Index Numbers and the Measurement of Real GDP

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Index Numbers and the Measurement of Real GDP

Brian Motley

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The measures of real GDP and inflation are aggregates of many individual prices and quantities. These variables are measured using fixed-weight indexes, which can give a misleading impression of price and output changes in a particular year if the structures of output and relative prices are different from those in the base year. This measurement problem adds to the uncertainties facing policymakers. These ambiguities result from the definitions of output and inflation in use. This article describes alternative measures of growth and inflation that have a stronger theoretical basis and avoid these ambiguities. Operational versions of these measures will be introduced by the Bureau of Economic Analysis in 1992. These new measures will remove one source of uncertainty facing policymakers.

The Bureau of Economic Analysis (BEA), a division of the Commerce Department, is responsible for preparing and publishing estimates of the gross domestic product (GDP), the most comprehensive measure of our economy's total output. Most commentators take it for granted that these BEA estimates of GDP represent objective measures of the nation's output. They assume, in other words, that there is a "correct" measure of output that could be computed exactly if sufficient information were available and that the GDP data issued by the BEA represent the best available estimate of this "correct" measure. In fact, however, these measures of real GDP are subject to an inherent arbitrariness known as the "index number problem."

This problem arises because the nation's total output consists of a huge number of individual goods and services. Measures of real GDP are constructed as an aggregate of these separate components and so depend on the method of aggregation used and the weights assigned to the individual components. Last December, the BEA released revised GDP estimates that, among other changes, altered these weights. These revised data suggest that the cyclical downturn in the winter and spring of 1990-91 was somewhat more severe than reported earlier.

Measures of the average price level encounter the same problem. Price index numbers, such as the GDP fixed-weight price index or the consumer price index, are weighted averages of the prices of individual goods and services. When the prices of some items change more than those of others, the value of such an index depends on the weights attached to these prices.

This article discusses a number of issues raised by these measurement problems. It examines the extent to which existing methods of data construction might introduce systematic biases into the numbers. Because of the arbitrariness inherent in existing measures of output and prices, a number of alternative procedures are described that have a stronger theoretical basis. The BEA plans to introduce one such alternative approach to measuring output and prices in 1992.

The plan of the paper is as follows. In Section I the index number problem is described and illustrated. Sections II and III explain two alternative approaches to measuring the
nation’s output and price level that avoid the arbitrariness of the existing measures. In the first of these, the focus is on GDP as an indicator of the “standard of living” of the typical consumer, while the second emphasizes the “productivity” of the representative firm in converting factors of production (“inputs”) into final products (“outputs”). Section IV discusses the recent benchmark revisions to the national accounts and describes alternative measures of GDP growth and inflation that the BEA plans to introduce later in 1992. These alternative measures are based on the theory of index numbers discussed in Sections II and III. Since these alternative indexes will be forms of a “chain index,” this section also includes a brief discussion of this type of index number. Section V concludes.

I. Pitfalls in Measuring the Nation’s Output

The nation’s total output includes a vast array of different goods and services. The nominal gross domestic product (GDP) measures the aggregate of these individual components, with each item valued at the price at which it was sold to its final purchaser. Thus, GDP may be viewed as the weighted sum of its component commodities, with their current prices serving as weights. Specifically, nominal GDP at date $s$ may be written as:

\[ \text{NOMGDP}_s = (p_1 q_{1s}) + (p_2 q_{2s}) + \cdots + (p_N q_{Ns}) \]  

(1)

\[ \text{GDP}_s = \sum_{n=1}^{N} p_n q_{ns}. \]

It is natural to use prices as weights since, in a competitive, private enterprise economy, the amounts paid for commodities are good indicators of their usefulness (at the margin) to their purchasers. However, if the average level of prices increases (or decreases) over time, the change in nominal GDP includes the effects of this price change and so does not provide an accurate measure of the growth in real output.

A measure of real output may be obtained by valuing the output of each commodity at the price existing in some (arbitrarily selected) base year rather than at the price buyers actually paid. Operationally, the BEA calculates its estimates of real GDP at date $s$ in date $t$ prices by deflating each component of nominal GDP by the change in the price of that component from date $t$ to date $s$:

\[ \text{REALGDP}_s = \left( \frac{p_1 q_{1s}}{p_{t1}} \right) + \cdots + \left( \frac{p_N q_{Ns}}{p_{tN}} \right) \]

(2)

\[ \text{REALGDP}_s = \sum_{n=1}^{N} \frac{(p_n q_{ns})}{(p_{t_n}/p_{t_n})} \]

This means that the growth rate of real GDP from date $s$ to date $s + 1$ is a weighted average of the growth rates of its components:

\[ \frac{\text{REALGDP}_{s+1} - \text{REALGDP}_s}{\text{REALGDP}_s} \]

(3)

The weights, $p_n q_{ns}/\sum p_{it} q_{is}$, are given by the expenditure shares of each component in GDP calculated at the base-year prices. This means that if the base period is changed, the weights, and hence the measured growth rate of real GDP, also will change. Between 1985 and 1991, real GDP was calculated with 1982 as the base year, but last December this was changed to 1987.

This procedure also means that real growth in a particular year is in many cases measured using relative prices ruling in the distant future or past. The most recent measures of real growth and inflation during the 1930s, for example, use the relative prices ruling a half-century later. The significant changes in relative prices over this period may introduce large biases into the data.

In constructing its estimates of real GDP, BEA breaks down nominal GDP (excluding the federal government) into 811 components, each of which is deflated separately by an appropriate price index (Young 1988, Table 5). Purchases of goods and services by the federal government are divided into no fewer than 17,000 components! Equations (2) and (3) show that not only the level but also the growth rate of measured real GDP depend on which year’s prices are used in the process of aggregating the outputs of these 17,811 separate components.

As discussed in the accompanying Box, changing the base to a later date usually reduces the estimate of long-run
An Example of the Index Number Problem

For a simple illustration of the effect of a change in the base date on the measurement of real GDP, consider a hypothetical economy producing only two commodities, bread and wine. The top panel of the table shows the prices, quantities produced, and current-dollar values of these two goods in four successive years. Nominal GDP in this simple economy is the total value of the two goods. The middle panel of the table shows measures of real GDP in this economy using each of the four years as a base year. These are calculated by multiplying the quantities of each good by its price in the base year and summing the resulting values. Finally, the bottom panel shows the corresponding annual growth rates of real GDP. Over the four years, real GDP increases 102.9 percent when the base is year 1, but 95.8 percent when the base is year 4.

In this example, selecting a later year as the base period produces a lower growth rate than selecting an earlier year. This result arises because the good with the smaller increases in output over the four-year period (bread) was selected as the one with the larger increases in price. This feature of the example corresponds to the observation that buyers tend to substitute away from goods and services with the largest price increases and toward those with the smallest increases. As a result, the sectors of the economy that experience the largest increase in prices tend to be those with the smallest increases in real output. Since sectors are weighted by relative prices, moving to a later base date tends to increase the weights given to sectors with below average increases in output and to decrease the weights given to those with above average output growth. As a result, a later base date tends to produce lower estimates of average growth.

The Index Number Problem in a Simple Economy

<table>
<thead>
<tr>
<th>Year</th>
<th>Price of Bread</th>
<th>Price of Wine</th>
<th>Quantity of Bread</th>
<th>Quantity of Wine</th>
<th>Value of Bread</th>
<th>Value of Wine</th>
<th>Nominal GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>7</td>
<td>6</td>
<td>15</td>
<td>23</td>
<td>105</td>
<td>138</td>
<td>243</td>
</tr>
<tr>
<td>Y2</td>
<td>8</td>
<td>6</td>
<td>17</td>
<td>35</td>
<td>136</td>
<td>210</td>
<td>346</td>
</tr>
<tr>
<td>Y3</td>
<td>10</td>
<td>7</td>
<td>18</td>
<td>50</td>
<td>180</td>
<td>350</td>
<td>530</td>
</tr>
<tr>
<td>Y4</td>
<td>13</td>
<td>9</td>
<td>19</td>
<td>60</td>
<td>247</td>
<td>540</td>
<td>787</td>
</tr>
</tbody>
</table>

Levels of Real GDP

<table>
<thead>
<tr>
<th>Year</th>
<th>Year 1 Base</th>
<th>Year 2 Base</th>
<th>Year 3 Base</th>
<th>Year 4 Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>243</td>
<td>258</td>
<td>311</td>
<td>402</td>
</tr>
<tr>
<td>Y2</td>
<td>329</td>
<td>346</td>
<td>415</td>
<td>536</td>
</tr>
<tr>
<td>Y3</td>
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<tr>
<td>Y4</td>
<td>493</td>
<td>512</td>
<td>610</td>
<td>787</td>
</tr>
</tbody>
</table>

Growth Rates of Real GDP

<table>
<thead>
<tr>
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<th>Year 1 Base</th>
<th>Year 2 Base</th>
<th>Year 3 Base</th>
<th>Year 4 Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1 to Y2</td>
<td>35.4</td>
<td>34.1</td>
<td>33.4</td>
<td>33.3</td>
</tr>
<tr>
<td>Y2 to Y3</td>
<td>29.5</td>
<td>28.3</td>
<td>27.7</td>
<td>27.6</td>
</tr>
<tr>
<td>Y3 to Y4</td>
<td>15.7</td>
<td>15.3</td>
<td>15.1</td>
<td>15.1</td>
</tr>
<tr>
<td>Y4 to Y1</td>
<td>102.9</td>
<td>98.4</td>
<td>96.1</td>
<td>95.8</td>
</tr>
</tbody>
</table>

*In terms of equation (3) in the text, components of GDP with weights, $p_tq_{tn}/\sum_t p_tq_t$, that become larger when a later base date is chosen tend also to be those with low growth rates (for which $(q_{tn+1} - q_{tn})/q_{tn}$ is small).
real GDP growth. This is because buyers substitute away from goods and services with larger than average price increases in favor of items with smaller than average gains. As a result, sectors of the economy that grow slowly tend also to be those that have the largest price increases, and so have larger weights in real GDP if a later base date is chosen. Conversely, sectors that grow rapidly are generally those with the smallest price increases and so have smaller weights in real GDP if the base date is later.

The inverse relation between changes in sectoral prices and outputs implies that most relative price changes are the result of changes in costs on the supply side rather than of taste changes on the demand side. If most relative price changes were due to demand shifts, one would observe that the sectors with the largest increases in prices also would be those with the greatest increases in sales. Historically, this has not been the case, implying that supply shifts were more important than demand shifts in changing relative prices.

An example of this effect is that between 1977 and 1990, real GDP increased at an annual rate of 2.7 percent when measured in 1982 dollars but only 2.5 percent in 1987 dollars (see Survey of Current Business 1991). A major portion of the difference may be traced to the computer industry. The output of computers increased very rapidly during this period, while their prices fell sharply. As a result of the price decline, the measured contribution of this industry to overall growth is smaller if it is weighted by 1987 prices than if 1982 prices are used.

Similar revisions occurred on earlier occasions when the base date was changed (see Survey of Current Business 1976 and 1985). When the base date was shifted from 1972 to 1982, the estimated average annual growth rate of real GDP between 1972 and 1984 was reduced by 0.4 percentage points. This also was due largely to the changed weighting of the computer industry. The change in the base from 1958 to 1972 lowered the average annual growth rate from 1958 to 1974 by 0.2 percentage points. In this case, the main cause was the decreased weight assigned to the auto industry. Auto prices rose less than average prices and auto sales increased more than total GDP over this period.

**Is There a "Correct" Measure of Real GDP?**

The fact that a change in the base date produces a different measure of real GDP growth suggests that there is an arbitrary element to these measures that can never be fully eliminated. Whereas nominal GDP is an aggregate of transactions that actually occurred, real GDP is a statistical construct that represents the sum of a set of fictional transactions. Hence, nominal GDP could, in principle, be measured exactly if we had full and complete information from the original transactors, but there may be no clearly "correct" measure of real GDP, even with unlimited data. For analogous reasons, there may be no measure of the average level of prices that is obviously "correct".

A branch of microeconomic theory known as the *economic theory of index numbers* suggests that this conclusion may be too pessimistic. This theory indicates that if we are prepared to define precisely what we mean by a "correct" measure of GDP, it is possible to derive index-number formulae that measure the quantity and price of GDP with no arbitrary element. Initially, this theory was applied to the problem of defining a price index that would measure the "cost of living." Later it was extended to the definition of other price and quantity indexes.

**II. Measuring the "Cost" and "Standard" of Living**

Consider first the problem of measuring changes in the "cost of living." Suppose that in a particular base period, the representative consumer faces a given set of prices and buys a certain bundle of goods and services. In a subsequent period, she faces a different set of prices and chooses a different bundle of commodities. The problem is to determine how much the average price level (or "cost of living") changed between the two periods. The corresponding "quantity" problem is to determine how much larger (or smaller) the second commodity bundle is compared to the first (that is, how much her "standard of living" changed).

One way to measure the change in the average price level is to compute how much the base period commodity bundle would cost at the second-period prices. This is the procedure that underlies both the consumer price index and the fixed-weight GDP price index. These types of measures are known as Laspeyres indexes. The drawback of this procedure is that it does not allow for the fact that the consumer generally can reduce her expenditures in the second period— with no reduction in her satisfaction—by substituting away from commodities that have become relatively dearer in favor of others that have become relatively cheaper. Because the Laspeyres index does not allow for such substitutions, this type of fixed-weight price index has an upward bias as a measure of the cost of maintaining a given level of satisfaction.

Alternatively, one may evaluate how much the second commodity bundle would have cost at base period prices and compute the increase in the cost of this bundle. However, an index number constructed this way, which is known as a Paasche index, tends to underestimate the increase in the cost of living. This is because the second bundle
was not the one that the consumer actually chose in the base period, so computing its cost at the first set of prices overstates the cost of living in that period.

If one knew the consumer's preferences, one could predict what substitutions she would make in order to maintain the same degree of satisfaction in response to any given changes in relative prices. Thus, one could calculate the minimum cost of attaining a particular level of satisfaction at any given set of prices. Changes in this minimum cost over time would provide an exact measure of changes in the "true cost of living," defined not as the cost of buying a particular bundle of goods and services but as the cost of obtaining a particular level of satisfaction. Although this approach has been attempted by some economists (for example, Klein and Rubin 1947-48), it has the disadvantage of requiring a large body of data from which to estimate consumers' responses to changes in the prices they face. The economic theory of index numbers provides an alternative and more economical approach.7

The Economic Theory of Index Numbers

This theory begins with the assumption that the quantities of individual goods and services that we observe consumers buying are those that maximize their satisfaction (or utility) given their incomes and the prices they face. The theory then shows that by making certain mathematical assumptions about the form of consumer preferences, one may derive index number formulae that measure changes in the true cost of living (that is, the cost of obtaining a certain level of satisfaction) in terms of the observable prices and quantities of individual goods and services. Index numbers that have this property are said to be "exact."8 The appeal of this approach is that it is necessary only to specify the form of the functions that describe consumers' preferences and not necessary to know the actual values of their parameters. This follows from the assumption that if the consumer buys a particular bundle of goods and services at a particular set of prices, this means that this bundle maximizes her utility from a given expenditure level (or minimizes the expenditure required to obtain a given utility level). Hence, price and quantity observations provide information about utility levels.

Two exact index number formulae that have been derived and used by advocates of this approach are the Fisher Ideal index and the Törnqvist index. The Fisher ideal measure of the increase in average prices from base period \(t\) to period \(s\) is the geometric average of the Laspeyres and Paasche price indexes:

\[
P_F = \left[ \left( \frac{\sum p_n q_{ns}}{\sum p_n q_{nt}} \right) \times \left( \frac{\sum p_n q_{ns}}{\sum p_n q_{nt}} \right) \right]^{1/2} - 1
\]

The Fisher Ideal price index exactly represents the consumer's true cost of living if the utility function that describes her preferences at date \(s\) is a quadratic function of the form:9

\[
U_s = \sum_{n=1}^{N} \sum_{m=1}^{N} \alpha_{nm} q_{ns} q_{ms}, \quad \text{where} \quad \alpha_{nm} = \alpha_{mn}.
\]

The Törnqvist measure of the overall price increase is the weighted geometric average of the increases in individual commodity prices, with weights equal to the average expenditure shares in the base period \(t\) and the current period \(s\):

\[
P_T = \prod_{n=1}^{N} \left( \frac{p_{ns}}{p_{nt}} \right)^{r_n}, \quad \text{where}
\]

\[
r_n = \frac{1}{2} \left[ \left( \frac{p_{ns} q_{nt}}{\sum_{l} p_{nt} q_{lt}} \right) + \left( \frac{p_{ns} q_{nt}}{\sum_{l} p_{ts} q_{ls}} \right) \right]
\]

The exact price index will be a Törnqvist one if preferences may be described by a translog expenditure function (Die-wert 1976). The translog unit expenditure function has the form:10

\[
\ln e_s = \alpha_0 + \sum_{n=1}^{N} \alpha_n \ln p_{ns} + \frac{1}{2} \sum_{n=1}^{N} \sum_{m=1}^{N} \alpha_{nm} \ln p_{ns} \ln p_{ms},
\]

where \(\alpha_{nm} = \alpha_{mn}\). In this equation, \(e_s\) represents the minimum expenditure that yields a unit level of utility at the prices ruling in period \(s\). This expenditure function imposes fewer restrictions on the structure of consumer preferences than the quadratic utility function.

At first sight, the assumptions on the forms of the utility and expenditure functions that underlie the Fisher and Törnqvist price indexes appear to be rather restrictive. However, it can be shown that a wide range of alternative
utility and expenditure functions can be approximated closely by either a quadratic or a translog function. Diwert describes forms of the utility or expenditure function that have this approximation characteristic as “flexible forms” and the corresponding exact index number formulae, such as the Fisher ideal or the Törnqvist, as “superlative” indexes.

By construction, the Fisher ideal price index lies between the Laspeyres and Paasche indexes. It can be shown that this also is true of the Törnqvist measure. For measuring changes in prices over time, there is little to choose between these alternative measures, since in most cases they give very similar results.

If the consumer’s nominal income rises by the same amount as the true cost of living, this means that her satisfaction is unchanged. It is natural, therefore, to measure the change in the consumer’s real income between two dates by the extent to which the increase in her nominal income exceeds the rise in the true cost of living, since “real income” then will be an indicator of her utility level or standard of living. If a measure of real GDP is constructed by deflating nominal GDP by a true cost of living price index number, the result is a measure of the “quantity” of output that represents changes in the standard of living enjoyed by the representative consumer. In other words, with this definition, an increase in real GDP represents a rise in consumer satisfaction or welfare. This seems to be a sensible way of defining what is meant by the quantity of output when the proportions of individual commodities in the total change over time.

A drawback to defining and measuring real GDP in terms of the standard of living of a representative consumer is that many of the commodities included in the GDP are not consumer goods and do not directly contribute to consumer welfare. An alternative approach that avoids this drawback is to base the measure of real GDP on the production capability of the representative firm rather than the preferences of the representative household.

III. PRODUCTION-BASED MEASURES OF REAL GDP

Suppose that, in the base period, a representative firm—with a given technology and set of inputs and facing a given set of output prices—produces a certain bundle of outputs with a certain dollar value. In a later period, facing a different set of output prices, it produces a different bundle of outputs, using a different technology and set of inputs. The problem is to determine how much of the change in the nominal value of the firm’s output (that is, in its revenue) is due to a change in the prices of its products and how much to a change in the quantities produced. The microeconomic theory of production may be used to address this problem.

A rise in the firm’s revenues represents an increase in the quantity of its output if it may be attributed entirely to a change in the inputs it uses or in its technology and not at all to changes in the prices of any of its outputs. Conversely, an increase in revenue that occurs with no change either in the inputs used or in technology, must be due to a change in the prices of its products and represents a rise in the average price of its output. Put in more technical terms, a revenue change is an increase in the quantity of the firm’s output if it represents an outward shift in its production possibility frontier, but is a price change if it represents a movement along the frontier.

In the same way as the consumption-based approach relies on the assumption that consumers choose their purchases so as to minimize the cost of obtaining any given level of satisfaction, the production-based approach assumes that firms choose their outputs so as to maximize their revenues given the technology and inputs they have available. This assumption guarantees that the observed quantities of output are those that maximize the firm’s revenues given its production possibilities and the prices that it faces. As in the case of the consumption-based approach, it is possible to derive exact output and price indexes by suitably choosing the mathematical form of the function that describes the firm’s production possibilities. Production possibilities may be described by either a production function or a revenue function. If the revenue function is assumed to be translog, the corresponding output price index will be a Törnqvist index. A similar restriction on the production function implies a Törnqvist output quantity index. Somewhat stronger restrictions on the production and revenue functions imply that these price and quantity measures will be Fisher ideal indexes.

If an exact price index is constructed, a measure of real output is obtained by deflating the nominal value of output using that index. Conversely, if an exact quantity index is constructed, the corresponding price index is obtained by dividing the nominal value of output by this quantity index. Fisher ideal indexes have the useful technical property that if a Fisher price index is used to deflate nominal GDP, the result is a Fisher index of the quantity of real GDP, and conversely. Thus, a Fisher price index is an exact measure of the price level, and the corresponding real GDP index is an exact measure of the quantity of output, but at the same time their product is equal to nominal GDP.

Neither the Törnqvist index nor the measures that are currently used by the BEA have this “factor reversal” property. Real GDP currently is measured by a Laspeyres fixed-weight output index and the preferred measure of
inflation is the fixed-weight GDP price index, which also is a Laspeyres index. The product of these measures of output and prices is not equal to nominal GDP. The measure of prices obtained by dividing nominal by real GDP (the implicit price deflator) is a poor indicator of inflation because it reflects not only changes in prices but also changes in the composition of GDP. Conversely, the measure of output that would be obtained by dividing nominal GDP by the fixed-weight price index (which might be described as an “implicit output measure”) would be a poor measure of real growth since it would reflect not only changes in output but also changes in relative prices. Adoption of Fisher ideal measures of prices and real GDP would avoid these ambiguities.

IV. RECENT CHANGES IN THE NATIONAL INCOME ACCOUNTS

The Bureau of Economic Analysis issued revised GDP estimates last December. In the course of this “benchmark” revision, the base date of the estimates was changed from 1982 to 1987. As mentioned earlier, the average rate of real GDP growth from 1977 to 1990 was 0.2 percentage point lower in the revised data. However, in some periods the rebasing caused much larger changes in measured growth. For example, the growth of real GDP was reduced by 0.5 percentage point in both 1987 and 1988 as a result of rebasing, and the decline in real GDP in the cyclical downturn in the winter and spring of 1990-91 appears to have begun earlier and been somewhat more severe when measured at 1987 prices than when measured at 1982 prices. Chart 1 compares the quarterly growth rates from 1975 to 1990 in the pre- and post-benchmark data.

The BEA has indicated that, beginning sometime in 1992, two alternative measures of both real growth and inflation will be published, using forms of the Fisher ideal index. These alternative indexes will eliminate the periodic revisions to measured growth resulting from the effects of rebasing, and will remove the long-run bias in the current measure of real output that results from the use of constant relative prices. In addition, because the Fisher ideal index is based on the economic theory of index numbers, these alternative measures of the economy’s total production will have a sounder theoretical basis.

“Chain” Measures of GDP Growth

The planned alternative indexes will be forms of chain indexes. A quarterly chain measure of GDP growth is constructed by computing the real growth rate between each successive pair of adjacent quarters, using current relative prices as weights. For several years, the BEA has published chain indexes of GNP growth, but these have attracted little attention. In these indexes, real GNP growth between each pair of adjacent quarters was measured using the relative prices ruling in the first quarter. Thus, these quarterly chain growth rates were Laspeyres indexes. Average growth over longer periods could have been computed by compounding these one-quarter chain growth rates, but in the past the BEA did not do this.

To measure the growth of real GDP in a particular quarter, it makes sense to weight its components by the relative prices prevailing in that quarter rather than in the distant past or future (see Moorsteen 1961). Measures of average growth over longer periods constructed by compounding these chain growth rates would take account of the changes in relative prices and the composition of output that occurred. Hence the measurement bias that results from the use of fixed-weight indexes would be reduced.

The measured average growth rate over a longer period would be...
computed by compounding quarterly chain growth rates would depend on the (changing) relative prices and composition of output throughout the period. This is because the growth rate between each successive pair of quarters depends on the relative prices and on the composition of output in those quarters. By contrast, a measure of growth calculated directly from the beginning to the end of the period depends only on relative prices and on the composition of output at the beginning and the end. In other words, a growth rate calculated by compounding quarterly chain growth rates is “path-dependent.” It represents the average growth rate during the period rather than the average growth rate from the beginning to the end of the period. In practice, however, the difference is likely to be very small.

New Measures of Growth and Inflation

The new alternative measures of real GDP and the price level to be introduced by BEA combine the features of the Fisher ideal index and the chain approach. The BEA terms these new measures time-series generalized Fisher ideal (TGFI) indexes. The TGFI index calculates real growth between benchmark years using the standard Fisher ideal formula. Growth rates in periods between the benchmarks are calculated as the geometric average of the growth rates calculated using the weights in the two benchmark years. Thus, if A and B are benchmark years and t and t+1 are years between A and B, the TGFI real growth rate from t to t+1 is:

\[
\left( \frac{\left( \sum_{n} q_{nt+1} p_{nA} \right) \times \left( \sum_{n} q_{nt+1} p_{nB} \right)}{\left( \sum_{n} q_{nt} p_{nA} \right) \times \left( \sum_{n} q_{nt} p_{nB} \right)} - 1 \right)
\]

Similarly, the TGFI increase in prices between t and t+1 is given by

\[
\left( \frac{\left( \sum_{n} p_{nt+1} q_{nA} \right) \times \left( \sum_{n} p_{nt+1} q_{nB} \right)}{\left( \sum_{n} p_{nt} q_{nA} \right) \times \left( \sum_{n} p_{nt} q_{nB} \right)} - 1 \right)
\]

Direct computation shows that the cumulation of the TGFI growth rates for the periods between A and B is equal to the Fisher ideal measure of growth calculated directly from year A to year B. As a result, the TGFI measure of growth between benchmark years is not path-dependent. The TGFI index also has the factor reversal property that the growth rates of real GDP and the price level from one benchmark year to the next sum to the growth rate of nominal GDP.

An attractive property of chain Fisher ideal indexes is that the measures of real growth and inflation in each quarter incorporate the structure of the economy and relative prices in that quarter and so should give a more accurate indication of current developments. For this reason, these measures might be more valuable to policymakers. We have found, for example, that the chain measure of real GNP growth is a slightly better predictor of changes in the unemployment rate than the standard measure. The TGFI indexes will have similar advantages, since the real growth and inflation measures for each quarter will be based on the relative prices and the structure of output in nearby benchmark years.

BEA plans to construct two alternative TGFI indexes. The first alternative index will use as weights the relative prices and composition of output in the preceding and current years. In terms of equations (8) and (9), years A and B refer to the previous and current years. The BEA describes this index as a “chain-type annual weights” index. The second index, which will be termed a “benchmark-years weights” index will use as weights the relative prices and composition of output in benchmark years five years apart.

A disadvantage of the chain approach (including the TGFI measures) is that it provides a measure of the growth rate of real GDP in a given quarter or year, but no unique measure of its dollar level. A measure of the level of real GDP can be constructed by multiplying nominal GDP in an arbitrary base year by the compounded chain growth rates. However, the resulting measure of real GDP does not have the easily understood interpretation of the fixed-weight measure now in use. Specifically, it does not measure what the GDP would be if all prices had remained constant since the base year.

A related disadvantage of a GDP measure computed by cumulating a chain index such as the TGFI is that the level of real GDP constructed in this way is not equal to the simple sum of its components (consumption, investment, etc.). Instead, it is a weighted sum of these components with weights that change as relative prices vary. Over short periods this might not cause problems, but it could be inconvenient for studying the sources of growth over longer periods. The BEA will avoid this aggregation problem by publishing only index numbers of real GDP and its principal components rather than dollar values. Hence it will not be possible to study the decomposition of GDP growth over time using these new measures.
V. Conclusion

The measures of real GDP and inflation to which policymakers respond are aggregates of vast numbers of individual prices and quantities. Measuring these macroeconomic variables using fixed-weight indexes adds to the uncertainties facing policymakers, since changes in the base date used in constructing measures of output and prices sometimes alter our perceptions both of the economy's long-run real growth and inflation rates and of its short-run cyclical behavior.

This article has shown that these ambiguities are the result of the particular definitions of output and inflation that are currently in use. The economic theory of index numbers shows that if an increase in total output were defined as a change in the bundle of goods and services produced that either raises the utility level of the representative consumer or increases the revenue of the representative firm with no change in the prices of its outputs, the ambiguities could, in principle, be resolved. These definitions may be made operational by specifying the mathematical form either of the household's utility function or of the firm's production function.

The alternative measures of real GDP and inflation that the BEA soon will introduce appear to be a sharp improvement over those that have been in use since the Census Bureau began constructing national product data on a regular basis in 1947. These new indexes of real GDP and inflation will make use of the economic theory of index numbers discussed in this paper, and so will have a sounder theoretical basis than the current measures. In addition, the alternative data will avoid much of the ambiguity associated with fixed-weight aggregates and will more closely reflect the current structure of the economy, because the price and quantity weights used will be based on conditions in nearby benchmark years. These improvements will remove at least one source of uncertainty facing policymakers.

Endnotes

1. Until last December, the BEA focused on gross national product rather than gross domestic product. GNP measures the output of resources owned by U.S. residents (including output produced abroad using American-owned labor and capital), whereas GDP measures the output produced within the borders of the U.S. (including the output of foreign-owned labor and capital). For purposes of the issues discussed in this article, this distinction is not an important one.

2. It also depends on the type of average used. The existing official price indexes are constructed as weighted arithmetic averages of the prices of their components, but index numbers also could be constructed as weighted geometric averages. The Törnqvist index discussed below is an example of one constructed as a geometric average of its components.

3. Measuring the prices of individual items correctly involves a host of difficult problems. For example, when the amount spent on an item increases at the same time as its quality improves, it may be difficult to determine whether its true price has risen or declined. The rising cost of medical care is an example of this problem. To keep its length manageable, this paper will ignore these issues and assume that the price and quantity produced of each individual commodity are measured without error.

4. The Laspeyres measure of the increase in prices from base period \( t \) to period \( s \) is:

\[
P_L = \left[ \sum_{\alpha=1}^{N} \frac{P_{\alpha}q_{\alpha s}}{P_{\alpha}q_{\alpha t}} \right] - 1.\]

5. If, for example, chicken has risen in price more than fish, she may obtain the same satisfaction at less cost by consuming less chicken and more fish.

6. The Paasche measure of the increase in prices from base period \( t \) to period \( s \) is:

\[
P_P = \left[ \frac{\sum_{\alpha=1}^{N} P_{\alpha}q_{\alpha s}}{\sum_{\alpha=1}^{N} P_{\alpha}q_{\alpha t}} \right] - 1.\]

7. For a useful survey of the literature on index numbers, see W.E. Diewert (1987). Diewert has been responsible for much of the recent theoretical development of this branch of economics.

8. In technical terms, the theory requires the mathematical form of the utility function or the expenditure function to be specified. The utility function assigns a utility value to each commodity bundle, such that if the consumer prefers one bundle to another, it will have a higher utility value. The expenditure function specifies the minimum cost of attaining a given utility level as a function of the commodity prices that the consumer faces. It can be shown that either of these functions may be used to represent the consumer's preferences.

9. This was first proved in Konits and Byushgens (1926).

10. The expenditure function defines the minimum expenditure required to obtain a given level of utility and hence depends on the specified utility level as well as on prices. However, since the measurement of utility is arbitrary, it is convenient to set the reference level of utility at
unity. This causes the terms involving the utility level to drop out of equation (7) since the logarithm of one is zero.

11. Specifically, either of these forms can provide a second order approximation to any twice continuously differentiable linearly homogeneous function.

12. In addition, an increase in the quantity of output that occurs with no increase in the amounts of inputs used must be attributed to a change in technology, and hence represents a rise in productivity. The index number methodology discussed in this section also may be used to define exact measures of productivity growth.

13. For more detailed discussions of this issue, see Moorsteen (1961) and Fisher and Shell (1972).

14. The production function describes the combinations of outputs and inputs that are feasible for the firm with its given technology. The revenue function defines the maximum revenue the firm can obtain from selling (at the output prices it faces) the outputs it can produce with a given set of inputs and a given technology. It can be shown that the firm's production possibilities may be fully described by either a production function or a revenue function.

15. The maximum revenue that the firm can obtain depends on the prices of its outputs and the quantities of inputs it has available. If the firm produces \( N \) outputs with prices \( p_1 \ldots p_N \) using \( M \) inputs \( v_1 \ldots v_M \), the translog revenue function is

\[
\ln R = a_0 + \sum_{m=1}^{M} \beta_m \ln v_m + \frac{1}{2} \sum_{j=1}^{M} \sum_{i=j}^{M} \gamma_{ij} \ln v_i \ln v_j + \sum_{n=1}^{N} \gamma_n \ln p_n
\]

This form is "flexible" since it can approximate any arbitrary linearly homogeneous twice-differentiable function.

16. Proofs of these results are given in Diewert (1983). The result with regard to the output deflator requires that the output distance function be translog in form. The distance function, which may be derived from the production function, measures the distance of the firm's present production possibilities frontier from some base frontier.

17. This can be shown by direct computation. For simplicity, consider the two-commodity case. The increase in nominal GDP from period 0 to period 1 divided by the Fisher ideal measure of the increase in prices is:

\[
\frac{(p_{11}q_{11}) + (p_{21}q_{21})}{(p_{10}d_{10}) + (p_{20}d_{20})} - \sqrt{\frac{(p_{11}q_{11}) + (p_{21}q_{21})}{(p_{10}d_{10}) + (p_{20}d_{20})} \cdot \frac{(p_{11}q_{11}) + (p_{21}q_{21})}{(p_{10}d_{10}) + (p_{20}d_{20})}}
\]

This expression may be simplified to:

\[
\frac{(p_{10}d_{10}) + (p_{20}d_{20})}{(p_{11}q_{11}) + (p_{21}q_{21})}
\]

This is the Fisher ideal measure of the increase in real output from period 0 to period 1.

18. In addition to altering the base date for measuring constant dollar quantities, this benchmark revision incorporated a number of other procedural changes, including the replacement of GNP by GDP as the primary measure of U.S. output.
REFERENCES


Exchange Rate Policy and Shocks to Asset Markets: The Case of Taiwan in the 1980s

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This paper uses a simple theoretical model to show how the credibility of unsterilized intervention policy may affect the pattern of adjustment in the exchange rate, velocity, and asset prices. When the outcome of unsterilized intervention is credible, any degree of exchange rate stability can be achieved at the cost of a sufficiently large, one-time change in the money supply. When the outcome of intervention is not credible, intervention can lead to persistent, and possibly accelerating, changes in exchange rates, the money supply, velocity, and asset prices. Under certain conditions, intervention may even amplify the cumulative change in the exchange rate, rather than reduce it. The model is used to interpret Taiwan’s experience with unsterilized exchange rate intervention in the second half of the 1980s.

Over the past decade, international capital mobility in many Pacific Basin economies has increased considerably. This trend has made it more difficult for policymakers to stabilize the foreign value of their currencies. The greater ability of speculators to buy and sell domestic currency in foreign exchange markets has in some cases resulted in unwelcome fluctuations in currency values, in spite of government efforts to limit such fluctuations.

Some progress has been made in understanding the problems of stabilizing the exchange rate in economies with mobile international capital. Research in open economy macroeconomics since the 1960s describes how disturbances to foreign exchange markets and government policies affect exchange rate behavior given certain institutional features of the economy, such as the degree of capital mobility or asset substitutability.

More recently, research has clarified how credibility affects the ability of the government to enforce an exchange rate target. For example, Krugman (1979) shows how government attempts to peg the exchange rate with limited foreign exchange reserves may lead to speculative attack and an abandonment of the peg. Another literature (see Lessard and Williamson 1987) analyzes capital flight in economies that are forced to deal with serious macroeconomic imbalances or that are saddled with large external debt burdens. Such capital flight may impair the government’s ability to stabilize the exchange rate. However, these approaches do not necessarily highlight the difficulties that may arise when a well-managed economy (one that faces no foreign exchange reserve constraints, maintains a largely balanced government budget, and has no external debt burden) attempts to stabilize its currency.

This paper draws on the experience of Taiwan in the 1980s to shed some light on these potential difficulties. Due to certain asymmetries in foreign exchange controls, Taiwan had a relatively high degree of capital mobility up to 1987, while it maintained a policy of limiting movements in the exchange rate. Taiwan’s relative openness exposed it to disturbances to its foreign exchange markets in the second half of the 1980s that illustrate the difficulties that may arise when a country attempts to stabilize its exchange rate.
Two features of Taiwan's experience in the 1980s are of particular interest. First, following a period of tranquility in foreign exchange markets in the first half of 1980s, the New Taiwan (NT) dollar appreciated at an accelerating rate against the U.S. dollar from late 1985 through 1987, in spite of increasing intervention in exchange markets designed to limit such appreciation. Second, in spite of the steep acceleration in money growth associated with intervention after 1985, there was relatively little inflation in the goods market. Rapid money growth was associated instead with a persistent decline in the income velocity of money and a boom in asset prices. Neither the persistent acceleration in exchange rate appreciation, nor the relationship between money growth and domestic goods and asset prices have been fully explained.

This paper suggests that the persistent and accelerating appreciation of the NT dollar may have been related to government efforts to limit such appreciation. Some simple examples are offered to illustrate how such a situation may arise if the government's exchange rate policy loses credibility. Using a conventional small open economy model, it is also shown that intervention in response to disturbances in Taiwan's foreign exchange markets may have contributed to persistent declines in the income velocity of money and to the boom in Taiwan's asset prices. It is suggested that weak international arbitrage links, which are at least partly attributable to Taiwan's relatively undeveloped domestic financial markets, facilitated the sharp changes in asset prices. While the paper uses conventional analytical tools, it offers a new way of thinking about the interaction between exchange market intervention and exchange rate expectations and about the potential effects of such interaction.

The paper is organized as follows. Section I provides some background on Taiwan's exchange rate policy, capital mobility, and the domestic financial sector. Section II describes a simple theoretical model that can be used to examine the likely effects of Taiwan's exchange rate policy on the persistence of shocks to exchange rate expectations and the behavior of money, velocity, and asset prices. Section III interprets Taiwan's experience using the framework developed earlier. Section IV sums up some of the lessons of Taiwan's experience.

I. Exchange Rate Policy, Capital Controls and the Domestic Financial Sector

To set the context for the theoretical analysis that follows, we review the characteristics of Taiwan's exchange rate policy, capital controls, and financial markets. Table 1 summarizes the evolution of Taiwan's external and domestic financial sector policies in the 1980s.

Exchange Rate Policy

The government's exchange rate policy in the 1980s reflected two basic criteria. Beginning in September 1982, daily fluctuations in the currency were limited by a policy rule requiring that the daily adjustment (upward or downward) of the spot rate not exceed 2.25 percent of the central rate on the previous business day. This rule was in effect until April 1989, when the currency was floated. Policymakers also sought to prevent currency movements from excessively impairing the competitiveness of Taiwan's export sector by limiting the rate of appreciation of the currency.

Controls on Capital Outflows, Not Inflows

The implementation of exchange rate policy also was influenced by the nature of capital controls. Until 1987 capital controls in Taiwan focused on preventing capital outflows. For example, the government required that all foreign exchange be sold to the central bank in exchange for local currency. (Authorized foreign currency deposits in local banks were exempt.) In contrast to the stringent controls on outflows, Taiwan historically had no effective controls on capital inflows. In particular, foreign asset holders could easily acquire NT dollar assets through the banking sector.

The asymmetry in Taiwan's capital controls was reduced in 1987 when the government significantly tightened restrictions on capital inflows while liberalizing capital outflows. (These measures were in response to a surge in short-term capital inflows discussed later.) In May 1987, the government froze the outstanding amount of commercial banks' foreign liabilities at US$13.8 billion (the level of May 31, 1987) and in July 1987 restricted inward remittances for each person to US$50,000 per year. Restrictions on capital inflows were liberalized in 1989 when the limit on individual remittances was raised to US$200,000 in July, to US$500,000 in September, and to US$1 million in November 1989.

At about the same time as restrictions on capital inflows were being imposed, restrictions on capital outflows were liberalized. Current account transactions were completely liberalized on July 15, 1987, and individuals or companies were allowed to purchase and remit outward up to an annual limit of US$5 million.

Thin and Underdeveloped Markets

As is the case in many developing economies, Taiwan's domestic financial markets are relatively underdeveloped.
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>February, The foreign exchange market is established and a managed float is adopted.</td>
</tr>
<tr>
<td></td>
<td>The spot central rate of the U.S. dollar against the NT dollar henceforth to be set daily by 5 major authorized banks on the basis of the weighted average of interbank transaction rates on the previous business day.</td>
</tr>
<tr>
<td></td>
<td>The buying and selling rates for the U.S. dollar between the bank and the customer are set within the limit of NT$0.05 above or below the central rate for transactions up to US$30,000. For larger transactions, the corresponding limit is NT$0.10.</td>
</tr>
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<td></td>
<td>March, Daily exchange rate ceiling abandoned by Central Bank.</td>
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<td></td>
<td>November, Banks allowed to set their own interest rates on NCDs and debentures, as well as on bill discounts.</td>
</tr>
<tr>
<td></td>
<td>A committee of the Bankers' Association is authorized to set, on a monthly basis, actual deposit and loan rates within ceilings determined by the Central Bank. The Central Bank sets maximum deposit rates and maximum and minimum loan rates.</td>
</tr>
<tr>
<td></td>
<td>Interest rates on commercial paper, bankers' acceptances and Treasury bills are fully liberalized.</td>
</tr>
<tr>
<td>1982</td>
<td>September, Central rate trading system established in the foreign exchange market with the exchange rate to be based on the daily weighted average exchange rate of interbank trading.</td>
</tr>
<tr>
<td>1983</td>
<td>December, Offshore Banking Statutes established allowing local banks to engage in offshore banking business.</td>
</tr>
<tr>
<td>1984</td>
<td>August, Bank restrictions on the holding of long positions in foreign currencies removed.</td>
</tr>
<tr>
<td></td>
<td>November, Range of maximum and minimum loan rates widened by the Central Bank. The base loan rate lowered ½ percentage point.</td>
</tr>
<tr>
<td>Table 1 - Financial Sector Policies (continued)</td>
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<td>-----------------------------------------------</td>
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<tr>
<td><strong>Domestic</strong></td>
<td></td>
</tr>
<tr>
<td><strong>March</strong></td>
<td></td>
</tr>
<tr>
<td>Banks allowed to set prime rate according to market conditions.</td>
<td></td>
</tr>
<tr>
<td><strong>August</strong></td>
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<tr>
<td>Banks allowed to set own rates on foreign currency deposits.</td>
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</tr>
<tr>
<td>Banker's association to set the range of maximum and minimum lending rates while the individual banks allowed to charge customer rates based on credit rating and loan maturity date.</td>
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</tr>
<tr>
<td><strong>External</strong></td>
<td></td>
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<tr>
<td><strong>October</strong></td>
<td></td>
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<tr>
<td>Allowed foreign banks to set up second branches in Taiwan.</td>
<td></td>
</tr>
<tr>
<td><strong>Domestic</strong></td>
<td></td>
</tr>
<tr>
<td><strong>March</strong></td>
<td></td>
</tr>
<tr>
<td>Limitation on the holding position and underwriting of short-term bills issued by any single firm removed.</td>
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</tr>
<tr>
<td>Upper limit on commercial paper underwriting for the branches of foreign banks raised.</td>
<td></td>
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<tr>
<td><strong>External</strong></td>
<td></td>
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<tr>
<td><strong>May</strong></td>
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<tr>
<td>The Central Bank freezes the outstanding amount of commercial banks' foreign liabilities at US$ 13.8 billion, the level of May 31, 1987.</td>
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<tr>
<td><strong>June</strong></td>
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<tr>
<td>Foreign banks permitted to join the local inter-bank remittance system and the interbank ATM sharing system.</td>
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<tr>
<td><strong>July</strong></td>
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<tr>
<td>Current account transactions are completely liberalized on July 15. Requirements to surrender export proceeds, advanced import deposits and restrictions on payments for invisibles are lifted.</td>
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<tr>
<td>An individual or a company is allowed to purchase and remit outward up to an annual limit of US$5 million.</td>
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</tr>
<tr>
<td>A ceiling on inward remittances for each person set at US$50,000 per year.</td>
<td></td>
</tr>
<tr>
<td><strong>October</strong></td>
<td></td>
</tr>
<tr>
<td>The Central Bank lifts the freeze on banks' foreign liabilities on October 1, 1987. Following capital inflow of $3 billion, the Central Bank reimposes a freeze at $16.2 billion on October 2.</td>
<td></td>
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<tr>
<td>Borrowing of foreign exchange by nonbanks is not subject to the freeze.</td>
<td></td>
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<tr>
<td><strong>External</strong></td>
<td></td>
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<tr>
<td><strong>April</strong></td>
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</tr>
<tr>
<td>A new system of foreign exchange trading is established, based on bid-ask quotations. The new system applies to interbank trading and retail trading over US$10,000. The previous limits on daily fluctuations of the interbank rate are rescinded.</td>
<td></td>
</tr>
<tr>
<td><strong>July</strong></td>
<td></td>
</tr>
<tr>
<td>The ceiling for banks' foreign liability is raised to 30% of the average daily balance during the 45-day period ended July 15, 1989.</td>
<td></td>
</tr>
<tr>
<td>The ceiling for inward remittances for each person is raised to US$200,000 on July 20.</td>
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<tr>
<td><strong>August</strong></td>
<td></td>
</tr>
<tr>
<td>Foreign exchange interbank call loan market established.</td>
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<tr>
<td><strong>September</strong></td>
<td></td>
</tr>
<tr>
<td>Annual capital inflow increased from US$200,000 to US$500,000 per person.</td>
<td></td>
</tr>
<tr>
<td><strong>November</strong></td>
<td></td>
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<tr>
<td>Capital inflow limitation increased to US$1 million per individual.</td>
<td></td>
</tr>
<tr>
<td><strong>Domestic</strong></td>
<td></td>
</tr>
<tr>
<td><strong>July</strong></td>
<td></td>
</tr>
<tr>
<td>All remaining regulations controlling maximum deposit rates and maximum and minimum loan rates are eliminated.</td>
<td></td>
</tr>
</tbody>
</table>
Although interest rate restrictions were gradually liberalized in the 1980s and a 1989 banking law significantly liberalized entry by allowing foreign banks to offer a full range of banking services, restrictions on the financial sector had an important effect on financial market behavior for much of the decade. Financial policies have traditionally guaranteed a dominant role for government-owned domestic banks. These policies included entry restrictions (particularly branching and operational restrictions that have limited the activities of foreign banks) and restrictions on deposit and loan interest rates that tended to limit competitive pressures.4

Financial sector restrictions tended to segment financial markets and reduced the allocation of funds outside the regulated financial sector. Flow of funds data reported by the Central Bank of China (1989) indicate that up to the mid-1980s, more than 50 percent of the financial uses of funds of households and non-profit institutions were channeled to regulated financial market intermediaries, notably banks.

Outside of regulated financial intermediaries, the bulk of household funds was channeled to two sectors. First, households placed funds in the unregulated “curb” market. On average, this sector accounted for less than 8 percent of household uses of funds, and its share tended to decline in the 1980s. Second, households invested between ⅙ and ⅓ of their funds in capital markets. The bulk of such investment was in the direct acquisition of shares in enterprises or in the stock market.

Stock market shares were the only tradable securities readily available to household investors. By all accounts, this market was quite thin, and a relatively limited amount of capital was raised in this market. In the period 1980-85, companies listed in the stock market accounted for only about 16 percent of the total capital of Taiwan enterprises, so that households may have allocated as little as 3 percent (the 20 percent total flow allocated to capital markets times the 16 percent share of listed firms in the capital of registered enterprises) of their funds to the stock market in the 1980s.

The allocation of household funds to long-term bonds, or to money markets was negligible. The holding of long-term bonds (mainly central bank securities) and money market instruments (negotiable certificates of deposit, bankers acceptances, and commercial paper) was dominated by financial intermediaries.

To sum up, three features characterize the macroeconomic and financial environment in the 1980s. First, exchange rate policy was influenced by the desire of policymakers to preserve the competitiveness of the export sector and by a policy rule that limited fluctuations in the exchange rate. Second, until 1987, capital controls curbed capital outflows but did not effectively restrict capital inflows. Subsequently, capital outflows were liberalized, while inflows were restricted. Third, Taiwan’s secondary financial markets were thin and underdeveloped.

II. A SMALL OPEN ECONOMY MODEL

To assess the implications of the institutional characteristics of Taiwan’s economy, consider a static, small open economy model with flexible prices. There are three assets: domestic money \( m \), a domestic financial asset earning nonzero returns \( h \) which will be called a bond, and a foreign asset \( f \) denominated in foreign currency.

For convenience, the return on the foreign asset is fixed at zero. Real money demand is then a function of the nominal return on the domestic asset \( i \), the expected rate of appreciation of the domestic currency \( x \), real wealth \( w \), and real income \( y \). In what follows variables in lower case, except for \( f \) and \( i \), are in logs. To simplify the discussion, which is mainly concerned with the effects of shocks to exchange rate expectations, we assume inflationary expectations are exogenous and set them to zero.

In equilibrium real money supply equals real money demand:

\[
\begin{align*}
(1) \quad m_t^i - p_t &= m_i + m_x x + m_y y + m_w w, \\
\end{align*}
\]

where \( p \) is the domestic price and \( m_i < 0; m_x, m_y, m_w > 0 \).

In equation (1), \( i \) reflects the opportunity cost of holding money rather than the domestic bond, while \( x \) is the cost of holding the foreign asset.

The equilibrium in the market for the foreign asset may be expressed as follows:

\[
(2) \quad f_t^f - (s_t + p_t) = f_i + f_x x + f_y y + f_w w,
\]

where \( s_t \) denotes the nominal exchange rate (foreign currency/NT$). It is assumed that \( f_i, f_x < 0, f_y, f_w > 0 \). Since real money and foreign asset and domestic bond holdings comprise total wealth, equilibrium in the domestic bond \( h \) market follows from the wealth constraint and equations (1) and (2).

The economy produces a single internationally traded good. Domestic demand \( a_t \) depends on wealth, while net exports \( b_t \) are determined by wealth and the real exchange rate \( r_t = s_t + p_t - p_t^* \), where \( p_t^* \) denotes the (exogenous) foreign price. Equilibrium in the goods market requires that the sum of domestic and net export demand equal an exogenously determined national income:\( ^5 \)
\[ y_t = a_0 + b_1 = a_w w_t + b_w w_t + b_r r_t, \]

where \( a_w, b_w > 0; b_r < 0 \). In the model, \( s, p, \) and \( r \) are endogenous and can be solved using equations (1), (2), and (3). As shown in Appendix A, the model yields the following reduced form responses to shocks to the exogenous variables:6

\[ \Delta s_i = s_p \Delta x_i + s_m \Delta m_t + s_f \Delta f_t, \]
\[ s_x > 0, s_m < 0, s_f > 0 \]

\[ \Delta p_i = p_p \Delta x_i + p_m \Delta m_t + p_f \Delta f_t, \]
\[ p_x < 0, p_m > 0, p_f < 0 \]

\[ \Delta i_i = i_p \Delta x_i + i_m \Delta m_t + i_f \Delta f_t, \]
\[ i_x < 0, i_m < 0, i_f < 0, \]

where \( \Delta \) is the first difference operator, so \( \Delta s_i = s_i - s_{i-1} \). We focus on the effects of disturbances to exchange rate expectations, the money supply, and foreign assets because they are particularly relevant for Taiwan's case over the time period being discussed.

Under plausible assumptions, an expected appreciation (a rise in \( x \)) increases the demand for domestic assets, resulting in currency appreciation, a lower price level, and a decline in the domestic interest rate. An increase in the money supply creates an excess supply of money, resulting in the depreciation of the domestic currency, an increase in the domestic price level, and a lower domestic interest rate. An increase in the supply of the foreign asset creates an excess demand for domestic assets, resulting in currency appreciation, a lower price level and a decline in the domestic interest rate (qualitatively the same as an expected appreciation). These effects conform to what might be expected from intuition.

Implications of Institutional Characteristics

The institutional characteristics of Taiwan's economy described in Section I affect the specification of the model or the model's parameters in a number of ways. In Taiwan, the absence of restrictions on capital inflows allowed speculators to arbitrage between domestic and foreign assets (it is assumed that speculators who use foreign assets to acquire domestic assets can reverse such transactions with relative ease, as seems to have been the case in Taiwan). This is reflected in the assumption that exchange rate expectations affect the demand for domestic assets. If capital controls were effective, speculators would be unable to exchange their foreign assets for domestic assets in response to changes in exchange rate expectations, and the terms \( s_x, p_x, i_x \) in equations (4) to (6) would equal zero.

In small open economy models that assume perfect substitutability between domestic and foreign assets, the domestic interest rate is determined by the interest parity condition \( i = x \). However, the thin and relatively less developed financial markets of Taiwan suggest that domestic and foreign assets are imperfect substitutes. As a result, the domestic interest rate \( i \), and exchange rate expectations \( x \) enter separately in the model rather than being directly linked by an arbitrage condition.7 Thin and undeveloped financial markets also reduce the interest sensitivity of the demand for money and foreign assets (\( m_t \) and \( f_t \)). Inspection of Appendix A shows that this increases the response of interest rates (or asset prices) to shocks to exchange rate expectations or to changes in the supply of domestic money or foreign assets (\( i_t, i_m, i_f \) increase in equation (6)). Relatively weak arbitrage links may partly explain why certain asset prices in Taiwan—notably the stock price—changed much more sharply than did comparable asset prices in the U.S. and Japan in the later part of the 1980s.

Implications of Exchange Rate Policy

Adjustment when the intervention outcome is credible. To highlight the consequences of central bank intervention more fully, it is useful to recall that the central bank can change the money supply in two ways. First, it can intervene in the foreign exchange market, which will be reflected in changes in the net foreign assets held by the central bank, labeled \( f_t \). Second, it can undertake open market purchases or sales of domestic bonds that change the supply of domestic credit, \( d_t \). These implications of the central bank balance sheet are approximated by:

\[ \Delta m_t = \omega \Delta f_t + (1 - \omega) \Delta d_t, \]

where \( \omega, 1 - \omega \) are respectively the average weights of net foreign and domestic assets in the central bank balance sheet.8 We assume for now that the government changes the money supply only by intervening in foreign exchange markets and that there are no domestic open market operations, so \( \Delta d_t = 0 \). This is known as “unsterilized” intervention.

Suppose a shock raises the expected rate of appreciation in the currency from 0 in period 0 to \( x_1 \) in period 1. The net change in the exchange rate in response to this shock is the sum of the changes in the exchange rate attributable to the private sector and the government.
(8) \[ \Delta s_i = \Delta s_{i}^{p} + \Delta s_{i}^{e} , \]

where the numeral subscripts refer to the time period. The change in the exchange rate attributable to the private sector follows from equation (4):

(9) \[ \Delta s_{i}^{e} = s_{e} \Delta x_{1} . \]

The change in the exchange rate attributable to the government depends on the government’s exchange rate policy. Suppose that the government has a policy of reducing the rate of change in the exchange rate that would otherwise result from private sector actions by a proportion \( 0 \leq \alpha < 1 \). This policy can be described by the following equation:

(10) \[ \Delta s_{i}^{e} = -\alpha \Delta s_{i}^{p} = -\alpha s_{e} \Delta x_{1} . \]

The first equality in equation (10) is the government’s exchange rate rule. The second equality follows from equation (9). Equations (8), (9), and (10) then imply that the one-period change in the exchange rate in response to a shock to exchange rate expectations is:

(11) \[ \Delta s_{i} = (1 - \alpha) s_{e} \Delta x_{1} . \]

The central bank can implement the exchange rate rule (10) by increasing the money supply in order to purchase foreign bonds in the foreign exchange market. In the absence of offsetting domestic open market operations, this will be reflected in an increase in the money supply and a matching reduction in the supply of foreign assets held by domestic residents \( (\Delta m_{i}^{f} = -\Delta f_{i}^{f} ) \). Equations (4) and (9) imply that in order to meet the central bank’s foreign exchange target, the money supply must adjust to a shock to exchange rate expectations according to the following:

(12) \[ \Delta m_{i}^{f} = -\alpha s_{e} \Delta x_{1} / s_{nfa} , \]

where we define the coefficient \( s_{nfa} = s_{m} - s_{f} < 0 \). In the absence of domestic open market operations, the central bank balance sheet relationship (7) implies that \( \Delta m_{i}^{f} = \omega \Delta f_{i}^{f} \). (The reader may recall that \( \omega \), the average share of foreign assets held by the central bank, appears in this expression because we are using a log approximation to the central bank balance sheet.) Using this last equality to substitute for \( \Delta m_{i}^{f} \) in equation (12), we find the increase in the foreign assets held by the central bank that is consistent with the exchange rate target, given an initial shock to exchange rate expectations:

(13) \[ \omega \Delta f_{i}^{f} = \frac{-\alpha s_{e} \Delta x_{1}}{s_{nfa}} . \]

We can use the preceding framework to assess the implications of policy and behavioral parameters. Equation (11) implies that the government can limit exchange rate changes to any degree desired by increasing the intervention parameter \( \alpha \). However, greater exchange rate stability will be associated with a larger change in the money supply and in the net foreign assets held by the central bank (equations (12) and (13)). This is a familiar tradeoff.

Equations (12) and (13) also indicate that the volume of intervention required to satisfy the exchange rate objective (10) is a function of institutional and behavioral parameters. The required intervention is larger, the larger the impact of expectations on the exchange rate \( s_{e} \). As discussed in Section 1, if capital were not mobile, \( s_{e} = 0 \) and no intervention would be required for the government to achieve its exchange rate target. The required intervention is smaller, the larger the impact of such intervention on the exchange rate \( (s_{nfa}) \).

Adjustment when the intervention outcome is not credible. The discussion up to this point has focused on the one-period response to a shock to exchange rate expectations. The total change in the exchange rate in the long run will depend on how expectations, so far treated as exogenous, are affected by intervention. Suppose that the outcome of intervention is credible, in the sense that speculators believe that there will be no further change in the exchange rate. Then agents will make no further effort to acquire domestic assets. Equation (11) then describes the total change in the exchange rate that will occur in response to the initial shock to exchange rate expectations.

To see how the pattern of adjustment differs when the outcome of intervention is not credible, assume that speculators believe that the exchange rate must ultimately adjust to some target exchange rate \( s^{*} \), regardless of the short-run attempts of policymakers to prevent such adjustment. We can think of \( s^{*} \) as the level of the exchange rate that will satisfy some long-run equilibrium condition (for example, the value of the exchange rate that will guarantee that the net present value of an economy's external liabilities is zero). Alternatively, we can think of \( s^{*} \) as the level of the exchange rate that is seen as acceptable by a country’s major trading partners or a country’s creditors.

Consider now a shock to exchange rate expectations in period 1, caused by a one-time increase in \( s^{*} \) above the spot exchange rate, or \( (s^{*} - s_{0}) > 0 \). Speculators acquire domestic assets on the expectation that the gap between the target exchange rate \( s^{*} \) and the spot rate \( s_{0} \) will be eliminated.
When markets reopen in the next period, the government has prevented full adjustment in the spot rate to \( s^* \) by the proportion \((1 - \alpha)\) (as in equation (11)), and speculators again acquire domestic assets on the expectation that the remaining gap between \( s^* \) and the spot rate will be eliminated. This process of repeated domestic asset acquisition and intervention will continue in subsequent periods, producing further changes in the exchange rate. In effect, we can say that intervention spreads the initial shock to exchange rate expectations over several periods. In each period, the shock to expectations is measured by the gap between the target rate and the spot rate:

\[
\Delta x_t = s^* - s_{t-1}; \quad t = 1, 2, 3, \ldots
\]

where \( \Delta x_t \) is now the shock to exchange rate expectations that occurs in each period as a result of the initial increase in \( s^* \) above \( s_0 \).

In equation (14), the path of \( \Delta x_t \) depends on the path of \( s_t \). We can solve for the path of \( s_t \) by using equations (4) and (14), which yield the following difference equation:

\[
\Delta s_t = s_c(1 - \alpha)\Delta x_t = s_c(1 - \alpha)(s^* - s_{t-1}); \quad t = 1, 2, 3, \ldots
\]

where the coefficient \( s_c \) is implied by equation (4). 10

As discussed in Appendix B, the solution to equation (15) is:

\[
\sum_{t=1}^{T} \Delta x_t = s_c(1 - \alpha)\sum_{t=1}^{T} \beta^{t-1}(s^* - s_0).
\]

Chart 1 illustrates the path of exchange rate changes implied by equation (16). The area under the curve is measured by equation (17). The chart assumes a 100 percent appreciation in the target exchange rate \( s^* \), and \( s_c = 1 \). The paths of exchange rate changes are illustrated for the cases in which the rate of appreciation in each period is limited to 2.5 percent (\( \alpha = 0.975 \)) and 10 percent (\( \alpha = 0.9 \)).

Inspection of the chart and the equations suggests that
the expectation that the spot exchange rate in any given period will tend to some target $s^*$ affects the pattern of exchange rate adjustment in a number of ways.

First, intervention can distribute the impact of a one-time shock to expectations over time under certain assumptions about the adjustment of expectations. The reason is that speculators seek to acquire domestic currency—and create upward pressure on the currency—in every period so long as the exchange rate is below $s^*$. In contrast, when the outcome of intervention is credible (as in equation (11)), the exchange rate change lasts only one period.

Second, intervention is effective in the short run, but not in the long run. In the absence of intervention ($\alpha = 0$), the spot exchange rate would appreciate 100 percent in one period, and there would be no further changes in the exchange rate. In contrast, in Chart 1, for the case $\alpha = 0.9$, the cumulative change in the exchange rate is limited to 10 percent in the first period and 65 percent after 10 periods. While intervention does stabilize the exchange rate in the short run, in the very long run the spot rate converges to $s^*$.

Third, the cumulative intervention is larger when the outcome of intervention is not credible. Equation (13) is now the starting point for a sequence of intervention actions, rather than representing the total intervention. Cumulative intervention over $T$ periods is now given by:

$$\omega \Delta f_t^{\omega} = -\alpha \frac{s_x}{s_{x^0}} \sum_{t=1}^{T} \Delta x_t = -\alpha \frac{s_x}{s_{x^0}} \sum_{t=1}^{T} \beta^{t-1} (s^* - s_0),$$

where the second equality follows because, from equations (15) and (16), $\Delta x_t = \beta^{-1} (s^* - s_0)$. Over an infinite horizon, cumulative intervention is:

$$\lim_{T \to \infty} \omega \sum_{t=1}^{T} \Delta f_t^{\omega} = -\frac{\alpha s_x (s^* - s_0)}{s_{x^0}} \lim_{T \to \infty} \left( \sum_{t=1}^{T} \beta^{t-1} \right),$$

$$\text{(18')}$$

which exceeds intervention in equation (13) by

$$\frac{\alpha \beta (s^* - s_0)}{(1-\alpha) s_{x^0}},$$

Fourth, the rate of intervention influences the pattern of exchange rate adjustment over time, as well as the total cumulative intervention. As can be seen in Chart 1, if the rate of intervention is very large ($\alpha = 0.975$), the first-period change in the exchange rate will be small, but subsequent exchange rate changes will decline very gradually. If the rate of intervention is smaller ($\alpha = 0.90$) the first period change in the exchange rate will be quite large, but subsequent exchange rate changes will drop off more steeply. The reader can verify that cumulative intervention in equation (18') increases with the rate of intervention $\alpha$.

Instability

The preceding analysis predicts a gradually declining rate of change in the exchange rate. At times, however, changes in the exchange rate accelerate rather than die down gradually. There is no easy way of modeling such a process. One way to proceed is to assume that speculators believe that the adjustment to the target exchange rate will need to be larger the longer the gap between the spot and the target exchange rate persists.

To motivate this last assumption, consider a country whose large trade surpluses provoke threats of protectionist retaliation by its trading partners. Agents set the target exchange rate $s^*_t$, which now may vary from period to period, at a level they think will reduce trade surpluses by enough to avert retaliation. They revise their estimate of $s^*_t$ upward if the news this period indicates no reduction in the trade surplus or complaints by trading partners. Otherwise, the target $s^*_t$ remains unchanged or is lowered. We can think of a situation where intervention prevents equilibrium exchange rate adjustment, resulting in a sequence of increasing trade surpluses. This in turn prompts a sequence of upward revisions in $s^*_t$ that are associated with accelerating appreciation over several periods. In this manner, the interaction between intervention and expectations may be destabilizing.

To illustrate this argument in a simple way, assume that the target or equilibrium exchange rate grows at the constant rate $(1+\phi)$ when the exchange rate is below target, where $\phi > 0$. Suppose also that in period 1 there is a shock that raises the target exchange rate by a factor $(1-\phi)$, so that $(s^*_t = (1+\phi)s_{0^*})$. Then, so long as the positive gap between the target and actual exchange rate remains, in subsequent periods,

$$s^*_t = (1+\phi)s^*_{t-1}; \ t = 2, 3, 4, \ldots$$

By suitably modifying equation (14), we have the following sequence of shocks to expectations:

$$\Delta x_t = (1+\phi) s^*_{t-1} - s_{t-1}; \ t = 1, 2, 3, \ldots$$

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By modifying equation (15), we find that the change in the exchange rate in each period is now governed by

\[ \Delta x_t = (1-\alpha) s_x x_j (1+\phi) z_t - \beta^{-1} s_y; \quad t=1,2,\ldots \]

The solution to this difference equation, derived in Appendix B, implies that:

\[ \Delta x_t = (1-\alpha) s_x (s_0^* + (1+\phi) z_t - \beta^{-1} s_y), \]

where \( z_t \) is defined in Appendix B. In equation (22), the path of the exchange rate is unstable, and the rate of change in the exchange rate increases over time. This instability is associated with the shocks to exchange rate expectations, which are increasing in each period. Equating \( \Delta x_t \) in equations (21) (first equality) and (22), we can express the shocks to expectations in terms of the starting values of the target and spot rates:

\[ \Delta x_t = (s_0^* + (1+\phi) z_t - \beta^{-1} s_y); \quad t=1,2,\ldots \]

Cumulative changes in the exchange rate and cumulative intervention now grow without bound and are respectively described by:

\[ \sum_{t=1}^{T} \Delta x_t = (1-\alpha) s_x \sum_{t=1}^{T} (s_0^* (1+\phi) z_t - \beta^{-1} s_y) \]

and

\[ \omega \sum_{t=1}^{T} \Delta \phi_t = -\frac{\alpha s_x}{s_y} \sum_{t=1}^{T} (s_0^* (1+\phi) z_t - \beta^{-1} s_y), \]

where we use equation (23) to obtain equations (24) and (25).

In the preceding we have assumed that speculators act as if \( \phi \) is fixed, so that \( s_0^* \) increases forever. This assumption allows us to solve a difference equation. In reality, however, the value of \( \phi \) and the continued accumulation of positive changes to the exchange rate in equation (24) will depend on news about the external balance or the reactions of trading partners or other pertinent events. Once agents receive the news that trade surpluses have fallen or that trading partners are satisfied with the current level of the exchange rate, exchange rate appreciation will cease, and may even sharply reverse direction if \( s_0^* \) falls below \( s_y \).

### Effects on Velocity and Asset Prices

In the unstable case just described, the target rate is growing each period, producing increases in the expected rate of appreciation in each period. According to equations (4) to (6), these period-to-period changes in exchange rate expectations will affect the price level and domestic interest rates as well as the exchange rate. Furthermore, the government’s intervention rule implies that these shocks to expectations will be associated with increases in the money supply and matching increases in the net foreign asset holdings of the central bank. To determine the combined effects of shocks to exchange rate expectations and money creation on the cumulative change in the price level, note that equation (5) implies that:

\[ \sum_{t=1}^{T} \Delta p_t = p_s \sum_{t=1}^{T} \Delta x_t + p_{nfa} \sum_{t=1}^{T} \Delta \phi_t, \]

where, from equation (5), \( p_s < 0; \quad p_{nfa} = p_m - p_r > 0 \). Applying (23) and (25) to (26) we obtain:

\[ \sum_{t=1}^{T} \Delta p_t = \left[ p_s - \frac{\alpha s_x p_{nfa}}{s_y} \right] \sum_{t=1}^{T} (s_0^* (1+\phi) z_t - \beta^{-1} s_y) \geq 0 \]

Equation (26) shows that the inflationary effects of the sequence of increases in the money supply due to intervention \( p_{nfa} \sum_{t=1}^{T} (\Delta \phi_t > 0) \) are offset by the deflationary effects of the sequence of positive shocks to exchange rate expectations \( p_s \sum_{t=1}^{T} \Delta x_t < 0 \). As a result, less than proportional increases in the price level may be associated with money growth. Given a constant level of real GNP, this may result in persistent declines in velocity (the ratio of nominal GNP to money).

Equation (26') shows how the path of the price level depends on the underlying behavioral and intervention parameters. It is apparent from (26') that velocity may decline at an accelerating rate influenced by the magnitude of \( \phi \). Also, the deflationary effects of shocks to exchange rate expectations will tend to be larger, the larger is the impact of expectations on the price level (\( p_s \)). If these deflationary effects are sufficiently large, the money growth resulting from intervention could be associated with a declining rather than increasing price level. Thus, an increase in the money supply resulting from intervention will be associated with a less than proportional increase in inflation (and possibly deflation) and with persistent and accelerating declines in velocity.
To determine the impact of shocks to exchange rate expectations and associated intervention on asset prices, we use equations (6), (23), and (25) to obtain:

\[
\Delta t_x = \sum_{t=1}^{T} \left( i_x - i_{m}\right) \Delta x_t + \sum_{t=1}^{T} \Delta f_{t}^{cb} =
\]

\[
\left( 1 - \frac{\alpha s \Delta f_{t}^{cb}}{s_{nfa}} \right) \sum_{t=1}^{T} \left( s_{0} \left( 1 + \phi \right)^{t} - \beta^{t} s_{0} \right) < 0,
\]

where, from equation (6), \( i_x < 0; i_{m} < 0; i_f < 0 \), and we assume that \( i_{nfa} = i_{m} - i_f < 0 \). Equation (27) says that both the sequence of increases in expected appreciation and the expansion in net foreign assets and money will contribute to persistent and accelerating declines in the domestic interest rate, or, equivalently, to persistent and accelerating increases in the domestic bond price. As noted in our earlier discussion of the implications of institutional characteristics, the magnitude of the changes in the money supply today at the cost of a sufficiently large, one-time change in the money supply. When the outcome of intervention is credible, any degree of exchange rate stability can be achieved at the cost of a sufficiently large, one-time change in the money supply. When the outcome of intervention is not credible, however, intervention can lead to persistent and possibly accelerating changes in exchange rates, the money supply, velocity, and asset prices. Under certain conditions, intervention may even amplify the cumulative change in the exchange rate rather than reduce it. The increased exposure to external shocks that may be associated with sterilized intervention is typically of great concern to policymakers.

Reducing the Exposure to External Shocks

The government may attempt to reduce the economy's exposure to external shocks in three ways. First, the monetary effects of exchange rate intervention may be offset by adjusting domestic credit. Such a policy is known as "sterilized intervention," and can be described by the rule:

\[
(1 - \omega) \Delta d_{x} = -\gamma \omega \Delta f_{t}^{cb}; \quad \gamma > 0,
\]

where \( \gamma \) is the degree of sterilization. The central bank balance sheet equation (7) then implies that the change in the money supply associated with intervention is \( \Delta m_{t}^{x} = \left( 1 - \gamma \right) \omega \Delta f_{t}^{cb} \). It is apparent that the change in the money supply associated with intervention falls as the rate of sterilization \( \gamma \) rises. Nevertheless, there is a limit to how much policymakers can sterilize. One difficulty is that sterilization may be incompatible with the government's exchange rate policy, as it reduces the impact of intervention on the exchange rate. With sterilization, the change in the exchange rate associated with government intervention is:

\[
\Delta s_{t}^{cb} = s_{m} \Delta m_{t}^{x} - s_{f} \Delta f_{t}^{cb} = (s_{m} (1 - \gamma) - s_{f}) \omega \Delta f_{t}^{cb} = s_{nfa} \omega \Delta f_{t}^{cb},
\]

where \( s_{nfa} = s_{m} - s_{f} < 0 \) and the gap between the two expressions increases with the rate of sterilization \( \gamma \). The effect of sterilized intervention on the exchange rate falls as the rate of sterilization \( \gamma \) rises. If sterilization is complete (\( \gamma = 1 \)), so that there is no change in the money supply, the impact of intervention on the exchange rate is entirely the result of the exchange of foreign for domestic bonds, as reflected in the term \( -s_{f} \omega \Delta f_{t}^{cb} \). Because \( s_{f} \) declines as the degree of substitutability increases, the impact of sterilized intervention also declines. Intuitively, sterilized intervention provides the speculator with a domestic bond rather than with money in exchange for the foreign asset. The greater the substitutability of the domestic bond for the foreign asset relinquished by the speculator, the smaller the impact on the exchange rate.

Aside from being potentially less effective, sterilized intervention may require the government to issue debt instruments in order to bring about sufficiently large adjustments in domestic credit, if central bank holdings of marketable securities are insufficient. In the absence of changes in fiscal policy, the intertemporal government budget constraint implies that government debt instruments issued today must be redeemed by printing money at some time in the future. Thus sterilization may reduce the change in the money supply today at the cost of a larger change in the money supply in the future.

Second, the government can impose capital controls. Such controls tend to insulate the economy from the impact of exchange rate expectations by making it difficult for speculators to transact in foreign exchange markets. Capital controls reduce \( s_{nfa}, p_{x}, i_{x} \) in equations (24), (25), (26'), and (27). Inspection of these equations shows that over any finite horizon, cumulative changes in the exchange rate, intervention, and any related disturbances to the domestic price level and the domestic interest rate associated with a shock to exchange rate expectations decline as these coefficients decline. If the controls are so extensive that they are
interpreted as a major regime shift, they may also drive the target exchange rate \( s^*_r \) below the spot rate and cause a reversal in the path of the exchange rate. While this possibility is not explicitly modeled here, it was probably important in Taiwan's case.

Third, the government can reduce the rate of intervention, thus allowing the exchange rate to float more freely in each period. As suggested by our discussion of Chart 1, reducing the rate of intervention tends to reduce the persistence of changes in the exchange rate attributable to a one-time shock to exchange rate expectations.

III. TAIWAN'S EXPERIENCE

To analyze Taiwan's experience in the 1980s, we examine the path of the exchange rate and some of the factors
that may have influenced exchange rate behavior. For this purpose, Chart 2 shows the nominal US$/NT$ exchange rate, the real trade-weighted NT dollar, and the current account in the 1980s. We also examine the pattern of intervention of the central bank by reviewing changes in foreign exchange reserves by the central bank, and its two major determinants—short-term capital flows and the current account, illustrated in Chart 3.\textsuperscript{13}

In Chart 3, changes in the foreign exchange reserves of the central bank are a proxy for intervention. To ascertain the suitability of this proxy, we need to do two things. First, we need to determine the extent to which changes in reserves result from shocks to exchange rate expectations, as only such changes can be said to correspond to intervention in foreign exchange markets. To deal with this question, we note that when there are positive shocks to exchange rate expectations speculators attempt to acquire domestic assets, and the central bank intervenes to dampen the resulting upward pressure on the exchange rate. These actions will simultaneously be reflected in the balance of payments accounts as an increase in short-term capital inflows and in the foreign exchange reserves held by the central bank. The converse holds when there are negative shocks to expectations. Thus, a high correlation between short-term capital flows and changes in foreign exchange reserves indicates whether such changes largely reflect intervention.

Second, we need to assess the likely effects of systematic changes in foreign exchange reserve holdings that are unrelated to intervention. In the case of Taiwan, the main source of such systematic changes was the requirement, in effect until July 1987, that exporters surrender their foreign exchange earnings (see Section I). The path of the current account balance thus provides an indicator of the influence of the trade sector on foreign exchange reserves.

As illustrated in Chart 3, changes in reserves are highly correlated with short-term capital flows, in spite of a widening gap between the level of changes in foreign exchange reserves and short-term capital flows in the course of the 1980s. This widening gap is attributable to the rising current account surpluses that are also shown in the chart. Thus, changes in foreign exchange reserves appear to be a reasonably good proxy for intervention in Taiwan in the 1980s.

\textit{Patterns in the Exchange Rate, Capital Flows, and Intervention}

Inspection of Charts 2 and 3 suggests that the 1980s may be divided into three periods. In the first period, 1980:1-1985:3, there was a downward trend in the US$/NT$ exchange rate up to 1982, followed by a period of stability.

In this period, the exchange rate against the U.S. dollar on average depreciated at a compound annual rate of just under 2 percent, in spite of growing current account surpluses. The real trade-weighted exchange rate also exhibited a slight downward trend. Short-term capital flows and the associated intervention were relatively small (capital outflows averaged $128 million per quarter), and showed no systematic trend. The relative tranquility in foreign exchange markets suggests that speculators did not doubt the government's ability to limit movements in the NT dollar over this period. In terms of the model developed in Section II, it appears that adjustments in the exchange rate in response to shocks could be described by equation (11).

Doubts about the government's ability to prevent the NT dollar from appreciating against the U.S. dollar appear to have arisen in the mid-1980s. One reason is that the NT dollar's relative stability against a falling U.S. dollar in 1985 was associated with a sharp real trade-weighted depreciation that was incompatible with Taiwan's growing external surpluses (Chart 2). In this context, the statement by the G-5 industrial countries, following their September 1985 Plaza meeting, that the U.S. dollar should depreciate further apparently created expectations that the Taiwan government would have to allow the NT dollar to appreciate against the U.S. dollar. This perception was reinforced in the course of the second half of the 1980s, as Taiwan's trading partners, notably the U.S., openly expressed concern about Taiwan's trade surplus and government exchange rate policy.

These developments provide the context for the behavior of the exchange rate and short-term capital flows in the second period, 1985:4 to about 1987:4. In this period, the rate of appreciation in the NT dollar accelerated every quarter for nearly two years, from a compound annual rate of 2.2 percent in 1985:4 to a peak of nearly 31 percent in 1987:3. On average, the NT dollar appreciated against the U.S. dollar at a compound annual rate of 14 percent in 1985:4-1987:4, compared to an average depreciation of 1.8 percent in the first period. There was a concomitant increase in short-term capital inflows, which averaged nearly US$2.4 billion per quarter, compared to average outflows of US$128 million in the first period. Largely as a result of stepped-up intervention, the accumulation of foreign exchange reserves rose to an average of US$6.5 billion a quarter, from an average of under $1 billion in the first period. By comparison to other economies, or to Taiwan's own historical experience, the amount of intervention was unprecedented. Taiwan's foreign exchange reserves rose to a peak of US$77 billion in 1987, third after Japan and Germany in that year. (In domestic currency terms, foreign assets held by the Central Bank of China
(CBC) increased from NT$504 billion in 1983, to a peak of NT$2.26 trillion in 1987, about 30 times its level ten years earlier.)

The discussion in Section II suggests that the apparent instability of the NT dollar and of capital inflows over this period may have been partly the result of government intervention in foreign exchange markets, in a situation where the exchange rate outcome of such intervention was not credible because of rising current account surpluses and expressions of concern by Taiwan's major trading partners. In particular, the behavior of the exchange rate over this period appears to be roughly consistent with the unstable case described by equation (24), while the sharp acceleration in intervention appears to conform to equation (25).14

The government sought to limit the impact of shocks from the external sector in a number of ways (see discussion in Section I). First, it sought to curb short-term capital inflows by freezing the external liabilities of the banking sector at the end of May 1987 and then again in October 1987. Second, it attempted to reduce the link between current account surpluses and changes in foreign exchange reserves by lifting all restrictions on current account transactions in July 1987, including the requirement that foreign currency export revenues be exchanged for domestic currency. Third, it shifted to floating exchange rates in April 1989.

These policy measures were followed by marked changes in the pattern of external disturbances and their impact on foreign exchange reserves, which characterized the third period, 1988-1989. Restrictions on capital inflows prevented speculators from freely acquiring NT dollar assets, contributing to a slowdown in the rate of appreciation of the NT dollar to 8.3 percent (the NT dollar actually fell sharply late in the period, a decline that continued in 1990). There was also a reversal in short-term capital inflows to average outflows of US$1.2 billion per quarter.15 Thus, in the later part of the 1980s, short-term capital flows had a contractionary influence on foreign exchange reserves and on the domestic monetary base.

The liberalization of current account transactions and the shift to floating had strong effects on the accumulation of foreign exchange reserves of the central bank. As is apparent in Chart 3, the gap between changes in foreign exchange reserves and short-term capital flows was largely eliminated after 1987, when the requirement that exporters surrender their foreign exchange reserves was suspended. Changes in foreign exchange reserves diverged sharply from short-term capital flows after the shift to floating in the second half of 1989, suggesting that the government had stopped intervening.

### Effects on the Domestic Money Supply, Velocity, and Asset Prices

The effects of intervention on the money supply were influenced by the government's sterilization policy. To describe this policy, we examine the patterns of changes in net foreign assets and in domestic credit (the two components of the monetary base in equation (7)), reported in Table 2. The table suggests that in the first two periods, net foreign asset expansion was associated with large reductions in domestic credit. The contraction in domestic credit was largely accomplished through the issuance of interest-bearing short-term central bank certificates of deposits and savings bonds, as the supply of Treasury securities is limited by Taiwan's conservative fiscal policy. Table 2 also shows that domestic credit expanded very strongly in the third period. This appears to have been related to earlier sterilization policy, as the Central Bank created money to redeem its maturing short-term liabilities in that period.16

In spite of the high rate of sterilization, Table 3 shows that the rate of base money growth accelerated from an average annual rate of 16 percent in the period 1980:1-1985:3 to 35 percent after 1988. The acceleration in money

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<td><strong>Growth in components of monetary base</strong></td>
</tr>
<tr>
<td>(billions of NT dollars)</td>
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<td></td>
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<tr>
<td>80:2-85:3</td>
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<tr>
<td>85:4-87:4</td>
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<td>88:1-89:4</td>
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<table>
<thead>
<tr>
<th>Table 3</th>
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<tbody>
<tr>
<td><strong>Growth in money and velocity</strong></td>
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<tr>
<td>(compound annual rates in percent)</td>
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<tr>
<td></td>
</tr>
<tr>
<td>80:1-85:3</td>
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<tr>
<td>85:4-87:4</td>
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<td>88:1-89:4</td>
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</tbody>
</table>
growth initially reflected the direct expansionary effects of intervention policy. However, base money growth continued to accelerate even after the reversal of capital inflows in 1988. One reason is that the government shifted to floating exchange rates in April 1989, which limited the contractionary influence of capital outflows on the monetary base.

Another reason for the acceleration in base money growth in the later part of the 1980s is that the redemption of short-term CBC paper had a strong expansionary impact on domestic credit. Thus, efforts to limit monetary growth through sterilization in the mid-1980s contributed to more rapid money growth later in the decade.17

The growth of M1 accelerated from 16 percent in the first period to about 44 percent in the second period, even faster than the rate of growth in the monetary base. In the third period, however, M1 growth slowed to about half the rate of growth in the monetary base. One possible explanation is that the efforts by speculators to exchange their NT dollar deposits for foreign assets offset the expansionary impact of the rapid growth in the monetary base.

The acceleration in money growth did not result in correspondingly large increases in inflation. In fact, inflation declined (from a compound annual rate of 6 percent in the first period to 2.3 percent in the second period) as money growth accelerated, suggesting that increases in the demand for M1 exceeded the growth in the money supply. Speculators were apparently not interested in purchasing goods with the NT dollars they acquired in the foreign exchange market, but held them on the expectation of earning large gains from currency appreciation. In line with this, M1 velocity declined at a 20 percent annual rate in the period 1985:4-1987:4, compared to 2 percent in the first period. Inflation picked up and the decline in velocity slowed sharply in the last two years of the 1980s, as the curbs on capital inflows took effect and the speculative demand for NT dollar assets ceased. The sharp fluctuations in velocity are consistent with the predictions of the model discussed earlier.18

**Effects on Asset Prices**

While the expansion of liquidity did not result in an increase in inflation in the short run, our earlier discussion suggests that it should have resulted in an increase in asset prices or (equivalently) declines in interest rates. Furthermore, the effects on asset prices should have been smaller in those domestic asset markets that are more tightly linked by arbitrage to foreign asset markets, or where domestic assets are closer substitutes for foreign assets. The results of Tables 4 and 5 are roughly in line with these expectations. As shown in Table 4, Taiwan’s domestic money market rate fell in comparison to foreign short-term rates (the 3-month eurodollar rate) as the 1980s progressed, but the relative decline in domestic interest rates was quite limited. The reason is that Taiwan’s domestic money market interacted quite extensively with international financial markets.

In stark contrast, the prices of assets that were not so closely linked by arbitrage to external markets increased sharply. Land prices rose as much as 250 percent between 1987 and 1989. Increases in stock prices were even steeper. As shown in Table 5, the compound annual rate of growth of stock prices in Taiwan accelerated from 2 percent in the first half of the 1980s to 70 to 80 percent in the second half. Table 5 also shows that the increases in Taiwan’s stock price were several orders of magnitude larger than stock price increases in Japan and the U.S., which also experienced stock market booms in the second half of the 1980s.

Taiwan’s stock price index rose from 162 at the end of 1986 to 1557 by the end of 1989, raising price/earnings ratios of listed companies to over 55 by the end of 1989 (compared to 13 in the U.S., and 62 in Japan).19

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**Table 4**

<table>
<thead>
<tr>
<th>(annual rates in percent)</th>
<th>Money market interest rate</th>
<th>3-month Eurodollar rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>80:1-85:3</td>
<td>-0.3</td>
<td>-0.4</td>
</tr>
<tr>
<td>85:4-87:4</td>
<td>-0.2</td>
<td>-0.05</td>
</tr>
<tr>
<td>88:1-89:4</td>
<td>-0.1</td>
<td>0.05</td>
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</table>

**Table 5**

<table>
<thead>
<tr>
<th>(compound annual rates in percent)</th>
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<tr>
<td>Taiwan</td>
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<tr>
<td>--------</td>
</tr>
<tr>
<td>80:1-85:3</td>
</tr>
<tr>
<td>85:4-87:4</td>
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<td>88:1-89:4</td>
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IV. CONCLUSIONS

In this paper we have attempted to explain certain puzzling features of the behavior of exchange rates, money velocity, and asset prices in Taiwan in the 1980s by suggesting a different way of looking at the interaction between exchange market intervention and exchange rate expectations. Using a simple theoretical framework, we have discussed how the credibility of intervention policy may affect the pattern of adjustment in the exchange rate, velocity, and asset prices. When the outcome of intervention is credible, any degree of exchange rate stability can be achieved at the cost of a sufficiently large, one-time change in the money supply. When the outcome of intervention is not credible, however, intervention can lead to persistent, and possibly accelerating, changes in exchange rates, the money supply, velocity, and asset prices. Under certain conditions, intervention may even amplify the cumulative change in the exchange rate rather than reduce it. An informal examination of the data suggests that the model developed in the paper can be used as a framework for explaining Taiwan’s experience.

Two implications of Taiwan’s experience are worth highlighting. First, disturbances to foreign exchange and domestic asset markets in a developing economy need not arise from unsustainable fiscal and monetary policies and macroeconomic instability. Foreign exchange rate intervention may be associated with large disturbances to asset markets even in a stable and well-managed economy. Second, there is a little recognized potential tradeoff between the desire to protect tradable goods production by limiting exchange rate movements and the desire to stabilize in foreign exchange and domestic asset markets. In economies with a high degree of capital mobility, and where intervention policy is not credible, efforts to protect the tradable goods sector through such intervention may contribute to instability in asset markets. This effect may be more pronounced when domestic and foreign assets are not good substitutes.

ENDNOTES

1. The upward pressure on the NT dollar appears to have been related to Taiwan’s current account surpluses, which on an annual basis averaged close to 14 percent of GNP between 1983 and 1988, and reached a peak (on an annual basis) of over 20 percent in 1986. These surpluses appear to be the largest ever recorded in the world. By comparison, at their respective peaks in the 1980s, current account surpluses reached 1.1 to 1.2 percent of GNP in Japan and Germany, and 7.7 percent in Korea.

2. A similar pattern of rapid money growth, low inflation and declining velocity, and asset price inflation was observed in Japan in the second half of the 1980s.


4. In particular, the interest-setting arrangements prevailing in Taiwan in the 1980s apparently introduced a certain amount of rigidity in deposit rates. Yang (1990) notes that the variation in bank rates in Taiwan tends to be smaller than the variation in market rates. She also refers to a study she has carried out using vector ARIMA techniques which finds that the bank rate in the 1980s adjusted about a month after the freely-determined money-market rate. (The latter rate is the rate set in the short-term bills exchange market established in 1976.) Some interest rate policies were also designed to subsidize credit to certain priority sectors, specifically the export sector up to the 1980s, and later the high-tech sector.

5. Strictly speaking, equation (3) also applies ex post to the national income accounting identity in levels rather than in logs. The present approach can be seen as an approximation that simplifies the exposition without changing the qualitative results.

6. For a full description of this type of model, see Branson and Henderson (1985).

7. One way to think about this is to argue that lack of domestic financial market development raises the transactions cost associated with investing in domestic marketable securities. Under these conditions, the influence of the external sector in affecting domestic interest rate determination is reduced. For a demonstration of these effects, see Niehans (1991). A similar argument appears to underlie the specification adopted by Edwards and Khan (1985).

8. The assumption that the weight $\omega$ is constant is an approximation that has no effect on the qualitative results of the model. Such an approximation would not be needed if the variables were expressed in levels rather than in logs. For a similar log-linear approximation of the central bank balance sheet, see Flood and Hodrick (1985).

9. To derive (12), note that the effect of sterilized intervention on the exchange rate is given by $s_a \Delta m_t - s_d \Delta f_t = (s_m - s_d) \Delta m_t^i = \Delta x_t^i$, where we use $\Delta m_t^i = |\Delta f_t^i|$. Applying equation (10), we have $\Delta x_t^i = -\alpha \Delta x_t$, which yields equation (12).

10. The agents in the model use information about the target exchange rate in forming their expectations. This is part of the information set we would expect rational agents to use. A fully developed rational expectations model would require us to assume that (i) exchange rate expectations depend on the rate of intervention and on the structure of the economy and (ii) the government takes into account how intervention affects expectations when formulating exchange rate policy. The equilibrium under these conditions is more difficult to derive and is a topic for future research.
The long-run ineffectiveness of intervention can also be seen in the more general case of equation (17). Note that

$$\lim_{T \to \infty} \sum_{t=1}^{T} \Delta s_{t} = \lim_{T \to \infty} \sum_{t=1}^{T} \beta^{t-1}(s_{t-1} - s_{t})$$

where we use

$$\lim_{T \to \infty} \sum_{t=1}^{T} \beta^{t-1} = \frac{1}{1 - \beta} = \frac{1}{1 - \alpha}.$$  

12. An alternative way of modeling instability in the path of the exchange rate is to use a monetary approach to the exchange rate with rational expectations and pick the unstable solution of the difference equation for the exchange rate. The disadvantage of this approach is that no intuition is offered for the underlying process that generates the explosion. Certain arguments have also been offered to rule out such explosive processes. Still another approach is to analyze what happens when an expected change in monetary policy is not realized over the sample period (the “peso problem”). Obstfeld (1989) shows that such a situation can lead to an exchange rate process that is indistinguishable from an explosive speculative bubble. In Obstfeld’s framework, persistent appreciation may arise if speculators expect that the government will have to reverse its monetary policy (or its sterilized intervention in exchange markets, in the case considered in the text) at some time in the future. In the text we suggest the alternative possibility that intervention itself may contribute to the apparent instability.

13. The underlying data used in Charts 2 and 3 and the Tables in this section were obtained from various issues of the Central Bank of China’s Financial Statistics, Taiwan District or the International Monetary Fund’s International Financial Statistics. The real trade-weighted NT dollar illustrated in Chart 2 was constructed by taking the geometric weighted average of the exchange value of the NT dollar with respect to the currencies of eight of its trading partners, including the U.S. dollar, the yen, and the deutschmark. The weights were based on Taiwan’s total bilateral trade with these trading partners in 1980.

14. An alternative explanation is that a sequence of shocks to exchange rate expectations in 1985-1987 (absent in 1980-85) that resulted in persistent and accelerating appreciation. However, it is not obvious what these shocks could be. As we shall see, on the domestic side, money growth accelerated in the second period, so that the persistent and accelerating appreciation in the NT dollar cannot be explained by progressively tighter monetary policy. There were no dramatic changes in Taiwan’s fiscal policy that could explain real appreciation either. On the external side, current account surpluses had been increasing since the early 1980s, so in this respect the period 1985-87 was not very different from 1980-85. The main shocks that may have affected exchange rate expectations differently in 1985-87 were the real trade-weighted depreciation of the NT dollar in 1985, which predates the persistent appreciation of the NT$ against the U.S. dollar, and the one-time decline in oil prices late in 1986. As these were one-time shocks, something else must explain why the appreciation persisted and accelerated in 1985-87. We suggest that the effects of intervention on expectations played an important role.

15. The effects of the freeze in external liabilities were already apparent in 1987. As can be seen in Chart 3, short-term capital flows drop from a peak of around $3.7 billion to nearly zero between the first and third quarters of 1987, with a concomitant dip in the accumulation of foreign exchange reserves by the central bank. There was an even larger drop between the fourth quarter of 1987 and the first quarter of 1988.

16. Sterilization policies produced sharp fluctuations in the amount of interest-bearing liabilities of the CBC. The outstanding value of these liabilities increased from NT$14 billion in 1983 to a peak of nearly NT$1.2 trillion in 1987. They subsequently fell to NT$415 billion at the end of 1989, as the CBC retired short-term liabilities as they came due.

17. This point is made in Yin (1990). The episode can be thought of as an illustration of Sargent and Wallace’s unpleasant monetarist arithmetic, where—absent changes in fiscal policy—the issuance of government bonds to reduce money growth today leads to more rapid money growth in the future. For a discussion of unpleasant monetarist arithmetic see Sargent (1987b).

18. In contrast to the sharp fluctuations in narrow money aggregates, there was no acceleration in M2 growth between the first and second periods. It appears that speculators acquiring NT dollar assets preferred to hold readily convertible or liquid assets, like M1, rather than the less liquid components of M2. This appears to have offset significantly any tendency for the demand for M2 to rise as a result of the overall increase in the demand for NT dollar assets. In line with this view, there was a smaller (rather than larger) rate of decline in M2 velocity as the decade progressed.

19. Other factors also appear to have contributed to the very steep increases in Taiwan’s stock prices. First, stock prices may have been undervalued, as the rate of increase in stock prices in Taiwan up to 1985 was low given Taiwan’s exceptional economic performance. Second, the expansion in liquidity in the mid-1980s appears to have triggered a speculative bubble in Taiwan’s stock markets that lasted until the end of the decade (the existence of a bubble is suggested by the fact that Taiwan’s stock market subsequently lost as much as 80 percent of its value in 1990).
APPENDIX A

RESPONSES TO SHOCKS IN A STATIC, SMALL OPEN ECONOMY MODEL

Differencing the system (1) to (3) yields:

\[ \begin{bmatrix} -1 & -m_i & 0 \\ -1 & -f_i & 1 \\ b_i(a+b_w) & 0 & -b_p \end{bmatrix} \begin{bmatrix} \Delta p_i \\ \Delta i_i \\ \Delta s_i \end{bmatrix} = \begin{bmatrix} m_x \\ f_x \Delta x_i + 0 \\ 0 \end{bmatrix} \begin{bmatrix} -1 \\ \Delta m_i \\ 0 \end{bmatrix} \begin{bmatrix} \Delta f_i \\ 0 \\ 0 \end{bmatrix}, \]

where the structural coefficients are discussed in the text. The inverse of the matrix on the left-hand side is:

\[ \begin{bmatrix} f_i b_r & -m_i b_r & m_i \\ -b_r - (a+b_w) & b_r & -1 \\ f_i(a+b_w) & -m_i(a+b_w) & f_i - m_i \end{bmatrix} \]

where \( DET = -b_r + m_i(a+b_w) < 0 \);

it is assumed that \( a_w + b_w + b_r > 0 \). From the preceding, we can derive the reduced form responses of the exchange rate, the domestic interest rate and the price level to a variety of shocks.

Exchange rate expectations:

\[ \begin{align*}
\frac{\Delta p_i}{\Delta x_i} &= \frac{b_r}{DET} \left[ f_i m_x - m_i f_i \right] < 0 \\
\frac{\Delta i_i}{\Delta x_i} &= \frac{1}{DET} \left[ -(b_r + (a+b_w)) m_x + b_r f_i \right] < 0 \\
\frac{\Delta s_i}{\Delta x_i} &= \frac{(a+b_w)}{DET} \left[ f_i m_x - m_i f_i \right] > 0.
\end{align*} \]

The sign of equation A4 is actually ambiguous, because the decline in the demand for the foreign asset tends to lower the domestic interest rate, while the concomitant increase in the demand for money tends to raise the domestic interest rate. The intuitively plausible case \( i_x < 0 \) is selected here.

Money supply

\[ \begin{align*}
\frac{\Delta p_i}{\Delta m_i} &= p_m = -\frac{f_i b_r}{DET} > 0 \\
\frac{\Delta i_i}{\Delta m_i} &= \frac{i_m}{DET} = \frac{b_r(a+b_w)}{DET} < 0 \\
\frac{\Delta s_i}{\Delta m_i} &= s_m = \frac{f_i(a+b_w)}{DET} < 0.
\end{align*} \]

Foreign assets

\[ \begin{align*}
\frac{\Delta p_i}{\Delta f_i} &= p_f = \frac{m_i b_r}{DET} < 0 \\
\frac{\Delta i_i}{\Delta f_i} &= \frac{i_r}{DET} = \frac{-b_r}{DET} < 0 \\
\frac{\Delta s_i}{\Delta f_i} &= s_f = \frac{m_i(a+b_w)}{DET} > 0.
\end{align*} \]

Summing equations A5, A8, and A11 yields equation (4) in the text. Summing A3, A6, and A9 yields equation (5), while summing A4, A7, and A10 yields equation (6).
APENDIX B

THE PATH OF THE SPOT EXCHANGE RATE UNDER ALTERNATIVE EXPECTATIONS ASSUMPTIONS

To illustrate how the solutions to difference equations in the text are derived, consider the most general case:

\[ \Delta x_t = (1 - \alpha) x_t \Delta x_t = (1 - \alpha) s_t (s_t^* - s_{t-1}) \]

The first equality in equation B1 says that the change in the exchange rate in this period depends on the rate of intervention \( \alpha \), the reduced form response of the exchange rate to a shock to exchange rate expectations \( s_x \) (from equation (4) in the text), and the magnitude of the shock to exchange rate expectations this period \( \Delta x_t \). The second equality shows that the shock to exchange rate expectations depends on the gap between the target exchange rate this period \( s_t^* \) and last period’s exchange rate \( s_{t-1} \).

Rewriting B1 yields

\[ s_t = \beta s_{t-1} + (1 - \alpha) s_t (s_t^* - s_{t-1}) \]

where \( \beta = 1 - s_t (1 - \alpha) \). We assume \( 0 \leq \beta \leq 1 \).

Recursive substitution into B1’ yields the following solution (alternatively, see Sargent (1987a) Chapter 9):

\[ s_t = \beta s_{t-1} + (1 - \alpha) s_t \sum_{i=0}^{t-1} \beta^i s_t^* \]

where \( s_0 \) is the initial value of the spot exchange rate. The change in the spot rate in each period is given by:

\[ \Delta s_t = (1 - \alpha) s_t \left[ \sum_{i=0}^{t-1} \beta^i s_t^* - \sum_{i=0}^{t-2} \beta^i s_{t-1}^* \right] - (1 - \beta) \beta^{t-1} s_0 \]

\[ = (1 - \alpha) s_t \left[ \sum_{i=0}^{t-1} \beta^i s_t^* - \sum_{i=0}^{t-2} \beta^i s_{t-1}^* \right] - \beta^{t-1} s_0 \]

where in the second equality we use \( 1 - \beta = s_x (1 - \alpha) \).

Special cases

Case 1: \( s_t^* = s^* \)

When the target exchange rate is the same in every period, B2 implies

\[ s_t = s_0 \]

In the very long run, we have

\[ \lim_{t \to \infty} s_t = \frac{(1 - \alpha) s_0 s^*}{1 - \beta} = s_0^* \]

where the second equality follows because \( 1 - \beta = (1 - \alpha) s_x \). The rate of change in the exchange rate in each period is now governed by:

\[ \Delta s_t = (1 - \alpha) s_t \left[ \sum_{i=0}^{t-1} \beta^i - \sum_{i=0}^{t-2} \beta^i \right] - (1 - \beta) \beta^{t-1} s_0 \]

\[ = \beta^{t-1} (1 - \alpha) s_x (s^* - s_0) \]

It follows from equation B6 that as \( t \to \infty \), \( \beta^{t-1} \) and \( \Delta s_t \) asymptotically approach zero. Equation (B6) corresponds to equation (16) in the text.

Case 2: \( s_t^* = s^* \); \( s_x = 1 \)

From the definition of \( s_x \) given earlier, this case implies that \( \beta = \alpha \). Equation B6 then becomes

\[ \Delta s_t = (1 - \alpha) \alpha^{t-1} (s^* - s_0) \]

This is the case plotted in Chart 1.
Case 3: $s_i^* = (1 + \phi)s_{i-1}^*$

Given an initial target exchange rate $s_0^*$, the target exchange rate in each period is given by:

$$B8 \quad s_i^* = (1 + \phi)s_{i-1}^*.$$

Substituting into equation B2, the spot rate is now given by:

$$B9 \quad s_t = \beta s_t + (1-\alpha)s_0^* \sum_{i=0}^{t-1} \beta^i (1+\phi)^{t-i}.$$

It is apparent from equation B8 that $s_t$ now grows without bound. Intervention cannot prevent this. It can also be shown that the rate of change in the exchange rate will accelerate indefinitely. To see this, note that the change in the spot exchange rate is now:

$$B10 \quad \Delta s_t =$$

$$= (1-\alpha) s_0 \left[ \sum_{i=0}^{t-1} \beta^i (1+\phi)^{t-i} - \sum_{i=0}^{t-2} \beta^i (1+\phi)^{t-1-i} \right] - \beta^{t-1} s_0$$

To simplify notation, define $z_t = 1 - \frac{(1-\beta)}{(1+\phi)} \sum_{i=0}^{t-1} \left( \frac{\beta}{(1+\phi)} \right)^i$,

$$t = 2, 3, \ldots,$$

where $z_t = 1$ when $t=1$ and

$$\lim_{t \to \infty} z_t = \frac{\phi}{(1-\alpha)s_0^* + \phi}.$$

Rewriting B10,

$$B10' \quad \Delta s_t = (1-\alpha) s_0^* (1+\phi)^t z_t - \beta^{t-1} s_0; \quad t = 1, 2, \ldots.$$

Equation B10', which is equation (22) in the text, shows that the appreciation in the exchange rate now accelerates.
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Consumer Sentiment: Its Causes and Effects

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This paper finds that consumer attitudes, as reflected in surveys of consumer sentiment, have a significant influence on household purchases of durable goods. Normally, consumer sentiment moves with current economic conditions and bears a stable relationship to a few economic variables. At times of a major economic or political event like the Gulf War, however, consumer sentiment can move independently from current economic conditions. At such times it provides useful information about future consumer expenditures that is not otherwise available.

The 1990-91 recession has been widely attributed to a collapse of consumer confidence following Iraq's invasion of Kuwait and the military response of the United States and its allies. Similarly, military victory for the allies was generally believed to have dispelled the gloom about prospects for jobs and business, thus helping to lead the economy out of the recession. Consistent with this hypothesis, the Index of Consumer Sentiment constructed by the Survey Research Center at the University of Michigan dropped by a record amount beginning in August 1990, at the time Kuwait was invaded. With the successful completion of the war, the index then surged back to its pre-recession level in March 1991. In April, however, it dropped again and made no significant improvement through the summer, as the economic recovery turned sluggish. It therefore appeared to respond to both political and economic events.

This is not the only episode in which swings in consumer sentiment have been tied to the business cycle. The Michigan index generally has led other business cycles, and three of its components are specifically included in the Commerce Department's Index of Leading Economic Indicators. Therefore, changes in consumer sentiment could have been instrumental in triggering earlier recessions as well. Alternatively, however, sentiment ordinarily may be just a reflection of economic conditions that generally precede or coincide with a recession, without necessarily being an independent cause of downturns.

This paper analyzes the causes and effects of consumer sentiment as measured by the University of Michigan survey index. It addresses the following interrelated set of questions. To what degree does consumer sentiment affect consumption spending? To the extent that it does, is consumer sentiment generally an independent factor in creating fluctuations in consumption spending, and, therefore, business as a whole, or does it usually simply respond to economic adversity, thereby reinforcing but not initiating business cycles? When swings in consumer sentiment occur, what specific economic variables are they related to and are such relationships stable? Finally, can the influences on spending that are captured by sentiment be predicted from readily available economic variables, or is
actual survey data on consumer sentiment necessary for making the most accurate forecast of consumer spending?

In Section I of the paper, earlier work on the role of consumer sentiment in consumer spending is reviewed. The role of sentiment in affecting consumer spending on durables, as well as nondurables and services, is then examined empirically in Section II. The relative significance of the individual components that go into the overall index is analyzed here as well. Section III then examines the extent to which consumer sentiment can be explained by current economic variables. Section IV compares the ability of the index of sentiment and the current economic variables that are related to it to improve the accuracy of forecasts of expenditures on consumer durables. The recent Persian Gulf War is a prime example of a situation in which consumer sentiment may have been driven by something other than current economic conditions—for example, by expected repercussions on future economic conditions or perhaps just by mass psychology. Therefore, this episode is examined separately. Finally, Section V provides a summary and some conclusions.

It is found that changes in consumer sentiment normally are caused by purely economic factors and that consumer sentiment usually bears a stable relationship to just a few economic variables. As a result, consumer sentiment usually is just a reflection of economic adversity or prosperity, reinforcing rather than initiating business cycles. At times of an unusual event like the Gulf War, however, consumer sentiment can move independently from current economic conditions. The relative importance of the index's different questions in measuring overall consumer attitudes, and hence their effect on durables purchases, differs during times of a major shock like the Gulf War from normal times.

I. BACKGROUND

The use of surveys to measure consumer sentiment was pioneered by George Katona and his associates at the University of Michigan in the 1950s. The rationale for such surveys is provided by the discipline of psychological economics. According to psychological economics, a household's response to a change in income or wealth depends upon its attitudes at the time. Thus, consumer expenditures depend not only on an ability to buy but also a willingness to buy.

In contrast, in standard economic theory households are assumed to react uniformly to changes in income or wealth at different points in time. Although changes in attitudes may matter for individual households, these individual differences are assumed to cancel out for the economy as a whole. But the law of large numbers applies to economic situations only if random factors prevail. If the same factor influences very many people in the same direction at the same time, deviations add up instead of canceling out. An obvious systematic factor that could produce relatively uniform reactions is the acquisition of new information through the mass media.

Katona argued that the attitudes that enter into consumer sentiment are more than simply a reflection of the current state of the economy. Therefore, they are not necessarily related to current economic variables in any stable way. Attitudes may be influenced by political and economic events that are nonquantifiable. Also, similar economic or financial developments may be perceived differently under different circumstances. Katona's point is that, while a purely mechanistic view of consumer behavior sometimes may be correct, it is not necessarily and not always correct. Particularly at turning points, consumer willingness to buy may be an important and unpredictable independent factor determining spending. If so, survey measures of consumer sentiment could contribute importantly to both forecasts of consumer spending and an understanding of consumer behavior.

As part of this study, we examine the importance of some of the individual questions in the index of sentiment for explaining consumer spending. Since 1955 the Michigan Index of Consumer Sentiment (ICS) has contained five questions, with equal weight. They are:

1. “We are interested in how people are getting along financially these days. Would you say that you (and your family living there) are better or worse off financially than a year ago?”
2. “Now looking ahead—do you think a year from now you (and your family living there) will be better off financially, or worse off, or just about the same as now?”
3. “Now turning to business conditions in the country as a whole—do you think that the next 12 months will have good times financially, or bad times or what?”
4. “Looking ahead, which would you say is more likely—that the country as a whole will have continuous good times during the next 5 years or so, or that we will have periods of widespread unemployment or depression, or what?”
5. “About the big things people buy for their homes—such as furniture, a refrigerator, stove, television, and things like that. Generally speaking, do you think now is a good or a bad time for people to buy major household items?”
As shown in Chart 1, the ICS tends to follow a cyclical pattern, with a strong tendency to lead economic downturns and a lesser tendency to lead upturns. An Index of Consumer Expectations (which is one of the 12 series in the Commerce Department's Index of Leading Economic Indicators), based on forward looking questions 2, 3, and 4, tends to lead both downturns and upturns; the Current Conditions Index (CIND) based on questions 1 and 5 leads downturns and some, but not all, upturns (Chart 2). The correlation matrix in Table 1 shows that there is a high intercorrelation among the responses to these five questions, with the exception of question 5. This question asks

![Chart 1: Index of Consumer Sentiment (ICS)](image1)

Shaded areas indicate periods of economic recession. The dotted line denotes the peak of the 1990 recession.

![Chart 2: Current and Expected Indices](image2)

Shaded areas indicate periods of economic recession. The dotted line denotes the peak of the 1990 recession.

### Table 1

**Correlations Among Components of Index of Consumer Sentiment**

<table>
<thead>
<tr>
<th></th>
<th>Personal Finances</th>
<th>Business Conditions</th>
<th>Buying Conditions</th>
</tr>
</thead>
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<td>Expected</td>
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<td>.790</td>
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<tr>
<td>Business Conditions</td>
<td></td>
<td>1.0</td>
<td>.874</td>
</tr>
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<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>
directly about household attitudes with respect to the purchase of major household items. The correlations between question 5 and all others are between .5 and .75, while the intercorrelations among the others range from .75 to .95.

Three main views on consumer sentiment have emerged in the literature. The first is the original one of Katona. In this view, sentiment is an important predictor, along with income, of spending on discretionary items like consumer durables. However, in this view consumer sentiment is not believed to be well represented by responses to any single question or to bear any stable relation to aggregate economic variables. As a result, a survey of a set of questions is deemed necessary in order to make accurate forecasts of consumer spending on durable goods, particularly at turning points. A second view is that sentiment mainly measures optimism or pessimism about future economic conditions. Contemporary theories of overall consumption and saving strongly emphasize economic agents' perceptions of the current environment and expectations of its future. Thus, in “life-cycle” or “permanent income” theories of consumption, current spending on nondurables and services, as well as on durables, depends importantly on expected future income. The index of sentiment may provide a better measure of this than conventional modeling based on past observations of incomes.

Yet a third view is that the most useful aspect of the index of sentiment is a measurement of the uncertainty or risk, associated with the likelihood of job loss and/or severe income loss and attendant financial distress. Although this probability is likely to be correlated to some extent with current or expected economic conditions, it affects consumer spending through different channels. A higher probability of financial distress would lead an individual household to save more in liquid form and less in illiquid form, so that liquid assets are available to cover a possible future short fall in future income. The most effective way to do this would be to postpone expenditures on consumer durables rather than on nondurables and services. In this view, the most important dimension of the index of sentiment is its measurement of confidence or mistrust, rather than optimism or pessimism. It is possible, however, that household perceptions of uncertainty or risk can be measured equally well, or better, by economic variables.

The rest of the paper attempts to discriminate among these three views. We first focus on whether the index of sentiment, or its components, provides useful information for predicting consumer spending on either durables or nondurables and services that is not contained in other readily available economic data. Finally, we ask whether sentiment or its components, contain information for forecasting consumer spending that is not contained in other economic data.

II. EFFECTS OF CONSUMER SENTIMENT

In modern consumption theory, households are viewed as making a conscious attempt at achieving a preferred distribution of consumption over their lifetime, subject to the size of the economic resources expected to accrue to them. Friedman’s (1957) permanent income hypothesis views consumption as a function of an anticipated long-term measure of income, equal to the expected yield on human and nonhuman wealth. The life cycle theory of Modigliani and his colleagues takes this idea one step further, allowing for the consumption of nonhuman wealth towards the end of a household’s lifetime. In both theories consumption refers not to current expenditures on consumer goods, but rather to the current flow of utility from consumer goods, including the existing stock of consumer durables. For simplicity, Friedman’s permanent income approach is adopted here.

In the permanent income framework, consumer expenditures on nondurables and services are simply a function of permanent income. However, expenditures on consumer durables usually are viewed as following a stock-adjustment process. The desired stock of consumer durables depends upon permanent income and interest rates, and possibly also on attitudes measured by the index of consumer sentiment. Expenditures on durables in any period then become some fraction of the difference between desired and actual stocks.

Earlier studies have found that consumer sentiment significantly affects expenditures on consumer durables. Using the permanent income framework, estimates of a model of expenditures on durables that uses polynomial distributed lags (a PDL model) for the period 1963.Q1 through 1990.Q4 are:

\[
\begin{align*}
LGCD & = -6.71 + 1.49 LYDP + \sum_{i=1}^{3} a_i ICP_{i-1} + \sum_{i=0}^{4} b_i ICS_{i} \\
& + .104 LKCD_{-1} + .146 e_{-1} \\
S.E. & = .0116 \\
D.W. & = 2.02
\end{align*}
\]

and

\[
\begin{align*}
R^2 & = .996 \\
S.E. & = .0235
\end{align*}
\]
The t-statistics (in parentheses) indicate a high degree of statistical significance of the consumer sentiment index (ICS). In addition, the current conditions component (CIND) of the index actually has somewhat more explanatory power than the overall index. Each of the questions in CIND contributes about equally to its explanatory power. A one-point change in CIND is estimated to move expenditures on consumer durables by 0.4 percent in the same direction over a period of four quarters. About half of this effect occurs in the contemporaneous quarter. Since CIND can swing as much as 30 points between the peak and trough of the business cycle, sentiment thus appears to be able to move spending on durables as much as 12 percent over a relatively short period.

Earlier studies of the causes and effects of consumer sentiment have been subject to two potentially serious econometric problems, however. These are the interpretation of contemporaneous correlations and the possibility of "spurious" relationships between time dependent variables. A common solution to the first problem of "simultaneity" is to specify some variables as exogenous that affect other variables but are not affected by them. These exogenous variables can then be used either as instruments to proxy endogenous independent variables or as independent variables in reduced form equations. A difficulty with this procedure, however, is that it is not always clear what variables are truly exogenous in a macroeconomic system.

The second problem of "spurious" regressions arises from the fact that variables that have random time trends may appear to be correlated in finite samples, even though there is no true relationship between them. Although the low estimated serial correlation in the errors of the above PDL model of consumer durables suggests that likelihood of spurious correlation due to random time trends is low, simultaneity bias still may exist. Also, previously estimated models of consumer sentiment generally do have highly serially correlated errors.

A Vector Error Correction Model

This study uses a "vector error correction" model to avoid these problems. In such a model, all variables are treated as potentially endogenous. Moreover, tests are made to ensure stationarity in the variables in order to avoid "spurious" regressions. In addition, because the change in any variable is assumed to be a function of its own past changes as well as past changes in other variables, a vector error correction system is a natural vehicle for generating ex ante forecasts that use only information available prior to the forecast period. The variables we initially consider in this framework are the log of expenditures on consumer durables (LGCD), the log of spending on nondurables and services (LCNS), the log of personal disposable income (LGYD), interest rates as represented by the six-month commercial paper rate (ICP), and a measure of consumer sentiment either (ICS or CIND).

The change in any variable is assumed to be a function of its own past changes as well as past changes in other variables, with lags of one to four quarters being chosen. The change in any variable also is assumed to respond to an "error correction" term equal to the lagged difference between the variable and its estimated equilibrium value. A nominal interest rate, rather than a real one, is used because of the importance of liquidity constraints for households. Theoretically, the lagged stock of durables might also be included, but as in the PDL regressions it turned out to be statistically insignificant. The reason is that, although a larger stock of durables reduces the difference between desired and actual stocks, it also generates more replacement investment, and the two effects on investment spending tend to cancel each other out.

The stationarity tests that were performed are described in Appendix A, as is the construction of the error correction term. A "general-to-simple" modeling strategy was employed in which insignificant variables were dropped from the model. The final equations of the estimated vector error correction system are shown in Table 2. In the equation for consumer durables, the error correction term is highly significant, whether the overall index of sentiment (ICS) or just the current conditions component (CIND) is used to measure sentiment, as shown in equations 1a and 1b. Since the error correction term is stationary, the usual distribution for the t-statistic applies, easily indicating significance at the 1 percent level or better. Moreover, sentiment contributes significantly to the importance of the error correction term.
Similar to the results with the PDL model, the use of CIND produces a lower standard error for the durables equation and a larger estimated response of durables expenditures to sentiment. Also, there are significant effects of lagged changes in both interest rates and sentiment on changes in expenditures on consumer durables using CIND, but not ICS. Recall that CIND contains the responses to one question that asks directly about household attitudes with respect to the purchase of major household items, as well as responses to another question that is highly correlated with those for the remaining questions in the overall index of sentiment. As a result, CIND appears to contain all the useful information in ICS for explaining expenditures on durables.

Interestingly, short-run changes in spending on durables (DLGCD) are more closely related to changes in spending on nondurables and services (DLCNS) than to changes in disposable income (DLGYD), as the latter is insignificant in both equations 1a and 1b in Table 2. This is consistent with the permanent income hypothesis, in which spending on nondurables and services is proportional to permanent income. If the desired stock of durables depends upon

---

**Table 2**

**Estimated Vector Error Correction System**

Sums of Coefficients on Lagged Changes in Independent Variables and Coefficient on Error Correction Term (E.C.)


<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Constant</th>
<th>ΔLGCD</th>
<th>ΔLCNS</th>
<th>ΔLGYD</th>
<th>ΔICP</th>
<th>ΔICS</th>
<th>ΔCIND</th>
<th>ΔU</th>
<th>E.C.</th>
<th>$R^2$</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. ΔLGCD</td>
<td>- .00758</td>
<td>2.380</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.601</td>
<td>.42</td>
<td>.0267</td>
</tr>
<tr>
<td></td>
<td>( -1.22)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(- 8.44)$^a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1b. ΔLGCD</td>
<td>- .00578</td>
<td>2.296</td>
<td></td>
<td>- .0011</td>
<td></td>
<td>.003</td>
<td></td>
<td></td>
<td>-.796</td>
<td>.48</td>
<td>.0254</td>
</tr>
<tr>
<td></td>
<td>( - .906)</td>
<td></td>
<td></td>
<td>( - 3.39)$^b$</td>
<td></td>
<td>(4.41)$^a$</td>
<td></td>
<td></td>
<td>(- 7.28)$^a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1c. ΔLGCD</td>
<td>- .00150</td>
<td>.584</td>
<td>2.92</td>
<td>- .0232</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.0374</td>
<td>.36</td>
<td>.0278</td>
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<tr>
<td></td>
<td>( - .186)</td>
<td></td>
<td>(2.10)$^d$</td>
<td></td>
<td>(4.46)$^a$</td>
<td></td>
<td></td>
<td></td>
<td>(- 3.22)$^a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1d. ΔLGCD</td>
<td>- .00395</td>
<td>2.194</td>
<td></td>
<td>- .0242</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.00318</td>
<td>-.671</td>
<td>.42</td>
</tr>
<tr>
<td></td>
<td>( - .594)</td>
<td></td>
<td>(2.72)$^c$</td>
<td></td>
<td>(5.54)$^a$</td>
<td></td>
<td></td>
<td></td>
<td>(- 6.36)$^a$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ΔLCNS</td>
<td>.003307</td>
<td>0.552</td>
<td></td>
<td>- .0015</td>
<td></td>
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<td></td>
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<td></td>
<td>.17</td>
<td>.00476</td>
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<tr>
<td></td>
<td>( -2.97)$^a$</td>
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<td>(4.71)$^a$</td>
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<td>(3.18)$^b$</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3. ΔLGYD</td>
<td>.00066$^d$</td>
<td>1.075</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.13</td>
<td>.00916</td>
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<tr>
<td></td>
<td>( - .306)</td>
<td></td>
<td>(4.07)$^a$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4. ΔICPQ</td>
<td>.04299</td>
<td></td>
<td></td>
<td></td>
<td>.0437</td>
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<td>.13</td>
<td>1.173</td>
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<td></td>
<td>( - .375)</td>
<td></td>
<td></td>
<td></td>
<td>(4.39)$^a$</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>5a. ΔICS</td>
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<td>-3.07</td>
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<tr>
<td>5b. ΔCIND</td>
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<td></td>
<td></td>
<td></td>
<td>-3.616</td>
<td>-.150</td>
<td></td>
<td></td>
<td></td>
<td>-.25</td>
<td>4.682</td>
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<td></td>
<td>( - .452)</td>
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<td></td>
<td></td>
<td>(7.29)$^a$</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Levels of Significance (F-Statistic for lagged changes and t-statistic for constant and error correction term (E.C.))

$^a$Significant at 1%

$^b$Significant at 2.5%

$^c$Significant at 5%

$^d$Significant at 10%
permanent income, then purchases of durables should be more closely related to the current consumption of nondurables and services than to current income in the short run. In the longer run, however, income should become a better measure of permanent income, which is consistent with the greater significance of disposable income than spending on nondurables and services in the error correction term.

The error correction term does not play a significant role in explaining changes in any of the variables besides expenditures on durables. This is consistent with the strong response of durables expenditures to sentiment, leaving no significant adjustment to be done elsewhere. The change in spending on nondurables and services (eq. 2) is found to depend only on past changes in the consumption of nondurables and services and past changes in interest rates; and it is not influenced by consumer sentiment in any way. This result is not consistent with a rational expectations version of the permanent income hypothesis in which consumption responds only to new information about permanent income, and hence is a random walk unrelated to past values of any variables. But it is consistent with a modified version of the rational expectations version permanent income hypothesis, in which adjustment costs prevent an instantaneous response to permanent income.

The finding that consumer sentiment significantly influences expenditures on consumer durables, but not spending on nondurables and services, suggests that consumer sentiment is something other than just a better measure of perceptions of permanent income. The important thing that it seems to measure is the perception of uncertainty, or risk, and the corresponding probability of financial distress. If the probability of financial distress is high, at the margin households should prefer to hold liquid assets and consume the income from them on nondurables and services, rather than holding illiquid consumer durables. They would therefore allocate their consumption away from the satisfaction provided by illiquid consumer durables and towards nondurables and services. However, greater uncertainty and risk also should lead to precautionary increases in the overall saving rate, causing a decline in total consumption. The effects on expenditures on nondurables and services appears to be approximately offsetting, leaving them roughly unchanged.

Current changes in disposable income (eq. 3) are found to be significantly related only to past changes in the consumption of nondurables and services. This too is consistent with a modified rational expectations version of the permanent income hypothesis. If expectations are forward-looking, then future changes in income should be related to past changes in spending on nondurables and services. Current changes in the commercial paper rate (eq. 4) are found to be significantly related only to past changes in itself. Changes in either of the sentiment indexes (eqs. 5a and 5b) are related only to own past changes and past changes in the commercial paper rate. Thus, changes in sentiment cause changes in spending on durables, in a statistical sense, and are not caused by them.

**Response of Durables Purchases to Sentiment and Other Factors**

Next we examine how spending on consumer durables responds to shocks to sentiment, as well to the other variables. These shocks are set equal to the standard deviation of the disturbances to each variable over the sample period. A disturbance to the system of first difference equations is temporary. But its effect on the level of spending on durables generally is permanent. Chart 3 shows that the effect on the level of durables expenditures of an “average” shock to the current component of consumer sentiment (CIND) is about as large as the effect of a shock from the commercial paper rate or from spending on nondurables and services. Thus, consumer sentiment is truly an important determinant of spending on durables, on a par with other factors that usually are thought to be important. The effect of a shock to disposable income on purchases of durables is somewhat smaller. Finally, the response of consumer durables to a shock to durables themselves affects durables purchases only temporarily. This occurs because a disturbance to durables is gradually eliminated through the response of durables expenditures to the error correction term.

**Chart 3**

Dynamic Response of Consumer Durables to an Increase in:

![Chart showing dynamic response of consumer durables to an increase in various factors](chart.png)
We have thus established that consumer sentiment is a statistically significant variable for explaining purchases of consumer durables. Also, disturbances to consumer sentiment are important relative to other variables in explaining the overall variation in expenditures on consumer durables. The next question is the usefulness of sentiment in making actual ex ante forecasts of durables purchases. For a preliminary answer, this vector error correction system (either eq. 1a or 1b and eqs. 2-5, Table 2) was estimated over an initial sample period, here chosen to be 1963.Q1-1975.Q4. Next the estimated system was used to make a forecast of spending on durables one, two, four, and eight quarters ahead. Then the system was reestimated using data from the initial sample plus the quarters just forecast. The “new” system was used to generate a new set of forecasts. Forecasting errors over the period 1976.Q1 to 1989.Q4 for systems using either no measure of sentiment (dropping eq. 5 and sentiment from eq. 1), or the ICS (using eqs. 1a and 5a) or CIND (with eqs. 1b and 5b) measures of sentiment, were then compared with those of a naive model that forecasts future expenditures simply on the basis of its trend rate of growth. These comparisons are shown in Table 3.

Even without including a sentiment variable, the estimated vector error correction system forecasts expenditures on consumer durables more accurately than a naive model does. The root-mean-squared forecasting error is reduced by 25 to 40 percent, depending on the forecast horizon (line 2 versus line 1, Table 3). Including the simple model of ICS (eqs. 1a and 5a, Table 2) in the system changes these forecast errors by relatively small amounts. It raises the two-quarter-ahead root mean squared error slightly, lowers the four-quarter-ahead error slightly, and reduces the eight-quarter-ahead error by 20 percent (line 3 versus line 2, Table 3). But substituting the simple model of the CIND (eqs. 1b and 5b, Table 2) measure of consumer sentiment in the system lowers the root mean squared error by 12 to 35 percent, depending on the forecast horizon (line 4 versus line 2, Table 3). Thus, for this period the inclusion of consumer sentiment improves the accuracy of ex ante forecasts of durable purchases markedly, but primarily only if the current conditions component of sentiment (CIND) is used.

### III. Causes of Consumer Sentiment

This section addresses the issue of the underlying explanation of consumer sentiment and its important current conditions component. Is sentiment mainly a psychological or anticipatory variable that is not easily explained by current economic variables? Or is the sentiment index basically just filtering current economic data? In the previous section, it was found that changes in consumer sentiment, or in the current conditions component of it, could be forecast fairly well by past changes in interest rates and past changes in sentiment itself. But if a better economic explanation of consumer sentiment could be found, better forecasts of durables spending might be obtainable. Alternatively, if the sentiment index filters the relevant economic variables poorly and also does not contain any important purely psychological component, better forecasts might be obtained by using those variables directly. We examine these issues next.

#### The Traditional Approach

There is little consensus in previous studies on the set of economic variables that might best explain consumer sentiment. However, one of the most coherent earlier approaches is Mishkin's “liquidity hypothesis” (1976, 1977, 1978). This hypothesis focuses on the illiquidity of consumer durables, which creates a loss for consumers if they try to sell durables (or borrow against them) in an emergency. As a result, consumers who expect not to be able to pay their bills readily would prefer holding liquid assets rather than illiquid consumer durables. In effect, the opportunity cost of holding consumer durables increases substantially when consumers get into financial trouble. Thus, as the probability of financial distress increases, consumers lower their demand for durables. As discussed earlier, the evidence of a positive response of spending on durables to movements in consumer sentiment, in contrast to the lack of response of nondurables and services, is consistent with this view. It suggests the important thing that consumer sentiment measures is perceptions of the

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Out of Sample Root Mean Squared Errors in Forecasting InGCD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quarters Ahead</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1. Naive</td>
<td>.035</td>
</tr>
<tr>
<td>Vector Error Correction System</td>
<td></td>
</tr>
<tr>
<td>2. Without Sentiment</td>
<td>.034</td>
</tr>
<tr>
<td>3. Basic Model with ICS</td>
<td>.034</td>
</tr>
<tr>
<td>4. Basic Model with CIND</td>
<td>.031</td>
</tr>
</tbody>
</table>
probability of financial distress, rather than perceptions of permanent income.

Mishkin argues that, besides depending upon the expected level and variance of income, the probability of financial distress should vary positively with the consumer's debt and negatively with his holdings of financial assets. When indebtedness is high, the consumer has large contractual payments for debt service that increase the likelihood of financial distress, thus decreasing the demand for consumer durables. In contrast, larger holdings of financial assets increase the consumer's buffer against bad times, and so increase the demand for consumer durables. Thus, consumer sentiment (ICS) should be positively correlated with real financial assets of households (FIN) and negatively correlated with their indebtedness (DEBT) at the beginning of the quarter. It should also be positively correlated with transitory income (YDT), which acts as a proxy for upside or downside risk. Also, inflation in consumer prices (DLCPI) tends to affect consumer sentiment adversely because it is usually associated with greater uncertainty. An updated estimate (sample period 1963.Q1-1990.Q4) of Mishkin's model of ICS is:

\[
ICS = 78.6 + .746 \text{FIN} - 1.94 \text{DEBT} + .169 \text{YDT} - 3.33 \text{DLCPI} + .708 e_1 + .708 e_1
\]

\[
R^2 = .885 \quad \text{S.E.} = 4.15 \quad \text{D.W.} = 2.24
\]

All of the variables have theoretically correct signs and significant t-statistics. Note also that the decomposition of the household balance sheet into its debt and financial assets components in the liquidity hypothesis is supported, since the absolute value of the estimated coefficient on debt is more than twice as large as on financial assets. The independent variables in this model could potentially affect ICS with a lag for two reasons. First, the impact of adverse conditions on consumer sentiment is likely to be stronger the longer these conditions have persisted. Second, the effect of economic conditions on sentiment may be "contagious," as consumers find out about the feelings of others. These effects, if they exist, could be captured by the inclusion of lagged ICS. But like Mishkin, we find that the lagged ICS is not significantly positive, suggesting an absence of lagged adjustment.

While Mishkin's model seems to work reasonably well as an explanation of consumer sentiment, other investigators have used a larger set of economic variables to explain sentiment. These have included changes in stock prices, the unemployment rate and its change, the real price of oil and its change, and interest rates. All of these variables can be interpreted as measures of general economic uncertainty and risk, but without special emphasis on household balance sheet positions.

When these explanatory variables are added to Mishkin's model of ICS, lagged ICS becomes significant, and the significance of FIN, DEBT, and YDT evaporates. Of the remaining variables, the rate of inflation (DLCPI), the percent change in the S&P index of stock prices (DLSP), and the change in the unemployment rate (DU) are statistically significant in explaining ICS, with a significant degree of lagged adjustment. The current conditions component of sentiment (CIND) turns out to be well explained by this same set of variables as well as by the percent change in the real price of oil (DLPOIL), also with a significant degree of lagged adjustment. Thus, the preferred equations following the traditional approach for selecting the set of explanatory variables are:

\[
ICS = 28.2 + 2.97 \text{DLCPI} + 2.00 \text{DLSP} - 5.40 \text{DU} + .710 ICS_{-1} - .320 e_1
\]

\[
R^2 = .967 \quad \text{S.E.} = 3.63 \quad \text{Significance level of LM test} = .36
\]

\[
CIND = 20.1 - 1.10 \text{DLCPI} + .193 \text{DLSP} - 9.60 \text{DLPOIL} - 5.74 \text{DU} + .798 \text{CIND}_{-1} - .418 e_2
\]

\[
R^2 = .876 \quad \text{S.E.} = 3.83 \quad \text{Significance level of LM test} = .70
\]

An Expanded Error Correction Model Approach

The equations for the levels of sentiment estimated by the traditional approach are potentially "spurious," however, due to possible correlations caused by random time trends. An indication that this is a possibility is that, in the absence of correction for serial correlation or the use of lagged dependent variables, the $R^2$ is almost as high as the Durbin-Watson statistic. This suggests that some of the independent variables are nonstationary and therefore possibly accidently correlated with consumer sentiment, the level of which is also nonstationary.

Even if some of these variables are nonstationary, however, so long as they are cointegrated with sentiment they can be used in level form in an error correction model.
<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>ΔICS</th>
<th>Dependent Variable</th>
<th>ΔCIND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.119 (.685)</td>
<td>.246 (.218)</td>
<td>.0905 (.620)</td>
</tr>
<tr>
<td>ΔICS</td>
<td>0.481 (3.49)b</td>
<td>.229</td>
<td>—</td>
</tr>
<tr>
<td>ΔCIND</td>
<td>—</td>
<td>—</td>
<td>-0.0424</td>
</tr>
<tr>
<td>ΔICP</td>
<td>-1.93 (2.80)b</td>
<td>-2.33 (2.07)c</td>
<td>-3.40 (6.17)a</td>
</tr>
<tr>
<td>ΔU</td>
<td>—</td>
<td>—</td>
<td>-6.36 (4.03)a</td>
</tr>
<tr>
<td>E.C.</td>
<td>-0.262 (-3.41)a</td>
<td>-0.204 (-3.15)a</td>
<td>-0.229 (-3.41)a</td>
</tr>
<tr>
<td>D72.1 Nixon wage and price controls</td>
<td>—</td>
<td>5.85c (1.52)</td>
<td>3.27 (.801)</td>
</tr>
<tr>
<td>D72.4</td>
<td>—</td>
<td>-11.2 (-2.98)a</td>
<td>-4.58 (1.17)</td>
</tr>
<tr>
<td>D74.1-3 Oil embargo</td>
<td>—</td>
<td>-9.95 (-2.49)a</td>
<td>-2.98 (1.27)c</td>
</tr>
<tr>
<td>D75.2-3</td>
<td>—</td>
<td>10.0 (2.50)c</td>
<td>9.34 (2.83)a</td>
</tr>
<tr>
<td>D80.2 Carter credit controls</td>
<td>—</td>
<td>3.81 (-.99)</td>
<td>-8.29</td>
</tr>
<tr>
<td>D80.3</td>
<td>—</td>
<td>11.0 (2.72)c</td>
<td>10.5 (2.35)c</td>
</tr>
<tr>
<td>D87.4 Stock market crash</td>
<td>—</td>
<td>-5.48 (-1.49)c</td>
<td>-5.61 (-1.43)c</td>
</tr>
<tr>
<td>D87.1</td>
<td>—</td>
<td>5.05 (1.37)c</td>
<td>5.64 (1.43)c</td>
</tr>
<tr>
<td>D90.3-4 Gulf War</td>
<td>—</td>
<td>-14.4 (-5.41)a</td>
<td>-9.87 (-3.45)a</td>
</tr>
<tr>
<td>D91.1</td>
<td>—</td>
<td>6.70 (1.66)c</td>
<td>—</td>
</tr>
<tr>
<td>D91.4 Post-Gulf War</td>
<td>—</td>
<td>13.2 (3.37)c</td>
<td>-10.2 (-2.52)a</td>
</tr>
<tr>
<td>$\bar{R}^2$</td>
<td>.27</td>
<td>.55</td>
<td>.35</td>
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<tr>
<td>S.E.</td>
<td>4.50</td>
<td>3.61</td>
<td>4.35</td>
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</table>

Levels of Significance (F-statistics for lagged changes and t-statistics for constant, E.C. term, and dummies)

- Significant at 1%
- Significant at 5%
- Significant at 10%
Therefore, we next examine the stationarity of the previous menu of independent variables and their degree of cointegration with consumer sentiment. This allows us to construct an error correction model that is free of spurious correlation.

The stationarity tests that were performed are described in Appendix B, as is the construction of the error correction term for models of sentiment. The only variables that are both nonstationary in levels and cointegrated with the two measures of consumer sentiment are the rate of inflation in consumer prices (DLCPI) and the civilian unemployment rate (U). Therefore, these variables are used to construct error correction terms for both ICS and CIND. However, other variables may contribute to short-run changes in sentiment. In conformity with a “general-to-simple” modeling strategy, error correction models (with 4 lags) using inflation and unemployment were first estimated, and insignificant lagged changes were dropped. The statistical significance of lagged changes in other variables then was tested. The final error correction equations for explaining both measures of consumer sentiment are shown in Table 4.

These expanded error correction models of sentiment confirm the importance of changes in interest rates, and changes in unemployment in the case of CIND, in conditioning short-run changes in sentiment. Changes in other variables, except lagged changes in sentiment itself, are insignificant. Also, a somewhat tighter fit is obtained for CIND than for ICS. This is not surprising. The current conditions component of sentiment should be more closely related to current economic variables than the expected conditions component. These expanded error correction models of sentiment are quite different from those obtained from the previous regressions in the levels of the variables. Stock prices and oil prices are not included as independent variables, but interest rates are, and the dynamics of the effects of inflation and unemployment on sentiment are more complex.

IV. RELATIVE FORECASTING POWER OF SENTIMENT INDICATORS

The expanded error correction models of consumer sentiment improve the in-sample explanation of the change in sentiment significantly, raising the coefficient of determination by 35 to 40 percent compared with simpler earlier error correction models (Table 4 versus Table 2). But this improved modeling of sentiment does not carry over into any greater accuracy in forecasting spending on durables. As shown in Table 5, the accuracy in forecasting durables is worsened somewhat at all horizons with the expanded models of ICS and CIND, even though actual rather than forecasted values of inflation and unemployment are used (lines 2 and 5). Furthermore, substituting actual survey values of ICS or CIND for predicted values in the durables equation does not improve the forecast of expenditures on durables either, but on the whole tends to worsen it (lines 3 and 6).

Thus, this evidence suggests that in the 1976 to 1989 period consumer sentiment generally did not have an important component that both helped to predict consumer spending on durables and was not stably related to current economic variables. Rather the opposite is suggested, namely, that as good or better forecasts of expenditures on durables might be obtained simply by using the economic variables that are related to sentiment directly in a forecasting equation for durables, rather than using survey values of sentiment. This possibility is examined by substituting the unemployment rate and the inflation rate for sentiment in the cointegrating equation for consumer durables (Table 5).
A2). The corresponding error correction model of expenditures on durables (Table 2, eq. 1c) has a somewhat higher standard error and somewhat lower coefficient of determination than before. But the resulting forecasts of durables expenditures, using actual values of unemployment and inflation, are significantly more accurate than if the actual survey value of ICS is used (Table 5, line 7 versus line 3). Also, forecasting accuracy is about on a par with that using the actual survey value of the more powerful CIND measure of sentiment, being better at some horizons and worse at others (Table 5, line 7 versus line 6). This system also forecasts durables expenditures about as well as the system containing either the simple (line 4) or expanded (line 5) error correction models of CIND.

Finally, a combination of indicators measuring sentiment was tried. Both the unemployment rate and CIND were included in the cointegrating equation for consumer durables (inflation being omitted because it takes on the “wrong” sign), shown in Table A2. Forecasts using the resulting error correction model of expenditures on consumer durables (Table 2, eq. 1d), and actual values of unemployment and CIND, were not significantly more accurate than ones using either unemployment and inflation or CIND alone. As shown in Table 5, at less than a 4-quarter horizon, the forecast error using both economic variables and sentiment (line 8) is slightly smaller than when either is used alone, but at an 8-quarter horizon it is much larger.

Thus, over the 1976 to 1989 period, neither the overall index of consumer sentiment (ICS), nor the more powerful current conditions component (CIND), generally appears to contain any information not already contained in economic variables that is useful for forecasting expenditures on consumer durables. In particular, the substitution of unemployment and inflation for sentiment produces forecast errors that are at least as small as those using sentiment alone; and an even simpler model of sentiment based just on interest rates also produces forecast errors at least as small. Moreover, measuring consumer attitudes with a combination of a sentiment index and economic variables does not reduce forecast errors below those obtained by using economic variables alone.

The Gulf War and Consumer Spending

From August through October of 1990, the Michigan index of consumer sentiment recorded the biggest decline in any three-month period in its 44-year history; and over the next year it failed to recover fully. This decline was triggered by Iraq’s invasion of Kuwait and the subsequent military response of the United States and its allies. As a result, consumer sentiment temporarily deviated from its normal relationship with economic variables.25 As shown in Charts 4A and 4B, the expanded error correction models of consumer sentiment (estimated through 1990.Q2) fail to predict both the sharp declines in the ICS and CIND measures of consumer sentiment from 1990.Q2 to 1990.Q4 and the subsequent increases from 1990.Q4 to 1991.Q3, even though the actual values of the explanatory economic variables are used. While higher unemployment tended to depress the predicted value of sentiment in this period, falling interest rates and declining inflation worked in the other direction. The net effect is a predicted increase in the ICS measure of sentiment and only a small predicted decrease in the CIND measure. This is thus a clear case of sentiment moving independently from current economic variables.
conditions as the result of a major political event, and an exception to the overall results for the 1976 to 1989 period. Whether the effect of consumer attitudes on expenditures is better measured by the indexes of sentiment or economic variables in this period is examined in Table 6. This shows the root-mean-squared errors in forecasting consumer expenditures on durables in the 1990.Q3 to 1991.Q3 period for models estimated through 1990.Q2. The evidence here very strongly suggests that when sentiment and economic variables diverge, consumer spending on durables tends to follow the path of sentiment.

In the first place, forecasts of durables purchases from the vector error correction system in this period have lower errors if sentiment is omitted entirely than if the economic variables usually explaining sentiment are employed. The errors with either the basic (lines 2 and 5) or expanded (lines 3 and 6) models of sentiment are both larger than without sentiment (line 1), as are the errors from using economic variables directly in the durables equation (lines 8 and 9). Thus, the economic variables that usually explain sentiment do not contribute at all to the accuracy of forecasts of durables purchases in this period.

Second, forecast errors are reduced by 20 to 40 percent if the actual value of a sentiment index is used in the model, compared with using no measure of sentiment at all. Interestingly, also in this period the broad ICS index of sentiment gives lower forecast errors than the narrower CIND index covering only current conditions, which is the opposite of the results in the earlier 1976.Q1 to 1989.Q4 period. The likely reason is that a major economic or political event, such as the Gulf War, significantly alters expectations of economic conditions relative to perceptions of current economic conditions, whereas normally expected conditions tend to be fairly highly correlated with current conditions and do not add any significant information. This is indeed seen in Chart 2, where in 1990 the index of expected conditions drops significantly more than the index of current conditions.

The relative size and patterns of these forecasting errors for the 1990.Q3 to 1991.Q3 period are shown graphically in Chart 5A. The forecast of durables purchases from the vector error correction system that is based on the actual value of the overall ICS index turns down immediately, due to the sharp drop in expected conditions, and is roughly in line with the actual drop in purchases of consumer durables in the latter half of 1990. The forecast based on the actual value of the current conditions index (CIND) drops much more gradually; and the forecast based on actual unemployment and inflation shows a sustained increase in spending.

The accuracy of these forecasts depends in part on the ability of the vector error correction system to capture an unexpected decline in income, as well as on the effect of consumer attitudes on spending. So a more precise reading of the best measurement of consumer attitudes can be had by looking at the predictive accuracy of the durables equation alone, using actual values of all the independent variables. As shown in Chart 5B, this strongly confirms the accuracy of the overall ICS index of consumer sentiment in measuring consumer attitudes during the Gulf War. The forecast of durables purchases using the ICS index follows the actual pattern of spending quite closely. The forecast using the CIND current conditions component shows a small increase in spending, with the effects of declining interest rates tending to offset the effects of the relatively small decline in CIND. Finally, the durables equation that substitutes unemployment and inflation for a measure of sentiment forecasts even larger increases in spending because of large interest rate effects relative to the depressing effect of higher unemployment.

The 1990-1991 period was an exceptional one, in which consumer sentiment lost its anchor to current economic conditions. However, sentiment remains cointegrated with inflation and unemployment even if observations from this
period are included. This suggests that sentiment returned to its long-run relationship with these variables once the special circumstances associated with the Gulf War had dissipated. This, in fact, appears to have occurred by the second and third quarters of 1991, following the allied victory in March 1991, as evidenced in Charts 4a and 4b.

When the expanded error correction model of sentiment is estimated through 1990.Q3, instead of through 1990.Q2, it still overpredicts changes in ICS and CIND in future periods, suggesting that significant “unexplained” effects on sentiment still were present. Then, if the end point of estimation is moved up to 1991.Q1, the model significantly underpredicts the change in sentiment as euphoria associated with the military victory in March drove it up. By the second and third quarters of 1991, however, the special influence associated with the Gulf War appears to have gone. This is indicated by the fact that the economic model of sentiment forecasts changes in either ICS or CIND between the second to third quarter of 1991 with little error.

There actually have been several other periods when consumer sentiment similarly became temporarily detached from current economic conditions. Dummy variables were introduced into the expanded error correction models of both ICS and CIND to test for these influences. As shown in Table 4, the statistical significance of these dummy variables indicates that there were unusual effects on consumer sentiment during the Nixon wage and price controls, the 1973-74 oil embargo, the 1987 stock market crash, and the Carter credit controls, in addition to the period of Gulf War. The Nixon wage and price controls had a positive effect on sentiment, while all of the other events depressed sentiment.

V. Summary and Conclusions

This paper has used error correction models to examine the causes and effects of consumer sentiment. It finds that movements in consumer sentiment cause changes in spending on consumer durables in a statistical sense at all times, but that expenditures on durables do not cause sentiment. Furthermore, expenditures on nondurables and services are not causally related to sentiment at any time, consistent with the hypotheses that sentiment measures the degree of uncertainty held by households, rather than just optimism or pessimism about the future.

In normal times, the important thing that consumer sentiment measures for forecasting durables expenditures is household perceptions of the current state of economy, including whether or not it is a good time to buy major household items. Ordinarily their perception of future economic conditions does not move very differently from their perceptions of current conditions, and so does not have any important additional effect on durables purchases. In fact, forecast errors normally are lower if only the current conditions component of the sentiment index is used, rather than the overall index. In addition, if economic variables such as the unemployment rate and inflation are substituted for the value of sentiment in a model
of durables expenditures, forecasts are usually at least as accurate as when only the current conditions component of the sentiment index is used.

This normal pattern tends to be reversed at times of an unusual economic or political event like the Persian Gulf War, however. Such an event can move expected economic conditions independently from current conditions, and the resulting change in consumer attitudes can significantly influence expenditures on durables. As a result, forecasting errors using the overall index of sentiment are lower in such a period than if just the current conditions index of sentiment is used. Furthermore, because sentiment is affected by unusual factors in such a period, it becomes detached from current economic variables. As a result, economic models of sentiment break down, and the substitution of economic variables for sentiment in models of durables expenditures no longer produces superior forecasts.

The practical ability to use the sentiment index for true \textit{ex ante} forecasts of durables expenditures at the time of a major shock is limited, however, by the fact that the lag between the values of sentiment that are actually known and future expenditures is relatively short. A majority of the response is completed within two quarters and the full response takes about four quarters. In contrast, in normal times reasonably good \textit{ex ante} forecasts of durables expenditures, using only information available prior to the forecast period, can be made over spans as long as eight quarters by modeling consumer sentiment with economic variables in a vector error correction system.

\textbf{ENDNOTES}

1. The Michigan index is available for a longer period than the alternative measure compiled by the Conference Board. In addition, preliminary tests showed it to be a better predictor of expenditures on consumer durables. See Throop (1991a).

2. A useful treatise on psychological economics is Katona (1975).

3. In compiling the ICS, for each question a "balance score" is calculated equal to the proportion of households giving favorable replies minus the proportion giving unfavorable replies, plus 100 (to avoid negative numbers). The balance scores to the individual questions are summed, and then divided by the base year figure (1966).

4. Strumpel, Morgan, and Zahn (1972) contains representative studies by leading economists and references to the rather large amount of literature on this subject.

5. This point of view is well represented by Tobin in Strumpel, Morgan, and Zahn (1972).

6. Juster and Wachtel (1972a, 1972b) have been consistent proponents of this view. Although Mishkin (1976, 1977, 1978) also argues that uncertainty is an important factor in consumer expenditures on durables, his work suggests that it is better captured by direct balance sheet measures than by consumer sentiment.


8. See, for example, Adams and Klein (1972) Juster and Wachtel (1972a and b), Dunkelberg (1972) and Shapiro (1972), as well as the consumption sector of the DRI model of the U.S. economy described in Eckstein (1983).

9. See endnote 19.


11. Overviews of vector error correction methodology are provided in Hendry (1986), Granger (1986), Hall (1986), Jenkinson (1986) and Engle and Granger (1987). See also the appendixes to this study.

12. See, for example, Wilcox (1989).

13. When the equations are estimated in unrestricted form, as in Table A3, the coefficients implied for the cointegrating vector are very close to the originals, providing a check on the original estimates. Also, \( t \)-statistics on the levels of ICS and CIND are 4 or more. Since the levels of ICS and CIND are nonstationary, although coefficient estimates are consistent the usual distribution for the \( t \)-statistic does not apply. A larger than normal \( t \) value, somewhere on the order of the Dickey-Fuller tests, is required for any level of significance. (On these points see Banerjee, et al. (1986) and Stock and Watson (1988). The \( t \)-statistics appear to be high enough to meet this test. Moreover, the indicated significance of ICS or CIND is roughly as high as that of interest rates, which clearly belong in the cointegrating vector.

14. Recent studies have found that consumption exhibits a lagged response to income in some degree, contrary to the rational expectations version of the permanent income hypothesis. As a result, changes in consumption would be related to past changes in consumption. See Hall (1978), Flavin (1981) and Nelson (1987).


17. Because errors in the different equations may be contemporaneously correlated, an assumption needs to be made about their causality. The common procedure is to order the variables so that errors in the equations that are ordered first affect the errors in the other equations, but are not affected by them. The “general-to-simple” modeling strategy that we employed provides a useful guide for such ordering. For example, interest rates and consumer sentiment affect spending on durables, but are not affected by that spending. Therefore, it seems reasonable to order interest rates and sentiment before durables purchases, so that disturbances to them affect durables but not vice versa. In accordance with this approach, the complete ordering that was used is ICP, CIND, LCNS, LGYD, LGCD.

18. These conclusions are relatively insensitive to the ordering of the variables. Two alternative orderings were tried. In the first, the initial ordering was reversed to give LGCD, LGYD, LCNS, CIND, ICP. In the second, CIND and ICP were interchanged in this reordering. In both alternatives, the response of durables purchases to shocks to sentiment was reduced compared with the response to interest rates, but still was at least half that of interest rates. The responses of durables to shocks to nondurables and services, income, and durables were affected to lesser degrees.

19. Transitory income (YDT) is defined as the difference between current income and permanent income (YPD), where YPD is calculated as \( \frac{1}{1-\alpha} \sum_{t=0}^{\infty} (1-\alpha)(1+T)YD_t \). The parameter, \( \alpha \), was chosen to minimize the error in predicting spending on nondurables and services. It equals about 0.5.

20. Fisher (1981) and Taylor (1981) find a positive correlation between the level and variance of inflation over time in both the U.S. and OECD countries. A more recent paper with similar findings is Ball and Cecchetti (1990).

21. These studies include Adams and Green (1965), Hyman (1970), Lovell (1975), and Eckstein (1983, ch. 5).

22. Variables in change form are all one-quarter changes. The unemployment rate is adjusted for estimated changes in the full employment rate of unemployment over time due to demographic shifts. Mishkin used a four-quarter change in consumer prices, as did we in updating his model of sentiment. However, these equations switch to a one-quarter change in consumer prices for DLCPI in order to be comparable with the results of the subsequent error correction model of sentiment. The insignificance of FIN, DEBT, and YDT and the significance of lagged ICS when other variables are added is not sensitive to whether DLCPI is measured as a one-quarter or four-quarter change.

23. A high \( R^2 \) relative to the D.W. statistic is generally regarded as a possible indication of a spurious regression due to random time trends. See Campbell and Perron (1991). The \( R^2 \) and D. W. statistics are .73 and 1.12, respectively, for ICS and .50 and .70 for CIND, in the absence of correction for serial correlation or the use of lagged dependent variables.

24. The vector error correction system actually forecasts better using predicted values of variables other than consumer sentiment rather than actual values. This appears to be attributable to the difficulty of measuring permanent income. Substituting actual for the predicted values of ICP improves the forecast of LGCD a little, while substituting actual for predicted values of LCNS and LGYD worsens it quite a lot.

25. Even including the period of the Gulf War, however, the measures of sentiment remain cointegrated with unemployment and inflation.

26. In fact, the decline in consumer and business confidence at the time of the Gulf War appears to have been the dominant impulse precipitating the recession that began in the summer of 1990. See Throop (1991b).
In constructing a vector error correction system, one first determines whether levels or first differences of the variables are stationary (or trend-stationary as the case may be) by using the Dickey-Fuller test, as described in Fuller (1976). This test consists of regressing the first difference of the variable in question on its own lagged level plus a constant, a time trend, and lagged first differences as appropriate. The null hypothesis that random disturbances permanently affect the level of the series—making it nonstationary—implies that the coefficient on the lagged level should be greater than or equal to zero. The test-statistic is just the ratio of the estimate of the coefficient to its standard error, except that under the null hypothesis this statistic does not have the usual t distribution.

Table A1 presents the results of this test for the levels and first differences of the logs of real spending on consumer durables (LGCD), real spending on nondurables and services (LCNS), and real disposable income (LGYD), as well as the levels and first differences of the six-month commercial paper rate (ICP), the index of consumer sentiment (ICS) and the current conditions component (CIND) of that index. In each case, three lags of the dependent variable are included to capture short-run dynamics.

Table A1 shows that in levels form the t-statistic (shown in parentheses) on the coefficient on the lagged level of the dependent variable does not exceed the critical value for any of the variables at even the 10 percent level of significance. So we cannot reject the hypothesis of nonstationarity for the level of the variable in all cases. By contrast, we can reject the hypothesis of nonstationarity for first differences at a 5 percent level of significance or less in all cases.

These results indicate that standard statistical tests of significance may be applied to regressions on these variables in first difference form because the first differences are stationary. Therefore, a natural representation is a vector autoregression in the first differences. However, this form throws away information about longer-run relationships between the levels of the variables that may in fact exist. Even though the levels of the variables are nonstationary, disturbances to them may be related, so they do not tend to drift apart in the long run. In this case they are said to be cointegrated.

We can test for the existence of such a long-run relationship by estimating an ordinary least squares regression and examining the residuals from this regression for stationarity. A finding that the residuals are stationary means that even though the variables in the regression are nonstationary, a linear combination of the variables is stationary. Moreover, if the residuals from this regression are added to the vector autoregression in the first differences as an "error correction" term, the residuals in those equations will continue to be stationary, and the usual statistical tests will continue to apply.

Table A2 shows the cointegrating vectors that are obtained by regressing LGCD on LCNS, LGYD, ICP, and a measure of consumer sentiment (either ICS or CIND). Using either measure of sentiment, both LCNS and LGYD have positive coefficients, the coefficient on ICP has the expected negative sign, and the coefficient on sentiment has the expected positive sign. The Dickey-Fuller test indicates stationarity in the residuals of the cointegrating vectors at a 5 percent level or better. Therefore, the estimated error (actual less predicted) from the cointegrating regression can be included as an error correction term. When entered into the vector autoregressions, its estimated coefficients will indicate the extent to which LGCD, compared with other variables, responds to deviations from the estimated long-run relationship.

A vector error correction system tends to be overparameterized since all lags on all variables are included. Therefore, a "general-to-simple" modeling strategy was employed in which insignificant variables were dropped. On the basis of F tests, lagged changes in LGYD, ICP, and ICS are dropped when ICS is employed as the measure of consumer sentiment, while only lagged changes in LGYD are dropped when CIND is the measure used. Also, LCNS clearly is not a significant factor in the error correction term, since dropping it from the cointegrating vector has no effect on the standard error of the estimated equation for consumer durables; and the cointegrating vector that omits LCNS continues to pass the test for stationarity, as shown in Table A2. The resulting vector error correction system for explaining spending on consumer durables is shown in Table 2 in the text.

1If lagged first differences are included, this is called the augmented Dickey-Fuller test.
2For example, in the simplest of time series processes, \( x = px_{t-1} + e \), where \( e \) is a random error. If \( p < 1 \), then a random disturbance will not permanently affect the level, so that \( x \) will be stationary. But if \( p \geq 1 \) the level of \( x \) will be permanently affected, and therefore \( x \) will be nonstationary.
3Subtracting \( x_{t-1} \) from both sides, \( \Delta x_t = -(1-p)x_{t-1} + e \). Thus, if \( p < 1 \), then when \( \Delta x_t \) is regressed on \( x_{t-1} \), the coefficient on \( x_{t-1} \) will be negative, indicating a stationary process. On the other hand, if \( p = 1 \), a unit root, the coefficient on \( x_{t-1} \) will be zero, and the process will be nonstationary. Similarly, if \( p > 1 \) and \( 1 - p > 0 \), the process also is nonstationary.
4Significance levels for Dickey-Fuller test on cointegrating equations are tabulated in Engle and Yoo (1987).
Table A1
Augmented Dickey-Fuller Tests for Stationarity

\[ \Delta x_t = \alpha + \beta r + \mu x_{t-1} + \sum_{i=1}^{3} \delta_i \Delta x_{t-i} \]

A. Tests on Levels of Variables

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<th>LGYD</th>
<th>ICP</th>
<th>ICS</th>
<th>CIND</th>
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<td>(−2.44)</td>
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<td>(−2.43)</td>
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B. Tests on Differences of Variables

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<td>−.743</td>
<td>−.910</td>
</tr>
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<td>(−4.17)\textsuperscript{a}</td>
<td>(−3.41)\textsuperscript{b}</td>
<td>(−5.24)\textsuperscript{a}</td>
<td>(−3.62)\textsuperscript{b}</td>
<td>(−4.07)\textsuperscript{a}</td>
</tr>
</tbody>
</table>

Notes:
Each regression contains three lags of the dependent variable.

Levels of Significance:
\textsuperscript{a}Significant at 1%
\textsuperscript{b}Significant at 5%
**Table A2**

**Dickey-Fuller Tests for Cointegration**


<table>
<thead>
<tr>
<th>Cointegration Equations: Dependent Variable is LGCD</th>
<th>With ICS</th>
<th>With CIND</th>
<th>With Unemployment and Inflation</th>
<th>With Unemployment and CIND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>−7.14</td>
<td>−7.12</td>
<td>−6.72</td>
<td>−6.69</td>
</tr>
<tr>
<td></td>
<td>(−56.0)</td>
<td>(57.3)</td>
<td>(63.5)</td>
<td>(65.9)</td>
</tr>
<tr>
<td>LCNS</td>
<td>.0716</td>
<td>−</td>
<td>.203</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>(.241)</td>
<td></td>
<td>(.881)</td>
<td></td>
</tr>
<tr>
<td>LGYD</td>
<td>1.56</td>
<td>1.63</td>
<td>1.36</td>
<td>1.55</td>
</tr>
<tr>
<td></td>
<td>(5.52)</td>
<td>(96.0)</td>
<td>(6.18)</td>
<td>(98.2)</td>
</tr>
<tr>
<td>ICP</td>
<td>−.00632</td>
<td>−.00628</td>
<td>−.00337</td>
<td>−.00326</td>
</tr>
<tr>
<td></td>
<td>(−3.98)</td>
<td>(4.01)</td>
<td>(−2.54)</td>
<td>(−2.47)</td>
</tr>
<tr>
<td>ICS</td>
<td>.00286</td>
<td>.00289</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>(7.25)</td>
<td>(7.78)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIND</td>
<td>−</td>
<td>−</td>
<td>−.00415</td>
<td>.00422</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(11.8)</td>
<td>(12.2)</td>
</tr>
<tr>
<td>U</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DLCPI</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>.991</td>
<td>.991</td>
<td>.994</td>
<td>.994</td>
</tr>
<tr>
<td>S.E.</td>
<td>.0377</td>
<td>.0374</td>
<td>.0303</td>
<td>.0302</td>
</tr>
<tr>
<td>Dickey-Fuller Test</td>
<td>5.62$^a$</td>
<td>5.66$^a$</td>
<td>4.27$^b$</td>
<td>4.28$^b$</td>
</tr>
</tbody>
</table>

Notes:

Levels of Significance

$^a$Significant at 1%

$^b$Significant at 5%

The Dickey-Fuller tests did not incorporate any lagged differences of the residual because they were not found to be significant.
### Table A3

**Unrestricted Estimation of Durables Equation**

(1963.1–990.4)

<table>
<thead>
<tr>
<th>$\Delta LGCD$</th>
<th>$\Delta LCNS_{-1}$</th>
<th>$\Delta LCNS_{-2}$</th>
<th>$\Delta LCNS_{-3}$</th>
<th>$\Delta LCNS_{-4}$</th>
<th>LGCD</th>
<th>LGYD</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-4.29$</td>
<td>$.0396$</td>
<td>$.0370$</td>
<td>$.791$</td>
<td>$.458$</td>
<td>$.591$</td>
<td>$.989$</td>
</tr>
<tr>
<td>($-8.53$)</td>
<td>$(.0669)$</td>
<td>$(.0656)$</td>
<td>$(1.36)$</td>
<td>$(.0797)$</td>
<td>$(-8.47)$</td>
<td>$(8.59)$</td>
</tr>
<tr>
<td>$.00716$ IC + $.00153$ ICS</td>
<td>$(5.92)$</td>
<td>$(4.14)$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| $R^2 = .444$ | S.E. = $.0260$ | D.W. = $2.48$

<table>
<thead>
<tr>
<th>$\Delta LGCD$</th>
<th>$\Delta LCNS_{-1}$</th>
<th>$\Delta LCNS_{-2}$</th>
<th>$\Delta LCNS_{-3}$</th>
<th>$\Delta LCNS_{-4}$</th>
<th>ICP</th>
<th>ICP</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-5.95$</td>
<td>$.0338$</td>
<td>$.202$</td>
<td>$.0471$</td>
<td>$.0671$</td>
<td>$.00472$</td>
<td>$.00446$</td>
</tr>
<tr>
<td>($-7.92$)</td>
<td>$(.578)$</td>
<td>$(-.354)$</td>
<td>$(1.78)$</td>
<td>$(-.113)$</td>
<td>$(1.61)$</td>
<td>$(-1.76)$</td>
</tr>
<tr>
<td>$.0000993$ ICP</td>
<td>$.0039$</td>
<td>$.00232$</td>
<td>$.000729$</td>
<td>$.000467$</td>
<td>$.000572$</td>
<td>$.000572$</td>
</tr>
<tr>
<td>$(-.0409)$</td>
<td>$(1.67)$</td>
<td>$(3.61)$</td>
<td>$(1.16)$</td>
<td>$(.794)$</td>
<td>$(1.07)$</td>
<td></td>
</tr>
<tr>
<td>$- .867$ LGCD</td>
<td>+ $1.37$ LGYD</td>
<td>$- .00744$ IC + $.00317$ ICS</td>
<td>$(-8.00)$</td>
<td>$(8.00)$</td>
<td>$(4.36)$</td>
<td>$(5.32)$</td>
</tr>
</tbody>
</table>
| $R^2 = .502$ | S.E. = $.0246$ | D.W. = $2.12$

**Implicit Cointegrating Vectors Normalized on LGCD**

$LGCD = constant + 1.67 LGYD - .0121 ICP + .00259 ICS$

$LGCD = constant + 1.58 LGYD - .00858 ICP + .00365 CIND$
In constructing an expanded error correction model of consumer sentiment, the stationarity of the menu of possible independent variables is examined first. Table B1 presents the results of such tests on the levels and first differences of the variables discussed in the text.

The first difference of DEBT is not stationary. Therefore, it cannot be cointegrated with consumer sentiment, which is stationary in first differences. Nor can short-run changes in sentiment truly be explained by changes in DEBT because the former is stationary and the latter is not. Since it does not make any sense to use FIN without DEBT, both FIN and DEBT are therefore dropped. In contrast, YDT, DLSP, DLPOIL, and DU are stationary in levels and so cannot be cointegrated with consumer sentiment either. However, since the first differences in these variables are stationary, they may be related to first differences in sentiment in the short run. This leaves inflation (DLCPI), oil prices (LPOIL), unemployment (U), and interest rates (ICP from results in Table A1) as possible candidates for cointegration with consumer sentiment.

Turning to Tables B2 and B3, all four variables appear to be significantly cointegrated with either measure of sentiment, although the inflation rate is the most closely related (eqs. 1 to 4). Next, in combining each of the other variables with inflation, unemployment improves the fit of the cointegration relationship the most (eqs. 5 to 7). The further addition of the price of oil to the relationship does not materially improve the fit and generates a “wrong” sign for the coefficient on oil prices (eq. 8). Alternatively, adding the interest rate to the relationship worsens the fit somewhat (eq. 9). This leaves inflation and the unemployment rate as the only variables that are cointegrated with the measures of consumer sentiment. Therefore, the errors from equation 6 are used to form the error correction terms in the expanded error correction models of consumer sentiment, shown in Table 4 in the text.

---

**Table B1**


<table>
<thead>
<tr>
<th>A. Tests on Levels of Variables</th>
<th>FIN</th>
<th>DEBT</th>
<th>YDT</th>
<th>DLCPI</th>
<th>DLSP</th>
<th>LPOIL</th>
<th>DLPOIL</th>
<th>U</th>
<th>DU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>284.38</td>
<td>-74.1</td>
<td>0.792</td>
<td>0.002</td>
<td>0.0107</td>
<td>0.0155</td>
<td>0.0057</td>
<td>0.0153</td>
<td>0.0013</td>
</tr>
<tr>
<td></td>
<td>(0.56)</td>
<td>(1.63)</td>
<td>(0.74)</td>
<td>(2.25)</td>
<td>(1.70)</td>
<td>(0.92)</td>
<td>(0.72)</td>
<td>(0.56)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Trend</td>
<td>—</td>
<td>2.483</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Coefficient on lagged level</td>
<td>0.003</td>
<td>-0.0137</td>
<td>-0.463</td>
<td>-0.139</td>
<td>-0.805</td>
<td>-0.0328</td>
<td>-0.962</td>
<td>-0.0412</td>
<td>-0.501</td>
</tr>
<tr>
<td></td>
<td>(1.36)</td>
<td>(2.06)</td>
<td>(3.88)*</td>
<td>(2.42)</td>
<td>(4.87)*</td>
<td>(1.40)</td>
<td>(5.68)*</td>
<td>(2.30)</td>
<td>(4.94)*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. Tests on Differences of Variables</th>
<th>FIN</th>
<th>DEBT</th>
<th>YDT</th>
<th>DLCPI</th>
<th>DLSP</th>
<th>LPOIL</th>
<th>DLPOIL</th>
<th>U</th>
<th>DU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>472.6</td>
<td>27.3</td>
<td>-0.509</td>
<td>0.00015</td>
<td>-0.0017</td>
<td>0.0057</td>
<td>0.0034</td>
<td>0.0833</td>
<td>0.0052</td>
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<tr>
<td></td>
<td>(2.44)</td>
<td>(1.92)</td>
<td>(0.46)</td>
<td>(0.35)</td>
<td>(0.26)</td>
<td>(0.71)</td>
<td>(0.40)</td>
<td>(0.12)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>Coefficient on lagged level</td>
<td>-0.945</td>
<td>-0.148</td>
<td>-1.56</td>
<td>-1.36</td>
<td>-2.31</td>
<td>-0.962</td>
<td>-2.37</td>
<td>-0.498</td>
<td>-1.55</td>
</tr>
<tr>
<td></td>
<td>(4.47)*</td>
<td>(2.52)</td>
<td>(5.72)*</td>
<td>(5.32)*</td>
<td>(7.84)*</td>
<td>(5.66)*</td>
<td>(8.50)*</td>
<td>(4.90)*</td>
<td>(6.81)*</td>
</tr>
</tbody>
</table>

Notes:
Each regression contains three lags of the dependent variable.
Significance Levels:
*Significant at the 1% level
### Table B2

**Dickey-Fuller Cointegration Tests on ICS**  

<table>
<thead>
<tr>
<th></th>
<th>Constant</th>
<th>DLCPI</th>
<th>LPOIL</th>
<th>U</th>
<th>ICP</th>
<th>S.E.</th>
<th>$\bar{R}^2$</th>
<th>Dickey-Fuller Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>99.7</td>
<td>-11.0</td>
<td></td>
<td></td>
<td></td>
<td>8.07</td>
<td>.551</td>
<td>-4.91&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(67.6)</td>
<td>(-11.7)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>75.6</td>
<td></td>
<td>-14.8</td>
<td></td>
<td></td>
<td>10.91</td>
<td>.179</td>
<td>-2.33</td>
</tr>
<tr>
<td></td>
<td>(35.3)</td>
<td></td>
<td>(-5.00)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3.</td>
<td>85.8</td>
<td></td>
<td></td>
<td>-2.43</td>
<td></td>
<td>11.48</td>
<td>.091</td>
<td>-2.14</td>
</tr>
<tr>
<td></td>
<td>(77.0)</td>
<td></td>
<td></td>
<td>(3.47)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>102.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-2.18</td>
<td>9.76</td>
<td>.344</td>
</tr>
<tr>
<td></td>
<td>(40.9)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-3.13&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>5.</td>
<td>94.2</td>
<td>-10.0</td>
<td>-6.48</td>
<td></td>
<td></td>
<td>7.81</td>
<td>.578</td>
<td>-4.90&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(39.6)</td>
<td>(-10.2)</td>
<td>(-2.85)</td>
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<tr>
<td>6.</td>
<td>100.2</td>
<td>-10.9</td>
<td></td>
<td>-2.27</td>
<td></td>
<td>7.27</td>
<td>.635</td>
<td>-5.33&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>(-12.8)</td>
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<td>(-5.11)</td>
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</tr>
<tr>
<td>7.</td>
<td>103.6</td>
<td>9.1</td>
<td></td>
<td></td>
<td>7.90</td>
<td>7.84</td>
<td>.576</td>
<td>-4.87&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>(51.1)</td>
<td>(7.78)</td>
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<tr>
<td>8.</td>
<td>106.2</td>
<td>11.9</td>
<td>6.72</td>
<td>-3.41</td>
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<td>.643</td>
<td>-5.64&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>(1.88)</td>
<td>(-4.56)</td>
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<tr>
<td>9.</td>
<td>101.4</td>
<td>10.3</td>
<td></td>
<td>-2.10</td>
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<td>7.28</td>
<td>.635</td>
<td>-5.26&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>(9.20)</td>
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<td>(-4.27)</td>
<td>(-.825)</td>
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</tr>
</tbody>
</table>

**Levels of Significance**

<sup>a</sup>Significant at 1%

<sup>b</sup>Significant at 5%
### Table B3

**Dickey-Fuller Cointegration Tests on CIND**


<table>
<thead>
<tr>
<th>Constant</th>
<th>DLCPI</th>
<th>LPOIL</th>
<th>U</th>
<th>ICP</th>
<th>S.E.</th>
<th>$\bar{R}^2$</th>
<th>Dickey-Fuller Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 102.8</td>
<td>-7.15</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>9.19</td>
<td>.281</td>
<td>-3.80&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>(61.1)</td>
<td>(-6.64)</td>
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<td></td>
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</tr>
<tr>
<td>2. 87.2</td>
<td>-9.60</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>10.35</td>
<td>.089</td>
<td>-2.67&lt;sup&gt;c&lt;/sup&gt;</td>
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</tr>
<tr>
<td>3. 93.7</td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>10.56</td>
<td>.051</td>
<td>-2.58&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
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<td>(-2.64)</td>
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<td></td>
</tr>
<tr>
<td>4. 105.2</td>
<td>---</td>
<td>---</td>
<td>---</td>
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<td>.186</td>
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<td>(-5.10)</td>
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<tr>
<td>5. 99.2</td>
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<td>-4.21</td>
<td>---</td>
<td>---</td>
<td>9.13</td>
<td>.291</td>
<td>-3.74&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
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<td>(-5.67)</td>
<td>(-1.59)</td>
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<td></td>
</tr>
<tr>
<td>6. 103.2</td>
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<td>---</td>
<td>-1.60</td>
<td>---</td>
<td>8.88</td>
<td>.329</td>
<td>-3.80&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>(-2.95)</td>
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</tr>
<tr>
<td>7. 105.7</td>
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<td>---</td>
<td>-.582</td>
<td>9.11</td>
<td>.294</td>
<td>-3.76&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
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<td>(-4.21)</td>
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<td>(-1.72)</td>
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</tr>
<tr>
<td>8. 108.3</td>
<td>-7.91</td>
<td>5.76</td>
<td>-2.58</td>
<td>---</td>
<td>8.85</td>
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</tr>
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<td>(-2.79)</td>
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<td></td>
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<tr>
<td>9. 104.2</td>
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<td>-1.45</td>
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<td>8.91</td>
<td>.325</td>
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<td>(-4.79)</td>
<td></td>
<td>(-2.43)</td>
<td>(-.561)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Levels of Significance**

<sup>a</sup>Significant at 1%
<sup>b</sup>Significant at 5%
<sup>c</sup>Significant at 10%
References


Modigliani, Franco. 1971. “Monetary Policy and Consumption: Linkages via Interest Rates and Wealth Effects in the FMP Model.” In...


