Economic Review

Federal Reserve Bank of San Francisco

Summer 1988 Number 3

Table of Contents

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.

The Federal Reserve Bank of San Francisco's Economic Review is published quarterly by the Bank's Research Department under the supervision of Jack H. Beebe, Senior Vice President and Director of Research. The publication is edited by Barbara A. Bennett. Design, production, and distribution are handled by the Public Information Department, with the assistance of Karen Rusk and William Rosenthal.

For free copies of this and other Federal Reserve publications, write or phone the Public Information Department, Federal Reserve Bank of San Francisco, P.O. Box 7702, San Francisco, California 94120. Phone (415) 974-2163.

Saving-Investment Determinants of Japan's External Balance

Reuven Glick

Senior Economist, Federal Reserve Bank of San Francisco.

Able research assistance by Mark Thomas, Kim Luce, and Laura Shoe is gratefully acknowledged. Editorial Committee members were Ramon Moreno, Carolyn Sherwood-Call, and Bharat Trehan.

This article examines the role of domestic and foreign saving-investment behavior in the determination of Japan's current account. Declining fiscal spending in Japan and rising fiscal spending in the United States both are found to be major factors in the emergence of Japan's recent external surpluses. This implies that policy changes in both countries may be necessary to reduce Japan's large surpluses.

In recent years, Japan's large external surpluses have drawn much attention. Its current account balance in nominal dollars rose from a small surplus of $5 billion in 1981 to $86 billion in 1986. Relative to GNP, the surplus increased over this period from less than one-half of one percent to more than four percent.

The rising surplus has stirred conflicts with many of Japan's trading partners. A better understanding of the causes of this increase is needed to determine what policy responses may be appropriate.

The explanations for Japan's apparent propensity to export more than it imports have varied. Some have focused on "closed markets" and "unfair trade practices" that Japan allegedly has erected as barriers to foreign goods. Advocates of this view have urged Japan to reduce its trade barriers and to "buy foreign." However, there is little evidence that Japan's existing trade barriers have risen in the last several years at the time that its surpluses have grown. In fact, on balance, such barriers probably have fallen.[1]

Others have asserted that an "undervalued" yen prior to 1985 contributed heavily to Japan's external surpluses.[2] However, when the yen appreciated more than fifty percent against the dollar between February 1985 and the end of 1986, these surpluses did not show signs of leveling off and falling until recently.[3] As a result, most doubt that exchange rate changes alone will suffice to eliminate Japan's surpluses.[4]

The relation between the current account, the exchange rate, and other macroeconomic variables depends fundamentally on underlying saving and investment flows. National income account relationships imply that a country's current account depends on domestic private saving and investment behavior, as well as on domestic fiscal saving. An excess of domestic private saving over domestic private investment that is not "absorbed" by an excess of government expenditures over tax receipts can result in domestic net savings flowing abroad. The counterpart of this outflow of savings is a current account surplus. From this point of view, some have argued that the Japanese "save too much," and they suggest that the high saving rate by the private sector in Japan is the cause of Japan's trade surpluses. Accordingly, Japanese authorities have been entreated, explicitly or implicitly, to adopt policy measures to discourage saving.

Still others have suggested that the recent rise in Japan's surpluses can be attributed in large part to the policies of the United States, Japan's largest trading partner. Since one country's current account deficit is another's surplus, macro developments in the rest of the world also are among the determinants of a country's current account. The rise in U.S. government deficits, according to this view, generated an excess demand for foreign goods by U.S. residents and accordingly, a rise in Japan's net exports.[5]

This paper provides an empirical analysis of Japan's current account as the product of its domestic and foreign saving-investment balances. The strategy of the paper is to estimate a current account equation relating the actual current account to variables generating short-run business cycle fluctuations in the current account and to non-business cycle, or "autonomous," movements in domestic and foreign net savings. The estimated equation is used to decompose current account movements into autonomous and cyclical components, and in particular, to determine the extent to which Japan's current surpluses can be attributed to domestic and foreign saving-investment behavior.

The major conclusion of this analysis is that most of Japan's present current account surplus can be related to autonomous factors affecting private and government net saving flows. Moreover, a decline in autonomous net saving in the United States associated with the emergence of fiscal spending deficits in the early 1980s has been a major contributor to this surplus. Autonomous net saving behavior in Japan and in the United States each accounts for 2½ percentage points of the 4 percentage point increase in the ratio of Japan's current surplus to GNP between 1981 and 1986. Cyclical factors actually worked to reduce the surplus by roughly 1 percentage point.

These findings suggest that adjustment by both the United States as well as Japan may be necessary to reduce Japan's external surplus. In fact, there are signs that these adjustments already are occurring. Following the recommendations of the 1986 Maekawa Report, Japan has moved to stimulate domestic demand and reduce net saving by increasing government expenditures, providing greater incentives for housing investment, and raising taxes on saving accounts.[6] At the same time, since 1986 the United States has moved in the direction of reducing its fiscal deficits.

The plan of this paper is as follows: Section I reviews recent trends in Japan's current account and in the private saving-investment and government saving balances of both Japan and the U.S. Section II presents a simple two-country model of the determinants of the current account balance. Section III describes the empirical analysis, and Section IV summarizes the results.

I. Recent Trends

From national account identities, the excess of the sum of domestic private (S) and government saving (TG) over domestic investment (I) equals a country's current account surplus (CA):

$$CA = S - I + TG$$

Chart 1 plots, over the period 1966 to 1986, four-quarter moving averages of Japan's current account, private saving-investment ($SI = S - I$), and government saving balances, each as a share of GNP.[7]

Over the past twenty years, Japan's current account balance has shifted widely, with deficits as well as surpluses. Surpluses averaging roughly 2 percent of GNP were recorded in 1971–1972 and in 1978. Deficits averaging 1 percent emerged at the time of the oil price crises of 1974 and 1979–1980.

The most recent surpluses, however, are significantly greater than those previously attained. From 1966–1980, Japan's current account averaged a surplus of only 0.6 percent of GNP, with a peak of 2.4 percent in 1971. In 1985, the surplus reached 3.7 percent of GNP and in 1986, 4.3 percent.

Chart 1 also shows that in recent years Japan's net private saving-investment balance (SI) has increased as a percent of GNP. From 1966 to 1974 this balance averaged 1.4 percent; from 1975 to 1980, 3.2 percent, and from 1980 to 1986, 3.7 percent. Between 1980 and 1986 it rose by almost three percentage points.

Contrary to the common view, this rise in Japan's net private saving balance is the result of a sharp decline in investment rather than a rise in saving. Private saving averaged 17.5 percent of GNP from 1966 to 1974, 16.6 percent from 1975 to 1980, and 14.1 percent over the 1981–1986 period.[8] The long-run trend, in fact, has been a small decline in Japan's private saving rate.

Since 1975, the rate of private investment in Japan has fallen sharply. Net investment averaged 18.9 percent of GNP during the 1966–74 period, 13.4 percent during 1975–80, and 10.3 percent from 1981 to 1986. A deceleration in Japan's long-run growth rate and a resulting reduction in domestic prospects for net investment have been associated with this declining investment.[9]

Japan's private saving-investment surplus is only part of the reason that the current account recorded such large surpluses in recent years. As the identity above implies, the behavior of government saving (i.e., government receipts minus expenditures) also has played a role.

Over the period from 1975 to 1979, the growth in surplus net private saving was largely matched by a rise in government budget deficits that reached 4.1 percent of gross national output in 1978, well above the average of 2.2 percent over the period from 1966 to 1974. Budget deficits rose because of increased government spending associated with the oil price shocks of the 1970s and the growth of social welfare programs. Since 1979, the budget deficit has declined steadily, with a small surplus attained in 1985. This improvement in the budget deficit reduced the demand for domestic saving. Thus the dramatic rise in Japan's external surpluses in the 1980s can be attributed more to sharp drops in private investment and the government budget deficit, than to an increase in private saving.

Chart 1
Japanese Net Saving and Current Account Balances

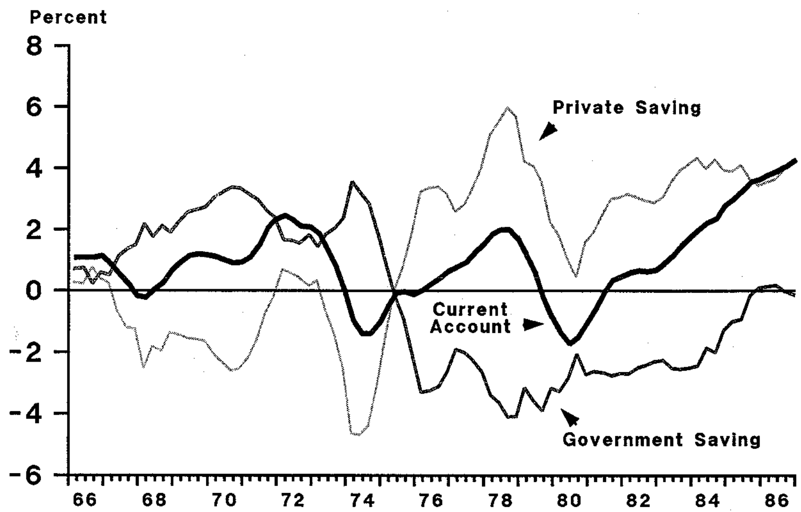
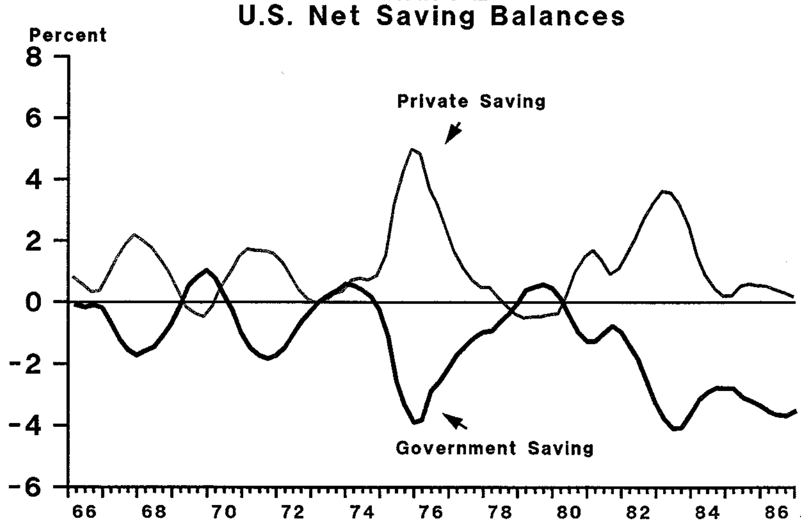


Chart 2
U.S. Net Saving Balances



In a global context, Japan's net exports (CA) are net imports by the rest of the world. Following the national account relation above, these net imports equal the excess of investment over private and government saving in the rest of the world.

Chart 2 plots four-quarter moving averages of the private saving-investment (SI*) and government saving (TG*) balances of the United States, Japan's largest trading partner, over the period 1966–1986. Observe that in contrast to recent trends in Japan, fiscal saving in the U.S. shifted from small surpluses (0.5 percent of GNP in 1979) to large deficits, averaging 3.4 percent during 1982–1986. Mirroring these increasing deficits has been a fall in the private saving-investment balance in recent years. This suggests that budget policies in the United States may be an important factor behind the development of Japan's current account surpluses.

In a general equilibrium context, saving and investment behavior both domestically and abroad are jointly determined by business cycle changes as well as by exogenous monetary and fiscal policy variables at home and abroad, and other fundamentally exogenous forces, such as autonomous shifts in private consumption or investment behavior. The following sections examine the extent to which the movements in private and government saving-investment balances and Japan's current account reflect autonomous or business cycle factors in Japan and abroad.

II. Theory

This section develops a simple two-country model of the determinants of the current account. The purpose of the analysis is not to capture all aspects of saving and investment behavior, but rather to focus on the essential channels of current account adjustment within a simplified framework.

The conditions for equilibrium in the goods market in the two countries can be written as (with time subscripts omitted):

$$CA = SI + TG \qquad (1)$$

$$-CA = SI^* + TG^* \qquad (2)$$

where SI, TG, and CA denote net private saving (private saving minus investment), net government saving (government receipts minus expenditures), and the current account balance, respectively. The variables with an asterisk denote the equilibrium for the foreign country—referred to as the United States. Those without an asterisk represent the domestic country—Japan, in this analysis.[10]

Net private saving for the domestic and foreign country takes the following form:

$$SI = SI_0[Z_1] + s_1(y - \bar{y}) + s_2 r \qquad (3)$$

$$SI^* = SI_0^*[Z_1^*] + s_1^*(y^* - \bar{y}^*) + s_2^* r^* \qquad (4)$$

where for Japan SI_0 denotes autonomous net private savings; y, real output; $\bar{y}$, full employment or potential output; r, the real interest rate; and Z_1, a set of exogenous variables that affect autonomous savings. The same variables for the United States again are denoted by an asterisk.

According to (3) and (4), net private saving depends on autonomous factors, the gap between actual and potential GNP, and the real interest rate.[11] The latter two terms reflect the effects of the business cycle and other short-run factors. The parameter s_2 is assumed positive: a rise in the interest rate raises saving and reduces investment. The sign of s_1 depends on the relative effect of an increase in the GNP gap on private saving versus investment.

Government net saving is specified as

$$TG = TG_0[Z_2] + t(y - \bar{y}) \qquad (5)$$

$$TG^* = TG_0^*[Z_2^*] + t^*(y^* - \bar{y}^*) \qquad (6)$$

where TG_0, TG_0^* represent autonomous government saving, and Z_2, Z_2^* denote exogenous variables that affect autonomous government saving for Japan and the United States, respectively. The parameters t and t^* are expected to be positive. TG_0 and TG_0^* may be interpreted as full-employment budget surpluses attained when actual output equals potential output.

To proceed, substitute (3) – (6) in (1) and (2), multiply (1) by s_2^* and (2) by s_2, take the difference, and solve for CA:

$$CA = \frac{s_2^*}{s_2 + s_2^*}(SI_0 + TG_0) - \frac{s_2}{s_2 + s_2^*}(SI_0^* + TG_0^*) + \frac{s_2^*(s_1 + t)}{s_2 + s_2^*}(y - \bar{y}) - \frac{s_2(s_1^* + t^*)}{s_2 + s_2^*}(y^* - \bar{y}^*) + \frac{s_2 s_2^*}{s_2 + s_2^*}(r - r^*) \qquad (7)$$

Equation (7) provides an equation describing the determinants of the current account of the domestic country in both the long and short run.

In long run equilibrium, $y = \bar{y}$ and $y^* = \bar{y}^*$ and, assuming domestic and foreign assets are perfect substitutes, $r = r^* = \bar{r}$. Thus the first two terms of equation (7) may be interpreted as the autonomous components of the current account that are unrelated to the movements in the domestic and foreign saving balances associated with cyclical changes in GNP gaps and interest rates. The difference between these components may be interpreted as the domestic country's long run current account balance, CA_0.[12]

The long-run current account tends to improve when autonomous domestic saving increases relative to that of the foreign country. Thus an increase in domestic private saving or domestic government saving, or a fall in autonomous foreign private or government saving leads to a rise in the current account balance.

Intuitively, an autonomous decrease in, say, foreign saving tends to reduce the net flow of capital to the domestic country. The counterpart to the fall in foreign saving and capital inflows to the domestic country is a rise in goods bought in the domestic country relative to goods bought abroad, causing a rise in the domestic country's current account balance. The mechanism through which these changes occur involves a rise in interest rates to crowd out investment and dampen the fall in saving, as well as a depreciation (appreciation) of the domestic (foreign) country's currency to dampen the rise (fall) in its currrent account.[13]

Note that the impact of autonomous changes on the current account depend on the interest elasticities of net saving both domestically and abroad (s_2 and s_2^*). Moreover, a testable implication is that the absolute values of the coefficients of these two terms sum to one.

The last three terms of (7) represent the short-run, cyclical determinants of the current account. In the short run the current account may differ from its long-run equilibrium level because the determinants of private and public saving—income and the interest rate—deviate from their long-run values.

Whether a positive domestic GNP gap ($y > \bar{y}$) increases or decreases the current account below its long-run level depends on the propensity for net private saving out of income (s_1). If this propensity is sufficiently negative (i.e., $s_1 < 0$ and $s_1 + t < 0$), then a rise in output above potential reduces the current account. Intuitively, an increase in income above its full employment level causes domestic investment to rise by more than private saving does, thereby inducing a fall in net domestic saving and a fall in the current account. On the other hand, if $s_1 + t > 0$ (a sufficient condition is $s_1 > 0$), a rise in output induces an increase in the current account.

At first glance, this latter case may seem contrary to the typical Keynesian view that a rise in domestic income worsens the trade balance. However, the result here presumes that other determinants of the current account, particularly the autonomous components, are held constant. If, for example, the increase in domestic income is generated by an expansionary autonomous fiscal policy (fall in TG_0), equation (7) may indeed imply that a worsening of the current account would be observed at the same time. Foreign GNP gaps produce symmetrical results.

Unlike the effect of a GNP gap, the effect of an interest rate differential between the domestic and foreign countries is unambiguous. A positive domestic interest rate differential induces greater net saving domestically than abroad and a corresponding rise in the current account.

In summary, the long run current account is determined by the autonomous levels of net private saving and government saving domestically and abroad. In the short run, business cycle movements in output and in interest rates can affect the current account as well.

III. Estimation

Methodology

The strategy of the paper now is to estimate the autonomous and cyclical components of Japan's current account following the approach suggested by Ueda (1987). First, measures of the autonomous components of net private and government saving domestically and abroad are derived from estimates of equations following the specifications of (3)–(6). Next, an equation is estimated which relates the current account to the autonomous factors and to cyclical variables, as suggested by (7). The resulting equation is then employed to determine the relative magnitudes of autonomous and cyclical factors.

Although Japan trades with many countries, it is difficult and cumbersome to construct savings measures for most countries, particularly on a quarterly basis. Consequently, the United States, Japan's largest trading partner, will be treated as representing the rest of the world in this analysis. In (fiscal year) 1986 Japan's bilateral trade surplus with the United States accounted for more than half (57.9 percent) of its total trade surplus.[14] Treatment of the

United States as a proxy for the "rest of the world" should provide a rough approximation of the role of foreign factors in Japan's current account.[15]

The data sample covers the first quarter of 1965 through the fourth quarter of 1986. The source and construction of the data are described in the appendix. A proxy for potential GNP was derived from fitted values of regressions of the log of GNP on constant, trend, and trend-squared terms.[16] In the case of Japan, separate regressions were run for the periods from 1966:1 to 1973:4 and from 1974:1 to 1986:4 to account for a shift in the pattern of real economic growth. Proxies for *ex ante* real interest rates were obtained from *ex post* real long-term government bond rates, deflated by two-year ahead inflation rates in the case of the U.S. and two-quarter ahead inflation rates in the case of Japan.[17]

The equations were log-linear approximations of (3)–(7), with dependent variables scaled by potential GNP. Since the saving-investment balances, GNP gap, and real interest rate measures are themselves endogenous, instrumental variables were employed in the estimation. The instruments used in each equation included potential output and lagged values of the dependent and all explanatory variables, except for the real interest rate. In addition, the TG equations included current and lagged money supply growth; the SI equations included four lags of the quarterly inflation rate, the lagged nominal interest rate, current and three lags of money supply growth, and two lags of government savings; the current account included four lags of the quarterly inflation rate for both countries, and four lags of money supply growth for both countries and the lagged nominal interest differential.[18]

Table 1

Regression Results

(1) $SI/\bar{y} = -.68 + .06 \ln \bar{y} - 1.85 (\ln y - \ln \bar{y})_{-1} + .16r$

(3.60) (3.64) (3.32) (1.47)

$\bar{R}^2 = .68$ SEE = 0.0178 DW = 2.36 RHO = .53

Sample: 1966:1–1986:4

(2) $SI^*/\bar{y}^* = -.08 + .03 \ln \bar{y}^* + .72 (\ln y^* - \ln \bar{y}^*) + .03r$

(.61) (1.84) (6.43) (2.83)

$\bar{R}^2 = .75$ SEE = .0072 DW = 1.63 RHO = .67

Sample: 1965:3–1986:4

(3) $TG/\bar{y} = .56 - .04 \ln \bar{y} + .64 (\ln y - \ln \bar{y})$

(5.81) (5.84) (2.01)

$\bar{R}^2 = .25$ SEE = .0230 DW = 0.81 Sample: 1965:4–1986:4

(4) $TG^*/\bar{y}^* = .38 - .05 \ln \bar{y}^* + .42 (\ln y^* - \ln \bar{y}^*)$

(6.84) (7.10) (8.42)

$\bar{R}^2 = .62$ SEE = .0099 DW = 0.43 Sample: 1965:4–1986:4

(5) $CA/\bar{y} = .01 + .56 (SI_0 + TG_0)/\bar{y} - .34 (SI_0^* + TG_0^*)q/\bar{y}$

(4.40) (6.44) (3.47)

$- .85 (\ln y - \ln \bar{y}) - .48 (\ln y^* - \ln \bar{y}^*) + .06 (r - r^*)$

(4.04) (2.60) (.97)

$\bar{R} = .31$ SEE = .0129 DW = 2.02 Sample: 1967:1–1986:4

The government saving equations were not corrected for serial correlation since they are structural rather than behavioral equations, and the t-statistics associated with the coefficient estimates did not matter. The private saving equations, however, were corrected for serial correlation in the following way: an estimate of the serial correlation parameter was obtained from the residuals of the initial application of the instrumental variables regression. The final results were then obtained by performing an ordinary least squares regression on the quasi-differences of exogenous variables and the instrumented values of endogenous variables.[19] The current account equation did not require correction for serial correlation.

Results

The results of the equations used to estimate autonomous and cyclical private saving and government saving are reported in lines 1–4 in Table 1.

Net private saving in Japan (SI) is positively related to the real interest rate and negatively to the lagged GNP gap. For the United States, both the GNP gap and the real interest rate enter positively. In both countries, the interest rate signs are as expected. The effect of the GNP gap on net private saving is theoretically ambiguous, as discussed earlier. An increase in the GNP gap causes saving to rise by more than investment in the U.S. ($s_1^* > 0$) and by less than investment in Japan ($s_1 < 0$). In the government saving (TG, TG*) equations the GNP gap entered significantly with the expected positive sign for both countries.

With these results, measures of the autonomous net private saving balances (SI_0, SI_0^*) were obtained by subtracting the GNP gap and real interest rate terms from the actual balances. Likewise, measures of autonomous government saving balances (TG_0, TG_0^*) were obtained by subtracting the terms representing the effect of the GNP gap from actual balances. This construction implicitly attributes the error terms in the estimated equations to autonomous factors.

Charts 3 and 4 depict four-quarter moving averages of autonomous and actual net private saving balances relative to potential GNP for Japan and the United States, respectively. Charts 5 and 6 depict the autonomous and actual government saving balances for the two countries.

Chart 3 indicates that autonomous factors (SI_0) account for most of Japan's net private saving (SI), particularly during the shift from deficits to surpluses in 1975. This suggests that the decrease in investment that occurred in the mid-1970s was not just a short-run business cycle phenomenon, but rather was the result of structural changes in Japan's economy. Since 1981, Japan's autonomous private saving has increased moderately.

Chart 5 shows that since the early 1970s movements in Japan's government saving balance (TG) have been dominated by autonomous factors (TG_0) to an even greater extent than was the case for private savings. In recent years, Japan's rising level of government saving (falling budget deficits) also primarily is the result of changes in autonomous, rather than business cycle, factors.

Chart 3
Japanese Net Private Saving

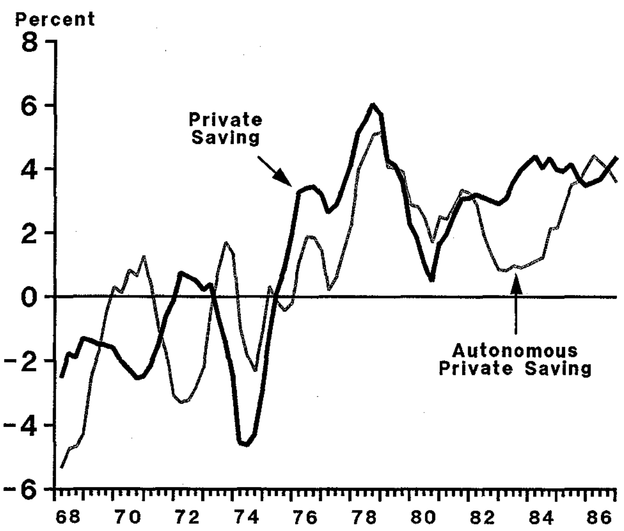


Chart 4
U.S. Net Private Saving

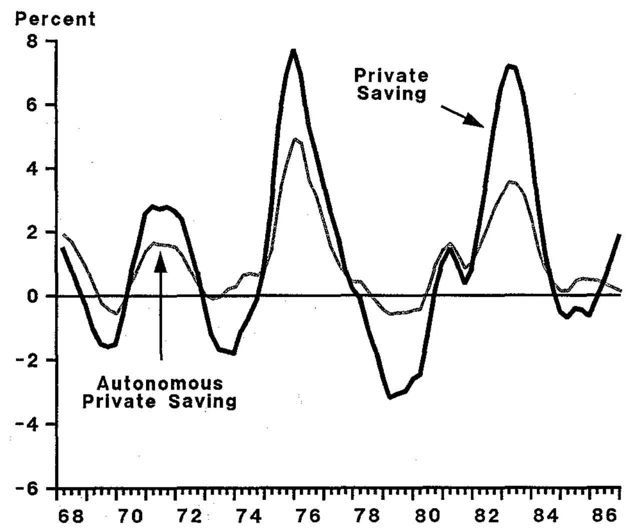


Chart 4 indicates that the portion of U.S. net private saving (SI^*) that is driven by autonomous factors (SI^*_0) declined sharply in 1983 but has since remained relatively flat.

Chart 6 shows that actual and autonomous government saving balances for the United States (TG^* and TG^*_0, respectively) do not track as closely as in Japan. Thus for the U.S., cyclical factors play a much greater role in government saving. Still, much of the fall in government saving (increase in the budget deficit) in the early 1980s has been autonomous in nature.

Summing autonomous government saving together with autonomous net private saving gives total autonomous domestic saving in each country ($SI_0 + TG_0$, $SI^*_0 + TG^*_0$). In Japan, autonomous domestic saving averaged surpluses of 2 to 3 percent of potential GNP in the mid-1970s, but fell to deficits of nearly 3 percent in 1976, as a result of the sharp increase in the structural government budget deficits. Since then, the reversal of fiscal policy and the moderate rise in private saving in Japan, have induced a strong rise in the autonomous domestic saving balance. In the United States, aggregate private and government saving both have declined sharply since 1982; the U.S. autonomous domestic saving balance, converted into yen-equivalent terms by the real yen price of the dollar (denoted by q in Table 1) has risen (in absolute value) to about 6 percent of Japan's potential output.

The estimated effects of domestic and foreign net saving behavior on Japan's current account are reported in line 5 of Table 1. All coefficients have the expected signs, and, except for the interest rate differential, are statistically significant at the .05 level.

Note, in particular, that the current account depends positively on autonomous Japanese saving and negatively on U.S. autonomous saving. As implied by theory, the hypotheses that the absolute values of these two coefficients sum to 1 cannot be rejected.

Cyclical factors also are important. An increase in the Japanese income gap worsens Japan's current account; an increase in the U.S. gap also reduces the current account. As discussed earlier, the finding that an increase in the U.S. GNP gap worsens its own external balance and improves that of Japan's presumes that all other factors are being held constant. If, for example, the increase in U.S. income is generated by an expansionary autonomous fiscal policy (fall in TG^*_0), this analysis may imply that Japan's current account would improve.

To see more clearly the effects of autonomous factors ($TG_0 + SI_0$ and $TG^*_0 + SI^*_0$) on Japan's current account, the actual (moving-average) current account balance (CA) and the estimated autonomous balance (CA_0) are plotted separately in Chart 7. For the years in which Japan experienced large surpluses in its current account (1972–1973, 1978, and 1982–1985) autonomous saving-investment behavior appears to have played a large role. The influence of cyclical factors associated with income and interest rate movements is apparent, particularly in 1981 and 1982 when the autonomous current account appears to have been

Chart 5
Japanese Government Saving

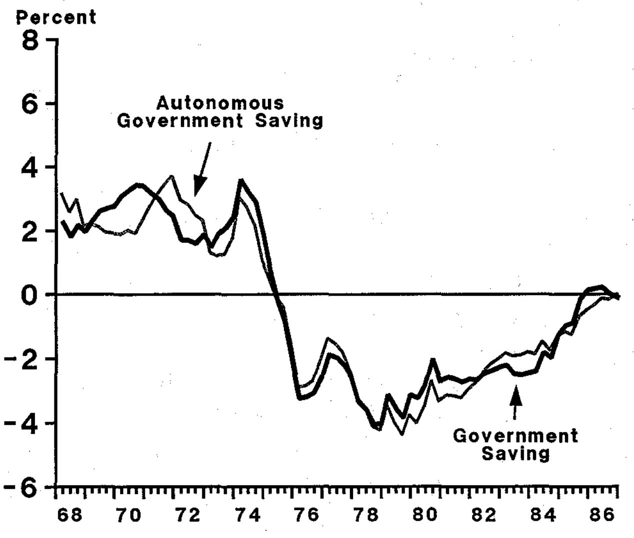


Chart 6
U.S. Government Saving

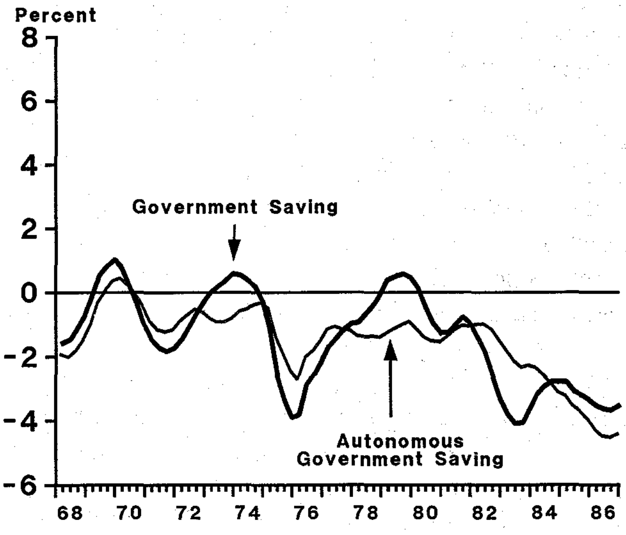
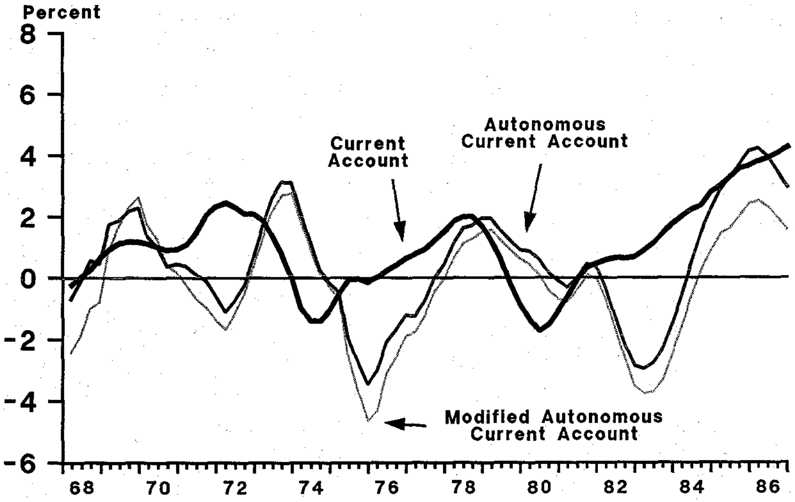


Chart 7
Japanese Current Account Balance



in deficit and actual surpluses were occurring. However, beginning in 1983, it is apparent that Japan's autonomous current account moved strongly into surplus, and now accounts for almost all of the recent actual balance.

Chart 7 also suggests that U.S. fiscal policies have played a major role in the recent emergence of Japan's external surpluses. By comparing Japan's autonomous current account (CA_0) with the estimated autonomous balance modified to remove the effects of autonomous U.S. budget policy, it is clear that, in the absence of any effects of U.S. fiscal policies, the autonomous current account in Japan decreases in almost all periods, particularly in the 1980s. In 1986, for example, this analysis implies that Japan's current account surplus would have been roughly one-half its actual level.

In other words, of the cumulative 4 percentage point increase in the ratio of its surplus to potential GNP between 1981 and 1986, autonomous net saving behavior in Japan explains 2.5 percentage points and net saving behavior in the U.S. accounts for 2.3 percentage points. Cyclical factors worked to reduce the surplus by roughly 1 percentage point. Thus U.S. policies as well as developments in Japan have played a role in Japan's emergence as a surplus country in international trade transactions.

IV. Conclusions

The framework used in this paper has focused on the role of domestic and foreign saving-investment balances in the determination of Japan's current account. This analysis indicates that autonomous changes, particularly those related to government budget policies, have been important determinants of Japan's current account. Most importantly, it suggests that Japanese saving-investment behavior alone does not explain recent increases in the external surpluses. The large U.S. budget deficits since 1982 also have played a major role.

These results imply that changes in autonomous government or private saving in both countries may be necessary to bring down Japan's large surpluses. Specifically, the United States needs to reduce its fiscal deficits, and Japan simultaneously ought to increase its deficit spending.

In fact, there are signs that such adjustments already are occurring. Following the recommendations of the 1986 Maekawa Report, Japan has moved to stimulate domestic demand and reduce net saving. Government expenditures have increased, stronger incentives for housing investment have been provided, and taxes on previously exempt savings accounts have been introduced. The desire to stimulate a lagging economy was the motive, but such measures also should contribute to a decline in Japan's current account surpluses.

In the U.S., the federal budget deficit has been reduced significantly, from $221 billion in 1986 to $156 billion in 1987. While it is unclear how quickly the deficit will be reduced in the future, the trend is in the proper direction.

ENDNOTES

1. Bergstrand (1986) cites evidence that Japanese tariffs are no higher on average than U.S. tariffs and that U.S. non-tariff barriers are as widespread as those in Japan.

2. Frankel (1984) discusses how prevalent this view was among U.S. Treasury officials when negotiating with Japan to reduce its barriers to international capital flows. Neither Frankel, nor Haynes, Hutchison, and Mikesell (1986), find any evidence that Japan's financial policies were directed towards depressing the value of the yen.

3. Haynes, Hutchison, and Mikesell (1986) surveyed recent evidence and found that in the 1980s Japanese trade flows have been relatively insensitive to exchange rate changes.

4. See Sakamoto (1988).

5. See Hutchison and Pigott (1984) and Bergsten and Cline (1985).

6. The Maekawa Report is formally known as "The Report of the Advisory Group on Economic Structural Adjustment for International Harmony," and was released by the Japanese government on April 17, 1986.

7. The GNP scaling variable used is "potential" output. The method used to construct this measure is described in Section III. The private saving measure used for Japan is defined to include statistical discrepancy.

8. Japan's traditionally high level of saving may reflect the need for retirement funds to supplement the low level of social security benefits, the high cost of housing, and heavy educational expenses. See Bergsten and Cline (1985) and Islam (1986).

9. Kasman (1987) estimates that Japan's potential real growth rate fell from 9 percent over the period 1967–1973 to 4.5 percent over 1976–1986. He attributes the deceleration of Japan's potential growth rate to declines in the rate of capital accumulation and in the rate of technical progress as the economy has matured. Other factors besides the slowdown in growth that also may have contributed to the sharp drop in the propensity to invest include (i) declining budget deficits beginning in 1979, which curbed public investment, and (ii) high real interest rates and the price of urban land, which caused residential construction to fall.

Some have argued that the timing of the shift in Japan's growth rate suggests that the oil price increases of the 1970s played a major role. While these shocks may explain cyclical movements in Japan's GNP, other countries more dependent on oil experienced less deceleration in trend growth in the 1970s.

10. Note that since goods market equilibrium in this model depends on the government budget balance, Ricardian equivalence does not hold.

11. Terms of trade and exchange rate effects on saving and investment are neglected. This specification also abstracts from the dynamics associated with the response of saving and investment to wealth accumulation. Turner (1986) specifies a model in which investment and saving depend directly on the exchange rate.

12. Since this specification abstracts from the dynamics associated with the response of saving and investment to wealth accumulation, in the long-run equilibrium of this model the current account may not equal zero. It also does not take into account complications arising from debt financing of the deficit in the short-run and the ultimate need to raise taxes to service the larger debt implied by the government budget constraint.

13. The implicit adjustment of the exchange rate and interest rate may be seen by specifying the determinants of the current account generally as follows:

$$CA = CA_a[Z_3] + c_1 q + c_2(y-\bar{y}) + c_3(y^*-\bar{y}^*) \quad (A.1)$$

where q is the real exchange rate, defined as the real yen price of the dollar, and Z_3 is a vector of exogenous variables that affect the current account. A Keynesian theory would imply $c_1 > 0, c_2 < 0, c_2^* > 0$. We abstract from the interest payments on net foreign assets.

In the short run, the two equilibrium conditions (1) and (2) determine the two output levels y and y^*, with the interest rates determined elsewhere in asset markets in an unspecified manner. In the long run, $y = \bar{y}$, $y^* = \bar{y}^*$, $r = r^* = \bar{r}$, and $q = \bar{q}$. Hence (1) – (6) imply

$$SI_0 + TG_0 + s_2\bar{r} = CA_a + c_1\bar{q}$$

$$SI_0 + TG_0 + s_2^*\bar{r} = -(CA_a + c_1\bar{q}).$$

Solving these two equations for the two unknowns $\bar{r}$ and $\bar{q}$ yields:

$$\bar{r} = -(1/(s_2+s_2^*))(DS_0+DS_0^*)$$

$$\bar{q} = (1/c_1)\ \{(s_2^*/(s_2+s_2^*))DS_0 - (s_2/(s_2+s_2^*))DS_0^* - CA_a\},$$

where $DS_0 = SI_0+TG_0$, $DS_0^* = SI_0^*+TG_0^*$. Thus, in the long run, the real interest rate and the exchange rate depend only on autonomous private and government saving. Substituting in (A.1) gives the long-run current account, CA_0:

$$CA_0 = (s_2^*/(s_2+s_2^*))DS_0 - (s_2/(s_2+s_2^*))DS_0^*, \quad \text{or}$$

$$CA_0 = CA_a + c_1\bar{q},$$

The long-run current account depends on the exogenous current account CA_a and the long-run exchange rate $\bar{q}$. An increase in either domestic private or government saving depreciates the country's currency and improves its current account.

14. Sakamoto (1988).

15. Ueda (1987) considers the saving behavior of both the United States and OPEC. Knight and Masson (1988) construct a simulation model of the interaction of saving and investment behavior in Japan, the United States, and Germany.

16. The trend-squared term allows trend growth to be flexible. An alternative approach used by Ueda (1987) and Kasman (1987) is to estimate full-employment GNP for Japan from a production function.

17. These inflation horizons worked best in the empirical analysis. Federal Reserve Bank of San Francisco staff forecasts were used for U.S. inflation during 1988 where appropriate.

18. Money growth, inflation, and nominal interest rates were included in the list of instruments to properly instrument out the real interest rate.

19. The instruments are quasi-differenced by taking the difference between the current value of the instrument and the lagged actual value of the instrumental variable (the latter, of course, multiplied by the serial correlation estimate). See Fair (1972), who points out that in generating instruments, the exogenous variables should include lagged values of all endogenous variables (including the dependent variable), and current and lagged values of predetermined variables.

DATA APPENDIX

Sources

Bank of Japan Statistical Monthly (BOJSM);
Bank of Japan Statistical Annual, National Income Statistics (BOJSANI);
Citibase (CB);
Data Resources, Japan Database (DRI);
International Financial Statistics (IFS)

Japan

Real GNP: billions of 1980 yen, BOJSM

Potential GNP: Calculated from antilog of fitted values of an OLS regression of the log of real GNP on constant, trend, and trend-squared terms estimated over periods 1965:2–1973:4 and 1974:1–1986:4

Price level: implicit GNP deflator, 1980 = 100, BOJSM

Long-term interest rate: central government bond rate, percent per year, end of period, DRI

Exchange rate: yen per dollar, period average, IFS line 158rf

Money supply: M1 + Quasi-money + CDs, billions of yen, end of period, IFS lines 34 + 35 + 36aa

The following series are in billions of yen and were seasonally adjusted using the SAS X-11 procedure:

Current account balance = net lending to rest of world − capital transfers from rest of world

Net lending to rest of world: BOJSANI, Table 6, line 3.3
Capital transfers from rest of world: BOJSANI, Table 6, line 3.6

Government savings = government receipts − government expenditures

Government receipts: BOJSANI, general government section

Government expenditures = government receipts − government savings + general government gross fixed capital formation − general government capital consumption

Government savings: BOJSANI, general government section; also DRI series SAVEGNS
General government gross fixed capital formation: BOJSANI, gross national expenditure section—Table 1, line 3.1.b.c; also DRI series GIFIXONS

General government capital consumption = total gross fixed capital consumption − private capital consumption

Total gross fixed capital consumption: BOJSANI (also DRI series CCANS)
Private capital consumption available annually from DRI series CCAP. Quarterly series computed assuming percentage of total to private capital consumption is constant over the year.

Net private savings = private savings − private investment

Private savings = total savings − general government savings + statistical discrepancy

Total savings: BOJSANI, Table 6
General government savings: see above
Statistical discrepancy: BOJSANI, Table 6

Private investment = change in inventories + private gross fixed capital formation − private capital consumption

Change in inventories: BOJSANI, Table 6, line 3.2
Private gross fixed capital formation: BOJSANI, Table 1, line 3.1.a
Private capital consumption: see above

United States

Real GNP: billions of 1982 dollars, CB

Potential GNP: Calculated from antilog of fitted values of an OLS regression of the log of real GNP on constant, trend, and trend-squared terms over period 1965:2–1986:4.

Long-term interest rate: 20 year Treasury bond rates, monthly average, percent per annum, CB series FYGT20

Money supply: M2, monthly average, billions of dollars, CB

Price level: GNP implicit deflator, CB. (Figures for 1988 used in calculating ex post real interest rate from FRBSF staff forecasts.)

The following series are in billions of dollars, at seasonally adjusted annual rates:

Net private savings = gross private savings − gross private domestic investment

Gross private savings: CB series GPS
Gross private domestic investment: CB series GPI

Government savings = government receipts − government expenditures

Total government receipts: CB series GGFR + GGSR
Total government expenditures: CB series GGFEX + GGSEX

REFERENCES

Bergsten, C. Fred and William Cline. *The United States-Japan Economic Problem,* Washington, D.C., Institute for International Economics, No. 13, October 1985.

Bergstrand, Jeffrey. "United States-Japanese Trade: Predictions Using Selected Economic Models," *New England Economic Review,* Federal Reserve Bank of Boston, May/June 1986.

Fair, Ray. "The Estimation of Simultaneous Models with Lagged Endogenous Variables and First Order Serially Correlated Errors," *Econometrica,* Vol. 38, May 1970, pp. 507-516.

Frankel, Jeffrey. *The Yen-Dollar Agreement: Liberalizing Japanese Capital Markets,* Washington, D.C.: Institute for International Economics, 1984.

Haynes, Stephen, Michael Hutchison, and Raymond Mikesell. "Japanese Financial Policies and the U.S. Trade Deficit," *Essays in International Finance,* No. 162, Princeton University, International Finance Section, 1986.

Hutchison, Michael and Charles Pigott. "Budget Deficits, Exchange Rates, and the Current Account: Theory and U.S. Evidence," *Economic Review,* Federal Reserve Bank of San Francisco, Fall 1984.

Islam, Shafiqul. "Does Japan Save Too Much?" Washington, D.C.: Institute for International Economics, June 1986.

Kasman, Bruce. "Japan's Growth Performance over the Last Decade," *Quarterly Review,* Federal Reserve Bank of New York, Summer 1987.

Knight, Malcolm and Paul Masson. "Fiscal Policies, Net Saving and Real Exchange Rates: The United States, the Federal Republic of Germany, and Japan," in J. Frankel (ed.), *International Aspects of Fiscal Policies,* Chicago: University of Chicago Press, 1988.

Sakamoto, Tomohiko. "Japan-U.S. Bilateral Trade," *Economic Review,* Federal Reserve Bank of San Francisco, Spring 1988.

Turner, P. "Savings, Investment, and the Current Account: An Empirical Study of Seven Major Countries, 1965-84," *Bank of Japan Monetary and Economic Studies,* October 1986.

Ueda, Kazuo. "Investment Savings Balance and the Japanese Current Account Surplus," Japan Center for International Finance, Policy Study Series, No. 7, May 1987.

Exploring the Relationships between National and Regional Economic Fluctuations

Carolyn Sherwood-Call

Economist, Federal Reserve Bank of San Francisco.

The author wishes to thank Bharat Trehan for his help with VARs, and the editorial committee for many helpful suggestions. Scott Gilbert provided invaluable research assistance. Editorial committee members were Barbara Bennett, Michael Keeley, and Ronald Schmidt.

Local economies are related to the national economy in different ways. Although most economists agree that such differences among states exist, the nature of these differences is not well understood. This paper develops a measure of the "strength of linkage" between regional and national economies that captures the degree of comovement between state and national economic growth rates. This measure is used to determine which characteristics of states' economies are associated with stronger or weaker linkages to the national economy. The analysis reveals that states that are linked more closely to the national economy tend to be large and diverse, with smaller than average farm and oil sectors and larger than average manufacturing sectors.

Local economies are related to the national economy in different ways. Casual observation suggests, for example, that economic fluctuations in California are linked more closely to national economic fortunes than are economic fluctuations in Alaska. Economists who forecast states' economies take these differences into account, relying more on national economic forecasts for some states than they do for others.

Although most economists agree that such differences among states exist, the nature of these differences is not well understood. Previous work has explored related issues. Several authors, including Brewer (1985) and Kort (1981), found that more diversified regions tend to have more stable economies. Browne (1982) found that the states that suffered the largest employment losses during the 1981-1982 recession tended to have relatively high wages and slow trend growth, and to depend more heavily on agriculture than other states. Belongia and Gilbert (1987) developed a simple measure of the relationship between national and regional economies, and found that farm and non-farm regions were not significantly different from one another according to that measure.

Like Belongia and Gilbert, this paper focusses on the long-term relationship between the national and regional economies. It develops a measure of the "strength of linkage" (LINK) between regional and national economies. LINK captures the degree of "comovement" between state and national economies. This measure is used to determine which characteristics of states' economies are associated with stronger or weaker linkages to the national economy. The analysis reveals that states that are linked more closely to the national economy tend to be large and diverse, with smaller than average farm and oil sectors and larger than average manufacturing sectors.

These findings make intuitive sense, and most of these findings also are consistent with those of other authors regarding related questions. However, they do contrast with the results of Tweeten (1985) and Rausser (1985), who found that agricultural economies are particularly susceptible to changes in macroeconomic variables such as interest rates.

The findings are interesting for several reasons. They suggest that forecasts of national economic activity are much more important in formulating some states' economic forecasts than they are for other states. Moreover, the economic characteristics associated with these differences among states provide a basis for speculating on the structural relationships between national and regional economies, a topic that is beyond the scope of this paper.

The paper is organized as follows. Section I examines alternative definitions of linkages between national and state economies. Section II describes the LINK measure used in this paper. Section III then examines characteristics of states' economies to determine which are associated with high and low values of LINK. Section IV summarizes the findings and draws conclusions.

I. Defining State-National Linkages

Several studies have examined the relationships between state and national economies, but these relationships have been defined in various ways. Browne (1982), for example, explored differences among peak-to-trough declines in employment for various states. This approach is useful for examining a particular business cycle, but observations drawn from such a short time frame have limited applicability for the whole cycle, let alone for longer periods.

Belongia and Gilbert, in contrast, focussed on changes in state and national economic activity over a 26-year period. In particular, they were interested in the magnitudes of the GNP coefficients in regressions of the following form:

$$(1)\quad \dot{PI}_{it} = \alpha_i + \beta_i \dot{GNP}_t + \epsilon_{it}$$

where $\dot{PI}_i$ is the quarter-to-quarter growth rate of personal income (PI) in region i, and $\dot{GNP}$ is the growth rate of gross national product (GNP). They ran separate regressions for two groups of states, ten "farm states" and forty "nonfarm states." They found that the coefficients on national GNP, β_i, were not significantly different between the two regions. Thus, they concluded that cyclical responses to the national economy were similar in farm and nonfarm regions.

Belongia and Gilbert's measure of the responsiveness of regions' economic fluctuations to those of the national economy, β, can answer only a limited range of questions. For one thing, their division of the nation into "farm" and "nonfarm" regions precludes analysis of other characteristics that might be associated with differences among states. In addition, β captures only the *magnitude* of the change in a region's economy that is associated with a given change in the national economy. Belongia and Gilbert do not consider the extent of the *comovement* between the national and regional economies.

These two concepts are quite distinct. Some regions experience only small fluctuations associated with national fluctuations, even though their economies exhibit substantial comovement with national cycles. These states would have small βs and high R^2s in regressions like equation (1) run on state data. Conversely, other regions respond sharply to shocks associated with national business cycles, but they also respond sharply to so many other economic shocks that their economic fluctuations may bear little resemblance to national fluctuations. These states would have large βs and low R^2s in regressions like equation (1).[1]

This paper focusses on *comovement* between national and regional economies, which also will be referred to as the "strength of linkage" between national and regional economies. In equations such as (1), this would be measured by the R^2. LINK, defined in the following section, provides an alternative measure of the strength of linkage.

Comovement between the pace of economic activity at the state and national levels could occur for many reasons. Comovement can result from common factors that drive all states' economies. For example, lower interest rates tend to stimulate economic activity in all states. Moreover, since the nation is the sum of the states, an appropriately weighted average of state growth rates would have to equal the national growth rate. Consequently, large states may exhibit comovement between their own growth rates and the nation's simply because their economies represent a large share of national economic activity.

It also is possible for changes in the national economy literally to cause changes in states' economies. For example, if the national economy is healthy, consumers in all states are more likely to purchase vacations (stimulating growth in Florida) or construction materials (stimulating growth in Oregon).

A state's economy also could exhibit comovement with the nation's because of an indirect rather than a direct chain of causation between the two economies. For example, Nevada's economy depends heavily on California's, which in turn is closely linked to the national economy (Cargill and Morus 1987). This indirect linkage between Nevada and the U.S. may be indistinguishable statistically from a direct linkage between the two economies.

II. Measuring Strength of Linkage

This paper focusses on differences among states' comovements with the national economy, without attempting to model the sources of those comovements. LINK, like the R^2 from equation (1), measures the extent to which the national economy "predicts" the pace of state economic activity. However, equation (1) assumes that any linkage between the two economies is contemporaneous and that causation always moves from the nation to the state. In contrast, the vector autoregression (VAR) approach used in this paper to derive LINK captures comovements that are not contemporaneous, and also (in principle, at least) allows causality to run in both directions.

VARs are atheoretical in their approach, and consequently have no structural content. In a VAR system, explanatory variables for each equation include lags of the dependent variable as well as lags of all other variables that the modeler chooses to include in the system.

Hence, one conceptually simple way to model the relationships between state and national economies would be to construct a 51-equation[2] VAR model in which each state's growth rate is a function of its own lags and lags of all other states' growth rates. Such a system would be huge, since using only one lag for each variable would result in 51 explanatory variables for each of the 51 equations, and VARs typically use several lags for each of the explanatory variables.

Although such a large VAR is impractical, a similar system of only two equations could provide a simple and more manageable way to model a given state's relationship to the national economy. Consider a model of the form:

$$(2)\quad \dot{PI}_{USt} = \gamma + \sum_{l=1}^{4}\delta_{t-l}\,\dot{PI}_{US,t-l} + \epsilon_t$$

$$(3)\quad \dot{PI}_{it} = \lambda_i + \sum_{l=1}^{4}\eta_{i,t-l}\,\dot{PI}_{US,t-l} + \sum_{l=1}^{4}\mu_{i,t-l}\,\dot{PI}_{i,t-l} + \xi_{it}$$

where $\dot{PI}_{US}$ equals the real quarter-to-quarter personal income growth rate (seasonally adjusted) in the U.S., $\dot{PI}_i$ equals the real quarter-to-quarter growth rate in state i's personal income, the t subscripts refer to time, and l denotes lag length in quarters. Fifty-one separate two-equation systems represent the relationship between each state's economy and the nation's.

Note that although an unrestricted VAR would include states' economies as causes of national economic activity, these variables are omitted in this system. If each two-equation system included lags of one state's growth in its U.S. equation, 51 different representations of the U.S. economy would result. To determine how to resolve this problem, 51 variants of equation (2) were run, in which four lags of a given state's growth rate were included. F tests on the state variables in these equations reveal that only two states provide significant explanatory power for the national economy at the 5 percent level.[3] With 51 states, two or three states are likely to appear statistically significant at the 5 percent level due solely to random chance. Consequently, to make the U.S. equation consistent in all two-equation systems, state lags are omitted as explanatory variables in the U.S. equation.

Personal income (PI) data are used rather than gross product data because the latter are not readily available at the state level. In order to avoid empirical problems caused by differences between PI and GNP at the national level, PI is used to measure national economic growth as well.

The system represented in equations (2) and (3) is estimated for the period 1970 to 1986[4], using seasonally adjusted quarterly data. Estimates using data for earlier years reveal that the relationships change over time. Starting the estimation period in 1970 omits observations from the years before the oil shocks and other structural changes that took place during the 1970s, but still provides a reasonably long estimation period. Four quarters of lags allow sufficient time for fluctuations to work through the system, while avoiding problems with overlapping cycles.

Because the system is estimated using growth rates rather than levels, individual states' equations are poor predictors of their economic activity.[5] However, the approach that is widely applied in the VAR literature follows the "atheoretic" logic of the VAR process and does not place any particular significance on individual coefficients or conventional econometric statistics. Instead, the approach uses the estimated relationship and the error structure from the estimation to attribute deviations in estimated values from actual values to shocks or "surprises" in one of the equations in the system. This "variance decomposition" procedure is based on the assumption that such surprises reflect some exogenous force not explicitly modelled in the system. Equations (2) and (3) are linked through lagged national values in the state equation, and surprises occur to both equations in nearly every period. Thus, the modeler can decompose the total observed deviation estimated from actual values in each state equation into that attributable to national shocks and that attributable to state shocks. (See Box.)

LINK represents the national component of this variance decomposition for each state. This statistic provides an intuitively appealing measure of the strength of linkage between state and national economies. A high value for

Vector Autoregressions and Variance Decomposition

The LINK measure used in this paper is calculated using a method called variance decomposition, which is used with an empirical technique called vector autoregression (VAR). This box explains the VAR technique and how it is used to compute a variance decomposition.

A vector autoregression is a system of equations in which lagged values of the dependent variables are used as explanatory variables. This allows the economist to explore short-term dynamic behavior, with few assumptions about the underlying structure of economic relationships.

Most VARs yield a large number of coefficients that are difficult to interpret, so characteristics other than coefficients and T-statistics frequently are used to interpret VAR results. One way to interpret the results is to look at the dynamic behavior implied by the VAR to see what it reveals about the economy's behavior over time.

The concept of an "innovation" is important in interpreting VAR "forecasts." An innovation is a surprise or shock; that is, a change in a given variable that is not anticipated by the model. Consider, for example, an estimate of PI growth in California using equations (2) and (3) in the text.[1] Based on actual data for the previous four quarters, this model estimates that PI should have grown 0.4 percent nationally and 0.6 percent in California during the second quarter of 1983.[2] In fact, during that quarter PI grew 1.3 percent for the U.S., and 1.6 percent for California. Since both growth rates were higher than the model predicted they would be, the U.S. and California experienced positive innovations, or shocks, of 0.9 percent and 1.0 percent, respectively.

Because a change in one period affects forecasts of future periods through the lagged endogenous variables, these innovations affect the model's predictions for all subsequent periods. A technique called variance decomposition provides one way to analyze the effects of these innovations. For any given time period after an innovation takes place, one can decompose the forecast error variance of the equation into the proportions associated with innovations in each variable.

The first step in a variance decomposition is to measure the equation's accuracy by calculating its error variance for a particular time period after an innovation. For California, the error ξ_t is the difference between the actual growth rate of California personal income and the growth rate consistent with the model's parameters. Table B1 lists the error variances for California one, four, eight, twelve, sixteen, twenty, and twenty-four quarters after a one standard deviation innovation takes place. Note that the error variance grows over time, indicating that forecasts are more accurate for shorter forecast horizons.

For each period, this error variance can be decomposed into the proportion associated with innovations in national PI and the proportion associated with innovations in California PI. This step is the actual variance decomposition procedure. To understand the intuition involved, consider the following two thought experiments. First, if the U.S. equation accurately described U.S. personal income growth so that no errors (surprises) occurred, what proportion of the forecast error variance would be removed? This is the number listed in the "U.S. innovation" column of Table B1. Secondly, if California personal income growth could be captured completely in the California equation, what proportion of the forecast error variance would that remove? This proportion is listed in the "California innovation" column of Table B1. If all surprises were eliminated from both U.S. and California PI growth, no prediction error would exist. Hence the third and fourth columns in any given row sum to 100 percent. The decomposition reveals that, 24 quarters after the innovation, 73.30 percent of the error variance in the California forecast is associated with innovations in the national economy. This number 73.30, is the LINK measure for California.

To see more clearly what the decomposition is, consider a two-quarter ahead forecast for California. The forecast is for period t = 1, given what is known about periods t = -1 and earlier, but with no information about t = 0. The error for California in period t = 1 is represented by[3]:

$$\text{(B1)} \qquad \xi_1 = PI_{CA\,1} - E[PI_{CA\,1}]$$

where

$$PI_{CA\,1} = \lambda + \eta_0 PI_{US\,0} + \mu_0 PI_{CA\,0} + \sum_{t=-1}^{-3} \eta_t PI_{USt} + \sum_{t=-1}^{-3} \mu_t PI_{CAt} + \xi_1$$

Table B1

Variance Decomposition for California

Quarters after innovation	Forecast error variance	US innovation	California innovation
1	1.05	74.98	25.02
4	1.09	74.63	25.37
8	1.10	73.49	26.51
12	1.10	73.33	26.67
16	1.10	73.30	26.70
20	1.10	73.30	26.70
24	1.10	73.30	26.70

$$PI_{CA\,0} = \lambda + \sum_{t=-1}^{-4} \eta_t PI_{USt} + \sum_{t=-1}^{-4} \mu_t PI_{CAt} + \xi_0$$

$$= E[PI_{CA\,0}] + \xi_0$$

$$PI_{US\,0} = \gamma + \sum_{t=-1}^{-4} \delta_t PI_{USt} + \epsilon_0 = E[PI_{US\,0}] + \epsilon_0$$

Plugging the expressions for $PI_{CA\,0}$ and $PI_{US\,0}$ into the expression for $PI_{CA\,1}$ yields:

$$PI_{CA\,1} = \lambda + \eta_0 \{E[PI_{US\,0}] + \epsilon_0\} + \mu_0\{E[PI\}_{CA\,0}] + \xi_0\}$$

$$+ \sum_{t=-1}^{-3} \eta_t PI_{USt} + \sum_{t=-1}^{-3} \mu_t PI_{CAt} + \xi_1$$

This expression, together with equation (B1), yields:

$$\text{(B2)} \quad \xi_1 = \eta_0\epsilon_0 + \mu_0\xi_0 + \xi_1$$

That is, the error in period 1 is related to the error made in estimating period 0 values for PI_{CA} and PI_{US}, as well as the error made in forecasting PI_{CA} for period 1 based on the forecasts of period 0 values. If the error terms are independent and identically distributed, the variance of the error for period 1 is thus:

$$\text{(B3)} \quad var(\xi_1) = \eta_0^2\, var(\epsilon) + (\mu_0^2 + 1)\, var(\xi)$$

$$+ 2\eta_0(\mu_0 + 1)cov(\epsilon\xi)$$

If the covariance between the two error terms ϵ and ξ equals zero, then the error variance for California is the weighted sum of the error variances for the U.S. and California equations. The third term in equation (B3) drops out, and the first and second terms provide a simple decomposition.

In general, however, the covariance between national and state error terms is not zero. In such cases, the error variance still can be decomposed into components associated with innovations in each variable if the researcher assigns "priority" to innovations in one variable over innovations in the other. For the California-U.S. system, excluding California from the U.S. equation assigns priority to U.S. shocks, and the method of decomposing the error variance is consistent with this assignment. This means that contemporaneous comovements are attributed to U.S. innovations.

ENDNOTES

1. Equations (B2) and (B3) technically do not comprise a VAR system, since state lags are not included as explanatory variables for the US. It can, however, be analyzed much as a VAR would be.
2. This period was chosen for expositional purposes.
3. State subscripts are omitted for ξ, λ, μ, and η since the state is California throughout the exercise.

LINK means that most state fluctuations are associated with national shocks, and cycles in the state economy tend to be associated closely with national cycles. Conversely, if a state's fluctuations generally result from shocks to the state's economy, rather than from shocks to the nation's economy, the state would have a low LINK value and a relatively weak linkage to national cycles.

Table 1 lists the values of LINK for the fifty states and the District of Columbia. On average, national surprises account for 44 percent of states' observed deviations. The states exhibit a wide range of LINK measures, from 75 percent for Florida to 8 percent for West Virginia. Moreover, states that one would expect from casual observation to be closely linked to the national economy, such as California, have high LINK values, whereas states that do not appear to be closely linked to the national economy, like Alaska, have low LINK values.

Table 1
Values of LINK Variable

	LINK		
Florida	74.56	Alabama	46.02
California	73.30	South Carolina	45.74
Tennessee	72.11	Georgia	44.57
Virginia	67.58	Wisconsin	44.19
Connecticut	66.02	Minnesota	43.57
Oregon	63.59	Mississippi	40.91
Massachusetts	63.28	Arkansas	39.40
Ohio	62.95	Kentucky	38.23
New York	62.34	Oklahoma	37.96
Colorado	61.30	Delaware	36.97
Washington	58.54	Pennsylvania	36.96
Vermont	58.21	Idaho	34.97
Arizona	56.78	Hawaii	32.53
New Jersey	56.36	Kansas	29.03
North Carolina	56.12	Michigan	28.64
Illinois	55.33	Montana	25.94
Maryland	54.72	Louisiana	25.33
Nevada	51.12	Wyoming	20.62
New Hampshire	51.02	Nebraska	17.80
Texas	50.70	Iowa	17.67
Indiana	49.81	South Dakota	17.48
Maine	49.25	District of Columbia	13.30
New Mexico	49.20	Alaska	13.15
Utah	48.05	North Dakota	12.81
Rhode Island	47.46	West Virginia	8.36
Missouri	46.48		

III. Examining the LINK Measure

To examine the characteristics of states with higher or lower LINK measures, some variables describing each state's economic characteristics are constructed. These characteristics, shown in Table 2,[6] were chosen to allow comparisons with the results of previous studies on related topics. The last three lines of Table 2 list the average value for each variable for the entire group of 51 states, and for the ten states with the highest LINK measures and the ten states with the lowest LINK measures.

Several authors have found that states with larger (Smith and Willis 1986) or more diverse (Brewer 1985, Kort 1981) economies tend to be more stable or to experience smaller job losses during cyclical downturns. These studies, however, focussed on the magnitude of the change in the state's economy that was associated with a national economic change, rather than the extent of comovement, which is measured here.

In the analysis presented here, state personal income (PI), in millions of constant 1982 dollars, measures the size of the state's economy. DIV captures the extent to which the industry structure in a given state's economy differs from the nation's, and proxies for economic diversity[7]. Using data disaggregated to the two-digit Standard Industrial Classification (SIC) level for all industries, the following formula was calculated for each state:

$$DIV_i = -\sum_{j=1}^{J} \frac{(E_{ij} - E_{USj})^2}{E_{USj}}$$

where E_j denotes the share of total employment in industry j, i subscripts denote states, and US subscripts denote national figures. If state i's industrial composition is identical to the nation's, $DIV_i = 0$, and DIV_i is negative if the state's economy deviates from U.S. industrial composition. The value of DIV_i rises (although its *absolute* value falls) as the state's industrial structure resembles U.S. industrial structure more closely and, presumably, the state's economy becomes more diversified.

It seems plausible that economic fluctuations in states that depend heavily on resource industries such as agriculture and oil would be more closely associated with changes

Table 2
State Economic Characteristics

	PI	DIV	FARM	OIL	MFG	DMFG	LINK
Alabama	31418	-0.397	0.077	0.001	0.345	0.123	46.02
Alaska	5931	-1.295	0.002	0.042	0.083	0.023	13.15
Arizona	25405	-1.233	0.032	0.000	0.288	0.161	56.78
Arkansas	18001	-0.494	0.185	0.002	0.261	0.093	39.40
California	276157	-0.088	0.051	0.002	0.254	0.161	73.30
Colorado	31802	-0.208	0.059	0.014	0.176	0.082	61.30
Connecticut	40957	-0.303	0.009	0.000	0.362	0.255	66.02
Delaware	6946	-0.739	0.070	0.000	0.324	0.054	36.97
District of Columbia	9411	-1.277	0.000	0.000	0.060	0.004	13.30
Florida	99184	-0.279	0.083	0.000	0.153	0.070	74.56
Georgia	49996	-1.607	0.067	0.000	0.311	0.073	44.57
Hawaii	10654	-1.014	0.063	0.000	0.092	0.013	32.53
Idaho	8014	-1.389	0.207	0.000	0.233	0.072	34.97
Illinois	135163	-0.123	-0.005	0.001	0.311	0.177	55.33
Indiana	54552	-0.334	-0.009	0.000	0.394	0.247	49.81
Iowa	31047	-0.269	0.082	0.000	0.279	0.117	17.67
Kansas	26376	-0.203	0.115	0.012	0.251	0.127	29.03
Kentucky	29980	-0.678	0.077	0.002	0.305	0.119	38.23
Louisiana	36970	-1.144	0.046	0.048	0.173	0.062	25.33
Maine	9659	-2.251	0.039	0.000	0.343	0.080	49.25
Maryland	49584	-0.653	0.012	0.000	0.213	0.103	54.72
Massachusetts	67643	-0.678	0.009	0.000	0.379	0.203	63.28
Michigan	99354	-0.530	0.019	0.001	0.383	0.267	28.64
Minnesota	43823	-0.955	0.102	0.000	0.263	0.131	43.57
Mississippi	18238	-1.113	0.081	0.007	0.369	0.129	40.91
Missouri	48579	-0.170	0.018	0.000	0.281	0.127	46.48
Montana	7423	-0.840	0.143	0.009	0.128	0.047	25.94
Nebraska	16584	-0.238	0.173	0.001	0.197	0.079	17.80
Nevada	8609	-4.691	0.017	0.000	0.058	0.027	51.12
New Hampshire	9157	-0.697	0.012	0.000	0.359	0.178	51.02
New Jersey	93832	-0.171	0.008	0.000	0.323	0.140	56.36
New Mexico	10833	-1.041	0.061	0.035	0.106	0.048	49.20
New York	215678	-0.214	0.006	0.000	0.252	0.114	62.34
North Carolina	51297	-1.830	0.075	0.000	0.429	0.100	56.12
North Dakota	7818	-0.531	0.403	0.016	0.079	0.024	12.81
Ohio	112659	-0.207	-0.007	0.001	0.364	0.226	62.95
Oklahoma	29406	-0.407	0.079	0.031	0.206	0.103	37.96
Oregon	24914	-2.523	0.070	0.000	0.283	0.153	63.59
Pennsylvania	125013	-0.133	0.019	0.001	0.339	0.170	36.96
Rhode Island	10003	-1.220	0.013	0.000	0.368	0.196	47.46
South Carolina	24993	-2.365	0.012	0.000	0.430	0.088	45.74
South Dakota	6711	-0.547	0.358	0.000	0.144	0.042	17.48
Tennessee	38280	-0.261	0.033	0.000	0.366	0.117	72.11
Texas	142846	-0.275	0.062	0.024	0.210	0.103	50.70
Utah	23814	-0.690	0.026	0.006	0.189	0.097	48.05
Vermont	4567	-0.415	0.090	0.000	0.290	0.123	58.21
Virginia	55589	-0.338	0.010	0.000	0.270	0.079	67.58
Washington	42841	-0.529	0.107	0.000	0.249	0.139	58.54
West Virginia	15562	-5.275	-0.011	0.009	0.252	0.110	8.36
Wisconsin	47419	-0.204	0.094	0.000	0.348	0.185	44.19
Wyoming	4760	-3.332	-0.021	0.055	0.077	0.025	20.62
MEAN							
all states	46970	-0.949	0.065	0.006	0.259	0.114	44.28
highest ten LINK states	96286	-0.510	0.034	0.002	0.286	0.146	66.70
lowest ten LINK states	14222	-1.475	0.117	0.018	0.147	0.053	17.25

in commodity prices and other factors peculiar to these industries than with changes in macroeconomic factors. However, several authors (Tweeten 1985, Rausser 1985) have emphasized the sensitivity of agriculture to interest rates and inflation, concluding that macroeconomic variables play a key role in explaining the farm problems of the early 1980s. Belongia and Gilbert (1987), in contrast, found no difference in the responsiveness to national fluctuations between farm and nonfarm regions. It is possible, however, that a state could respond sharply to macroeconomic variables, without exhibiting strong co-movement, if its economy also responds sharply to economic variables that are uncorrelated with macroeconomic cycles. FARM, which measures each state's dependence on agriculture, was calculated by taking the ratio of net farm income to total state personal income. Similarly, a state's dependence on energy extraction may be related to the strength of its linkage to the national economy. OIL captures the importance of the oil industry by calculating the proportion of total employment in oil extraction (SIC 13).

Table 3
Regression Results
(T statistics in parentheses)

Dependent variable: LINK

PI	DIV	FARM	OIL	MFG	DMFG	$\overline{R}^2$
0.9E-4**	2.55	-62.85**	-337.5*	20.59		0.35
(2.03)	(1.20)	(2.21)	(1.86)	(0.83)		
0.8E-4*	2.63	-66.98**	-389.5**		17.42	0.35
(1.91)	(1.20)	(2.33)	(2.32)		(0.43)	
1.1E-4***		-50.78*	-336.4*	26.63		0.35
(2.74)		(1.90)	(1.85)	(1.10)		
1.0E-4**		-53.61*	-388.4**		32.00	0.34
(2.45)		(2.01)	(2.31)		(0.83)	
	4.31**	-82.11***	-373.0*	19.58		0.31
	(2.15)	(2.97)	(2.00)	(0.77)		
	4.06*	-81.08***	-400.2**		29.51	0.31
	(1.91)	(2.83)	(2.32)		(0.72)	
		-67.08**	-388.1*	31.31		0.26
		(2.41)	(2.01)	(1.21)		
		-63.00**	-402.2**		59.52	0.27
		(2.27)	(2.27)		(1.53)	
1.2E-4***	1.13			56.84***		0.29
(2.82)	(0.54)			(2.71)		
1.1E-4**	0.94				79.13**	0.25
(2.39)	(0.44)				(2.12)	
1.2E-4***				58.39***		0.30
(3.21)				(2.83)		
1.1E-4**					82.52**	0.26
(2.62)					(2.27)	

indicates statistical significance at the 10 percent level in a two-tailed test, while ** and * denote significance at the 5 percent and 1 percent levels, respectively.*

Some early studies also found a correlation between dependence on (durable) manufacturing industries and the extent to which state economies declined during national recessions (Borts 1960, Engerman 1965). Thus, one might expect states in which manufacturing is more important to have higher LINK measures. The variables MFG and DMFG capture the importance of the manufacturing and durable manufacturing industries by calculating the proportions of total employment in manufacturing and durable manufacturing, respectively.

Table 3 presents the results of regressions in which the variables listed in Table 2 are used to explain differences among states' LINK measures. Various combinations of variables are used to ensure that possible correlation among explanatory variables does not contaminate the results.[8] These regressions suggest that stronger linkages between state and national economies are associated with larger, more diversified state economies, and less dependence on oil and agriculture. The signs of the coefficients suggest that states with higher LINK measures also depend more heavily than average on manufacturing activity, and this relationship is statistically significant in regressions in which FARM and OIL are omitted.

As expected, results for the size variable, PI, show that states with larger economies tend to have stronger linkages with the national economy. This relationship is statistically significant at least at the 10 percent level in all eight equations in which it is included, and at the 5 percent level in seven of the eight. These results are consistent both with *a priori* expectations and with the results of previous studies.

Smaller deviations from national industry structure, measured by DIV, are associated with higher LINK measures in all six regressions that include the measure. However, DIV is statistically significant only when PI is omitted from the regressions. DIV and PI are positively correlated with each other, and DIV appears to have little or no explanatory power beyond that associated with state size.

The coefficients on FARM and OIL suggest that states that depend heavily on farming and oil extraction tend to be linked less closely to the national economy. These results are statistically significant at least at the 10 percent level in all regressions that include FARM and OIL.[9] The FARM results contrast with those of Tweeten (1985) and Rausser (1985), who concluded that macroeconomic variables were key causes of farmers' economic problems during the mid-1980s. These results also differ from Belongia and Gilbert's finding that farm and nonfarm states respond similarly to macroeconomic shocks.

In all equations, the signs of coefficients on the manufacturing variables (MFG and DMFG) are consistent with the previous literature, suggesting that greater dependence on manufacturing is associated with stronger linkages between state and national economies. The coefficients are statistically significant only when FARM and OIL are omitted, reflecting the negative correlations between these two sets of variables.

The regression results leave open the possibility that the relationships between LINK and FARM, OIL, MFG, and DMFG exist only for states that depend heavily on these sectors, and that these relationships may not hold throughout the range of possible values. However, the mean values of each variable for the ten states with the highest LINK measures and the ten states with the lowest LINK measures, listed in Table 2, lead to the same conclusions as the regression results do. This suggests that the regression results describe the relationships among variables accurately throughout the range of LINK values, and not simply at one extreme or the other.

IV. Summary and Conclusions

The empirical results presented in Section III suggest that states differ in terms of their strength of linkage with the national economy, and that these differences are associated with the economic structure of the states.

According to the LINK measure, states tend to have stronger linkages to the national economy if they are larger, have industrial structures that resemble the nation's more closely, depend relatively heavily on manufacturing industries, and depend relatively little on farming and oil extraction. Most of these results are consistent with the results of previous studies on similar topics.

However, results for the agricultural sector are different from what previous studies might lead one to expect. The results for the FARM variable lead to a strong conclusion that the linkages between national and state economies are weaker in states that depend more heavily on agriculture. This conclusion contrasts with the results of several recent studies, including those by Rausser and Tweeten, which found that the agricultural economy is particularly sensitive to macroeconomic variables such as interest rates and inflation during the past decade. While this study does not test hypotheses regarding specific macroeconomic variables, the LINK results suggest that macro variables as a group are *less* important determinants of economic activity in states that depend heavily on agriculture than they are in other states.

The results of this study also contrast with Belongia and Gilbert's finding that farm and nonfarm regions respond similarly to macroeconomic shocks. Nevertheless, it is possible that agriculture is more sensitive than other sectors are to macroeconomic variables, but that farm states also are particularly sensitive to economic shocks that are not associated with national cycles.

ENDNOTES

1. These regressions must be interpreted carefully. A simple equation such as (1) can be used to summarize the relationships between two variables, but causal or structural interpretations are likely to be inappropriate, since the equation omits important variables at least for some of the states.

2. The 51 equations represent the 50 states and the District of Columbia. Throughout this paper, the District of Columbia will be referred to as a "state." Note that, with this structure, U.S. variables are not included explicitly, necessitating further calculations to assess the relationship between a given state's economy and the nation's.

3. The two states with statistically significant F statistics are Michigan, which makes intuitive sense, and the District of Columbia, which does not.

4. With four quarters of lags, data for 1969 were required to estimate the system beginning in 1970.

5. Low predictive power is not unusual for VARs that use growth rates, but it does cast doubt on the ability of LINK to measure comovements accurately. Nevertheless, the author has found no clearly superior way to measure comovements, and the results presented in Section III are strong enough to suggest that LINK is a viable measure of comovements.

6. With the exception of DIV, each variable was calculated using 1973 data and 1983 data, and the value listed is an average of the two. Due to data constraints, DIV was calculated for 1973 only.

7. Interpreting this as a "diversity" measure involves making the rather aribitrary assumption that the industry structure of the national economy represents "absolute" diversity. Nevertheless, it is a reasonably sensible measure, and its data requirements are not prohibitive. Other diversity measures include the much more arbitrary "ogive" measure, which measures the deviations from an equal distribution of employment across different industry categories, and the "portfolio variance" measure, which has prohibitive data requirements. Conroy (1975) describes each measure.

8. Note that the shares of agriculture, oil, and manufacturing do not add up to one, mitigating a potential multicollinearity problem in these equations. The oil and manufacturing measures are based on nonagricultural employment data, which also include other industries, such as trade, services, government, and finance. Because the employment data exclude agricultural jobs, the farm measure is based on income data rather than employment data. Moreover, correlations between DIV and other industry mix variables are low, at 0.10 or less. The correlation between PI and DIV is only slightly higher at 0.13.

9. Interestingly, in all equations that include the MFG variable, OIL is significant at the 10 percent level, and the significance level improves to the 5 percent level in all equations that include the DMFG variable. This suggests that OIL may be correlated with the nondurable manufacturing component of MFG, which is not included in DMFG. In fact, the correlation between OIL and MFG is 0.26, compared with a 0.14 correlation between OIL and DMFG.

REFERENCES

Belongia, Michael T. and R. Alton Gilbert. "The Farm Economies of the Plains," *Review of Regional Studies,* Fall 1987.

Borts, George H. "Regional Cycles of Manufacturing Employment in the United States, 1914-1953," *National Bureau of Economic Research Occasional Paper* 73, 1960.

Brewer, H.L. "Measures of Diversification: Predictors of Regional Economic Instability," *Journal of Regional Science* (25:3), 1985, pp. 463-470.

Browne, Lynn E. "Two Years of Stagnation: A Regional Perspective," *New England Economic Review,* September/October 1982, pp. 35-44.

Cargill, Thomas F. and Steven A. Morus. "A Vector Autoregression Model of the Nevada Economy," *Economic Review,* Federal Reserve Bank of San Francisco, Winter 1988, pp. 21-32.

Conroy, Michael E. "The Concept and Measurement of Regional Industrial Diversification," *Southern Economic Journal* (41:3), 1975, pp. 492-505.

Engerman, Stanley. "Regional Aspects of Stabilization Policy," in Richard A. Musgrave, ed., *Essays in Fiscal Federalism*. Washington, DC: The Brookings Institution, 1965.

Fritz, Richard G. and W. Warren McHone. "Forecasting Local Business Activity from Aggregate Indicators," *The Annals of Regional Science* (22:1), 1988, pp. 63-74.

Howland, Marie. "The Business Cycle and Long-Run Regional Growth," in William C. Wheaton, ed., *Interregional Movements and Regional Growth*. Washington, DC: The Urban Institute, 1979.

Kort, John R. "Regional Economic Instability and Industrial Diversification in the U.S.," *Land Economics* (57:4), 1981, pp. 596-608.

Long, John B., Jr. and Charles I. Plosser. "Sectoral vs. Aggregate Shocks in the Business Cycle," *American Economic Review* (77:2), 1987, pp. 333-336.

Lucier, Gary, Agnes Chesley, and Mary Ahearn. *Farm Income Data: A Historical Perspective,* U.S. Department of Agriculture, Economic Research Service, Statistical Bulletin No. 740, May 1981.

Rausser, Gordon C. "Macroeconomics and U.S. Agricultural Policy," in Bruce L. Gardner (ed.), *U.S. Agricultural Policy: the 1985 Farm Legislation*. Washington DC: American Enterprise Institute for Public Policy Research, 1985.

Siegel, Richard A. "Do Regional Business Cycles Exist?," *Western Economic Journal* (5:1), 1966, pp. 44-57.

Smith, Gary W. and David B. Willis. "An Analysis of the Performance of Washington and Oregon Counties: Three Years of Decline and Stagnation 1980-82," paper presented at the Pacific Northwest Regional Economic Conference, Missoula, Montana, May 1-3, 1986.

Tweeten, Luther. "Farm Financial Stress, Structure of Agriculture, and Public Policy," in Bruce L. Gardner (ed.), *U.S. Agricultural Policy: the 1985 Farm Legislation*. Washington DC: American Enterprise Institute for Public Policy Research, 1985.

U.S. Department of Commerce, Bureau of Economic Analysis, *State Personal Income: Estimates for 1929-1982 and a Statement of Sources and Methods*. Washington, DC, February 1984.

U.S. Department of Commerce, Bureau of Economic Analysis, *United States Department of Commerce News*. Washington DC, September 1986.

U.S. Department of Commerce, Bureau of Economic Analysis, "State Quarterly Personal Income, 1984:I–1986:I," *Survey of Current Business* (66:7), July 1986, p. 93.

An Evaluation of Alternative Measures of Expected Inflation

Adrian W. Throop

Research Officer, Federal Reserve Bank of San Francisco.

Research assistance by Mirjam Fried, Eric McClusky, and Jerry Metaxas is gratefully acknowledged. Editorial committee members were Barbara Bennett, Vivek Moorthy, Ramon Moreno, and Brian Motley.

This study evaluates the performance of three alternative measures of inflationary expectations in the context of the investment sector of a structural econometric model of the U.S. economy. Overall, the evidence suggests that actual expectations of inflation are close to being purely autoregressive, depending only on current and past inflation itself. Survey measures of expectations, which potentially might contain more forward-looking and "rational" elements, generally do not have any more explanatory power than other measures. Also, purely autoregressive measures remained a good representation of actual expectations of inflation even when monetary policy was changing sharply in the post-October 1979 period of disinflation.

Accurate forecasting of the response of the economy to changes in monetary policy requires an accurate modeling of the public's expectations of inflation. Conventional macro-econometric models typically incorporate relatively backward looking and slowly adjusting expectations of inflation. Critics stress that these models usually omit information about past values of other variables, such as the money supply, and also information about how monetary policy is likely to respond to the state of the economy in the future. Moreover, backward looking models of inflationary expectations tend to produce systematic forecasting errors, which economic agents might be expected to correct. In view of these criticisms, Robert Lucas (1976) has stated:

> "The long run implications of current forecasting models are without content, and the short-term forecasting ability of these models provides no evidence of the accuracy to be expected from our simulations of hypothetical policy rules."

In contrast, Lucas holds to the view that the inflationary expectations of economic agents in all markets tend to be fully "rational" in the sense that they are unbiased forecasts of future inflation. If this is the case, monetary policy is not able systematically to affect either real interest rates or output and employment.

On the other hand, many economists believe that the condition of full rationality assumes too much about the knowledge of economic agents. The assumption of full rationality requires that economic agents know the "true" model of the economy and make unbiased estimates of its parameters. Furthermore, full rationality assumes that economic agents know how policy affects the economy and even what policy rules will be followed by the government in the future. Given the inherent uncertainties about such things, a model that gradually adjusts inflationary expectations according to recent experience may be an adequate representation of the best that economic agents are able to do. Reflecting this view, Otto Eckstein (1981) said:

> "The data tell us that it takes workers, investors, and businessmen several years to accept conditions of inflation or output growth as permanent. . . The rational expectations school needs to specify the learning process by which information enters decisions

explicitly, particularly how individuals form permanent expectations from temporary data and how they modify their behavior to changes in the economic structure."

To shed some light on the appropriate way of modeling inflationary expectations, this article evaluates the performance of three alternative measures of inflationary expectations in the context of the investment sector of a structural econometric model of the U.S. economy. This model is used for forecasting and policy simulations at the Federal Reserve Bank of San Francisco.[1] The three alternative measures of expected inflation are: 1) a purely autoregressive measure that depends only on current and past values of inflation; 2) an "augmented" autoregressive measure that depends as well on current and past values of other variables that determine the inflation rate in the San Francisco model; and 3) a survey-based measure that potentially might contain more forward-loooking information than either of the other two measures. While the tests necessarily are joint tests of both the model's specifications and the measurement of expected inflation, taken together, the results provide useful evidence on the nature of actual inflationary expectations.

Agents in different markets may have access to different sets of information and incur varying costs of collecting such information. Also, arbitrage may force rapid adjustments to new information in some markets but not in others. As a result, different measures of inflationary expectations may be appropriate in different markets. We therefore examine the explanatory power of the three different measures of expected inflation in three different areas of the investment sector of the structural econometric model: consumer durables, the Aaa corporate bond rate, and nonresidential fixed investment.

Overall, the evidence suggests that inflationary expectations in the investment sector of the economy tend to be relatively backward-looking and adjust only gradually to new information. Survey measures of expectations, which potentially might contain more forward-looking and "rational" elements, generally do not have greater explanatory power than the other measures. Except in the bond market, where past values of variables other than inflation do have some significance, the actual formation of expectations of inflation generally appears to be purely autoregressive. Finally, the purely autoregressive measures remained good representations of actual inflationary expectations even when monetary policy was changing sharply in the post-October 1979 period of disinflation.

In section I, we develop the three alternative measures of short-term inflationary expectations and compare their relative forecasting accuracies. Since the concern in this paper is not with forecasting accuracy, but with accurate representations of the way expectations are formed, Section II uses these measures to estimate corresponding real short-term interest rates and then compares their explanatory powers in the equation for consumer spending on durable goods. Section III develops three alternative measures of long-term expectations of inflation and tests their explanatory power in an equation for the corporate bond rate. Section IV tests similar measures of long-term expectations of inflation in equations for business investment in structures and equipment. A summary and conclusions are provided in Section V.

I. Alternative Measures of Short-Term Expectations of Inflation

In this section, we develop the three alternative measures of expected inflation over a short-term forecasting horizon of two quarters ahead, and then compare their relative forecasting accuracies. These measures of expected inflation are then used in the next section to estimate the real 6-month commercial paper rate.

Purely Autoregressive Measure

In his pioneering studies of the effect of expected inflation on nominal interest rates, Irving Fisher (1930) used simple autoregressive measures of expected inflation that depended on only current and past inflation. Phillip Cagan (1956) subsequently developed a theoretical rationale for imposing geometrically declining weights on the past values of inflation in his hypothesis of adaptive expectations. Although rationales for more flexible lag patterns and techniques for their estimation have been developed since then, Cagan's adaptive expectations hypothesis has been widely used as an autoregressive representation of expectations.[2]

According to this hypothesis, economic agents revise expectations of inflation ($\dot{p}^e$) from one period to the next in proportion to the difference between the actual inflation rate ($\dot{p}$) in the most recent period and the rate of inflation the had been expected.

$$\dot{p}^e - \dot{p}^e_{-1} = \alpha(\dot{p} - \dot{p}^e_{-1}) \quad (1)$$

Collecting terms, the adaptive expectations hypothesis says that the current expectation of inflation is equal to a weighted average of current inflation and the most recent expectation of inflation.

$$\dot{p}^e = \alpha\dot{p} + (1 - \alpha)\dot{p}^e_{-1} \qquad (2)$$

The coefficient of adjustment, α, determines the weight economic agents put on new information about inflation. Solving this equation recursively, we obtain:

$$\dot{p}^e = \sum_{i=0}^{\infty} \alpha(1 - \alpha)^i \dot{p}_{-1} \qquad (3)$$

In the current context, $\dot{p}^e$ is interpreted as the expectation of inflation for two quarters ahead, and $\dot{p}$ is the quarterly rate of inflation in the GNP fixed weighted price index. The speed of adjustment, α, is estimated at 0.2 from the equations in the San Francisco model containing the real 6-month commercial paper rate.[3] The lag was truncated at 31 quarters, at which point the lag weight became trivially small. Because $1 > \alpha > 0$, the sum of these weights on past inflation equals one; and $\dot{p}^e$ ultimately converges to any steady actual rate of inflation. When inflation is rising, however, the adaptive expectations model systematically underestimates inflation; and when inflation is falling, it systematically overestimates. A criticism of the adaptive expectations hypothesis is that such errors potentially are correctable.

Augmented Autoregressive Measure

A more sophisticated measure of expected inflation can be derived from the inflation equation in the San Francisco econometric model. This equation collapses wage and price determination into one. The equation is an expectations-augmented Phillips curve, with inflation being determined as a function of the unemployment rate, past inflation, and variables that capture the direct effects of shocks to the price level from changes in the real price of oil and the real value of the dollar. Past inflation enters in the form of a polynomial distributed lag. In this augmented specification, past inflation captures not only inflationary expectations in the labor market, but also the effects of lags introduced by the contracting process.

Given past inflation, the current rate of change in wages, and hence prices in this equation, is assumed proportional to the excess demand for labor.[4] The presence of excess demand for, or excess supply of, labor implies that the adjustment to equilibrium does not occur instantaneously. The slow convergence to equilibrium in this model is appropriate because the labor market is not organized as an auction market.[5] Furthermore, because of an inverse relationship between vacancies and unemployment, the unemployment rate can be used to measure excess demand for labor.[6] Since the sum of the estimated coefficients on past inflation is not significantly different from one, we constrain them to that value. This implies a vertical long-run Phillips curve in which the rate of inflation at full employment is equal to the rate of inflation inherited from the past. It also reflects the view that excess demand, corresponding to an unemployment rate below the full employment level, leads to a continuous acceleration in the inflation rate.

The GNP fixed weighted price index that we use for the measure of prices does not include prices of imports. However, changes in import prices that are brought about by changes in the real value of the dollar indirectly influence prices of domestically produced goods. In purely competitive product markets for homogeneous goods such as agriculture, the "law of one price" suggests that changes in the price of imports due to real exchange rate changes will be fully passed through to domestic producers. In markets for non-homogeneous products, the degree of pass-through will be less though still greater than zero. Changes in the real value of the dollar therefore have an impact on the overall mark-up of domestic prices over domestic unit labor costs. These relationships are captured by a distributed lag on current and past percent changes in the real trade-weighted value of the dollar.

A second type of "supply shock" to the price level comes from changes in the real price of oil. Changes in the real price of oil alter the mark-up of prices over unit labor costs by changing the price of an important non-labor input. A distributed lag on the percentage change in the real price of oil is therefore the final component of the inflation equation.[7]

To obtain the augmented autoregressive measure of expected short-term inflation, the inflation equation in the San Francisco model was estimated with two-quarter ahead inflation in the GNP fixed weighted price index as the dependent variable. The sample period is 1958 to 1986. The fitted values of this equation are:

$$\dot{p}^e = .168 - .455U + \sum_{i=0}^{10} a_i\dot{p}_{-1} + \sum_{i=0}^{3} b_i\dot{POIL}_{-i} + \sum_{i=0}^{5} c_i\dot{EXCH}_{-i} \qquad (4)$$

$$\sum_{i=0}^{10} a_i = 1.0 \qquad \sum_{i=0}^{3} b_i = 0.0289 \qquad \sum_{i=0}^{5} c_i = -0.114$$

where $\dot{p}^e$ = two quarter ahead inflation rate
U = civilian unemployment rate, adjusted for demographic changes

$\dot{p}$ = quarterly inflation rate
$\dot{POIL}$ = rate of change in real price of oil
$\dot{EXCH}$ = rate of change in real value of the dollar

Unlike the purely autoregressive measure, this augmented autoregressive forecasting equation allows economic agents to take into account other information in forming expectations of inflation. This measure is based on relevant theory describing the dynamics of the inflationary process. It therefore contains information that is missing from the simple adaptive expectations hypothesis.

It also corrects a possible deficiency of the adaptive expectations hypothesis. Forecasts from the adaptive expectations model systematically underpredict inflation when it is rising and overpredict it when it is falling. In contrast, the augmented measure does not lead to systematic over- or underprediction. Therefore, it meets the condition of unbiased forecasts that is basic to the idea of rational expectations.

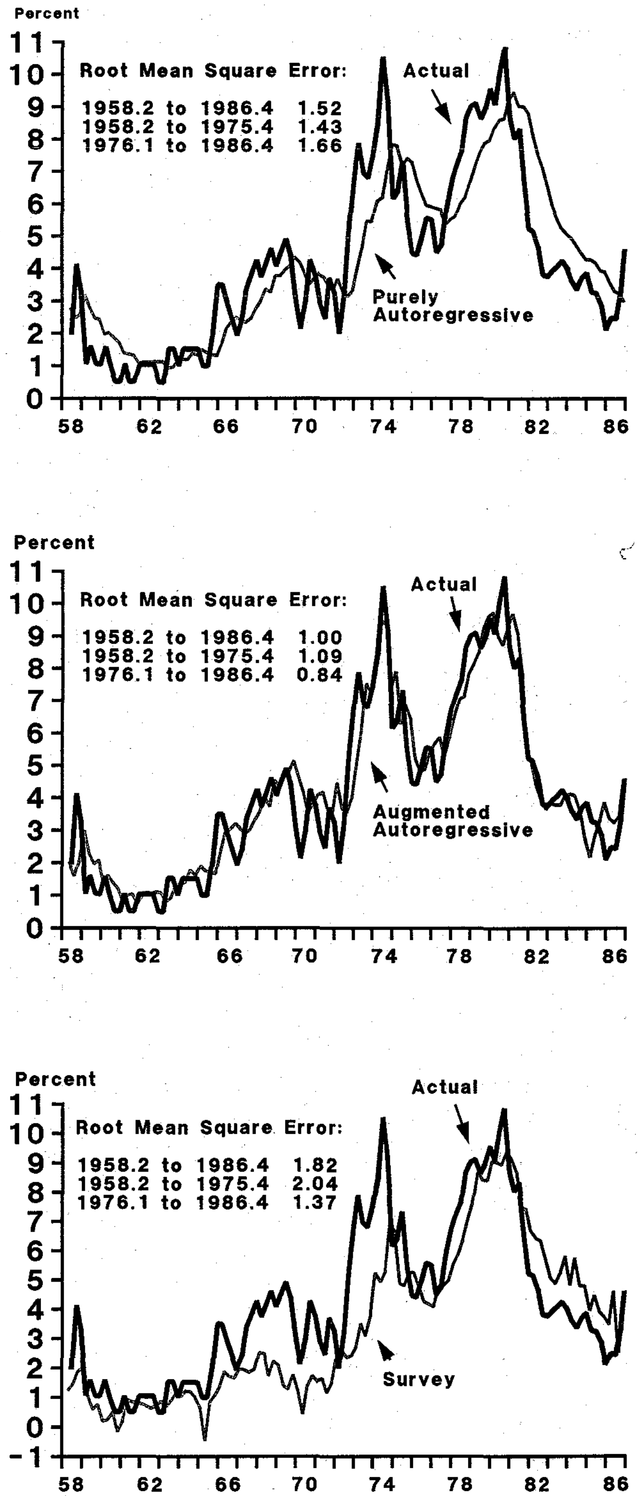
The augmented autoregressive forecasting equation produces unbiased forecasts because it is based on an expectations-augmented Phillips curve. When the unemployment rate is at its full employment level, it contributes nothing to current inflation. Current inflation is then the same as past inflation, except as it is disturbed by shocks to the price level from oil or the dollar. But when the unemployment rate is below full employment and current inflation exceeds past inflation, the deviation of the unemployment rate from its full employment level explains the extent to which current inflation exceeds past inflation.

The augmented autoregressive forecasting equation omits growth in the money supply—a variable that most proponents of rational expectations think is important in the formation of expectations of inflation. Since inflation generally is believed by economists to be a monetary phenomenon, particularly in the long run, Rutledge (1974) and others have argued that past movements in the stock of money should be the primary determinant of inflationary expectations. But the augmented autoregressive equation already describes the dynamic process by which monetary impulses are transmitted to prices, and nothing is added by including money growth.[8]

Survey Measure

A survey measure of expected inflation might provide even better forecasts of inflation, as it could incorporate projected values of any and all determinants of inflation that market participants might think are important. In particular, it could include information on current and past

Chart 1
Alternative Measures of Expected Inflation*



* Expected two quarters ahead

values of economic variables that are omitted from the augmented autoregressive measure and judgments about the likely stance of monetary policy and other government actions in the future.

For a survey measure of two quarter ahead expectations, we use the NBER-ASA survey for the period from the fourth quarter of 1968 to the fourth quarter of 1986 and the Livingston survey for the years not covered by the NBER-ASA survey. Both these surveys cover forecasts of professional business economists that were available to the public.[9] The NBER-ASA survey is preferred for our purposes since it gauges inflation by a GNP index, while the Livingston survey refers to consumer prices. Movements in consumer prices and GNP prices have tended to diverge the most when there have been supply shocks from oil, food, or the dollar. Consequently, little is lost by using the Livingston survey for the relatively tranquil period through the end of the 1960s. Moreover, we have adjusted the Livingston survey to remove systematic differences between the trend rate of inflation in the consumer price index and prices in the GNP index.[10]

Ironically, extensive analysis of the NBER-ASA survey by Zarnowitz (1985) and the Livingston survey by Carlson (1977), Pearce (1979), and Figlewski and Wachter (1981) shows that the inflation forecasts of professionals are not fully rational and instead, display systematic bias in their forecast errors, the more so the longer the term of the forecast. As shown by Zarnowitz (1985), however, their forecasts of most other variables have come considerably closer to satisfying the criterion of rationality.[11]

Also, the inflation forecasts of these surveys generally have been no more accurate than the forecasts of either the purely autoregressive or augmented autoregressive measures of expectations. Chart 1 shows the forecasts of these three measures of expected inflation compared with the actual inflation rate realized for two quarters ahead from 1958 to 1986. The root-mean-squared forecasting errors of the survey, purely autoregressive, and augmented autoregressive measures of inflationary expectations for the period 1958.2 to 1986.4 are 1.82, 1.52, and 1.00 percentage points, respectively. The purely autoregressive measure systematically lags behind actual inflation due to the way it is constructed. But its forecast errors in the period since 1958 actually are smaller than those of the survey measure, and the errors of the augmented autoregressive measure of inflationary expectations are smaller still.

Although the survey measure chronically underestimated inflation through the mid-1970s, the professional forecasters covered by the surveys became more sophisticated over time. Despite continued shocks from oil and the dollar, the root-mean-squared error of their forecasts dropped from 2.04 percentage points in the period 1958.2–1975.4 to 1.37 percentage points in 1976.1–1986.4. As a result, their forecasting error dropped below the 1.66 percentage point error of the purely autoregressive forecast in the second period, but still was considerably larger than the 0.84 percentage error of the augmented autoregressive forecast.

II. Short-Term Inflationary Expectations and Consumer Durables

In this section, the San Francisco econometric model's equation for expenditures on consumer durables is used to determine which of the three alternative measures of expected inflation best represents the short-term inflationary expectations of households. In this equation, expenditures on consumer durables follow a stock adjustment process. The desired stock of durables is determined, in part, by a real short-term interest rate. To obtain this rate, the measures of short-term inflationary expectations derived in the preceding section are used. The best measure of household inflationary expectations ought to generate a measure of the real interest rate that gives the best fit to the durables equation.

In the San Francisco model, the desired stock of durables depends upon the level of permanent income.[12] The adaptive expectations hypothesis is used to measure permanent income, so that permanent income is a geometrically declining distributed lag on disposable income. Transitory income, which is the difference between current income and permanent income, is allocated to either real or financial assets, including consumer durables. A freely fitted distributed lag on disposable income captures both of these effects. If the speed of adjustment of the actual to the desired stock of durables is slow compared with the rate of replacement, then the stock of consumer durables in the previous period enters the equation with a positive sign.

Finally, an important determinant of the relative price of durables is the real short-term rate of interest. We use the real 6-month commercial paper rate to measure this. The effect of the real interest rate on the desired stock of durables is captured by a distributed lag on the product of the real interest rate and permanent disposable income, which allows the absolute effect of a change in the real interest rate on real expenditures to increase with the level of real income. Thus, the form of the equation that is estimated is:[13]

$$CD = a + \sum_{i=0}^{3} b_i YD_{-1} - \sum_{i=1}^{2} c_i (i - \dot{p}^e)_{-i} YD^p_{-i} + d_i K_{-1} \qquad (5)$$

where CD = real expenditures on consumer durables
YD = real disposable personal income
i = nominal 6-month commercial paper rate
$\dot{p}^e$ = measure of two quarter-ahead expected inflation
YD^p = permanent real disposable personal income
K = real stock of consumer durables

The estimated standard errors of this equation, using the three alternative measures of two quarter-ahead expectations of inflation, are shown in Table 1. Since the survey forecast became considerably more accurate after the mid-1970s, the sample period was split into two sub-periods of 1958.2–1975.4 and 1976.1–1986.4. In the first sub-period, the standard errors associated with the three alternative measures of expected inflation are quite close to one another. Household expectations of inflation in this period are not measured well by any of the three alternative measures, given the maintained hypothesis that consumer expenditures on durables are affected by expected inflation. Otherwise, one of the three measures would have fit the data distinctly better than the others, given the strong differences between them in this period.

In the second sub-period, household short-term expectations of inflation are most closely represented by the purely autoregressive measure. The purely autoregressive measure of expected inflation produces the lowest standard error for the consumer durables equation of the three alternative measures of expected inflation. There is a relatively small difference from the survey measure and a much larger difference from the augmented autoregressive measure. The relatively small difference between the closeness of fit of the purely autoregressive and survey measures in this period is due to the high correlation between their movements, as shown in Chart 1. The forecast errors of these two measures also are similar in the second sub-period. Apparently, the survey measure does not contain much extra information that households could have used. Thus, households' expectations of inflation in recent years appear to have been basically adaptive.

In an important work, Lucas (1976) has criticized the use of autoregressive expectations in econometric modeling. Lucas argued that agents form expectations rationally, and not adaptively, and as a result, the relationship beween past inflation and expected inflation would change if economic agents recognize that a significant shift in monetary policy is taking place. Therefore, an additional test of whether household expectations are adaptive is whether the consumer durables equation that uses autoregressive expectations of inflation is stable in a period of significant change in monetary policy.

One such period is the post-October 1979 disinflation in the U.S. economy. At the beginning of this period, a technical change in the Fed's operating procedures both signaled the Federal Reserve's commitment to lower inflation and facilitated the achievement of the desired reduction in monetary growth. The policy achieved its objective. Inflation in the GNP price index dropped from a 9.8 percent rate in 1980 to 2.3 percent in 1986. If any recent change in monetary policy could have altered expectations of inflation independently of the past history of inflation, this would appear to be it. Not only were there indications of a new resolve on the part of the Federal Reserve, but the Reagan Administration was highly supportive of a disinflationary policy. In addition, as Huizinga and Mishkin (1986) recently have shown, the post-October 1979 period

Table 1

Estimated Standard Errors of Consumer Durables Equation

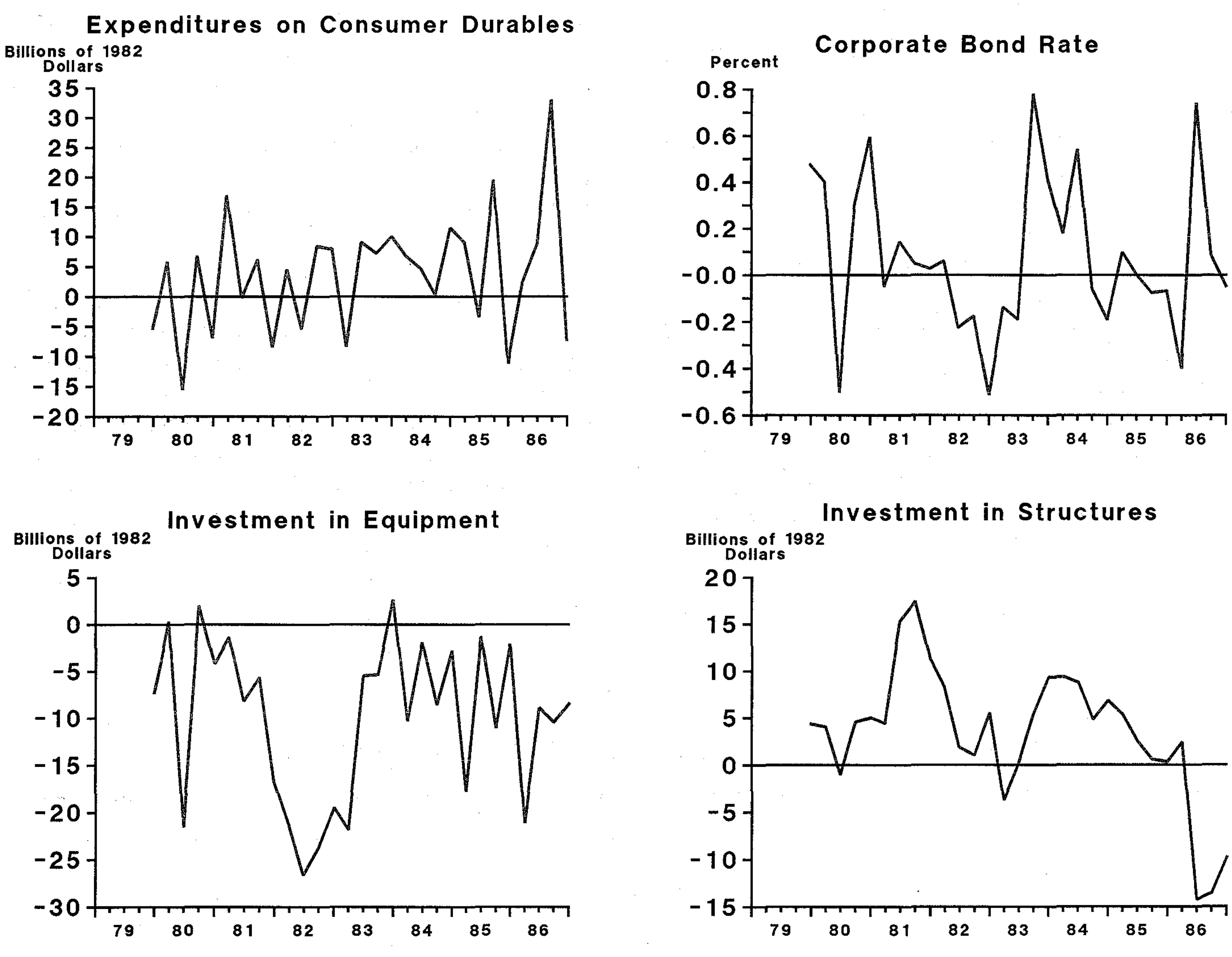
Sector	Model of Expected Inflation		
Expenditures on Consumer Durables (Billions of 1982 Dollars)	Purely Autoregressive	Augmented Autoregressive	Survey
1958.2–1975.4	4.47	4.41	4.37
1976.1–1986.4	6.59	7.60	6.81

meets the technical criteria for a "regime shift" in monetary policy.

According to the Lucas critique, this shift in the monetary policy regime should have helped to bring down expectations of inflation faster than usual. As a result, an autoregressive measure of expected inflation would tend to overestimate true expectations and therefore underestimate true real interest rates. A consumer durables equation using this estimate of real interest rates would therefore tend to overpredict spending.

As shown in Chart 2, however, there is no systematic tendency for the consumer durables equation to overpredict spending in the period after October 1979 even when the autoregressive measure of inflationary expectations is used. Moreover, as shown in Table 2, an F test rejects the hypothesis of instability in the coefficients of the consumer durables equation, suggesting that no shift in the formation of expectations occurred.[14] This is contrary to the prediction of the Lucas critique. Not only do household expectations of inflation appear to be basically adaptive, but their estimated structure continued to hold up in a period of significant policy change.

Chart 2
Out-of-Sample Forecasting Errors*



* Actual less predicted

Table 2
F Tests for Stability

Equation	Model of Expectation Formation	Sub-Periods	Critical F Values 1%	Critical F Values 5%	F Statistic
Expenditures on Consumer Durables	Purely Autoregressive	1958.2–1979.3 1979.4–1986.4	1.92	2.51	1.33
Corporate Bond Rate	Augmented-Autoregressive	1961.4–1979.3 1979.4–1986.4	1.77	2.24	2.86
Investment in Equipment	Purely Autoregressive	1964.1–1979.3 1979.4–1986.4	2.21	3.04	1.74
Investment in Structures	Purely Autoregressive	1964.1–1979.3 1979.4–1986.4	2.06	2.75	2.75

III. Short-Term and Long-Term Inflationary Expectations and the Bond Rate

In this section, three alternative measures of expected long-term inflation are developed within the context of the equation in the San Francisco model that explains the Aaa corporate bond rate. This equation is based on the "preferred habitat" theory of the term structure of interest rates developed by Modigliani and his colleagues. This approach synthesizes the market segmentation and expectational theories of the term structure of interest rates. In this approach, the long-term rate is equal to the average of current and expected short-term rates, modified by a risk premium reflecting the relative preferences of the two sides of the market for long versus short securities. In the original statement by Modigliani and Sutch (1966), expectations are formed autoregressively, with the past history of nominal short-term rates being used to forecast expected future short rates. In an improved version by Modigliani and Shiller (1973), expectations continue to be formed autoregressively, but the possibility that the process of expectation formation may differ for the real and inflationary components of future short-term rates is allowed.

The Modigliani and Shiller model for the long-term bond rate is:

$$i_l = K + \sum_{i=0}^{11} w_i(i_s - \dot{p})_{-i} + \sum_{i=0}^{11} v_i\dot{p}_i \qquad (6)$$

where i_l = Aaa corporate bond rate
i_s = 6-month commmercial paper rate
$\dot{p}$ = quarterly inflation rate
K = constant risk premium

In this model, expectations of future real short-term rates are formed autoregressively on the basis of a weighted average of current and past real short-term rates, with weights w_i. Moreover, short-term inflationary expectations in current and past real rates are modeled in the simplest possible autoregressive way. They are equal to the inflation rate at issuance of the short-term security, implying no expected change in inflation over the short-term horizon. Expected inflation premiums in future short rates —or equivalently, the long-term expectation of future inflation —also are measured autoregressively, but with weights v_i on current and past rates of inflation. Collecting the inflation terms, the equation that Modigliani and Shiller estimate for the bond rate then becomes:

$$i_l = K + \sum_{i=0}^{11}[w \cdot i_s]_{-i} + \sum_{i=0}^{11}[(v-w)\dot{p}]_{-1} \qquad (7)$$

We use this Modigliani and Shiller equation (7) for the purely autoregressive representation of inflationary expectations in the bond market.[15] Not only are expectations of inflation in current and past short rates formed autoregressively, but so also are expectations of the two components of future short rates.

More information would be incorporated if the augmented autoregressive measure of short-term expectations of inflation developed in the first section of this paper were used to calculate the current and past short-term real rates in equation (6). Thus, for the augmented autoregressive representation of expectations in the bond market, we substitute the augmented autoregressive measure of current and past short-term real rates for $i_s - \dot{p}$ in equation (6). Since current and past inflation represents current and past short-term expectations of inflation in the Modigliani and Shiller approach, the long-term expectation of inflation actually is formed on the basis of current and past short-term expectations of inflation. Therefore, in the augmented autoregressive representation of expectations, we can substitute the augmented autoregressive measure of short-term expectations for $\dot{p}$ in the rest of equation (6). The augmented autoregressive measures of short-term expectations of inflation can then be collected to form an equivalent of equation (7).

For the model of the bond rate with survey-based measures of expectations, the Livingston and NBER-ASA data were used for expected inflation in current and past short-term real rates and a survey of 10 year-ahead expectations of inflation collected by Richard Hoey of Drexel, Burnham, and Lambert was used for long-term expectations of future inflation. These 2-quarter-ahead and 10-year-ahead survey measures of expected inflation are plotted in Chart 3. Since the Hoey survey of 10-year-ahead expectations does not go back before 1978.4, we estimated the 10-year-ahead expectations for the prior years, based on a geometric lag on the 2-quarter-ahead expectations. Analysis of the two survey measures revealed that short-term and long-term expectations of inflation have a rather well behaved term structure, similar to that assumed in the two autoregressive measures. Thus, it was reasonable to approximate the 10-year-ahead expectations for the period prior to the Hoey survey by means of a geometric lag on 2-quarter-ahead expectations. This geometric lag assumes that long-term expectations of inflation are revised in proportion to the difference between the current short-term expectation of inflation and the previous long-term expectation.[16]

For the survey-based measure of expectations, the bond rate equation was estimated in the form of equation (6), with the survey measure of short-term expectations of inflation incorporated into $i_s - \dot{p}$ and the survey measure of long-term expectations being used for the final term. In contrast, the bond rate equation estimated for the other two measures of expectations takes the form of equation (7), where the measures of short-term expectations of inflation are collected.

The sample period again was split in the mid-1970s. Recall that the forecast errors of the survey measure of short-term expectations of inflation dropped considerably in the second of the sub-periods. Also, remember that the survey measure of long-term expectations of inflation is

Chart 3
Survey Measures of Expected Inflation

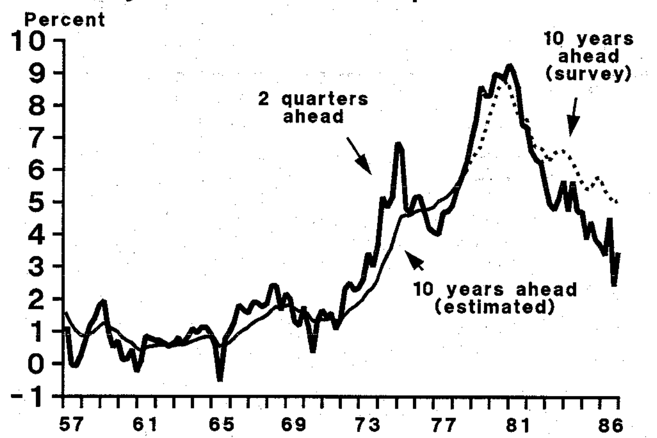


Table 3
Estimated Standard Errors of Bond Rate Equation

Sector	Model of Expected Inflation		
Corporate Bond Rate (Percent)	Purely Autoregressive	Augmented Autoregressive	Survey
1961.4–1975.4	.128	.105	.147
1976.1–1986.4	.374	.376	.423

mostly actual data in this period, rather than being estimated through a term structure relation with short-term expectations. Nevertheless, as shown in Table 3, the bond rate equation using the survey measure has distinctly the largest standard errors of any of the three measures of expectations in *both* sub-periods. A partial explanation of the relatively poor fit of the survey measure in the bond rate equation may be that the survey evidence measures *average* rather than *marginal* beliefs. The presence of arbitragers in this market suggests that actions of marginal investors are likely to be much more critical than in other markets.

The augmented autoregressive measure of expected inflation has the lowest standard error in the 1961.4–1975.4 subperiod, and about the same standard error as the purely autoregressive measure in the 1976.1–1986.4 subperiod. Thus, the forecasts of marginal investors appear usually to have incorporated at least some of the extra information contained in the augmented autoregressive measure of expectations. This is true even in the second sub-period when the standard errors of the bond rate equation are about the same for these two measures of expectations. Since the augmented autoregressive measure of expectations contains more information and has a lower forecasting error, the equal standard errors generated by the bond rate equation suggest that market participants used some, but not all, of this extra information in this period.

Once again, we examine the Lucas critique of the adaptive expectations approach by testing for stability of the term-structure equation in the period following the post-October 1979 shift in monetary policy. The Federal Reserve's shift to a disinflationary monetary policy could have produced two opposite effects on the term structure of interest rates. On the one hand, a credible disinflationary policy could produce expectations of a sustained period of tight money in which the real short-term interest rates expected in the relatively near future would rise by more than ordinarily would be explained by the behavior of current and past short-term rates. On the other hand, such a policy also could dampen expectations of inflation, which would reduce the nominal short-term rates expected in the more far distant future due to lower inflationary premiums in interest rates. If the first effect dominates, the term-structure equation would tend to underpredict nominal long-term rates of interest. But if the second effect dominated, overprediction would result. For a bond with a long maturity, the second effect would be more likely to dominate if inflationary expectations were significantly affected.

Chart 2 shows out-of-sample forecast errors of the equation for the Aaa corporate bond rate for the post-October 1979 period. The augmented autoregressive measure of inflationary expectations was used since it best fits the data for the entire sample period. From 1979.4 through 1982.1, the forecast errors (actual minus predicted) are positive for eight out of the ten quarters, suggesting that there was an upward shift in expectations of future *real* short-term interest rates due to the shift to a disinflationary policy. This shift is strong enough that an F test for the whole period from October 1979 through the end of 1986 rejects stability at the 5 percent level, as shown in Table 2. But the effect was only temporary. After the first quarter of 1981, forecast errors are neither predominantly positive nor negative.

Thus, in the period immediately after October 1979, there is evidence of an upward shift in expectations of future real short-term interest rates. Any response of an expected decline in inflationary premiums was not strong enough to offset this, even though the Aaa corporate bond has a long maturity. Moreover, after 1982 when real interest rates had dropped, there is no predominance of negative forecast errors, as would have been the case if the augmented autoregressive forecasts were overpredicting the market's expectation of future inflation. Therefore, although there is evidence to suggest that bond market participants believed tight monetary policy would affect real interest rates in a manner that could not have been predicted by extrapolation from past history, this belief does not appear to have extended to their expectations of disinflation in wages and prices.[17]

IV. Long-Term Inflationary Expectations and Business Fixed Investment

Alternative measures of longer term expectations of inflation are evaluated next within the context of the real after-tax bond rate in the San Francisco econometric model's equations for business investment in equipment and structures. These equations follow the neoclassical theory of investment developed by Jorgenson (1963) and Hall and Jorgenson (1967). In this approach, capital is a substitute for other factors of production, and firms combine capital with these other factors so as to minimize costs and maximize profits.

These investment equations follow a stock-adjustment process in which the desired stock of capital is determined by final sales and the real rental cost of capital. Lag weights are imposed according to the lags between capital appropriations and expenditures, as estimated by Almon (1965). A 2-quarter time lag between investment decisions and capital appropriations is assumed. In addition, we allow investment plans to be cancelled or expanded after the initial appropriations process when sales turn out to be greater or less than originally anticipated. This is captured by adding a variable equal to the difference between sales lagged one quarter and expected sales, as measured by a distributed lag (with weights the same as between appropriations and capital expenditures) on past sales, adjusted for normal growth. Thus, the form of these equations is:[18]

$$I = b_0 + b_1 \sum_{i=2}^{9} (w \cdot FS)_{-i} + b_2 \sum_{i=2}^{9} (w \cdot RC \cdot FS)_{-i} - b_3 \sum_{i=3}^{10} (w \cdot K)_{-i} + b_4 [FS_{-1} - \sum_{i=3}^{10} w_{-i} \cdot FS_{-i} (1+T)^{i-1}]. \quad (8)$$

where I = real investment in equipment or structures
FS = real final sales
RC = real rental cost of capital
K = real stock of capital at end of quarter
w = lag weights

The real rental cost of capital can be shown to be equal to:[19]

$$RC = T(i - \dot{p} + d) \quad (9)$$

where i = nominal long-term interest rate
$\dot{p}$ = long-term expectation of inflation
d = physical rate of depreciation of capital
T = term that depends on corporate income tax, any investment tax credits, and allowable depreciation

The real rental cost of capital is a function of the real rate of interest, $i - \dot{p}$, as well as the physical rate of depreciation and taxes. For long lived capital investment, such as plant and equipment, the relevant real rate of interest is a long-term one. We calculate this as a weighted average of the real cost of debt and equity capital, with weights of ⅓ and ⅔, respectively, equal to their average values over the past two decades. The real cost of equity capital is measured by a distributed lag on earnings per dollar of share price. The real cost of debt is calculated on an after-tax basis. Since interest cost is deductible from earnings, every dollar of interest cost reduces corporate taxes by the amount of the corporate tax rate.

Equations for business investment in equipment and structures were estimated with three alternative measures of the long-term expectations of inflation that enter into the real after-tax Aaa bond rate in the rental cost of capital. The autoregressive measure of long-term inflation expectations is a purely adaptive one calculated as a geometrically declining weighted average of past inflation, where the estimated rate of decline is slower than in the adaptive measure of two quarter-ahead expectations.[20] This adaptive measure is subtracted from the nominal after-tax Aaa bond rate to obtain the purely autoregressive measure of the real after-tax bond rate.

The augmented autoregressive measure of the real after-tax bond rate is obtained from a weighted average of expected real after-tax short rates, plus a risk premium, calculated from the first two terms of equation (6). Specifically, this measure of the real after-tax bond rate is calculated by weighting the augmented autoregressive measure of current and past real after-tax short-term rates with estimated weights, w_i. To this we add the tax-adjusted value of the estimated risk premium, K, to obtain the augmented autoregressive measure of the real after-tax bond rate.

Finally, the survey measure of long-term expectations of inflation that we use is simply the 10-year-ahead Hoey survey, which was extrapolated backward on the basis of the estimated relationship between the short- and long-term surveys, as discussed in Section III. This survey measure is subtracted from the nominal after-tax Aaa bond rate to obtain the survey measure of the real after-tax bond rate.

The standard errors of the model's equations for investment in equipment and structures using the three alternative measures of long-term expectations of inflation are presented in Table 4. The standard errors for the survey and adaptive measures are about equally low, suggesting that economic agents who make long-term capital investments form their long-term expectations of inflation adaptively. The augmented autoregressive measure of long-term expectations of inflation gives distinctly larger standard errors in both equipment and structures than do the other two measures. Even though this measure incorporates information that is used to some extent by arbitragers in the bond market, there is no indication that this information also is utilized by economic agents undertaking business investment in equipment and structures.

Turning to the question of the stability of the structure of these adaptive expectations, out-of-sample forecast errors for these investment equations in the period after October 1979 are shown in Chart 2. In the case of investment in

Table 4
Estimated Standard Errors of Investment Equations

Sector	Model of Expected Inflation		
Nonresidential Fixed Investment (Billions of 1982 Dollars)	Purely Auto-regressive	Augmented Autoregressive	Survey
Equipment			
1964.1–1986.4	5.19	5.47	5.12
Structures			
1964.1–1986.4	2.82	2.99	2.81

equipment, there is a general tendency for the equation to overpredict, as would occur if the real bond rate were being understated due to overpredictions of inflation associated with adaptively formed expectations. However, the largest of these errors occur during the 1981–82 recession when the equation appears to be prone to missing a turning point. Any errors from an adaptive mismeasurement of long-term inflationary expectations likely would have died out more gradually than these do. Also, an F test cannot reject stability of the equipment equation, as indicated in Table 2. Thus, the forecast errors of the equipment equation are not atypically large, and they appear to be more closely related to business cycle factors than to the mismeasurement of expected inflation.

The equation for investment in structures tends to underpredict in the post-October 1979 period, which is the opposite of what would be expected from an adaptive mismeasurement of expected inflation. Also, the F test indicates stability. Taken together, the results for investment in equipment and structures do not suggest that the Federal Reserve's shift to a disinflationary monetary policy had any significant direct effect on the formation of long-term expectations of inflation over and above the adaptive response of market participants to current and past inflation.

V. Summary and Conclusions

In this article, we have evaluated the explanatory power of alternative measures of expected inflation in the investment sector of a structural econometric model of the U.S. economy. Previous research has indicated that purely autoregressive models of expected inflation fit labor market data about as well as survey measures that might capture any additional information used by market participants in the formation of expectations.[21] These studies also have found that an autoregressive representation of inflationary expectations in the labor market generally is robust to sharp changes, such as the acceleration of inflation in the 1970s and the post-1981 disinflation in the United States.[22] Likewise, in this study, we have found that the inflationary expectations of participants in the investment sector of the economy generally have these same characteristics.

The short-term expectations of inflation reflected in households' purchases of consumer durables are as well represented by a purely autoregressive measure based on past inflation alone as by a survey measure, suggesting that actual expectations are basically adaptive.

We also examined alternative measures of long-term expectations of inflation in the context of business decisions with respect to long-lived capital investment. These long-term expectations of inflation are about equally well represented by a purely autoregressive measure and a survey measure, suggesting that here too, actual expectations of inflation are basically adaptive.

In contrast, investors who arbitrage between short-term and long-term securities appear to take into account additional information that is not captured by either a purely autoregressive or a survey measure of expected inflation. This additional information is at least partly captured by an augmented autoregressive measure containing not only past inflation, but also current unemployment and current and past changes in the real price of oil and the real value of the dollar.

Since neither the purely autoregressive nor the augmented autoregressive measure of expected inflation contains any forecast of future monetary policy, both might be poor estimates of inflationary expectations when changes occur in monetary policy that potentially might change relationships between future inflation and the current and past values of inflation or other variables—the Lucas critique. An important example of such a change is the disinflation that was produced by a change in U.S. monetary policy in October 1979. But stability tests on the equations for spending on consumer durables, the long-term bond rate, and business fixed investment do not indicate that the Federal Reserve's October 1979 shift in monetary policy significantly affected the formation of inflationary expectations, either short- or long-term, in any direct way. Although there is evidence that this policy temporarily affected expectations of future *real* interest rates, its influence does not appear to have extended in any significant way to the formation of expectations of inflation premiums in future nominal interest rates.

In conclusion, inflationary expectations in the U.S. economy appear close to being purely adaptive, formed simply by extrapolating from past inflation. Moreover, autoregressive representations of inflationary expectations appear quite stable, even in the face of major changes in monetary policy. Contrary to the Lucas critique, conventional macro-econometric models that contain relatively backward looking and slowly adjusting autoregressive expectations of inflation can be expected to generate reasonably accurate forecasts of the economy's response to changes in monetary policy.[23] This response includes a significant short-run effect on real interest rates, output, and employment, but one that diminishes over several years so that in the long run only inflation is affected.

ENDNOTES

1. An earlier version of this structural macro-econometric model, described in Throop (1984b), contained only the aggregate demand side of the economy. The current version of the model includes additional equations for the inflation rate, the unemployment rate, the share of disposable income in GNP, and the demand for money. A complete description of the current version is forthcoming in the *Working Papers in Applied Economic Theory and Econometrics* series of this Bank, and an article summarizing its dynamic properties will be published shortly in the *Economic Review.*

2. See, for example, Friedman (1957) and Nerlove (1958).

3. The parameter α was estimated from equations in the model, rather than from the actual two quarter-ahead inflation rate, because we want the best representation of the public's expectation of inflation. This is not necessarily the same thing as the best forecast of inflation.

4. This relationship between the speed of adjustment and the degree of excess demand has been advanced by Samuelson (1974), Baumol (1959), Reder (1947), and Lipsey (1960), among others.

5. According to an alternative view, markets always are in equilibrium, and movements in employment and output are due solely to misperceptions of future inflation. The equilibrium view, which was proposed in an early form by Irving Fisher (1926), underpins the "new" classical macroeconomics of Lucas (1972, 1975) and Sargent (1976). In the equilibrium view, price and wage changes cause output and employment changes, and so would normally tend to precede them; whereas in the more conventional view, causation runs in the reverse direction and with the opposite lags. The available evidence suggests that changes in employment and output generally tend to precede the price and wage changes associated with them, supporting the conventional view. See Gordon (1980), Laidler (1978), Nelson (1981), Okun (1980), and also the recent survey article by Kniesner and Goldsmith (1987) on this subject.

6. The civilian unemployment rate is adjusted for the effects of changes in the full employment rate of unemployment due to changes in the demographic composition of the labor force. This is done by subtracting from the civilian unemployment rate a measure of variation in the unemployment rate due to demographics that has been calculated by the Congressional Budget Office (1987). Partly as a result of these demographic changes, Medoff and Abraham (1982) find that in the United States the vacancy rate is a more accurate measure of excess demand than the unemployment rate, but the Bureau of Labor Statistics has collected vacancy data experimentally for only a relatively brief period. Better data on vacancies is available in the U.K., where a stable inverse relationship between vacancies and unemployment has been observed. See Dicks-Mireaux and Dow (1958, 1959).

7. Our treatment of the role of the value of the dollar and the price of oil in the inflation process draws on the earlier work of McElhattan (1985). A useful survey of previous studies on the impact of the value of the dollar on prices is Hooper and Lowry (1979). For more recent evidence, see Woo (1984).

8. The relationship between inflation and M1 growth deteriorated badly after 1982. Compare Karnosky (1976) with Judd and Trehan (1987). But even before 1982, inflation could be predicted as well by an augmented Phillips curve that describes the dynamics of the process by which monetary impulses are transmitted to prices as by money itself, as shown by Throop (1984). Moreover, as

Wachter (1976) has demonstrated, past money growth does not contribute any more to an explanation of inflation than past inflation does when either one is included in an augmented Phillips curve.

Some recent research has emphasized the distinction between the effects of anticipated and unanticipated money growth on prices. For example, Barro (1987) argues that anticipated money growth has a one-to-one contemporaneous effect on prices, while deviations in output growth from trend are due only to unanticipated money growth. However, the notion of an immediate response in prices to anticipated changes in money makes sense only in the case of auction markets where there is no inertia in price adjustment. It would be difficult to characterize U.S. labor markets and many product markets in such terms. Studies which dispute the importance of the distinction between anticipated and unanticipated money growth include Mishkin (1982) and Gordon (1982).

9. The NBER-ASA survey is published periodically by the Survey Research Center of the University of Michigan in *Economic Outlook USA.* Complete data tapes are maintained by the National Bureau of Economic Research. We used the Livingston survey as adjusted by Carlson's (1977) method and maintained by the Federal Reserve Bank of Philadelphia.

10. Actually, the NBER-ASA survey uses the GNP implicit price deflator, rather than the GNP fixed-weighted price index used in our structural econometric model. But each of the survey measures of expectations was adjusted to remove any systematic difference between their trend rates of inflation and the trend rate of change in the GNP fixed-weighted price index. This was done by subtracting from each the average difference between two quarter-ahead inflation in its concept and two quarter-ahead inflation in the GNP fixed-weighted price index in neighboring quarters.

11. Zarnowitz (1985) shows that the NBER-ASA survey is not free of systematic bias, the more so the longer the term of the forecast. A lack of randomness in the errors from the Livingston forecast is confirmed by Carlson (1977). Pearce (1979) has found that univariate time series models yield better inflation predictions than the Livingston survey. In addition, Figlewski and Wachtel (1981) have examined the individual forecasts contained within the Livingston sample. They conclude that the condition of unbiasedness can easily be rejected and that current forecast errors can be explained by past forecast errors. Webb (1987) points out a number of pitfalls in using *ex post* tests of statistical bias to infer the *ex ante* rationality of forecasts. Even so, the difference between the accuracy of survey forecasts of inflation and the accuracy of their other forecasts is striking.

12. The permanent income hypothesis of Friedman (1957) was used in early versions of the San Francisco econometric model. Studies applying this approach to consumer durables include Juster and Wachtel (1972) and Darby (1975). In the forthcoming version, however, the consumption function is based on the life-cycle model of Ando and Modigliani (1963).

13. Permanent disposable income was calculated as a 16 quarter geometric lag on current disposable income, adjusted for the trend in income:

$$YD^P = \sum_{i=0}^{15} \alpha(1-\alpha)^i(1+T)^i YD_{-i}.$$

The parameter α was estimated at 0.5. Also, dummy variables were included to capture the effects of the Carter administration's credit controls in the period 1980.2 through 1980.4.

Until the 1986 reform of the tax law, interest paid on the purchases of consumer durables was deductible from taxable income for households who itemized. Thus, the real *after-tax* rate of interest is the theoretically correct measure of the cost of capital for these individuals, as well as households whose alternative is investment in financial assets. The consumer durables equation was first estimated with the real after-tax commercial paper rate, using the Barro and Shahasakul (1983) estimates of the average marginal tax rate of households. However, when alternative weights between zero and one were placed on the tax rate, the best fitting equation was the one with a zero weight. Therefore, the real pre-tax commercial paper rate was chosen for the equation.

14. In Table 2, the variables were all transformed according to the estimated serial correlation coefficient for the full period. F tests were then performed on the residuals from the estimated equations that use these transformed variables. This procedure avoids a rejection of stability simply because of instability in the error pattern, as opposed to a shift in the structural equation itself.

15. An additional component of the term structure equation that we estimated, which for simplicity is not discussed in the text, allows for the fact that the average effective maturity, or "duration," of a coupon bond depends upon the level of interest rates. When interest rates are high, the duration of newly issued bonds is shorter because a larger portion of the total payment of interest and principal occurs relatively early. Conversely, when interest rates are low, the duration of a bond becomes longer. Thus, the lags on past interest rates in an autoregressive model of expectations should be shorter the shorter is the average effective maturity of the bond. The term structure equation captures this duration effect by adding a term formed by multiplying a distributed lag on the commercial paper rate by the recent average level of the commercial paper rate, with the sum of the weights on the lagged values of the commercial paper being constrained to zero. The estimated coefficients on these lagged values of the commercial paper rate are first positive and then negative. Thus, the mean length of the overall lag distribution on the commercial paper rate shortens when the level of interest rates rises, confirming the existence of a duration effect. For further discussion of the duration effect, see Van Horne (1984).

We also experimented with the assumption of a greater degree of rationality in expectations by including the change in the ratio of the federal high employment budget to high employment GNP from the last four quarters to four quarters ahead as an additional variable. Information is generally available about what the budget will look like in the coming year, and a rational market should incorporate this information into its view of where short-term interest rates in the future will be, and therefore what bond yields should be today. However, even when the test for such an effect was restricted to the period of large and growing budget deficits under the Reagan administration, no statistically significant impact of expected changes in the budget deficit could be detected.

16. The best fitting geometric lag has a speed of adjustment, equal to the coefficient α in equation (3), of 0.17.

17. Blanchard (1984) reaches a similar conclusion.

18. The equation for structures also contains a distributed lag on the real price of oil. An important component of investment in structures is oil drilling, which responds positively to its price.

19. For a derivation, see Hall and Jorgenson (1967) or Throop (1984b).

20. The best fitting geometric lag in equipment and structures has a speed of adjustment, equal to the coefficient α in equation (3), of 0.05.

21. McNess (1979) compared an expectations-augmented Phillips curve using an autoregressive measure of expected inflation with an alternative version using the survey measure collected by Joseph Livingston, a columnist with the *Philadelphia Inquirer.* Kaufman and Woglom (1984) perform a similar test on union wages using microeconomic data and conclude that their data "do not provide strong support to allow us to reject the hypothesis that inflationary expectations are backward looking."

22. Blanchard (1984), Englander and Los (1983), and Perry (1983) found that expectations-augmented Phillips curves with autoregressive expectations were stable in face of the sharp disinflation after 1981. An earlier study demonstrating similar stability in the 1970s is Smaistrla and Throop (1980).

23. This conclusion holds only for the time periods and policies in this and other studies cited—basically post-World War II U.S. experience. Although there has been a significant amount of variation in inflation in the U.S. economy during this period, extreme variability could cause an autoregressive model of the formation of inflationary expectations to break down. Thus, for example, when comparing countries with vastly different variability in inflation rates, Lucas (1973) finds that the short-run trade-off between inflation and unemployment tends to steepen in those countries where the variability in inflation is greater. A stable autoregressive structure of inflationary expectations, therefore, would not hold up across this range of experience. Similarly, Sargent (1982) finds that in cases where hyperinflations caused by the monetization of government debt have been ended by the creation of an independent central bank and a simultaneous alteration in the fiscal policy regime, inflations were ended quickly and with little adverse effect on output and employment. In these instances, extreme changes in policy and institutions caused an abrupt shift in inflationary expectations that would be inconsistent with a stable autoregressive structure of expectations.

REFERENCES

Anderson, Paul A. "Rational Expectations Forecasts from Nonrational Models," *Journal of Monetary Economics,* No. 5, 1979.

Ando, Albert and Franco Modigliani. "The 'Life-Cycle' Hypothesis of Saving: Aggregate Implications and Tests," *American Economic Review,* March 1963.

Almon, Shirley. "The Distributed Lag Between Capital Appropriations and Expenditures," *Econometrica,* January 1965.

Barro, Robert J. "Unanticipated Money, Output, and the Price Level in the United States," *Journal of Political Economy,* August 1978.

________and Chaipot Shahasakul. "Measuring the Average Marginal Tax Rate from the Individual Income Tax," *Journal of Business,* October 1983.

Baumol, William J. *Economic Dynamics.* New York: Macmillan Co., 1959.

Blanchard, Oliver J. "The Lucas Critique and the Volcker Deflation," *American Economic Review,* May 1984.

Cagan, Phillip. "The Monetary Dynamics of Hyperinflation," in Milton Friedman (ed.), *Studies in the Quantity Theory of Money.* Chicago: University of Chicago Press, 1956.

Carlson, John A. "A Study of Price Forecasts," *Annals of Economic and Social Measurement,* Winter 1977.

Congressional Budget Office, *The Economic and Budget Outlook, An Update 1987,* Appendix B.

Darby, Michael. "Postwar U.S. Consumption, Consumer Expenditures, and Saving," *American Economic Review,* May 1975.

Dicks-Mireaux, L.A. and J.C.R. Dow. "The Excess Demand for Labor: A Study of Conditions in Great Britain, 1946–56, *Oxford Economic Papers,* February 1958.

________"The Determinants of Wage Inflation: United Kingdom, 1946–56," *Journal of the Royal Statistical Society,* Part II, 1959.

Eckstein, Otto. *The DRI Model of the U.S. Economy.* New York: McGraw-Hill Book Co., 1983.

Englander, A. Steven and Cornelis A. Los. "The Stability of the Phillips Curve and Its Implications for the 1980s," Working Paper, Federal Reserve Bank of New York, January 1983.

Figlewski, S. and P. Wachtel. "The Formation of Inflationary Expectations," *Review of Economics and Statistics,* February 1981.

Fisher, Irving. *The Theory of Interest.* New York: Macmillan, 1930.

_________ "A Statistical Relation Between Unemployment and Price Changes," *International Labor Review,* 1926. (Reprinted as: "I Discovered the Phillips Curve," *Journal of Political Economy,* March/April 1973.)

Friedman, Milton. *A Theory of the Consumption Function.* Princeton: Princeton Unviersity Press, 1957.

Gordon, Robert J. "A Consistent Characterization of a Near-Century of Price Behavior," *American Economic Review,* May 1980.

_________ "Price Inertia and Policy Effectiveness in the United States, 1890–1980," *Journal of Political Economy,* December 1982.

Hall, Robert E. and Dale W. Jorgenson. "Tax Policy and Investment Behavior," *American Economic Review,* June 1967.

Hooper, Peter and Barbara Lowrey. "Impact of the Dollar Depreciation on the U.S. Price Level: An Analytical Survey of Empirical Estimates," International Finance Discussion Paper 128, Board of Governors of the Federal Reserve System, January 1979.

Huizinga, John and Frederic Mishkin. "Monetary Policy Regime Shifts and the Unusual Behavior of Real Interest Rates" in Karl Brunner and Allan Meltzer (eds.), *The National Bureau Method, International Capital Mobility and Other Essays,* Carnegie Rochester Conference on Public Policy, Vol. 24 (1986).

Jorgenson, Dale W. "Capital Theory and Investment Behavior," *American Economic Review,* May 1963.

Judd, John L. and Bharat Trehan. "Portfolio Substitution and the Reliability of M1, M2, and M3 as Monetary Policy Indicators," *Economic Review,* Federal Reserve Bank of San Francisco, Summer 1987.

Juster, F. Thomas and Paul Wachtel. "Anticipatory and Objective Models of Durable Goods Demand," *American Economic Review,* September 1972.

Karnosky, Denis. "The Link Between Money and Prices," *Review,* Federal Reserve Bank of St. Louis, June 1976.

Kaufman, Roger T. and Geoffrey Woglom. "The Effects of Expectations on Union Wages," *American Economic Review,* June 1984.

Kniesner, Thomas J. and Arthur Goldsmith. "A Survey of Alternative Models of the Aggregate U.S. Labor Market," *Journal of Economic Literature,* September 1987.

Laidler, David. "Money and Money Income: An Essay on the Transmission Mechanism," *Journal of Monetary Economics,* April 1978.

Lipsey, Richard G. "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1862–1957: A Further Analysis," *Economica,* February 1960.

Lucas, Robert. "Expectations and the Neutrality of Money," *Journal of Economic Theory,* November/December 1972.

_________ "Some International Evidence on Output-Inflation Trade-Offs," *American Economic Review,* June 1983.

_________ "An Equilibrium Model of the Business Cycle," *Journal of Political Economy,* December 1975.

_________ "Econometric Policy Evaluation; A Critique," in Karl Brunner and Allan H. Meltzer (eds.), *The Phillips Curve and Labor Markets,* Carnegie-Rochester Conference on Public Policy, Vol. 1 (1976).

McElhattan, Rose. "Inflation, Supply Shocks and the Stable-Inflation Rate of Capacity Utilization," *Economic Review,* Federal Reserve Bank of San Francisco, Winter 1985.

McNess, Stephen K. "The Phillips Curve: Forward- or Backward-Looking," *New England Economic Review.* Federal Reserve Bank of Boston, July/August 1979.

Medoff, James L. and Katharine G. Abraham. "Unemployment, Unsatisfied Demand for Labor, and Compensation Growth," in Martin N. Bailey (ed.), *Workers, Jobs, and Inflation.* Washington, D.C.: The Brookings Institution, 1982.

Mishkin, Frederic S. "Does Anticipated Monetary Policy Matter? An Econometric Investigation," *Journal of Political Economy,* February 1982.

Modigliani, Franco and Richard Sutch. "Innovations in Interest Rate Policy," *American Economic Review,* May 1966.

Modigliani, Franco and Robert L. Shiller. "Inflation, Rational Expectations, and the Term Structure of Interest Rates," *Economica,* February 1973.

Muth, John F. "Rational Expectations and a Theory of Price Movements," *Econometria,* July 1961.

Nelson, Charles R. "Adjustment Lags Versus Information Lags: A Test of Alternative Explanations of the Phillips Curve Phenomenon," *Journal of Money, Credit and Banking,* February 1961.

Nerlove, Marc. "Adaptive Expectations and Cobweb Phenomena," *Quarterly Journal of Economics,* May 1958.

Okun, Arthur M. "Rational-Expectations-with-Misperceptions as the Theory of the Business Cycle, *Journal of Money, Credit and Banking,* November 1980, Part 2.

Pearce, Douglas K. "Comparing Survey and Rational Measures of Expected Inflation." *Journal of Money, Credit, and Banking,* November 1979.

Perry, George L. "What Have We Learned About Disinflation?" *Brookings Papers on Economic Activity,* No. 2, 1983.

Reder, Melvin W. *Studies in the Theory of Welfare Economies.* New York: Columbia University Press, 1947.

Rutledge, John. *A Monetarist Model of Inflationary Expectations.* Lexington, Mass.: D.C. Heath & Co., 1974.

Samuelson, Paul A. *Foundations of Economic Analysis.* Cambridge: Harvard University Press, 1947.

Sargent, Thomas. "A Classical Macroeconomic Model of the United States," *Journal of Political Economy,* April 1976.

________ "The Ends of Four Big Inflations," in Robert E. Hall (ed.), *Inflation: Causes and Effects.* Chicago: The University of Chicago Press, 1972.

________ *Macroeconomic Theory.* Orlando: Academic Press, 1987.

Smaistrla, Charles, and Adrian W. Throop. "A New Inflation in the 1970s?" *Financial Analysts Journal,* March/April 1980.

Throop, Adrian W. "Comparing Inflation Forecasts," *Weekly Letter,* Federal Reserve Bank of San Francisco, March 16, 1984a.

________ "A Structural Model of Real Aggregate Demand," *Working Paper in Applied Economic Theory and Econometrics,* No. 84-03, Federal Reserve Bank of San Francisco, July 1984b.

Van Horne, James C. *Financial Market Rates and Flows.* Englewood Cliffs, N.J.: Prentice Hall, 1984.

Wachter, Michael L. "The Changing Cyclical Responsiveness of Wage Inflation," *Brookings Papers on Economic Activity,* No. 1, 1976.

Webb, Roy H. "The Irrelevance of Tests for Bias in Series of Macroeconomic Forecasts," *Economic Review,* Federal Reserve Bank of Richmond, November/December 1987.