the future. We assumed both the annual property tax and depreciation rates to be 2 percent of plant value, based on the 1981 tax rate and on a 50-year service life for plant and equipment. We used a real discount rate of 10 percent and a nominal interest rate of 16 percent as the discount factors.

Variable List:

r	= Real Interest Rate	k	= Initial Capital Outlay
i	= Nominal Interest Rate	K	= Stream of Capital Costs
Π	= Inflation Rate	om	= Annual Operation & Maintenance Costs
δ	= Depreciation Rate	OM	= Stream of Operation & Maintenance Costs
t	= Tax Rate	T	= Stream of Tax Costs
p	= Annual Water Production	C_I	= Incremental Cost

Each of the cost streams can be expressed as follows:

$$K = (r+\delta)k, (r+\delta)k(1-\delta),(r+\delta)k(1-\delta)^2,(r+\delta)k(1-\delta)^3 \ , \ . \ . \ .$$

$$T = tK+tK(1-\delta),tK(1-\delta)^2,tK(1-\delta)^3, \ . \ . \ .$$

$$OM = om(1+\Pi),om(1+\Pi)^2,om(1+\Pi)^3, \ . \ . \ .$$

Taking the present value of each cost stream:

$$PV(K) = \frac{(r+\delta)k}{1+r} + \frac{(r+\delta)k(1-\delta)}{(1+r)^2} + \frac{(r+\delta)k(1-\delta)^2}{(1+r)^3} + \frac{(r+\delta)k(1-\delta)^3}{(1+r)^4} + \ . \ . = k$$

$$PV(T) = \frac{tk}{(1+i)} + \frac{tk(1-\delta)}{(1+i)^2} + \frac{tk(1-\delta)^2}{(1+i)^3} + \frac{tk(1-\delta)^3}{(1+i)^4} + \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . = \frac{tk}{i+\delta}$$

$$PV(OM) = \frac{om}{(1+i)} + \frac{om(1+\Pi)}{(1+i)^2} + \frac{om(1+\Pi)^2}{(1+i)^3} + \frac{om(1+\Pi)^3}{(1+i)^4} + \ . \ . \ . \ . \ . \ . \ . = \frac{om}{i-\Pi} = \frac{om}{r}$$

Multiplying the present value of each cost stream by the real rate of interest and dividing by production of 440,000 acre-feet yields an incremental cost of $324/Acre Foot of Water

C_I = (Real Interest Rate (Capital Cost + Taxes + Operation and Maintenance))/Annual Water Production

$$C_I = (r(k+\frac{tk}{i+\delta}+\frac{om}{r}))/p$$

$$C_I = (.10(1217\times10^6+\frac{24.34\times10^6}{.16+.02}+\frac{7.6\times10^6}{.10}))/440x10^3$$

C_I = $324/Acre-Foot

Appendix B: Adjustment of Central Valley Project's Realized Average Price (Private Utility Basis)

The following technical note describes the methodology used by the author to adjust the Central Valley Project's realized average price for irrigation water delivered at canalside for the 1948-81 period, to include the major cost items and historical accounting methodology employed by private-owned water utilities. The realized and imputed prices appear in Appendix B, Tables 1 and 2 respectively.

Taxes: Annual property-tax payments were imputed by applying the average property-tax rate for two privately-owned California water utilities in any given year to the Central Valley Project's total irrigation plant in service as of that year, valued on an historical cost basis.

Amortization: Amortization costs were imputed annually for the 1948-81 period by developing a straight-line depreciation schedule. Depreciation was calculated by applying the average life of service of the equipment to the total value of the plant in service, measured on an historical (original) cost basis. This amortization procedure follows that used by most private utilities. The average service life of the CVP's total irrigation plant is estimated to be 75 years. For any given year, depreciation thus was calculated as 1/75th of the total value of irrigation plant in service. Since depreciation is calculated on a 75-year basis, compared with the Bureau responsibility to recover borrowings within a 50-year period, depreciation charges thus calculated would fall short of meeting the CVP's payment responsibilities. A reconciliation charge therefore was calculated, representing the difference between 1/50th and 1/75th of the value of the plant in service.

Interest: Interest payments on an opportunity-cost basis were imputed for any given year n by the formula:

$$P_n = \sum_{y=1948}^{n} i_y A_y$$

where: P_n = total interest payment in year n
i_y = Moody's Aaa interest rate on public (private investor) utility issues in year y
A_y = unamortized portion of appropriations received in year y as of year n

This formula simply states that total interest payments in any given year P_n, equal the sum of all interest payments on outstanding CVP debt in that year. In other words, total interest payments equal new debt (for irrigation plant) times the prevailing interest rate, plus any unamortized old debt multiplied by the rate(s) in effect when the debt was incurred. The first debt was assumed to be incurred in 1948, the earliest date for which data were available. Each increment in debt was amortized on a straight-line basis by 1/50 each year after it was incurred, in line with the 50-year payback period specified by law. Note that Moody's Investor Service refers to private investor-owned utilities as public utilities, using that term in a general sense.

A consistent series showing annual Congressional appropriations to the CVP was not available. A proxy for "new debt" was developed by taking the total value of the plant in service, i.e., the capital stock, and calculating the annual change, i.e., the new investment added each year. That proxy was used under the assumption that borrowing was for capital investment.

Appendix B, Table 1
Average Price for Central Valley Irrigation Water, As Realized

Fiscal Year	Revenues[2]	Water Sales[3]	Realized Unit Price[4]
1948–1960[1]	2.20	.78	2.83
1961	3.42	.98	3.48
1962	3.95	2.04	1.93
1963	5.13	2.16	2.37
1964	5.46	1.64	3.32
1965	5.57	2.60	2.14
1966	6.28	1.88	3.33
1967	4.75	2.53	1.88
1968	7.88	1.00	7.87
1969	5.85	2.36	2.47
1970	10.49	2.52	4.16
1971	9.37	2.70	3.47
1972	11.52	2.58	4.46
1973	10.89	3.31	3.29
1974	14.73	3.98	3.70
1975	16.65	3.96	4.20
1976	21.68	3.17	6.84
1977	5.72	1.06	5.41
1978	14.04	3.50	4.02
1979	23.58	4.04	5.83
1980	19.93	4.38	4.55
1981	20.99	4.12	5.10

[1] Annual average computed from cumulative totals for the 12-year period 1948–1960.

[2] Millions of dollars. Revenues from irrigation sales under 9-c water-service contracts as reported by the U.S. Bureau of Reclamation.

[3] Millions of acre-feet.

[4] Dollars per acre-foot. Derived by dividing revenues from water sales to irrigation districts by acre-feet of water sold.

Source: Revenues and sales data from U.S. Bureau of Reclamation, Mid-Pacific Regional Office. Realized unit price derived from that data by author as described in footnote 4.

Appendix B, Table 2
Average Price for Central Valley Irrigation Water, As Imputed on a Private-Utility Cost Basis[1]
(Cost data in millions of dollars)

Fiscal Year	Variable Costs	Fixed Costs							
	Operation Maintenance	Property Tax[2]	Depreciation[3]	Reconciliation Depreciation & Amortization[4]	Total Costs Excluding Interest	Interest[5]	Full Costs[6]	Interest-Subsidized Unit Price	Full-Cost Unit Price
								(Dollars/acre-foot)	
1948–1960	1.87	3.45	1.60	.80	7.72	3.08	10.80	9.91	13.87
1961	3.65	4.93	2.74	1.37	12.69	5.39	18.08	12.93	18.41
1962	3.63	4.84	2.75	1.37	12.59	5.28	17.86	6.17	8.76
1963	4.20	7.12	3.96	1.98	17.26	9.03	26.28	7.99	12.17
1964	1.85	7.49	4.25	2.12	15.70	9.79	25.49	9.55	15.51
1965	5.96	7.64	4.34	2.17	20.10	9.86	29.96	7.72	11.50
1966	7.32	8.01	4.36	2.18	21.87	9.72	31.59	11.60	16.76
1967	3.83	8.36	4.37	2.19	18.76	9.55	28.31	7.42	11.20
1968	.77	12.87	6.60	3.30	23.54	19.71	43.24	23.51	43.19
1969	7.61	13.67	6.63	3.31	31.22	19.42	50.64	13.20	21.41
1970	8.52	13.59	6.71	3.36	32.17	19.49	41.66	12.75	20.46
1971	8.68	14.48	6.77	3.39	33.32	19.41	52.73	12.35	19.55
1972	9.12	14.52	6.79	3.40	33.83	19.06	52.89	13.09	20.46
1973	8.51	14.91	7.50	3.75	34.68	22.63	57.31	10.48	17.32
1974	9.26	14.79	7.58	3.79	35.43	22.62	58.05	8.90	14.57
1975	11.05	17.09	8.44	4.22	40.81	27.87	68.68	10.31	17.34
1976	14.56	17.65	8.72	4.36	45.28	28.97	74.25	14.29	23.43
1977	10.39	18.35	9.23	4.62	42.58	31.43	74.01	40.29	70.02
1978	13.40	13.61	9.31	4.65	40.97	31.18	72.15	11.72	20.64
1979	15.53	10.89	9.36	4.68	40.46	30.80	71.26	10.01	17.63
1980	17.15	12.44	10.70	5.35	45.63	42.32	87.95	10.42	20.08
1981	16.45	13.43	11.55	5.78	47.21	50.69	97.91	11.46	23.77

[1] These costs represent the author's interpretation of the amounts that should have been recovered directly by the U.S. Bureau of Reclamation in the form of revenues for water delivered to irrigation districts if the Central Valley Project had been operating as a private investor-owned utility, using the historical average-cost accounting method to determine unit price. The costs consist of the variable costs as actually measured and reported by that agency, plus computations of fixed costs to include imputed property-tax payments, interest charges reflecting the opportunity cost of capital, and a straight-line depreciation and amortization charge to repay all outstanding debt on a consistent and continuous basis.

[2] Derived by applying an estimated California property-tax rate for private investor-owned water utilities (property taxes paid as a percentage of total plant in service) to the Central Valley Project's total irrigation plant (excluding CVP-financed distribution facilities from irrigation districts to the farm gate), valued on an historical-cost basis.

[3] Private water utilities recover their long-term borrowings for capital investment through their depreciation charges. The average service life of the Central Valley Project's total irrigation plant is estimated to be 75 years. Straight-line depreciation has been used so that depreciation is 1/75th of the total value of the plant in service, measured on an historical-cost basis.

[4] Depreciation is calculated on an average 75-year basis, whereas the Central Valley Project is required to amortize (pay back) its borrowings within a maximum of 50 years. The "reconciliation" charges represent the difference between 1/50th and 1/75th of the value of irrigation plant in service.

[5] Derived on an "opportunity cost" basis; total interest payments in each year equal the product of new debt and the current Moody's average Aaa interest rate for public (private investor-owned) utilities, plus the product of old amortized debt and the interest rate in effect when the debt was incurred. Debt is reduced (amortized) on a straight-line basis by 1/50th each year after it is incurred. Total value of irrigation plant in service was used as a proxy in determining outstanding debt, under the assumption that borrowing was for capital investment.

[6] Purchasers of Central Valley Project irrigation water have been allowed an interest subsidy by law (i.e., the Bureau of Reclamation is not required to recover through its rates any interest on public funds appropriated by Congress for Central Valley irrigation projects). Therefore, we calculate a price without interest (i.e., an interest-subsidized imputed price) in addition to the full-cost unit price. Prices are in dollars per acre-foot.

Source: For data pertaining to the private-utility sector: Moody's Investors Services, *Moody's Public Utilities Manual*. Average property-tax rates per year derived from data for California Water Service Company and Southern California Water Company. For reported data pertaining to the Central Valley Project, U.S. Bureau of Reclamation, Mid Pacific regional office, Sacramento.

FOOTNOTES

1. For the most comprehensive recent assessment of the long-term outlook for U.S. and California water supplies and demands see, U.S. Water Resources Council, **The Nation's Water Resources 1975–2000** (Washington, D.C.: U.S. Water Resources Council, 1978). See especially, Volume 3: Analytical Data Summary and Volume 4: California Region, pp. 17–30. Also, **Governor's Commission to Review California Water Rights Law, Final Report** (Sacramento, December 1978).

2. Southern California refers to the area south of the Tehachapi Mountain Range, the natural barrier that sets the south apart from the rest of the state. An acre-foot of water is the amount of water required to cover one acre one foot deep. The measure is equal to 325,851 gallons of water. California's loss of Colorado River water will occur as a result of a 1963 Supreme Court decision declaring that Arizona is entitled to over one-half of the Colorado River that has been coming to California. The diversion will take place as soon as the Central Arizona Project is completed, making the re-routing possible.

3. The literature on the pricing of water is relatively sparse compared with that for other important resources such as energy and non-fuel minerals. Important contributions include: Jack Hirshleifer, James C. De Haven and Jerome W. Milliman, **Water Supply Economics, Technology and Policy** (Chicago: The University of Chicago Press, 1960);

Joseph Bain, Richard Caves and Julius Margolis, **Northern California's Water Industry** (Baltimore: Resources for the Future, 1966); Charles E. Phelps, Morlie H. Graubard, David L. Jacquette et. al., **Efficient Water Use in California** (Santa Monica: Rand Corporation, November 1978); and Donald Erlenkotter, Michael Haneman, Richard E. Howitt and Henry J. Vaux, Jr., "The Economics of Water Development and Use in California," **California Water Planning and Policy, Selected Issues** (Berkeley: University of California, June 1979), pp. 169–207.

4. For a discussion of the social objectives embodied in early reclamation law, see E. Phillip Le Veen, "Reclamation Policy at the Crossroads," **Public Affairs Report,** Vol. 19 (Berkeley: Institute of Governmental Studies, October 1978). Also, Alan R. Dickerman, George E. Radosevich and Kenneth C. Nobe, **Foundation of Federal Reclamation Policies; an Historical Review of Changing Goals and Objectives** (Fort Collins: Colorado State University, 1968); William E. Warne, **The Bureau of Reclamation** (New York: Praeger Publishers, 1973).

5. For a description of the average-cost pricing methodology followed by private investor-owned water utilities in establishing the level of rates, see American Water Works Association, **Water Rates Manual** (Denver: American Water Works Association, 1972).

6. For private investor-owned utilities, the return on invested capital consists of three components: 1) interest payments on bonded indebtedness, 2) dividends on preferred stock, and 3) a return to common-equity holders, a residual amount which becomes available to these owners only after all other legitimate claims of the company have been settled. The first two are specified on the bond indenture and the preferred-stock certificates. At present, Federal reclamation law does not require the Bureau of Reclamation to recover any return on long-term borrowings for investment in the Central Valley Project irrigation system. We argue in this article, however, that reclamation law should be changed to require the return of interest to the U.S. Treasury for funds appropriated for such investment, and that the rate of interest should be determined on an opportunity-cost principle.

7. For proof that marginal-cost pricing of all goods and services leads to optimum welfare, see Edward Berlin, Charles J. Cicchetti and William J. Gillen, **Perspective on Power, A Study of the Regulation and Pricing of Electric Power,** A Report to the Energy Policy Project of the Ford Foundation (Cambridge: Ballinger Publishing Company, 1975), pp. 127–130.

8. In a perfect-competition model, there is one situation in which short and long-run marginal (incremental) costs are equal—that is, in long-run competitive equilibrium. In this situation, plant capacity has been adjusted to its optimum size for achieving a given level of output. It is assumed that a firm starts from scratch in planning its optimal-size production facility. In reality, this optimum is never realized. Instead, firms operate with plants of various ages, and must make decisions with regard to adding new capacity, either for replacement or growth purposes. Pricing on the basis of short-run costs would not necessarily recover the capital costs associated with this new plant.

Marginal cost, strictly speaking, refers to the additional cost of supplying a single, infinitesimally small additional amount. Incremental cost refers to the average additional cost of a larger finite addition to production. Since rate changes are relatively infrequent, additions to output where costs must be recovered are of an incremental rather than marginal magnitude.

9. The cost curves for an individual firm are drawn under the assumption that the firm has no influence on the prices of the factors of production it uses. Internal economies therefore are those enjoyed by a firm apart from any change in factor prices. When an industry as a whole expands its output, the prices of factor inputs may be affected. External economies affect the slope of the industry supply curve.

10. This chart, to emphasize, depicts the economic model of decreasing long-run average costs that originally characterized the operations of individual utility firms and led regulators to prescribe average rather than incremental-cost pricing. The cost schedules shown in Chart 1A depict the behavior of long-run average and incremental costs at a given point in time. Capital costs—i.e., amortization and interest—are determined on the basis of the current cost of plant and equipment valued at the time of the planning decision. This conforms with the economist's definition of average and incremental cost. Although this model provided the rationale for pricing on the basis of average cost, regulatory commissions have prescribed the historical accounting method for valuing plant and equipment. This method differs from the economic model in that average costs are determined on the basis of plant valued at original cost. As we shall see, most utility commissions continue to prescribe average-cost pricing even though utilities are currently characterized by increasing long-run incremental costs, even in the static sense as defined in economic theory.

11. For a physical description of this project see, U.S. Department of the Interior, Bureau of Reclamation, **A Financial Analysis of the Authorized Central Valley Project, Past, Present, Future** (Sacramento: Bureau of Reclamation, May 1972), pp. 7–9. For a summary of the official cost-benefit analysis of the project see, U.S. Department of the Interior, Water and Power Resources Service, **A Summary of Economic Reanalysis Related to the Auburn-Folsom South Unit Central Valley Project, California** (Sacramento: Water and Power Resources Service, September 1980). This analysis was challenged by the U.S. General Accounting Office, **Federal Charges for Irrigation Projects Reviewed Do Not Cover Costs** (Washington, D.C.: Comptroller General of the United States, 1981), pp. 23–27 and 44–72.

12. In its cost-benefit analysis of the Auburn-Folsom South Unit project, the Bureau of Reclamation estimated the average annual output of the project to be 550,000 acre-feet of irrigation water annually. Discussion with the staff of the General Accounting Office and the California Department of Water Resources indicated that the 440,000 acre-foot estimate is more realistic.

13. These figures are as of the beginning of 1982 (January 1, 1982) and therefore really reflect costs as of 1981. See, U.S. Department of the Interior, Bureau of Reclamation, **Project Data Sheet** (Sacramento: Bureau of Reclamation, January 1, 1982). In developing our estimate of long-run incremental cost, we subtracted out the estimated distribution cost from canalside to farmgate.

14. For the methodology for determining the long-run incremental cost of water, see Hirshleifer et. al., *op. cit.* pp. 152–165. Due to the absence of additional literature on long-run incremental costs, the author had to use literature available in the electric utility area. See, for example, Charles R. Cichetti, William G. Gillen and Paul Smolensky, **The Marginal Cost and Pricing of Electricity: An Applied Approach** (Cambridge: Ballinger Publishing Company, 1977; Charles R. Scherer, **Estimating Electric Power System Marginal Costs** (Amsterdam: North Holland Publishing Company, 1977; and Ralph Turvey, **Optimal Pricing and Investment in Electricity Supply, An Essay in Applied Welfare Economics** (Cambridge: Massachusetts Institute of Technology, 1968).

15. Office of Management and Budget, Executive Office of the President, "Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits," **Circular No. A-94**, Revised (Washington, D.C.: Office of Management and Budget, March 27, 1972). The 10-percent real discount rate called for in this policy memorandum is still in effect.

16. The General Accounting Office estimated the long-run incremental cost of irrigation water from the Auburn-Folsom South Unit project at canalside to be $73.17 in 1978, with interest at 7½ percent. Our figure is much higher because of the use of later cost data and methodological changes. See U.S. General Accounting Office, **Federal Charges for Irrigation Projects Reviewed Do Not Cover Costs, op. cit.**, page 58.

17. For affirmation of this point see, *Ibid*, pp. 1, and 9–10. Also, E. Phillip Le Veen, *op. cit.*, page 1 and U.S. General Accounting Office, **Reforming Interest Provisions in Federal Water Laws Could Save Millions** (Washington, D.C.: Controller General of the United States, October 22, 1981), page 5.

18. The U.S. General Accounting Office reached this conclusion in a recent study of the interest subsidy. **Reforming Interest Provisions in Federal Water Laws Could Save Millions, op. cit.**, page 19. That agency argues for the use of the "constant maturities yield" rate series.

19. U.S. General Accounting Office, **Federal Charges for Irrigation Projects Reviewed Do not Cover Costs, op. cit.**, pp. 4–10.

20. *Ibid*, pp. 10–11 and 15–19.

21. The Bureau of Reclamation uses the "separate costs-remaining benefits" method of allocating total project costs to various functions, i.e., water, electric power, flood control, etc. Critics charge that the Bureau does not allot a sufficient proportion of total costs to the irrigation function. For a description of that process see, U.S. Department of the Interior, Office of Audit and Investigation, **Review of the Central Valley Project Bureau of Reclamation** (Washington, D.C.: Office of Audit and Investigation, January 1978), Appendix III. For a critical evaluation see, Ralph Nadar Associates, **Damming the West**.

22. U.S. Department of the Interior, Water and Power Resources Service, **Central Valley Project Water Service Rate Policy** (Sacramento: January 8, 1981), pp. 1–3.

23. U.S. Department of the Interior, Office of Audit and Investigation, *op. cit.*, page 63.

24. Major cost items were included only if appropriate. For example, the return to equity owners was excluded because the Central Valley Project is financed solely through Congressional appropriations.

25. Capital costs equal the present value of the total investment in plant, valued in current dollars. Again, we used a real discount rate of 10 percent for this calculation.

26. The difference between this replacement cost estimate ($47.69/acre foot) and the average price actually realized by the Bureau for CVP irrigation water in 1981 ($5.09/acre-foot), multiplied by the number of acre-feet of water delivered (4.12 million acre-feet) yields an estimated total subsidy to irrigators of nearly $175 million for that year.

27. For a discussion of this view, characterized as the "water-is-different syndrome," see Maurice Kelso. "The Water is Different Syndrome, or What is Wrong with the Water Industry?" Paper Presented at the Third American Water Resources Conference, American Water Resources Association, San Francisco, California, 1967.

28. The formula for arc elasticity of demand is percentage change in quantity divided by percentage change in price. The resultant numerical value is the coefficient of price elasticity. When the elasticity coefficient exceeds one, demand is said to be elastic. When the value of the elasticity coefficient is less than one, demand is said to be inelastic. And when the value of the coefficient is one, demand has unitary elasticity.

29. For a summary of this literature see, Larry D. Schelhorse, et. al., **The Market Structure of the Southern California Water Industry** (La Jolla: Copley International Corporation, June 1974, pp. 167–175.

30. For example, based on a cross-section sample of 38 irrigation districts in California in 1958, Bain estimated a price elasticity of demand of −0.64. See Joseph Bain, et. al., *op. cit.*, page 176.

31. This estimate was reached by Richard E. Howitt, William D. Watson and Richard M. Adams, "A Reevaluation of Price Elasticities for Irrigation Water," **Water Resources Research** (August 1980), page 623. These authors used a quadratic programming model.

32. *Ibid*.

33. For a detailed analysis of the concept of the demand for irrigation water see, Joseph Bain, et. al., *op. cit.*, pp. 675–686. These authors refer to marginal revenue product as "net value of marginal product."

34. The Bureau of Reclamation uses a marginal principle in calculating payment capacity but calculates the measure incorrectly. The agency determines the additional gross revenue attributable to a new increment of irrigation water, but the agency then incorrectly subtracts out all additional variable and fixed costs plus a return on investment to arrive at a residual value that represents the amount the farmer can afford to pay for water. As correctly measured, marginal revenue product should be the additional profit yielded by the last increment of water. Profit should not be treated as a cost, as is the practice of the Bureau. Instead, it should constitute the residual value that measures ability to pay. By treating the return to management and investment as a cost, the Bureau underestimates "ability to pay."

35. Joseph Bain, et. al., *op. cit.*, pp. 679–681.