Linda S. Goldberg

Industry-Specific Exchange Rates for the United States

- The effect of exchange rate movements on U.S. producers and U.S. economic activity has drawn renewed interest lately following the large declines in the trade-weighted dollar.
- At the national level, analyses of exchange rate moves often rely on aggregate trade-weighted exchange rates. However, aggregate indexes can be less effective than industry-specific indexes in capturing changes in industry competitive conditions induced by moves in specific bilateral exchange rates.
- To inform the discussions of the currency valuation changes influencing specific industries, this article constructs three industry-specific real exchange rate indexes for the United States and analyzes the extent to which each index co-moves or diverges from the aggregate economywide measures.
- The study shows how analyses that use aggregate exchange rate indexes instead of industry-specific ones might not recognize the empirical importance of exchange rates for the producer profits of specific U.S. industries.

1. Introduction

Recent significant declines in the trade-weighted U.S. dollar again raise questions about what exchange rate fluctuations mean for U.S. producers and for U.S. economic activity more broadly. When the dollar depreciates, the prices of goods imported into the United States typically rise.[1] All else equal, such exchange-rate-induced import price increases generally improve the competitiveness of U.S. producers in manufacturing and nonmanufacturing industries relative to that of foreign competitors. Although some industries are made worse off by real dollar depreciation, perhaps due to their net reliance on imported productive inputs, on average the profits of U.S. producers rise.

At the national level, discussions of exchange rate movements often rely on aggregate trade-weighted exchange rates, such as the carefully constructed measures computed by the Board of Governors of the Federal Reserve System for the aggregate economy.[2] Those aggregate indexes use weighting schemes applied to trade-partner exchange rates; the weights are based on all imports and exports of the entire U.S. economy. Such indexes are extremely useful at a macroeconomic level—for example, in discussions of the relationships between exchange rates and the aggregate trade balance. Yet this focus on national aggregates necessarily omits industry-specific distinctions concerning trade partners and competition. The importance of particular countries as

Linda S. Goldberg is a vice president at the Federal Reserve Bank of New York.
<linda.goldberg@ny.frb.org>

The author thanks Robert Lipsey and two anonymous referees for constructive comments. Luis Gonzalez and Glenda Oskar provided valuable research assistance. The views expressed are those of the author and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

competitors within an industry can differ substantially from their importance in the aggregated trade of the United States. As a consequence, aggregate trade-weighted indexes may be less effective than industry-specific real exchange rate indexes in capturing changes in industry competitive conditions induced by movements in specific bilateral exchange rates.

In this article, we demonstrate how such industry-specific real exchange rates can be constructed and present the recent paths of these indexes. We next present three basic real exchange rate measures for each industry: one using export partner weights only, a second using import partner weights, and a third using an average of export and import weights by industry. After we detail construction methods for these three industry-specific real exchange rates, we present diagnostics on the extent to which each construct co-moves or diverges from aggregate economywide measures. One basic and well-known observation is that there is a large divergence between U.S. exports and imports across country trade partners. Compared with the partners of U.S. exporters, U.S. importers tend to purchase a larger share of goods from less developed countries. Even within an industry, such differences mean that exporting producers may experience an exchange-rate-induced change in competitive conditions quite different from that of U.S. producers facing import competition or using imported components in production.[3] Distinctions across industries are sometimes even larger, and specific bilateral exchange rate changes can trigger vastly different pressures on producers in different industries.

All of these instances underscore the potential for industry-specific exchange rates to follow distinct paths. Those paths in turn depend on whether they are constructed using import or export data. Throughout this discussion, our goal is to emphasize that movements in bilateral exchange rates—for example, between the dollar and the euro, the dollar and the yen, or the dollar and the Chinese yuan—mean different things to different producers. Accordingly, the trade-weighted exchange rate series appropriate for a producer or an industry depends on the industry and the issue under consideration. This idea is borne out by an analysis of the sensitivity of corporate profits and exchange rates. A basic illustration demonstrates how researchers might fail to recognize the empirical importance of exchange rates for the producer profits of specific U.S. industries if their analyses use aggregate exchange rate indexes instead of industry-specific ones. Such qualitative differences are apparent when data on U.S. industries are disaggregated broadly (at the two-digit Standard Industrial Classification [SIC] level), and would presumably be even more pronounced if trade-weighted exchange rates were constructed at finer levels of industry disaggregation.

Using available data and construction methods, we observe that there can be a better matching of exchange rate indexes to industry-specific concerns. The lessons from our discussion and the relevant exchange rate series that we make available should thus encourage more widespread and informed analysis of the effects on U.S. industries of movements in the dollar's real value.[4]

2. Aggregate Real Exchange Rate Indexes

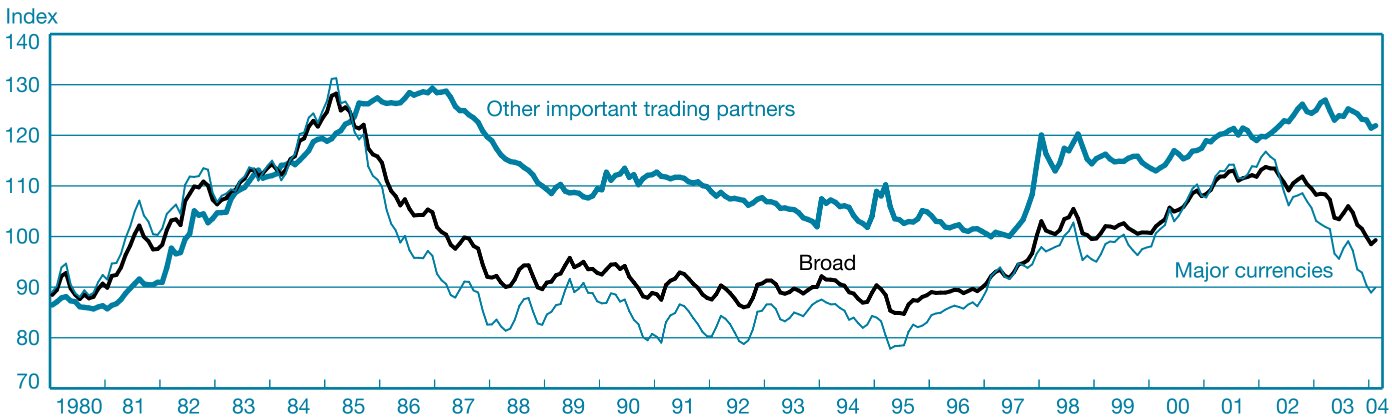
The Board of Governors of the Federal Reserve System constructs a number of very useful and carefully devised aggregate exchange rate indexes that shed light on the overall value of the U.S. dollar (<http://www.federalreserve.gov/releases/h10/summary/>). Among these measures, we focus exclusively on the "real" indexes, meaning that exchange rates used in the calculations are adjusted for aggregate price inflation in the markets of partner countries. The Federal Reserve's Broad Index of the Foreign Exchange Value of the Dollar (the broad index) is a weighted average of the foreign exchange values of the U.S. dollar against the currencies of a large group (approximately thirty-five) of major U.S. trading partners. The index weights change over time and are derived from U.S. export shares and U.S. import shares. Two other real exchange rate series constructed by the Federal Reserve differ from the broad index in terms of the trading partners used. The major currencies index reflects the value of the dollar against the currencies of countries in the euro area, Australia, Canada, Japan, Sweden, Switzerland, and the United Kingdom. The other important trading partners (OITP) index shows the dollar value against other currencies that are not heavily traded outside their home markets. Chart 1 shows the recent paths of those indexes.

The Board of Governors of the Federal Reserve System constructs a number of very useful and carefully devised aggregate exchange rate indexes that shed light on the overall value of the U.S. dollar.

Although they do not yet address the important issue of different trade partners for different U.S. industries, these alternative aggregate series from the Federal Reserve illustrate

Chart 1

Aggregate Real Exchange Rate Indexes



Source: Board of Governors of the Federal Reserve System, monthly data.

the significance of properly measuring the value of the dollar against alternative trading partners of the United States. Since January 2000, the real broad and major currencies indexes have shown substantial movements in the value of the U.S. dollar. The broad index appreciated by 12 percent through January 2002, then depreciated by a cumulative 12 percent through February 2004. The major currencies index, which concentrates more on the industrialized countries than the broad index does, showed more overall volatility during this period, appreciating by 18 percent before depreciating 22 percent overall. By contrast, the dollar appreciated against the currencies in the OITP index through most of the period.

3. Industry-Specific Real Exchange Rates

Just as the differences between country groups are important in computing the weights on currencies used in these real exchange rate series, the distinctions between particular industries are highly revealing. As Table 1 shows, these distinctions arise because industries have different trading partners, and because the export destinations of an industry can differ dramatically from the import sources of products of that same industry. For example, the share of the euro area is 18 percent in U.S. overall imports, but 25 percent in imports of precision instruments and 13 percent in imports of toys and sporting goods (miscellaneous manufacturing).[5] By contrast, while China represents 11 percent of overall U.S. imports, it accounts for 9 percent of imports of precision instruments and 38 percent of imports of toys and sporting goods. Because of these differences, we expect corresponding currencies and their exchange rates relative to the dollar to play distinct roles in the relative competitive conditions for different U.S. industries.

For U.S. manufacturers, industrialized countries are often more important as export markets than as import suppliers. Generally, non-oil-producing developing countries figure more prominently as sources of U.S. imports than as destinations for U.S. exports. Therefore, movements in a major currency like the euro generally have a stronger presence in U.S. exports than imports. As Table 1 shows, euro-area countries account for a large share of U.S. exports, and, with the exception of machinery, a slightly smaller share of U.S. imports in those industrial categories. For Japan and China, however, the comparisons between export markets and import source shares in these industries are far more dramatic. An import-competing producer, therefore, may assign a higher weight to the yen or yuan in its relevant trade-weighted exchange rate compared with producers in noncompeting industries.

Chart 2 also illustrates our general point that some industrialized countries (for example, the euro area, the United Kingdom, Canada, and Japan) have very different representation in the exports than in the imports of U.S. industries. This comparison of the 2001 shares of these

Table 1
Country/Region Shares in Trade by Industry

U.S. Export Destinations by Standard Industrial Classification (SIC), 2001	SIC Number	Euro Area	Japan	China
Electronics	36	13	8	3
Industrial machinery	35	20	8	4
Precision instruments	38	28	15	3
Toys and sporting goods	39	20	10	1
Transportation equipment	37	18	5	3
All U.S. exports	—	18	9	3

U.S. Sources of Imports by SIC, 2001	SIC Number	Euro Area	Japan	China
Electronics	36	8	15	15
Industrial machinery	35	17	20	11
Precision instruments	38	25	23	9
Toys and sporting goods	39	13	11	38
Transportation equipment	37	19	23	1
All U.S. imports	—	18	13	11

U.S. Export Destinations by North American Industry Classification System (NAICS), 2002	NAICS Number	Euro Area	Japan	China
Computer and electronics	334	17	8	4
Machinery	333	16	6	4
Electrical equipment	335	14	5	3
Toys and sporting goods	339	26	11	1
Transportation equipment	336	18	6	3
All U.S. exports	—	17	8	3

U.S. Sources of Imports by NAICS, 2002	NAICS Number	Euro Area	Japan	China
Computer and electronics	334	8	13	16
Machinery	333	27	23	8
Electrical equipment	335	12	9	27
Toys and sporting goods	339	15	7	35
Transportation equipment	336	17	23	1
All U.S. imports	—	17	12	13

Source: Author's calculations.

Note: Figures for the euro area, Japan, and China are in percent.

countries/regions in U.S. exports (denoted by M) and in U.S. imports (denoted by X) shows that these industrialized countries account for 32 percent of total exports for education, and up to 81 percent of U.S. exports for the film sector. The corresponding shares of these countries as sources of U.S. imports range from 12 percent in apparel to 87 percent in repair services.

3.1 Industry-Specific Exchange Rate Construction

We can construct exchange rate measures that reflect these industry-by-industry distinctions by using the time histories of the weights of U.S. trading partners in the exports and imports of each U.S. industry. Each industry is denoted by an index i and each country/trade partner of that industry by an index c. The *industry-specific* real exchange rate indexes depart from the aggregate indexes in that the weights of each partner currency (country c) are the shares of that partner c in the U.S. exports or imports of that specific industry i. In contrast, aggregate indexes use the weights of each trade-partner country in the total international trade activity of the entire U.S. economy.

We begin by constructing three real exchange rate measures by industry. They differ primarily in the choice of weights applied to bilateral real exchange rates, rer_t^c, with respect to each trading partner c. The formulas for these indexes are provided in equations 1-3:

(1) Export-weighted:

$$xer_t^i = \sum_c w_t^{ic} \cdot rer_t^c \text{, where } w_t^{ic} = \frac{X_t^{ic}}{\sum_c X_t^{ic}}$$

(2) Import-weighted:

$$mer_t^i = \sum_c w_t^{ic} \cdot rer_t^c \text{, where } w_t^{ic} = \frac{M_t^{ic}}{\sum_c M_t^{ic}}$$

(3) Trade-weighted:

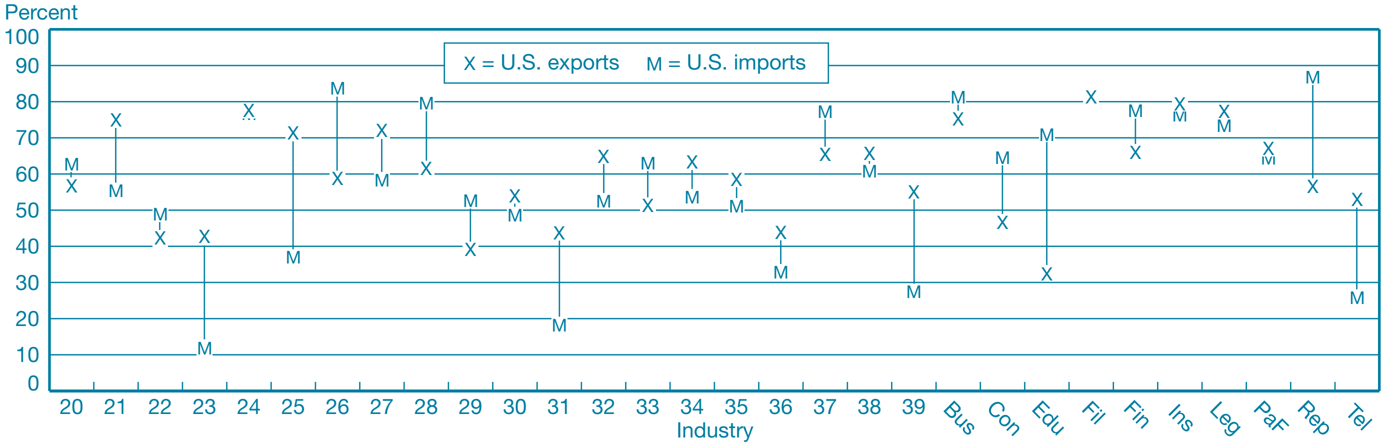
$$ter_t^i = \sum_c \left(\left(.5 \frac{X_t^{ic}}{\sum_c X_t^{ic}} + .5 \frac{M_t^{ic}}{\sum_c M_t^{ic}} \right) \cdot rer_t^c \right),$$

where rer_t^c are the bilateral real exchange rates of each U.S. trading partner c. The bilateral real exchange rates are constructed by multiplying a country's nominal exchange rate (local currency per dollar) by the ratio of the consumer price indexes of the United States against that partner country.[6] For any industry indexed by i, these constructions define the export real exchange rate xer_t^i, the import real exchange rate mer_t^i, and the trade-average real exchange rate ter_t^i, with each construction using industry-specific and time-varying trade weights.[7] An increase in the value of any index implies a real appreciation of the U.S. dollar in trade-weighted terms.

Our construction method for each industry has the flavor of the method used in the Board of Governors' broad index.[8] Instead of calculating that single aggregate measure, however, we compute separate series for each of the twenty two-digit manufacturing and

CHART 2

Selected Industrialized Country Weights in U.S. Exports and Imports



20 Food and kindred products
21 Tobacco manufactures
22 Textile mill products
23 Apparel and related products
24 Lumber and wood products
25 Furniture and fixtures
26 Paper and allied products
27 Printing and publishing
28 Chemicals and allied products
29 Petroleum refining
30 Rubber and plastic products
31 Leather and leather products
32 Stone, clay, glass, and concrete products
33 Primary metal products
34 Fabricated metal products
35 Machinery, excluding electrical
36 Electrical and electronic
37 Transportation equipment
38 Scientific instruments
39 Miscellaneous manufactures
Bus Advertising and computer data
Con Construction, engineering, mining
Edu Educational services
Fil Film and tape rental
Fin Financial services
Ins Net insurance
Leg Legal services
PaF Passenger fares
Rep Installation, maintenance, repair
Tel Telecommunications

Source: Author's calculations.

Notes: The constructed shares depict the combined weight in the 2001 trade of specific U.S. industries with European Union countries, the United Kingdom, Canada, and Japan. The manufacturing industries are listed by number and follow Standard Industrial Classification designations; nonmanufacturing industries are identified by letter codes. Where only X is visible, exports are equal or nearly equal to imports.

ten nonmanufacturing U.S. industries (Appendix Table A1 provides the complete industry list). The countries indexed by *c* in equations 1-3 total up to thirty-four trade partners of the United States in manufacturing industries and up to twenty-nine trade partners in nonmanufacturing industries.[9]

4. Do Industry-Specific and Aggregate Real Exchange Rate Indexes Track Each Other?

Because the export and import partners of specific industries can differ substantially, the weights of partner currencies in the industry exchange rates vary correspondingly. These distinctions are apparent both across industries and over time as the importance of different partner-country currencies grows or shrinks.

Our basic correlation analysis clearly shows that various industry-specific exchange rates and the aggregate broad index are highly positively correlated. Table 2 presents four sets of correlations, with each figure in a column showing the number of industries in the correlation range depicted in that row. Compared with import exchange rates, the export exchange rate series are more highly correlated with the broad index. These correlations exceed 0.90 for five of the thirty industries and exceed 0.80 for an additional seventeen industries. Across all of the manufacturing and nonmanufacturing industries, roughly a third have correlations with the broad exchange measure that are below 0.8. The industry exchange rate, ter^i, constructed using both export and import shares in partner weights, tracks the broad series more closely than do the indexes that use either export or import weights alone.

Although correlations greater than 0.80 across the exchange rate indexes can be construed as strong, the period-to-period percentage changes in industry-specific and aggregate exchange

Table 2

Correlations between Alternative Industry Exchange Rate Series

Measured Contemporaneous Correlations (corr)	Number of Industries in Each Correlation Grouping Out of Thirty Industries: xer^i with Broad (1)	mer^i with Broad (2)	xer^i with mer^i (3)	ter^i with Broad (4)
corr ≥ 0.90	5	6	10	9
0.90 > corr ≥ 0.80	17	14	5	15
0.80 > corr ≥ 0.70	4	7	7	6
0.70 > corr	4	3	8	0

Source: Author's calculations.

Notes: SIC is Standard Industrial Classification; NAICS is North American Industry Classification System. The four data columns report the number of industries in any size range of correlations between:
(1) an industry's export exchange rate and the broad index,
(2) an industry's import exchange rate and the broad index,
(3) an industry's export exchange rate and its import exchange rate,
(4) an industry's trade-weighted exchange rate and the broad index.

Correlations use quarterly data. Manufacturing uses SIC trade data for 1973-96 and NAICS trade data for 1997-2002. Nonmanufacturing data span 1986-2002.

rates can differ substantially. To illustrate this point, in Table 3 we provide real exchange rate movements since January 2002 using the same subset of industries that we presented in Table 1. Recall that the aggregate broad index peaked in early 2002, marking the end of a prolonged trade-weighted appreciation of the U.S. dollar. Over the recent period, we observe that precision instruments and transportation equipment industries have export and import exchange rates that have depreciated more than the broad index, with each showing a 10 to 11 percent trade-weighted dollar depreciation since 2002:1. However, the movements in the exchange rates for the computer and electronics industries have registered a smaller real dollar depreciation than the broad measure did during this period. This result may occur because the euro area (and the euro) represents a smaller weight in the trade of the computer and electronics industries compared with its weight in the precision instruments and transportation equipment categories. In the case of many import-weighted series and even exports of electronics, industrial machinery, and toys and sporting goods (miscellaneous manufacturing), the broad index can greatly misrepresent the apparent change in currency valuation.

Additional information on the extent of co-movements of different exchange rate measures available for each industry is provided in Appendix Tables A1 and A2. In Table A1, we show the correlations between quarterly data for the broad index and

Table 3

Percentage Change in Real Trade-Weighted Exchange Rate from 2002:1

Panel A: To 2003:4, Using SIC Classifications

Industry	xer^i	mer^i	ter^i	Broad Index
Electronics	-8	-6	-7	-11
Industrial machinery	-13	-10	-11	-11
Precision instruments	-15	-13	-14	-11
Toys and sporting goods	-14	-7	-10	-11
Transportation equipment	-14	-15	-15	-11

Panel B: To 2003:4, Using NAICS Classifications

Industry	xer^i	mer^i	ter^i	Broad Index
Computer and electronics	-9	-5	-7	-11
Machinery	-12	-15	-14	-11
Electrical equipment	-10	-6	-8	-11
Toys and sporting goods	-15	-8	-11	-11
Transportation equipment	-15	-14	-15	-11

Source: Author's calculations, quarterly data.

Notes: In panel A, trade weights by Standard Industrial Classification (SIC) designations for calculating industry-specific exchange rates were only available to 2001, so these 2001 weights were assumed in calculating 2002 and 2003 industry-specific exchange rates. In panel B, trade weights by North American Industry Classification System (NAICS) designations for calculating industry-specific exchange rates were only available to 2002, so these 2002 weights were assumed in calculating 2002 and 2003 industry-specific exchange rates.

xer^i, mer^i, and ter^i for each industry from 1973 to 2002. In Table A2, we report the percentage of periods in which any two alternative measures move in the same direction over each quarter, with both measures contemporaneously appreciating or depreciating. The broad real exchange rate measure and the xer^i measures tend to co-move more strongly than the broad measure and mer^i exchange rates.

4.1 An Application to Corporate Profit Data

We find the advantage of using industry-specific constructs immediately apparent when analyzing the relationships between U.S. producer profits and exchange rates. The data on corporate profits, compiled by the Bureau of Economic Analysis, cover the period from 1970:1 to 2003:2 and include eight manufacturing industries, plus six nonmanufacturing industries.[10] We convert these profit aggregates into real values by deflating by the seasonally adjusted U.S. consumer price index and run regression specifications of the form

$$(4)\quad \Delta CorporateProfits_t^i = \alpha^i + \beta_0^i \Delta realexchangerate_t^i + \beta_{0,1}^i Trade_t^i \cdot \Delta realexchangerate_t^i + \beta_1 \Delta GDP_t + \beta_2 \Delta rint_t + \varepsilon_t ,$$

where Δ refers to a change in logarithms of all variables except for interest rates (change in levels), and all variables are represented in real terms. The regressions introduce controls for the effects of the business cycle (real GDP) and real interest rates ($rint_t$, ten-year bonds) and use alternative real exchange rates (xer_t^i, mer_t^i, ter_t^i, or $Broad_t$), all defined as foreign currency per dollar so that an upward movement is a real dollar appreciation. In some regression specifications, we introduce only the noninteracted exchange rate term. In other specifications, we add an exchange rate term interacted with the overall level of trade exposure of an industry, $Trade_t^i$. This variable is a slower moving (annual) series constructed as the total trade (exports plus imports) of a specific broad industry i relative to that industry's annual shipments or output.[11] We also had some regression specifications that excluded the noninteracted exchange rate term, but included the exchange rate term interacted with $Trade_t^i$. When the multiplicative variable $Trade_t^i$ is excluded from the regression, the exchange rate term picks up the effects on profits of changes over time in the composition of an industry's trade partners (except in the broad measure) and the relative values of their currencies. By including the $Trade_t^i$ variable, we also capture changes over time in an industry's overall level of exposure to international trade. The latter term permits the influence of exchange rates on profits to grow as the overall role of trade grows relative to an industry's shipments.

We find the advantage of using industry-specific constructs immediately apparent when analyzing the relationships between U.S. producer profits and exchange rates.

In the full sample of fourteen industries for which we have the BEA corporate profit data, a dollar depreciation on average raises U.S. corporate profits, but this average effect is noisy and generally not statistically different from zero. Table 4 provides the results of time-series panel regressions run using data for the subset of industries with the highest degree of international trade orientation. We report the regression results for specifications where the trade variable is interacted with the exchange rate (the $\beta_0^i \Delta realexchangerate_t^i$ is excluded) and where we have a pooled time-series panel of industries. The regression coefficients reported in Table 4 should be viewed as the average across the included industries.

TABLE 4

Corporate Profits and Exchange Rates for High-Trade-Exposure Industries

Category	xer^i	mer^i	ter^i	Broad Index
Constant	-0.037***	-0.037***	-0.037***	-0.038***
	(0.008)	(0.008)	(0.008)	(0.008)
$Trade^i \cdot \Delta$ *real exchange rate*^{i}	-1.428*	-1.198*	-1.387*	-0.539
	(0.783)	(0.627)	(0.717)	(0.569)
Δ *real GDP*	3.520***	3.431***	3.468***	3.502***
	(0.742)	(0.742)	(0.742)	(0.743)
Δ *real interest rate*	0.020*	0.021*	0.021*	0.018*
	(0.011)	(0.011)	(0.011)	(0.011)
Adjusted R^2	0.047	0.048	0.048	0.043
Degrees of freedom	624	624	624	624

Source: Author's calculations.

Note: Standard errors are in parentheses.

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.

In these five high-trade-orientation industries, the broad exchange rate measure is statistically insignificant in the regressions: a dollar appreciation on average lowers the profits of U.S. corporations, but this effect remains noisy and statistically insignificant. By contrast, the industry-specific exchange rates are all statistically significant. Thus, the profit effects of dollar movements are more precisely identified: dollar appreciations (depreciations) reduce (stimulate) corporate profits. Typical of industry corporate profit regressions, the majority of movements in corporate profits are unexplained by these broad macroeconomic variables. Nonetheless, our industry-specific exchange rates play a statistically significant and noteworthy role.

Still more pointed results are obtained from our analysis of specific industries. Table 5 presents the results of industry-by-industry corporate profit regressions for various manufacturing industries. We report results from regressions that omit the exchange rate term and use only the exchange rate term interacted with industry trade orientation: the most pronounced effects of exchange rates on specific industries generally are evident in regressions that allow for changes over time in industry exposure to international trade. Those results

Table 5

Corporate Profits and Exchange Rates: High-Trade-Oriented Manufacturing Industries

	Chemical and Allied Products		Primary Metal Products		Nonelectrical Machinery		Electrical Machinery and Electronics		Transportation Equipment	
Category	mer^i	Broad Index	mer^i	Broad Index	mer^i	Broad Index	mer^i	Broad Index	mer^i	Broad Index
Constant	-0.020**	-0.020**	-0.039***	-0.038***	-0.042***	-0.043***	-0.025*	-0.026*	-0.059*	-0.061*
	(0.010)	(0.010)	(0.011)	(-1.119)	(0.014)	-(0.014)	(0.013)	(0.013)	(0.033)	(0.033)
$Trade^i \cdot \Delta$ *real exchange rate*^{i}	0.570	-0.598	1.316	-1.119	-1.50*	-0.976	-1.477*	-1.034	-2.016	1.020
	(1.236)	(1.281)	(1.445)	(1.196)	(0.871)	(0.809)	(0.759)	(0.695)	(2.553)	(2.200)
Δ *real GDP*	1.573*	1.570*	3.443***	3.354***	3.768***	3.880***	2.331*	2.468**	6.087**	6.252**
	(0.895)	(0.895)	(1.002)	(0.998)	(1.268)	(1.274)	(1.197)	(1.203)	(2.997)	(2.995)
Δ *real interest rate*	0.012	0.014	-0.001	0.002	0.011	0.006	0.005	0.004	0.074	0.065
	(0.013)	(0.013)	(0.015)	(0.015)	(0.019)	(0.019)	(0.017)	(0.018)	(0.074)	(0.044)
Adjusted R^2	0.021	0.021	0.075	0.075	0.078	0.0661	0.042	0.030	0.049	0.045
Degrees of freedom	124	124	124	124	124	124	124	124	124	124
2001 SIC trade share (percent)	0.33		0.34		0.63		0.75		0.58	

Source: Author's calculations.

Notes: Standard errors are in parentheses. SIC is Standard Industrial Classification.

* Statistically significant at the 10 percent level.
** Statistically significant at the 5 percent level.
*** Statistically significant at the 1 percent level.

suggest that the strong relationship between import exchange rates and the profits of specific industries with high trade exposures may have been driven by the nonelectrical machinery, electrical machinery, and electronics industries.

5. Other Considerations in Constructing Industry-Specific Real Exchange Rates

Although we have provided three specific measures of industry-specific exchange rates, alternative constructions of exchange rate indexes may be more useful for answering other questions. In this section, we discuss some relevant issues. First, we consider the possibility that our index construction may be corrupted by contemporaneous changes in the trade orientation or partner weights of an industry as induced by exchange rate changes. If so, it may be appropriate to consider alternative dating schemes on the weights used in exchange rate construction. Second, we address the type of bilateral exchange rate that is most appropriate to use with equations 1-3.

Specifically, we note that some analysts may be concerned with underlying *trends* in real exchange rates instead of period-to-period current values, and may prefer to use exchange rate movements decomposed into permanent (trend) and transitory elements.

5.1 Endogeneity of Trade Weights

Equations 1-3 use contemporaneous weights, meaning that each calculation of an industry-specific exchange rate employs the pattern of trade partners that is in place during that same period of time (for that year, for that industry). Contemporaneous trade weights have the advantage of providing the most current information on real changes in currency values that would be useful in making future production and revenue decisions. One valid concern, however, is whether today's exchange rate movements affect today's trade patterns, so that using weights contemporaneous to the exchange rate movement may introduce undesirable simultaneity biases in the data. In other words, both the left-hand-side and right-hand-side variables in a regression may move together as a result of reactions to some other variable. This objection is theoretically valid if the current trade-partner weights are endogenous to current exchange rates.

For U.S. industries, we observe considerable stability and persistence in trade-partner share weights in annual data. We nonetheless turn to the data to determine how well this observation is supported across industries.[12] We conduct two suggestive exercises. First, we correlate industry-specific exchange rates constructed with contemporaneous trade weights with ones constructed using one-year *lagged* trade shares as weights on the contemporaneous bilateral exchange rates of the thirty-four trading partners of the United States. Second, we construct a trade-weighting scheme that uses a three-year moving average of the shares of each country partner in an industry's international trade. In this measure, export exchange rates for an industry are constructed as

$$(5) \qquad xer_t^i = \sum_c w_t^{ic} \cdot rer_t^c \text{, where } w_t^{ic} = \frac{\sum_{T=t-1}^{t-3} X_T^{ic}}{\sum_{T=t-1}^{t-3} \sum_c X_T^{ic}} .$$

We regress the industry exchange rates constructed using contemporaneous trade weights against industry exchange rates constructed using the two alternative weighting schemes. Most of the year-on-year variability in industry-specific exchange rates results from fluctuations in the component bilateral real exchange rates. Accordingly, Table 6 suggests that such small changes in weighting have very little effect on the final real exchange rate series for each industry. Contemporaneous and lagged constructions of industry-specific exchange rates are highly correlated, typically in excess of 0.95. The data suggest marginally more potential for instability of trade-partner shares in import exchange rates than in export exchange rates.

Table 6

Correlations between Contemporaneous and Lagged Trade Weight Constructs of Industry Exchange Rates

Measured Contemporaneous Correlations (corr)	Number of Industries in Each Correlation Grouping Out of Thirty Industries: xer^i with $xler^i$	mer^i with $mler^i$	ter^i with $tler^i$
corr ≥ 0.98	25	21	24
0.98 > corr ≥ 0.95	2	3	3
0.95 > corr	3	6	3

Source: Author's calculations.

Notes: $xler^i$ is constructed as in equation 1, except using w_{t-1}^{ic} in place of w_t^{ic}. Analogous construction methods are used for $mler^i$ and $tler^i$.

5.2 Permanent versus Transitory Changes in Exchange Rates

Some analyses might focus on industry adjustments when fluctuations in exchange rates are perceived as "permanent" (expected to persist), as opposed to those perceived as "transitory" (expected to reverse soon). In pricing, employment, and investment decisions, producers may make choices that have a fixed-cost component only in response to the part of an exchange rate fluctuation expected to persist. Producers would make other adjustments to more transitory fluctuations, as in the Campa and Goldberg (2001) finding that overtime hours and earnings in the United States are highly sensitive to the transitory component of the exchange rate. Permanent fluctuations, by contrast, have a greater effect on regular employment and hours of U.S. workers.

There are many techniques available to decompose exchange rate movements into transitory or permanent elements. The bilateral exchange rates may pass through a filter that delivers a permanent component, $rer_t^{c,p}$, or a transitory component. The relevant component is substituted back into the exchange rate formulas of equations 1-3 and weighted up using the import or export weights, yielding a variant such as

$$(6) \qquad xer_t^{i,p} = \sum_c w_t^{ic} \cdot rer_t^{c,p}\text{, where } w_t^{ic} = \frac{X_t^{ic}}{\sum_c X_t^{ic}} .$$

Note that this construction considers the permanent versus transitory components of the bilateral exchange rates, but does not decompose trends in the underlying trade weights.[13]

6. Conclusion

The industry-specific measures that we describe, although data-intensive and cumbersome to construct, enable us to take important steps forward in analyses of exchange rate effects on U.S. industries. Despite such progress, these indexes are not perfect indicators of changes over time in the competitiveness of U.S. producers relative to foreign competitors. Our measures do not adjust for industry-specific changes in productivity or the strategic pricing actions attributable to specific industries or partners. These measures also do not directly track changes in the third-country competitiveness of U.S. producers—for example, how the United States competes with non-euro-area competitors within the euro-area market. In addition, alternative methods of constructing industry-specific exchange rates are sometimes appropriate for understanding the effects of exchange rate fluctuations on specific U.S. industries.[14]

Our overall purpose has been to provide a range of construction methodologies and make available the underlying data in order to promote more informed discussions of the currency valuation changes influencing specific industries. Although other methods may also be useful to that end, our contributions offer a number of concrete advances in data availability and tools for analyzing the real and financial effects of exchange rate movements.

Appendix Tables

Table A1

Correlations of Industry-Specific Exchange Rate Measures

Industry Code	Industry Title	xer^i / *Broad RER*	mer^i / *Broad RER*	xer^i / mer^i	ter^i / *Broad RER*
20	Food and kindred products	0.917	0.827	0.833	0.904
21	Tobacco manufactures	0.897	0.869	0.792	0.933
22	Textile mill products	0.802	0.910	0.862	0.897
23	Apparel and related products	0.647	0.885	0.743	0.821
24	Lumber and wood products	0.734	0.557	0.336	0.793
25	Furniture and fixtures	0.564	0.817	0.784	0.723
26	Paper and allied products	0.913	0.587	0.686	0.793
27	Printing and publishing	0.782	0.909	0.792	0.895
28	Chemicals and allied products	0.907	0.929	0.953	0.930
29	Petroleum refining	0.880	0.523	0.478	0.770
30	Rubber and plastic products	0.822	0.902	0.804	0.909
31	Leather and leather products	0.868	0.900	0.868	0.915
32	Stone, clay, glass, and concrete products	0.816	0.890	0.756	0.912
33	Primary metal products	0.886	0.876	0.920	0.899
34	Fabricated metal products	0.773	0.853	0.638	0.901
35	Machinery, excluding electrical	0.878	0.875	0.782	0.928
36	Electrical and electronic	0.851	0.774	0.688	0.881
37	Transportation equipment	0.802	0.836	0.695	0.890
38	Scientific instruments	0.936	0.741	0.840	0.860
39	Miscellaneous manufactures	0.935	0.940	0.970	0.945
Bus	Advertising and computer data	0.869	0.791	0.934	0.837
Con	Construction, engineering, mining	0.623	0.745	0.472	0.787
Edu	Educational services	0.840	0.770	0.723	0.870
Fil	Film and tape rental	0.857	0.831	0.952	0.853
Fin	Financial services	0.879	0.789	0.927	0.851
Ins	Net insurance	0.789	0.841	0.922	0.834
Leg	Legal services	0.878	0.875	0.989	0.879
PaF	Passenger fares	0.854	0.879	0.970	0.874
Rep	Installation, maintenance, repair	0.822	0.825	0.944	0.835
Tel	Telecommunications	0.591	0.790	0.623	0.771

Source: Author's calculations.

Notes: The manufacturing industries are listed by number and follow Standard Industrial Classification (SIC) designations; nonmanufacturing industries are identified by letter codes. Correlations use quarterly data. Manufacturing uses SIC trade data for 1973-96 and North American Industry Classification System trade data for 1997-2002. Nonmanufacturing data span 1986-2002.

Table A2
Co-Movement of Industry-Specific Exchange Rate Measures

Industry Code	Industry Title	*xer^i* / *Broad RER*	*mer^i* / *Broad RER*	*xer^i* / *mer^i*	*ter^i* / *Broad RER*
20	Food and kindred products	0.924	0.790	0.765	0.874
21	Tobacco manufactures	0.899	0.756	0.756	0.874
22	Textile mill products	0.765	0.849	0.765	0.824
23	Apparel and related products	0.731	0.714	0.664	0.782
24	Lumber and wood products	0.891	0.672	0.647	0.874
25	Furniture and fixtures	0.672	0.731	0.790	0.731
26	Paper and allied products	0.866	0.697	0.714	0.798
27	Printing and publishing	0.765	0.874	0.807	0.857
28	Chemicals and allied products	0.874	0.874	0.899	0.874
29	Petroleum refining	0.790	0.739	0.731	0.798
30	Rubber and plastic products	0.739	0.916	0.723	0.849
31	Leather and leather products	0.798	0.706	0.639	0.824
32	Stone, clay, glass, and concrete products	0.807	0.857	0.815	0.874
33	Primary metal products	0.824	0.840	0.832	0.832
34	Fabricated metal products	0.706	0.908	0.731	0.840
35	Machinery, excluding electrical	0.874	0.924	0.832	0.950
36	Electrical and electronic	0.840	0.874	0.815	0.899
37	Transportation equipment	0.773	0.899	0.807	0.891
38	Scientific instruments	0.874	0.891	0.849	0.916
39	Miscellaneous manufactures	0.891	0.849	0.857	0.916
Bus	Advertising and computer data	0.776	0.851	0.776	0.866
Con	Construction, engineering, mining	0.746	0.776	0.731	0.791
Edu	Educational services	0.896	0.731	0.776	0.791
Fil	Film and tape rental	0.746	0.731	0.896	0.731
Fin	Financial services	0.836	0.776	0.881	0.806
Ins	Net insurance	0.806	0.806	0.881	0.791
Leg	Legal services	0.896	0.866	0.940	0.881
PaF	Passenger fares	0.881	0.866	0.896	0.866
Rep	Installation, maintenance, repair	0.851	0.776	0.836	0.881
Tel	Telecommunications	0.672	0.701	0.701	0.761

Source: Author’s calculations.

Notes: Co-movement is defined as the percentage of quarters in which the two exchange rate measures both depreciated, without regard to the actual size of the depreciations or appreciations. The manufacturing industries are listed by number and follow Standard Industrial Classification (SIC) designations; nonmanufacturing industries are identified by letter codes. Correlations use quarterly data. Manufacturing uses SIC trade data for 1973-96 and North American Industry Classification System trade data for 1997-2002. Nonmanufacturing data span 1986-2002.

Table A3

Correlations between Contemporaneous and Lagged-Weight Exchange Rates

Industry Code	Industry Title	xer^i / $xler^i$	mer^i / $mler^i$	ter^i / $tler^i$
20	Food and kindred products	0.990	0.997	0.996
21	Tobacco manufactures	0.995	0.956	0.989
22	Textile mill products	0.984	0.995	0.995
23	Apparel and related products	0.988	0.994	0.996
24	Lumber and wood products	0.995	0.999	0.998
25	Furniture and fixtures	0.989	0.998	0.996
26	Paper and allied products	0.997	0.999	0.999
27	Printing and publishing	0.998	0.998	0.999
28	Chemicals and allied products	0.994	0.999	0.999
29	Petroleum refining	0.986	0.987	0.989
30	Rubber and plastic products	0.994	0.998	0.999
31	Leather and leather products	0.990	0.994	0.995
32	Stone, clay, glass, and concrete products	0.995	0.999	0.999
33	Primary metal products	0.993	0.992	0.997
34	Fabricated metal products	0.992	0.999	0.998
35	Machinery, excluding electrical	0.997	0.998	0.999
36	Electrical and electronic	0.997	0.993	0.997
37	Transportation equipment	0.995	0.997	0.997
38	Scientific instruments	0.997	0.999	0.999
39	Miscellaneous manufactures	0.995	0.996	0.998
Bus	Advertising and computer data	0.978	0.978	0.984
Con	Construction, engineering, mining	0.930	0.915	0.968
Edu	Educational services	0.993	0.750	0.942
Fil	Film and tape rental	0.904	0.766	0.852
Fin	Financial services	0.996	0.813	0.952
Ins	Net insurance	0.963	0.833	0.911
Leg	Legal services	0.996	0.994	0.999
PaF	Passenger fares	0.997	0.998	0.999
Rep	Installation, maintenance, repair	0.988	0.960	0.985
Tel	Telecommunications	0.589	0.681	0.964

Source: Author's calculations.

Notes: The manufacturing industries are listed by number and follow Standard Industrial Classification (SIC) designations; nonmanufacturing industries are identified by letter codes. Correlations use quarterly data. Manufacturing uses SIC trade data for 1973-96 and North American Industry Classification System trade data for 1997-2002. Nonmanufacturing data span 1987-2002.

Endnotes

1. The response of dollar prices is small if foreign producers absorb the exchange rate movements in their profit margin in order to sustain their U.S. market share. Exchange rate "pass-through" into import prices may be complete, as occurs under "producer currency pricing;" partial; or negligible, as occurs under "local currency pricing." Campa and Goldberg (2002) analyze the degree of exchange rate pass-through into import prices for the United States and other Organization for Economic Co-operation and Development countries. Campa and Goldberg (2004) explore the reasons behind the relative stability of consumer prices with respect to exchange rates.

2. Available at <http://www.federalreserve.gov/releases/h10/summary/>.

3. Campa and Goldberg (1995, 1997, 1999, 2001) show that a "net external orientation" measure accounting for both the export orientation and use of imported inputs by producers is appropriate in some analyses, including studies of investment sensitivity to exchange rates.

4. The industry-specific exchange rate database constructed by the author is available at <http://www.newyorkfed.org/research/global_economy/industry_specific_exrates.html>.

5. The U.S. Census Bureau recently adopted the North American Industry Classification System (NAICS) and has dropped reporting by SIC. Industry-level trade data are available only up to 2001 by SIC and available up to 2002 by NAICS. Both systems are reported in Table 1.

6. The resulting series are converted into indexes (based at 100 in 1990:1).

7. The averaging of export and import weights in equation 3 is an *ad hoc* convention. Another variant would be to use as weights the sum of bilateral exports and imports, relative to total exports plus imports of a particular industry.

8. Available at <http://www.federalreserve.gov/releases/h10/summary/>. From the *Federal Reserve Bulletin*, October 1998: "The currencies of all foreign countries or regions that had a share of U.S. non-oil imports or nonagricultural exports of at least 1/2 percent in 1997 are included in the broad indices, as rankings of U.S. trading partners by share of U.S. trade in that year show."

9. The countries are: Canada, euro area (Germany, France, Italy, Netherlands, Belgium, Luxembourg, Spain, Ireland, Austria, Finland, Portugal), Japan, Mexico, China, United Kingdom, Taiwan, Korea, Singapore, Hong Kong, Malaysia, Brazil, Switzerland, Thailand, Australia, Indonesia, Philippines, Russia, India, Sweden, Saudi Arabia, Israel, Argentina, Venezuela, Chile, and Colombia. The trade data treat Belgium and Luxembourg as one country; this article also references them as one country. Problems with the time-series price data led us to remove Russia from this sample. The nonmanufacturing indexes do not include Austria, Colombia, Ireland, Portugal, Russia, and Finland because disaggregated data on these countries are absent in our source data from the *Survey of Current Business*, published by the Bureau of Economic Analysis (BEA).

Industry-specific export and import data for twenty manufacturing industries and thirty-four major U.S. trading partners from 1972-94 were downloaded from <http://www.econ.ucdavis.edu/faculty/fzfeens/>, with 1970, 1971, and 1972 manufacturing trade weights set at 1972 shares. Post-1994 data are from the U.S. International Trade Commission website (<http://dataweb.usitc.gov/>). Some weighting observations for some countries in some years have been suppressed for confidentiality reasons. Manufacturing sector data are from the U.S. Department of Commerce and the International Trade Commission and nonmanufacturing data are from the BEA as reported in the *Survey of Current Business* for 1986 onward. For lack of appropriate earlier data, we assume the 1986 country-partner weights for nonmanufacturing industries apply to pre-1986 years. We use economywide price indexes to deflate bilateral exchange rates. Post-2001 weights use NAICS conversions in industry definitions.

10. Profits from current production are estimated by the BEA as the sum of profits before tax, the inventory valuation adjustment, and the capital consumption adjustment. For a discussion of these data, see the BEA's *Survey of Current Business*, September 2003, pp. 13-4.

The manufacturing industries are: primary metal industries, fabricated metal products, industrial machinery and equipment, electronic and other electrical equipment, food and kindred products, chemicals and allied products, petroleum and coal products, and transportation equipment. The nonmanufactuting industres are: financial services, passenger fares, telecommunications, electricity and gas, retail trade, and wholesale trade.

11. For nonmanufacturing industries, we use the industry Gross Product Originating data.

12. The database posted with this article (<http://www.newyorkfed.org/research/global_economy/industry_specific_exrates.html>) provides export and import data that permit researchers to choose their own weighting schemes and timing decisions for these weights.

13. Consistent with an extensive literature on dollar exchange rates against major currencies, the permanent component we construct using standard Beveridge and Nelson (1981) or Hodrick and Prescott (1997) methodologies closely tracks the actual real exchange rate over most dates. The intuition behind the Beveridge and Nelson definition is that expected growth in the exchange rate should be higher than average when the exchange rate is below its trend level. The Hodrick-Prescott filter assumes an alternative definition of the cycle in the underlying data, and “removes a smooth trend as one would draw it with a free hand drawing” (Pedersen 2001).

14. This statement is confirmed in our own work and in recent work by Pollard and Coughlin (2003) on the topic of import prices and exchange rates. They show that industry-specific exchange rate measures statistically outperform aggregate trade-weighted exchange rates in explaining patterns in industry-level import price adjustment.

References

Beveridge, Stephen, and Charles Nelson. 1981. "A New Approach to the Decomposition of Economic Time Series into Permanent and Transitory Components." Journal of Monetary Economics 7, no. 1 (March): 151-74.

Campa, Jose, and Linda S. Goldberg. 1995. "Investment in Manufacturing, Exchange Rates, and External Exposure." Journal of International Economics 38, no. 3-4 (May): 297-320.

———. 1997. "The Evolving External Orientation of Manufacturing: Evidence from Four Countries." Federal Reserve Bank of New York Economic Policy Review 3, no. 2 (July): 53-81.

———. 1999. "Investment, Pass-Through, and Exchange Rates: A Cross-Country Comparison." International Economic Review 40, no. 2 (May): 287-314.

———. 2001. "Employment versus Wage Adjustment and the U.S. Dollar." Review of Economics and Statistics 83, no. 3 (August): 477-89.

———. 2002. "Exchange Rate Pass-Through into Import Prices." Revised unpublished paper, Federal Reserve Bank of New York, December. Earlier version distributed as NBER Working Paper no. 8934, May 2002.

———. 2004. "Do Distribution Margins Solve the Exchange Rate Disconnect Puzzle?" Revised unpublished paper, Federal Reserve Bank of New York, January.

Cogley, Timothy. 2001. "Alternative Definitions of the Business Cycle and Their Implications for Business Cycle Models: A Reply to Torben Mark Pedersen." Journal of Economic Dynamics and Control 25, no. 8 (August): 1103-7.

Hodrick, Robert J., and Edward C. Prescott. 1997. "Postwar U.S. Business Cycles: An Empirical Investigation." Journal of Money, Credit, and Banking 29, no. 1 (February): 1-16.

Pedersen, Torben Mark. 2001. "The Hodrick-Prescott Filter, the Slutzky Effect, and the Distortionary Effect of Filters." Journal of Economic Dynamics and Control 25, no. 8 (August): 1081-1102.

Pollard, Patricia, and Cletus Coughlin. 2003. "Pass-Through Estimates and the Choice of an Exchange Rate Index." Unpublished paper, Federal Reserve Bank of St. Louis.

Watson, Mark W. 1986. "Univariate Detrending Methods with Stochastic Trends." Journal of Monetary Economics 18, no. 1 (July): 49-75.

Thomas Klitgaard and Laura Weir

Exchange Rate Changes and Net Positions of Speculators in the Futures Market

- Economists, taking a cue from currency traders, are looking at transaction-related data sets to enhance their understanding of short-term exchange rate dynamics. One such data set, often cited by private sector analysts, is the net positions of speculators in the futures market.
- The authors' analysis of weekly net position data from the Chicago Mercantile Exchange since 1993 reveals a strong contemporaneous relationship between weekly changes in speculators' net positions and exchange rate moves. Specifically, by knowing the actions of futures market speculators over a given week, an observer would have a 75 percent likelihood of correctly guessing an exchange rate's direction over that same week.
- However, net positions do not appear to be useful for anticipating exchange rate moves over the following week.
- Policymakers can use net position data as a quantitative measure to complement their broader assessments of foreign exchange activity.

1. Introduction

When pressed to explain short-term exchange rate movements, economists typically point to the seminal article by Meese and Rogoff (1983).[1] The authors conclude that exchange rate models do a poor job of tracking movements over short horizons. So, while the variables in macroeconomic models—such as interest rates, prices, and GDP—can explain exchange rate changes over medium and long horizons, they are not useful for tracking rate changes on a daily, weekly, or monthly basis. After twenty years, the Meese and Rogoff article for the most part still defines the conventional wisdom in this field of economics.[2]

Currency traders and other market participants who focus on the short-term horizon look beyond macroeconomic models. They search for signs of short-term changes in the demand for currencies, using any available measures of market transactions and behavior. Indeed, over the past few years, this focus on transaction-related data sets has led some economists to consider using such data to model short-term exchange rate dynamics.

This approach to understanding exchange rate movements may also be of interest to policymakers, who want to understand what drives the changes over relatively short periods. While one can cite the major economic, financial, and

Thomas Klitgaard is a research officer and Laura Weir a vice president at the Federal Reserve Bank of New York.
<tom.klitgaard@ny.frb.org>
<laura.weir@ny.frb.org>

The authors acknowledge the useful comments of Michael Fleming, Michael Leahy, Deborah Leonard, Richard Lyons, Carol Osler, Joshua Rosenberg, Steven Weinberg, and two anonymous referees. The views expressed are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

political developments over such intervals, these factors alone generally do not explain exchange rate movements very well. Accordingly, any publicly available data that can shed light on short-term changes in demand merit examination.

In this article, we pursue a transaction-oriented line of research to help track short-term exchange rate movements. By examining a publicly available data set well known to currency market analysts—net positions held by speculators in the futures market—we are able to document a strong empirical relationship between changes in speculators' net positions and changes in exchange rates. We find that by knowing what speculators on the Chicago Mercantile Exchange did over the course of a week, an observer would have a 75 percent chance of guessing correctly an exchange rate's direction *during that same week*. We also provide evidence that the connection between net positions and exchange rates is strong and stable: From 1993 to 2003, weekly changes in the net positions of speculators can track 30 to 45 percent of exchange rate movements of the major currencies over the same week. We do not find, however, that the position data can predict the exchange rate changes over the following week.

To add some perspective to our findings, we present a framework in which speculators in the futures market are constantly interpreting public and private information about ongoing shifts in foreign currency demand as they develop their directional views. We argue that net positions change when speculators, acting on their interpretation of public and private information, bet that underlying demand will move exchange rate values from their prevailing levels. The strong correlation with exchange rate movements suggests that the behavior of these speculators reflects, to an extent, the broader speculative community that interprets and influences short-term price dynamics.

2. An Alternative Data Set

The empirical failure of macroeconomic models to explain exchange rate movements over daily, weekly, or monthly intervals has spurred efforts by economists to find new data that might offer insight into how currency markets set prices in the short term. One data set frequently cited in private sector market commentary is the net positions of speculators on the futures market published by the U.S. Commodity Futures Trading Commission (CFTC) in its weekly Commitments of Traders report. This report, released on Fridays, states the positions held at the end of the preceding Tuesday. Armed with these data, private sector analysts consider whether speculators have increased or decreased their net positions in a particular currency and, in conjunction with other information, often make a judgment about how the change relates to recent trends and future movements in exchange rates.[3] Implicit in the commentary of private sector analysts is the belief that tracking speculators helps those trying to understand exchange rate

The empirical failure of macroeconomic models to explain exchange rate movements over daily, weekly, or monthly intervals has spurred efforts by economists to find new data that might offer insight into how currency markets set prices in the short term.

dynamics and that changes in the position data of the Commitments of Traders report are a good proxy for changes in speculators' short-term directional views.[4]

The question from an economist's perspective is whether these data do a good job of tracking short-term exchange rate movements and whether the moves are predictive. Specifically, is there a meaningful relationship between the net positions held by speculators and exchange rates, and if there is, how strong is it? Before addressing these questions, we describe net position data in more detail.

3. The Futures Market for Foreign Exchange

The Chicago Mercantile Exchange operates markets where participants can buy and sell futures contracts for major currencies. Such contracts require one firm to supply and another to accept the foreign currency at a future date at an agreed-to price against the dollar (the futures price).[5] The firm supplying the foreign currency, or taking a short position, gains if the currency depreciates against the dollar relative to the futures price. The one buying the foreign currency, or taking a long position, gains if the currency appreciates. Participants in the futures market can use these contracts either to speculate or to hedge. Speculators' potential gains and losses from taking a position are straightforward. For those using the market to hedge, a futures contract is a form of insurance against an adverse currency swing. For example, a firm that would lose money in its business operations because of a currency appreciation would take a long position. The business loss from the currency's rise would then be offset by profits from having a long position in the futures market.

The CFTC compiles data on long and short positions of "commercial" and "noncommercial" firms along with data on firms taking positions that are too small to classify (categorized as "nonreportable"). The CFTC describes commercial traders generally as hedgers, or firms using futures to hedge their business operations and thus not necessarily motivated by a directional view of the exchange rate. Noncommercial traders are described as speculators, or firms taking positions in the futures market not as a hedge but as speculation on exchange rate movements.[6]

The distinction between commercial and noncommercial traders is based on how firms identify themselves to the CFTC, which in turn monitors firms to verify their self-designation.[7] The more diverse group is that of commercial traders, which is made up of banks, hedge funds, and nonfinancial corporations that use the futures market to hedge their business activities. It is important to note that according to the CFTC, this group also includes currency dealers that are not necessarily participating in the market to hedge or to speculate. Instead, such currency dealers act as market makers, taking up imbalances that arise in the futures market, and then manage their risk exposure to currency swings by taking an offsetting action in the cash market.[8] Dealers often play the role of market makers because their access to narrower spreads in the interdealer market makes it profitable to participate in the futures market with its larger spreads.

The more homogenous group is that of noncommercial traders. This group, which includes commodity trading advisors, speculates on the futures market using its own funds and investors' funds. Commodity trading advisors and other noncommercial accounts are seen as being profit-driven and as acting on their views of the market's short-term direction. As a consequence, market analysis of position data almost exclusively focuses on noncommercial positions, which are called "speculative."[9]

Because every purchase of a futures contract is matched by a sale, the sum of all positions in the futures market is always zero. This means that the sum of all long contracts equals the sum of all short contracts. It also means that the CFTC breakdown of the net positions of commercial and noncommercial firms adds up to zero. (Net position is defined here as long contracts in the foreign currency minus short contracts in the foreign currency.) More formally, assuming that the small nonreporters are allocated into the two categories:

net position of noncommercial accounts
\+ *net position of commercial accounts* = 0.

If commercial accounts are defined as primarily dealers and hedgers, while noncommercial accounts are defined as speculators, then one could rearrange and relabel the above relationship as follows:

net position of speculators =
-(*net position of dealers* + *net position of hedgers*).

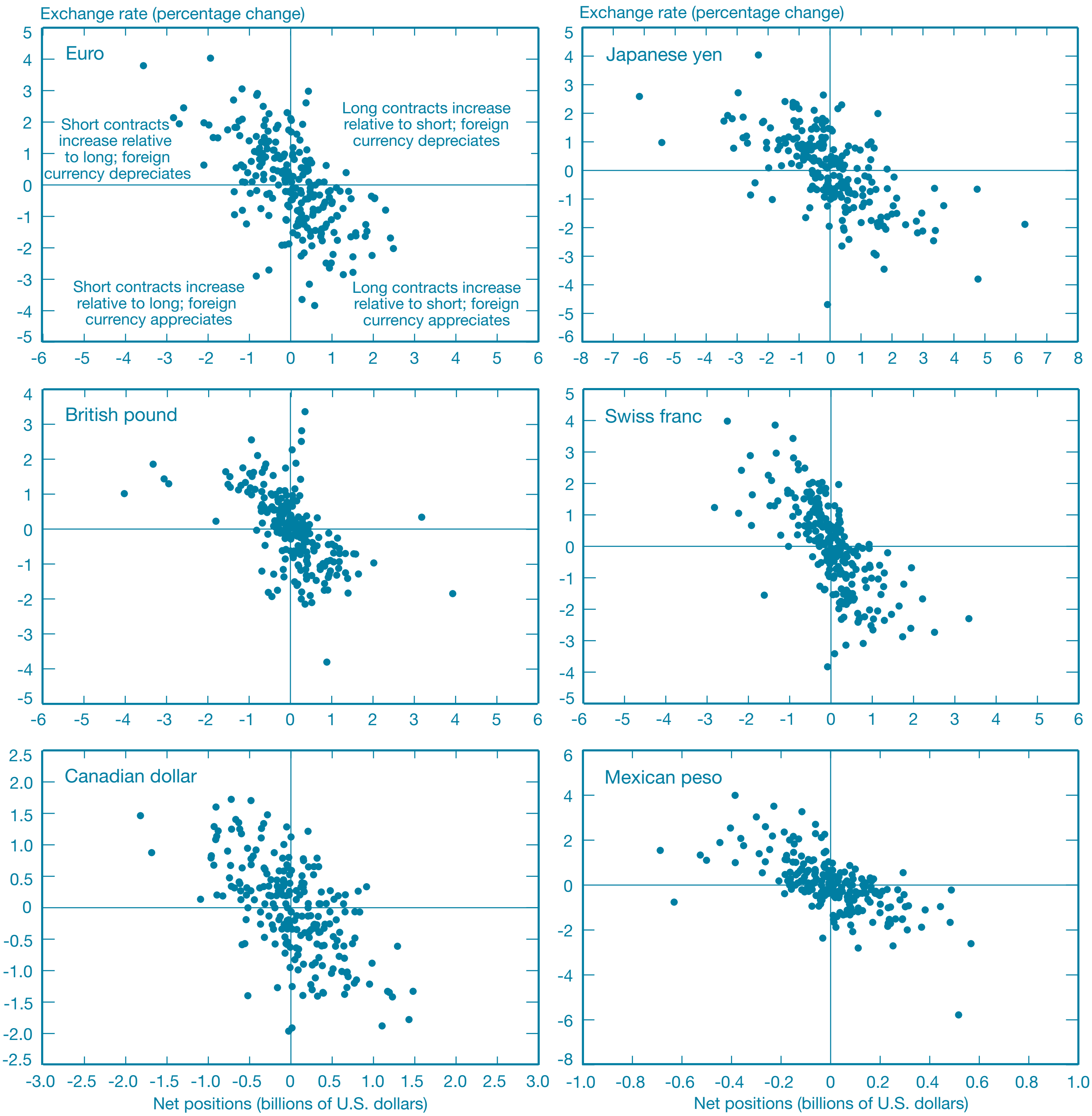
Our focus going forward is on the net positions of speculators as measured by the noncommercial position data. Hedgers' net positions would certainly also be of interest, but the CFTC data are limited in this regard because currency dealers and hedgers are grouped together as commercial firms.

4. Net Positions and Exchange Rates

The first step in evaluating the strength of any relationship between net position data and exchange rates is to look for visual evidence. Plotting the levels of net positions against exchange rate levels reveals no obvious pattern. However, a fairly clear relationship emerges when looking at changes in the two variables. The chart depicts weekly percentage changes (Tuesday to Tuesday) in exchange rates versus the U.S. dollar plotted against changes in net positions for six foreign currencies from January 2000 through May 2003.[10] To interpret the chart, note that an observation in the upper-left quadrant of each panel represents a week when speculators, as a group, increased their holdings of short contracts in the foreign currency relative to long contracts, and the foreign currency depreciated relative to the dollar in the same week. Similarly, the lower-right quadrant shows speculators increasing the long foreign currency positions relative to short positions during a week when the foreign currency appreciated, also suggesting a move in a consistent direction. Observations in the other two quadrants suggest speculators moved in a direction inconsistent with the contemporaneous change in the currency over the same week.

For the six foreign currencies, it is clear that the vast majority of observations are in the upper-left and lower-right quadrants.[11] Indeed, when expanding the data set to the beginning of 1993, we find that weekly observations land in those two quadrants in all the currencies covered in the futures market about 75 percent of the time (Table 1). For example, knowing the direction of the change in speculators' net positions in the yen-dollar futures market would have allowed someone to guess correctly the direction of the yen 74 percent of the time during this period. The other currencies range between 75 percent (for the German mark) and 72 percent (for the Mexican peso).

Exchange Rates and Net Positions
Weekly Data from January 2000 to May 2003



Sources: Bloomberg L.P.; Federal Reserve Bank of New York.

Notes: An observation in the upper-left quadrant represents a week when speculators increased their holdings of short contracts relative to long contracts in the foreign currency, and the foreign currency depreciates relative to the U.S. dollar in the same week. Similarly, the lower-right quadrant shows speculators increasing long positions during a week when the foreign currency appreciates, also suggesting a move in a consistent direction. Observations in the other two quadrants (lower left and upper right) suggest speculators moved in a direction that is inconsistent with the contemporaneous change in the currency over the same week. Quandrant designations in the euro panel apply to all panels. Exchange rates are the percentage change in foreign currency per dollar multiplied by 100. Net positions are the dollar change in long minus short positions of speculators (noncommercial and nonreporting firms), in billions of U.S. dollars. Measuring net positions by number of contracts (instead of U.S. dollars) yields essentially the same pattern.

Table 1

Success Rate of Position Data Tracking the Direction of Exchange Rate Changes

Share of Total

Currency	Success (Percent)	Failure (Percent)
Japanese yen	74	26
Euro	74	26
German mark	75	25
British pound	74	26
Swiss franc	73	27
Canadian dollar	74	26
Mexican peso	72	28

Sources: Bloomberg L.P.; Federal Reserve Bank of New York.

Notes: The data are weekly from January 5, 1993, through May 20, 2003, with shorter periods for the peso (January 1996 through May 2003), the mark (January 1993 through December 1998), and the euro (January 1999 through May 2003). A tracking success is defined as a week when noncommercial and nonreporting firms went more long (more short) and the foreign currency appreciated (depreciated). A tracking failure occurs when these firms went more long (more short) and the foreign currency depreciated (appreciated).

Regressions using these data measure the strength of this relationship (see Table 2 for descriptive statistics of the data). The regressions take the following form:

$$dfx_t = \alpha_1 dsp_t + \varepsilon_t .$$

The left-hand-side variable, *dfx*, is the percentage change in the foreign currency per dollar exchange rate. The variable *dsp* is the change in the net foreign currency position of speculators (long contracts in the foreign currency minus short contracts), in billions of dollars. A negative coefficient means that an increase in the number of long positions relative to the number of short positions is correlated with an appreciation of the foreign currency relative to the dollar.[12]

The visual impressions from the chart are confirmed by the regression results using weekly data from January 1993 to May 2003 (Table 3), with changes in net position data capturing around 30 to 45 percent of contemporaneous exchange rate movements as measured by the adjusted R^2.[13, 14] The regressions for the British pound, the Canadian dollar, the euro, the Mexican peso, and the Swiss franc achieve the best fit, with R^2s near .40.[15] The fits are not quite as tight for the Japanese yen (.34) and the German mark (.30).[16]

The coefficients on net positions can be interpreted as the average percentage change in the exchange rate when there is a \$1 billion swing in net positions.[17] For example, the coefficient estimate of -0.72 for the yen-dollar exchange rate means that a \$1 billion shift to more long (or more short) yen positions by speculators is correlated with a 0.72 percent appreciation (or depreciation) of the yen against the dollar. To put this relationship into context, recall from Table 2 that the standard deviation of weekly changes in net positions for the yen is \$1.3 billion. The coefficient estimates for the other currencies are between 0.6 and 0.9, with the exception of the Swiss franc at 1.18 and the Mexican peso at 4.56 (Table 3). The larger estimate for the peso is consistent with a particular dollar amount having a bigger effect in a much smaller and less liquid market.

The regressions show a strong contemporaneous relationship in weekly changes, which raises the question of whether one variable moves ahead of the other. The conventional approach to answering this type of question is to test whether the two variables "Granger-cause" each other. The test is based on a

Table 2

Descriptive Statistics

Currency	Mean (Absolute Value)	Median (Absolute Value)	Standard Deviation	Maximum	Minimum
Change in foreign currency/U.S. dollar (percent)					
Japanese yen	1.2	0.9	1.6	6.2	-8.6
Euro	1.1	0.9	1.4	4.1	-3.8
German mark	1.1	0.8	1.4	5.2	-6.2
British pound	0.8	0.7	1.1	6.5	-3.7
Swiss franc	1.2	0.9	1.5	7.1	-6.4
Canadian dollar	0.6	0.4	0.8	3.0	-3.3
Mexican peso	0.8	0.5	1.4	7.0	-5.6
Change in net positions of speculators (billions of U.S. dollars)					
Japanese yen	0.9	0.6	1.3	-6.3	6.1
Euro	0.7	0.6	1.0	-2.5	3.6
German mark	0.9	0.6	1.3	-4.9	4.5
British pound	0.7	0.4	1.0	-3.8	6.3
Swiss franc	0.6	0.3	0.8	-4.3	3.8
Canadian dollar	0.4	0.3	0.5	-1.8	2.5
Mexican peso	0.1	0.1	0.2	-0.6	0.7

Sources: Bloomberg L.P.; Federal Reserve Bank of New York.

Notes: The data are weekly from January 5, 1993, through May 20, 2003, with shorter periods for the peso (January 1996 through May 2003), the mark (January 1993 through December 1998), and the euro (January 1999 through May 2003). Percentage change values are multiplied by 100. Position data are short minus long positions for noncommercial and nonreporting firms. The mean and median calculations are for the absolute value of the changes in exchange rates and positions.

Table 3

Regression Results: Exchange Rates against Net Positions

			Diagnostics		
Currency	Net Position	AR(1)	R^2	Standard Error	Serial
Japanese yen	-.72				
	(.05)		.34	1.32	.76
Euro	-.88				
	(.10)		.36	1.13	.61
German mark	-.62				
	(.10)		.30	1.20	.00
	-.66	-.26			
	(.09)	(.06)	.35	1.17	.80
British pound	-.74				
	(.03)		.43	0.85	.03
	-.74	-.10			
	(.04)	(.05)	.43	0.85	.52
Swiss franc	-1.18				
	(.06)		.43	1.14	.00
	-1.18	-.12			
	(.06)	(.04)	.44	1.14	.37
Canadian dollar	-.86				
	(.05)		.36	0.60	.00
	-.85	-.16			
	(.05)	(.06)	.38	0.59	.07
Mexican peso	-4.56				
	(.50)		.39	0.90	.00
	-4.56	-.15			
	(.47)	(.09)	.40	0.88	.68

Sources: Bloomberg L.P.; Federal Reserve Bank of New York.

Notes: The table reports ordinary least squares estimates. The left-hand-side variable is the weekly percentage change of the foreign currency per dollar measured at the end of each Tuesday multiplied by 100. Net position is the weekly change in net positions (long minus short contracts in the foreign currency) of noncommercial and nonreporting firms, in billions of dollars. AR(1) is the first-order autoregressive term used in equations with evidence of serial correlation. The regressions do not include a constant term, which was never statistically significant. The three diagnostic values are the adjusted R^2, the standard error of the regression, and the probability value of the Breusch-Godfrey Lagrange multiplier test for first-order residual serial correlation. An AR(2) term was also needed for the peso. It had a coefficient of 0.09 with a standard error of .07. Standard errors of the coefficient estimates are shown in parentheses, corrected for heteroskedasticity (as suggested by a Lagrange multiplier test of residuals) for the yen, mark, Canadian dollar, and peso using the Newey-West procedure. The estimation period is January 5, 1993, through May 20, 2003. The regressions had 540 observations, with shorter periods for the peso (January 1996 through May 2003), the mark (January 1993 through December 1998), and the euro (January 1999 through May 2003).

regression of a variable on lags of itself and lags of the other variable. The probability values are all above .05, suggesting that Granger causality is not evident (Table 4) and that position data do not help predict exchange rate changes over the following week.

Furthermore, tests for the basic form of trend-following behavior do not find that past exchange rate movements anticipate how speculators change their net positions, with the exceptions of the Canadian dollar and the Swiss franc. However, closer examination of these two currencies suggests that the statistical strength of the relationship is not meaningful. Regressions of changes in net positions on lagged exchange rate changes and net position changes yield very small R^2s of .07 for the Canadian dollar and .04 for the Swiss franc, meaning that very little about changes in net position can be attributed to past exchange rate movements.[18]

Our regression results show a strong contemporaneous connection between speculators' net positions and exchange rates. That is, over weekly intervals, net positions and exchange rates move together in a reliable and stable fashion.

It is important to note that Granger causality tests help us to understand the nature of the data discussed here, but, as we note later, they are not the final word on whether one variable moves in anticipation of the other. In particular, the tests can miss any relationship that might exist over a shorter horizon, such as minute-to-minute or hour-to-hour or a relationship of a more complicated nature.

In summary, our regression results show a strong contemporaneous connection between speculators' net positions and exchange rates. That is, over weekly intervals, net positions and exchange rates move together in a reliable and stable fashion. However, position data do not appear to be useful in anticipating exchange rate changes in the following week.

Table 4
Granger Causality Tests

Currency	F-Statistic	Probability
Japanese yen		
Hypothesis 1: Exchange rates do not anticipate positions	1.17	0.31
Hypothesis 2: Positions do not anticipate exchange rates	0.21	0.81
Euro		
Hypothesis 1: Exchange rates do not anticipate positions	0.14	0.87
Hypothesis 2: Positions do not anticipate exchange rates	0.31	0.73
German mark		
Hypothesis 1: Exchange rates do not anticipate positions	0.46	0.62
Hypothesis 2: Positions do not anticipate exchange rates	0.07	0.93
British pound		
Hypothesis 1: Exchange rates do not anticipate positions	2.33	0.10
Hypothesis 2: Positions do not anticipate exchange rates	0.73	0.48
Swiss franc		
Hypothesis 1: Exchange rates do not anticipate positions	3.14	0.04
Hypothesis 2: Positions do not anticipate exchange rates	1.03	0.36
Canadian dollar		
Hypothesis 1: Exchange rates do not anticipate positions	3.78	0.02
Hypothesis 2: Positions do not anticipate exchange rates	2.10	0.12
Mexican peso		
Hypothesis 1: Exchange rates do not anticipate positions	0.33	0.72
Hypothesis 2: Positions do not anticipate exchange rates	0.94	0.39

Sources: Bloomberg L.P.; Federal Reserve Bank of New York.

Notes: The F-statistic is from a Granger regression equation with two lags on both variables. Probability denotes the corresponding probability values. A probability value near or below .05 suggests the hypothesis can be rejected. The data sample is weekly from January 5, 1993, through May 20, 2003, with shorter periods for the peso (January 1996 through May 2003), the mark (January 1993 through December 1998), and the euro (January 1999 through May 2003).

5. Possible Explanations for the Correlation between Net Positions and Exchange Rates

One interpretation of our results is that they reflect a tendency for speculators to react to currency movements after the fact. For example, it is possible that speculators tend to go long (short) after the currency appreciates (depreciates), so that at a weekly interval, one would find the strong contemporaneous relationship documented in the previous section. The economic logic behind such simple trend-following behavior, though, is hard to accept even with the Granger causality results for the Canadian dollar and Swiss franc. Specifically, in efficient markets, exchange rate movements over the previous minute, hour, day, or week have no new information about future exchange rate movements. Thus, basic trend-following behavior does not make economic sense for speculators as a whole, though more sophisticated trend-following models indeed drive some speculators. The nature of exchange rate dynamics would therefore argue against simple trend-following behavior as the source of the measured contemporaneous relationship between positions and exchange rates.[19]

Another explanation for the strong correlation is that the two variables tend to respond jointly to market developments, such as the release of public information. For this argument to hold, exchange rates and net positions need to react at similar speeds since speculators stop changing their positions once currency values reflect this new information.[20] But given the nature of exchange rate determination—with rapid price adjustments possible without the need for trading—it seems likely that spot exchange rates would react to new information well before speculators had a chance to change their futures market positions. In that case, the change in currency values would mitigate the incentive for speculators to change their net positions, calling into question the notion that the observed correlation of net positions and exchange rates occurs because both move together in response to a third factor.

6. Order Flows and the Role of Private Information

Recent research on order flows in currency markets provides a framework that can help explain our findings.[21] Order flow data measure the difference in the amount of buyer-initiated and seller-initiated orders placed in the currency market. Some dealers believe that an increase in buyer-initiated orders relative to seller-initiated orders suggests an underlying increase in the demand for a currency.

Economists who have gathered order flow data (which are not publicly available) have found that order flows, like net positions, have a strong contemporaneous relationship with short-term exchange rate changes. One recent study by Evans and Lyons (2002) found that the daily differences between buyer- and seller-initiated orders capture roughly 45 to 65 percent of contemporaneous daily exchange rate movements for the mark and the yen.[22]

The explanation given for the success of order flow data in tracking exchange rates starts with the assumption that there are two types of information in currency markets: public and private. This is a more expansive assumption than the one used in standard macroeconomic exchange rate models, which only have an explicit role for public information. In those standard models, exchange rates respond immediately when public information ("news") hits the market.[23] But because prices reflect public information without the need for transactions, these models do not address the issue of why certain transactions take place or why transactions might have a role in setting currency values.

Economists who have gathered order flow data (which are not publicly available) have found that order flows, like net positions, have a strong contemporaneous relationship with short-term exchange rate changes.

Evans and Lyons assume that currency market participants are heterogeneous and act on their own bits of private information, as well as on public information. Examples of private information include participants' expectations of future economic variables, perceptions of official and private sector demand, and perceptions of developing shifts in global liquidity and risk appetite. For certain types of participants, private models of price behavior and momentum are also a factor. According to this view, order flows are correlated with exchange rates because they are a measure of how market participants act on their private information. Specifically, order flows represent the process through which small bits of private information are revealed to the market as a whole through the sequence of transactions.

An important aspect of this explanation is that order flows to some extent anticipate exchange rate movements. For example, foreign currency buyer-initiated orders exceed seller-initiated orders when the array of participants, on net, are willing to bet that the foreign currency will appreciate. The currency appreciates after a collection of transactions—measured by order flows—reveals these private bits of information to the rest of the market.

The existence of private information might also be used to explain the strong correlation between net positions and exchange rates. Speculators alter their net positions when their interpretation of public and private information indicates that underlying demand will move exchange rates from their prevailing levels. While private information among speculators can and does differ, it is the *aggregate* net changes that these data represent that prove to be correlated with exchange rate movements.

Similar to the explanation for order flows, this explanation is based on the idea that speculators act immediately in advance of exchange rate movements. That is, speculators in the futures market seem to have enough bits of useful private information to allow them, as a group, to change their net positions in a way that anticipates the direction of exchange rates.

7. The Relative Importance of Speculators in the Futures Market

One reason to pay attention to speculators in the futures market is that their actions are often viewed as a proxy for the behavior of speculators worldwide. But are these position changes important enough to cause exchange rate movements? Specifically, do transactions in the futures market that anticipate a foreign currency's depreciation help cause that currency to weaken?

At first glance, the possibility that futures market transactions can move currency values might seem unlikely given the low turnover in net position changes relative to the high turnover of all foreign exchange transactions. The Bank for International Settlements estimates that in April 2001, currency transactions worldwide averaged $354 billion *per day* for the euro-dollar pair and $231 billion for the yen-dollar pair (Table 5).[24] By comparison, the standard deviation of *weekly* changes in speculators' net positions is roughly $1 billion for both the euro and the yen (Table 2).

However, an important qualification must be made. The difference in magnitude between speculators in the futures market and all foreign exchange transactions is perhaps less overwhelming when one considers that a large share of the

Table 5
Exchange Rate Turnover by Currency Pair
Daily Averages in April 2001

Pair	Billions of U.S. Dollars	Percentage of Total
U.S. dollar-euro	354	30
U.S. dollar-Japanese yen	231	20
U.S. dollar-British pound	125	11
U.S. dollar-Swiss franc	57	5
U.S. dollar-Canadian dollar	50	4
U.S. dollar-other	242	21
All currency pairs	1,173	100

Source: Bank for International Settlements (2002).

daily turnover is attributable to a series of risk management transactions between dealers. To illustrate this point using a hypothetical example, Lyons (2001) starts with a dealer who takes a customer order for $10 million of euros. To minimize his exposure to any subsequent price moves, the dealer sells 90 percent of the euros ($9 million) to another dealer. The process repeats itself with that dealer also selling 90 percent of the purchase. This "hot potato" process would lead to $90 million in dealer trades to accommodate the initial customer transaction of $10 million ($9 million/(1-0.9)). The smaller the percentage held by each dealer following each transaction, the higher the transaction turnover. In this case, each dealer holding on to 5 percent would lead the initial $10 million transaction to translate into $180 million in trades.

Lyons' example illustrates that the high volume of foreign exchange transactions is not as overwhelming a factor as it might initially appear when compared with the volume of futures market transactions. This outcome suggests that the global volume by itself does not preclude the possibility that speculators in the futures market help cause currency movements.

8. Usefulness for Policymakers

The information derived from the strong contemporaneous relationship between exchange rates and net position data has at least two potential uses for policymakers. First, it is not unusual for policymakers to be asked to explain recent exchange rate movements. In general, they may describe such movements in the context of changing expectations following specific news and announcements. They may also draw upon evidence about the types of flows that occurred over the interval. Little else can be said to explain robustly the magnitude of short-term price changes. Because changes in net speculative positions in the futures market move with exchange rates, these data can be drawn upon as one piece of the puzzle and can be used to support or reconsider theories about what drove price action over a given period.

Second, policymakers may be able to use position data to help ascertain the changing level of currency market exposures. While policymakers are not expected to predict short-term exchange rate movements, they are often expected to help ensure the orderly functioning of markets. To do so requires a fairly current understanding of how market positioning is evolving. Futures market position data can provide policymakers with a quantitative measure to complement their broader assessments.

9. Conclusion

Currency traders recognize that in efficient markets, publicly available information cannot predict short-term exchange rate movements. They nevertheless seek data to help them understand what is driving the market at any given time. Variables that economists view as fundamental to dictating currency values—such as relative output and inflation rates along with interest rate differentials—are constantly analyzed and forecast. In addition, market participants examine various transaction data to gauge demand changes. This article has looked at one such publicly available data set—the net positions of speculators in the futures market.

We find a strong and stable contemporaneous connection between changes in speculators' positions and exchange rate moves, with net positions tracking 30 to 45 percent of weekly exchange rate movements of the major currency pairs over a ten-year period. One explanation for our results is that changes in net positions reflect the actions of speculators, who—reacting to their own interpretation of public and private information—bet that underlying demand will move exchange rates from their prevailing values. The results suggest that position data merit inclusion in policy analysis and in ongoing research on exchange rate dynamics.

Endnotes

1. See Meese and Rogoff (1983).

2. One recent paper (Clarida et al. 2003) asserts that it is possible to improve upon the random-walk model using a sophisticated statistical technology that relies on forward rates. The authors provide no economic explanation for their results. Also see the survey of exchange rate models in Flood and Taylor (1996).

3. For example, on May 27, 2003, a Citigroup publication attributed the continued depreciation of the U.S. dollar to the speculative community (Saywell 2003). Specifically noting changes in these net position data, the report stated that "the combination of positive portfolio and speculative flows has been explosive for the euro." This type of reference to speculative positions in general and to this data series in particular is quite common.

4. Analysts often focus on periods when speculators' net positions are unusually long or short, believing that they expose the market to a change in speculator sentiment.

5. All contracts are standard, listed in foreign currency terms and are versus the U.S. dollar. The Commodity Futures Trading Commission does not supply data on the maturity distribution of contracts.

6. Details on the commercial and noncommercial breakdown are available from the CFTC at <http://www.cftc.gov/opa/backgrounder/opacot596.htm>.

7. The breakdown between commercial and noncommercial likely suffers from various measurement problems. For example, the groupings are based on self-identification of firms by what they tend to do, and do not change based on the purpose of a specific transaction. A commercial firm can make a transaction that would be more typical of a noncommercial firm, yet the trade would still be considered commercial in this data set. Such measurement problems work against finding statistically significant results.

8. Dealer efforts to limit exposure are discussed in Lyons (1995).

9. This designation does not preclude some commercial transactions from being speculative on occasion.

10. The chart quadrants look the same if net positions are denominated in foreign currencies instead of the dollar because the choice of currency does not alter the direction of a change in speculators' positions. The regression results that follow are essentially unchanged if net positions are in foreign currency terms or number of contracts instead of dollars.

11. The Australian dollar is also traded on the futures market but is excluded from this study because of gaps in the data. The available data show a pattern that is very similar to the chart's pattern.

12. The data on the net position changes of commercial firms are the exact opposite of the position data for speculators, so the regression results would be the same for that grouping except that the coefficient estimates would be positive instead of negative. Data for testing the behavior of hedgers (commercial firms excluding dealers) are not available.

13. The estimation periods are shorter for the euro, the German mark, and the Mexican peso. See Table 3 for details.

14. Nonreportable firms are treated as speculators, based on our discussions with market participants. Dropping the nonreportable firms from the group of speculators reduces the R^2s by roughly .05 and marginally reduces the coefficient estimates.

15. An alternative measure of *dsp* would be net positions divided by the sum of short and long contracts. Regressions with this measure lowered the R^2s by .05 to .10.

16. Wang (2003) briefly looks at this relationship. His regressions have similar R^2s using monthly data for four currencies. He attributes the finding to speculators engaging in "herding" behavior.

17. Some currencies have two regressions because there is evidence of serial correlation in the residuals, which raises questions about the standard errors of the estimates. The second regression has an autoregressive term to eliminate this problem.

18. The fitted values of these regressions were used as the position variable in the Table 3 regressions. No measurable relationship was found.

19. Trend following is in practice much more complicated than presented here because models are designed to distinguish between exchange rate changes that reflect valuable information about trends and those changes that have no information content.

20. This discussion adopts arguments made by Lyons (2001).

21. Lyons (2001) has an extensive review of the research on order flows. For an example of similar research conducted by the Federal Reserve Bank of New York, see Osler (2000).

22. Evans and Lyons (2002) regress changes in currency values against contemporaneous changes in interest rate differentials (representing fundamental macroeconomic information) and the daily sum of order flows from an interdealer trading system (Reuters Dealing 2000-I). The results, based on a four-month period in 1996, show that the order flow data captured 65 percent of the mark-U.S. dollar variation and 45 percent of the yen-U.S. dollar variation.

23. A recent empirical examination of the effect of macroeconomic announcements on exchange rates can be found in Andersen et al. (2003).

24. Estimates of foreign exchange turnover appear in Bank for International Settlements (2002). The data include spot, outright forwards, and foreign exchange swap transactions, adjusted for double counting.

References

Andersen, Torben, Tim Bollerslev, Francis Diebold, and Clara Vega. 2003. "Micro Effects of Macro Announcements: Real-Time Price Discovery in Foreign Exchange." American Economic Review 93, no. 1 (March): 38-62.

Bank for International Settlements. 2002. "Foreign Exchange and Derivatives Market Activity in 2001." Triennial Central Bank Survey, March.

Clarida, Richard, Lucio Sarno, Mark P. Taylor, and Giorgio Valente. 2003. "The Out-of-Sample Success of Term Structure Models as Exchange Rate Predictors: A Step Beyond." Journal of International Economics 60, no. 1 (May): 61-83.

Evans, Martin, and Richard Lyons. 2002. "Order Flow and Exchange Rate Dynamics." Journal of Political Economy 110, no.1 (February): 170-80.

Flood, Robert, and Mark Taylor. 1996. "Exchange Rate Economics: What's Wrong with the Conventional Macro Approach?" In J. A. Frankel, ed., The Microstructure of Foreign Exchange Markets, 261-94. NBER Conference Report. Chicago: University of Chicago Press.

Granger, Clive. 1969. "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods." Econometrica 37, no. 3 (August): 424-38.

Lyons, Richard. 1995. "Tests of Microstructural Hypotheses in the Foreign Exchange Market." Journal of Financial Economics 39, no. 2-3 (October): 321-51.

———. 2001. The Microstructure Approach to Exchange Rates. Cambridge, Mass.: MIT Press.

Meese, Richard, and Kenneth Rogoff. 1983. "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" Journal of International Economics 14, no. 1-2 (February): 3-24.

Osler, Carol. 2000. "Support for Resistance: Technical Analysis and Interday Exchange Rates." Federal Reserve Bank of New York Economic Policy Review 6, no. 2 (July): 53-68.

Saywell, Steven. 2003. "Current Account and Capital Flow Trends Diverge." CitiFX Views Capital Flow Update: Euro Area, May 27.

Wang, Changyun. 2003. "The Behavior and Performance of Major Types of Futures Traders." Journal of Futures Markets 23, no. 1 (January): 1-31.

Kenneth D. Garbade

The Institutionalization of Treasury Note and Bond Auctions, 1970-75

- Despite the appeal of auctions as an effective way to offer securities, the U.S. Treasury failed in its first two attempts, in 1935 and 1963, to introduce a program of regular auction sales of long-term bonds.

- That pattern changed between 1970 and 1975, when the Treasury replaced its fixed-price offerings of notes and bonds with regular auctions—a practice that continues today.

- An analysis of the Treasury market suggests that the turnaround in the early 1970s owes to three key decisions: the Treasury closely imitated its successful and well-known bill auction process; it announced auctions for securities of gradually increasing maturity, rather than immediately auctioning long-term bonds; and it was willing to alter the auction process when improvements were called for.

1. Introduction

Since 1976, the U.S. Treasury has financed the federal deficit, and refinanced maturing debt, primarily with auction sales of bills, notes, and bonds. However, prior to 1970 the Treasury did not auction coupon-bearing securities. (It did auction bills, more or less as it does today.) Instead, it raised new cash, and refinanced maturing debt, with fixed-price subscription and exchange offerings of notes and bonds.

The substitution of market-driven auctions for fixed-price offerings between 1970 and 1975 was a milestone in the evolution of the Treasury market. However, the outcome of the effort was initially quite uncertain. The Treasury had tried twice before—in 1935 and 1963—to auction long-term bonds, but both attempts had failed. Although many observers believed that auctions would be a more efficient way to identify market-clearing prices, it was far from evident—especially in light of past experience—how to introduce successfully a program of regular auction sales.

This article examines the introduction of regular auction offerings of Treasury notes and bonds in the early 1970s. We do not take issue with the conventional wisdom that auctions are more efficient and less costly than fixed-price offerings. Rather, we seek to identify why the Treasury twice tried and failed to adopt the more efficient method but succeeded on its third attempt. We suggest that the success of the effort rested on

Kenneth D. Garbade is a vice president at the Federal Reserve Bank of New York.
<kenneth.garbade@ny.frb.org>

The author thanks Jack Bennett, Clay Berry, Mychal Campos, My Caohuy, Maryalice Cassidy, Francis Cavanaugh, Jeff Huther, Henry Kaufman, Jim Mahoney, Paul Malvey, Peter Nagan, Leonard Santow, William Silber, David Simon, Mark Stalnecker, Paul Volcker, and two anonymous referees for assistance in researching this article and for comments on preliminary drafts. The views expressed are those of the author and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

three pillars. First, the Treasury closely imitated its successful and well-known bill auction process. This strategy gave dealers a familiar starting point for developing the risk management and sales programs needed to support auction bidding for coupon-bearing securities. Second, the Treasury announced auctions for securities of gradually increasing maturity, rather than jumping immediately to auctioning long-term bonds, as it did in 1935 and 1963. This action allowed dealers an opportunity to build up their risk management and sales programs in an orderly fashion. Third, the Treasury demonstrated a willingness to alter the auction process when shortcomings appeared—rather than simply jettisoning the entire effort, as it did in 1935 and 1963. By combining familiarity, gradualism, and a willingness to improvise, the Treasury successfully moved the primary market for coupon-bearing securities to a more efficient configuration.

The history of the Treasury's attempts to institutionalize auction offerings of notes and bonds is important in its own right, but also for its larger implications. It suggests that the mere prospect of greater efficiency may not necessarily effect change that requires a large number of actors to alter familiar patterns of behavior; change sometimes also depends on following a path that facilitates learning and implementation of new patterns. The Treasury accomplished its objectives in the early 1970s because it gave dealers an opportunity to learn gradually about how to participate in note and bond auctions and because it was itself willing to learn from experience.

The article proceeds as follows. The next two sections set the stage by describing how the Treasury sold securities before 1970: Section 2 looks at fixed-price offerings of notes and bonds and Section 3 explains how bills were auctioned. Section 4 summarizes the debate over whether to auction coupon-bearing securities—a debate that flared up in the late 1950s with Milton Friedman's well-known criticism of fixed-price offerings. Section 5 describes the unsuccessful 1963 attempt to auction long-term bonds to competing syndicates of securities dealers. Section 6 relates the introduction of auction sales of notes and bonds in the early 1970s, and Section 7 shows how the Treasury fine-tuned the auction process in the mid-1970s.

2. Fixed-Price Offerings before 1970

Prior to 1970, the Treasury sold notes and bonds for cash in subscription offerings, and typically refinanced maturing notes and bonds by offering to exchange them for new notes and bonds.[1] This section describes the two types of offerings and identifies their shortcomings.

2.1 Subscription Offerings

In a subscription offering, the Treasury set the maturity date and coupon rate of a new issue, announced how much of the security it wanted to sell, and invited public subscriptions at a fixed price. It typically announced that it would accept all subscriptions for amounts below some stated threshold and that it would allocate the remaining notes or bonds to larger subscribers in proportion to the amounts sought. For example, on July 31, 1968, the Treasury announced that it would sell approximately $5.1 billion of 5 5/8 percent notes maturing on August 15, 1974, at a price of 99.62 percent of principal. The subscription books would be open for a single day, on August 5; subscriptions for $250,000 or less would be filled in full and the notes would be issued on August 15. The Treasury received subscriptions for $23.5 billion—4.6 times the amount offered. Subscriptions for more than $250,000 were allotted 18 percent of the amounts subscribed for, subject to a minimum allocation of $250,000.

In a subscription offering, the Treasury set the maturity date and coupon rate of a new issue, announced how much of the security it wanted to sell, and invited public subscriptions at a fixed price.

Before setting the terms of an offering, Treasury officials consulted with banks, insurance companies, and securities dealers to assess the prospective demand for notes and bonds of different maturities and to identify the yield needed to sell a given amount of a particular issue.[2] The Treasury set the coupon rate on a new issue to the nearest one-eighth of a percent below the intended offering yield and then reduced the offering price below 100 to fine-tune the yield to the desired level.[3] A Treasury economist (Baker 1976, p. 147) observed that a debt manager "succeeded perfectly in his pricing effort if the volume of subscriptions . . . just cover[ed] the amount . . . offered."

2.2 Drawbacks to Subscription Offerings

Friedman (1960, p. 65) characterized the process of setting the terms of an offering as "crystal gazing . . . and plain guesswork." In setting terms, the Treasury bore the risk of misjudging market demand. If it set the offering yield too low, the issue would be undersubscribed and the offering would fail. The risk of a failed offering was compounded by the possibility that market yields might rise between the time the Treasury announced a new issue and the time it opened the subscription books—usually an interval of several days to a week.[4]

To limit the likelihood of an undersubscribed offering, the Treasury added a premium to contemporaneous market yields when it set the terms of an offering.[5] Friedman (1964, p. 513) noted that this premium sometimes led to unduly generous yields. Generous yields in turn led to substantial oversubscriptions and low allotment ratios. Cecchetti (1988, pp. 1117-8) reports that the average allotment ratio between 1932 and 1940 was 15.4 percent. Substantial oversubscriptions were clear signs that the Treasury was giving away yield at taxpayer expense. Not surprisingly, some market participants would subscribe for new issues and then seek to sell their allotments quickly at a premium to the subscription price. This practice, known as "free-riding," was widely criticized because it hindered direct sales to final investors and was believed to contribute to price volatility.[6]

2.3 Exchange Offerings

In an exchange offering, the Treasury announced maturity dates and coupon rates for one or more new notes and/or bonds and invited the public to exchange one or more maturing issues for an equal principal amount of the new securities.[7] For example, in the summer of 1970, the Treasury faced the imminent maturity on August 15 of $5.6 billion of notes and bonds. On July 29, it offered to exchange either a three-and-a-half-year note or a seven-year note for the maturing securities. Following the close of the offering, the Treasury announced that investors had tendered $4.8 billion (85 percent) of the maturing securities and had redeemed the balance ($0.8 billion). In exchange for the maturing debt, investors took $3.0 billion of the three-and-a-half-year notes and $1.8 billion of the seven-year notes.

In an exchange offering, the Treasury announced maturity dates and coupon rates for one or more new notes and/or bonds and invited the public to exchange one or more maturing issues for an equal principal amount of the new securities.

To finance "attrition," or cash redemption of unexchanged securities, the Treasury sometimes announced a cash subscription concurrently with an exchange offering. For example, when the Treasury announced the exchange offering described above, it also announced that it would sell $2.75 billion in eighteen-month notes "to pay for the August 15 maturities not exchanged and to raise new cash."[8] At other times, the Treasury's cash balances were large enough to fund the redemption of unexchanged securities.

2.4 Drawbacks to Exchange Offerings

In setting the terms of an exchange offering, the Treasury bore the risk that it might set the yields on its new issues too low and that investors would choose to redeem an unexpectedly large fraction of the maturing debt. This outcome could expose the Treasury to a cash-flow crisis as it scrambled to meet investor demands for cash redemption.[9] As with subscription offerings, the risk of misjudging the market was compounded by the potential for market yields to rise between the time the Treasury announced the terms of an offering and the time the subscription books were opened. To limit the risk of an unexpectedly high attrition rate, the Treasury added a premium to contemporaneous market yields when it set the terms of an offering.[10]

A second problem with exchange offerings was that holders of maturing issues were not "natural" buyers of new issues with longer maturities. Accepting an exchange offer materially altered the risk exposure of the holder of a maturing issue. In any particular offering, some investors could be expected to be uninterested in such a sharp change in risk. Sophisticated holders who wanted cash sold their debt shortly before maturity, thereby capturing the exchange option value of the debt. This strategy, however, required the (costly) market-making services of a securities dealer.[11]

Finally, because exchange offerings usually gave investors a choice of several different securities, the Treasury lost direct control of the maturity structure of its debt. For example, in the August 1970 exchange offering described earlier, investors could have opted for as much as $5.6 billion of the three-and-a-half-year note (and none of the seven-year note), or as much as $5.6 billion of the seven-year note (and none of the three-and-a-half-year note). The Treasury was prepared to accommodate either extreme, as well as any intermediate outcome. Gaines (1962, p. 79) noted that "In a very real sense, the maturity distribution of the debt was left in the hands of the investors."[12]

3. Treasury Bill Auctions before 1970

Throughout the 1950s and 1960s, the Treasury was auctioning bills even while it wrestled with the risks and uncertainties of fixed-price offerings of notes and bonds. By 1970, the Treasury was auctioning four different series of bills on a regular basis. Thirteen-week bills had been offered weekly since before World War II and a weekly offering of twenty-six-week bills was added in 1958. Year bills were first offered in 1959 on a quarterly basis, and then on a monthly basis beginning in 1963. Monthly offerings of nine-month bills were added in 1966.

Bill auctions before 1970 were much like the bill auctions of today. An investor could submit one or more competitive tenders or a single noncompetitive tender. A competitive tender specified a bid price (as a percentage of face amount) and the quantity of bills desired at that price.[13] A noncompetitive tender specified only a quantity (limited to some specified maximum amount) and agreed to pay the average accepted competitive bid. The Treasury accepted all noncompetitive tenders for the full amount sought. Competitive tenders were accepted in order of declining bid price until the balance of the offering was accounted for. Tenders specifying prices in excess of the stop-out, or minimum accepted, price received the full amount sought and were invoiced at their respective bid prices.[14] The remaining bills were distributed in proportion to the quantities sought among those who bid at the stop-out price.

4. The Debate over Whether to Auction Notes and Bonds

The argument for auctioning notes and bonds was well-known by the early 1960s. Friedman (1960, pp. 64-5) had pointed out the practical difficulty of setting the yield on a new issue at a level where investors would buy the full amount offered but hardly any more. He recommended that the Treasury eliminate fixed-price offerings and sell all of its marketable debt through regularly scheduled public auctions.[15]

The most extensive defense of the Treasury's reliance on fixed-price offerings came in testimony by Secretary of the Treasury Robert Anderson before the Joint Economic Committee in 1959 (Joint Economic Committee 1959a, pp. 1147-61). Anderson observed that bills had been sold at auction ever since they were introduced in 1929, that the Treasury had extended the auction method of sale to twenty-six-week bills and year bills when those series were introduced, and he acknowledged (p. 1150) that bill auctions were "an efficient mechanism." Anderson further acknowledged (p. 1148) that auction offerings of notes and bonds would "relieve [the Treasury] of a major responsibility in pricing and selling coupon issues" and noted that the Treasury had introduced auction offerings of year bills to reduce the quantity of one-year certificates of indebtedness that it had to price.

Nevertheless, Anderson argued that fixed-price offerings of notes and bonds were preferable to auction sales of those securities. His analysis rested on the premise that many of the small banks, corporations, and individuals who subscribed to fixed-price offerings did not have the "professional capacity" to bid in an auction. Lacking professional expertise, they were liable to either bid too high and pay too much or bid too low and be shut out, and therefore were likely to avoid note and bond auctions altogether and to buy new securities in the secondary market. Anderson suggested that the withdrawal of small investors from the primary markets for notes and bonds would have several adverse consequences:

The failure of an auction offering of Treasury-guaranteed federal agency bonds in late August 1935 was widely noted and led the Treasury to abandon the auction method.

1. Small investors would lose the opportunity to buy securities directly from the Treasury on the same terms as large investors.
2. The Treasury's ability to distribute its debt as widely as possible would be impaired. (He characterized broad distribution as a "major objective" of Treasury debt management policy.)
3. Since relatively few market participants had the expertise to bid for notes and bonds, the auctions might not be competitive. Indeed, there might be so few bidders that auctions might fail from time to time. (The Treasury viewed this as a particular risk for long-term bonds.)

Anderson asserted (p. 1153) that "The present practice of offering [notes and bonds] at prices and interest rates determined by the Treasury . . . result[s] in an effective distribution of new . . . issues at minimum cost to the taxpayer."

He also pointed out that the Treasury had tried auctioning long-term bonds in 1935. Between May and August of that year, the Treasury auctioned $500 million of thirteen- and twenty-five-year bonds in a series of five auctions (see the box for details). The auctions were generally successful but

The 1935 Bond Auctions

Between May and August 1935, the Treasury auctioned $200 million of thirteen-year bonds and $300 million of twenty-five-year bonds in five auctions of $100 million each. The auctions were part of a plan to move away from a debt management program of large quarterly financings and toward a program of selling smaller amounts in more frequent offerings.[a] (There is also some indication that the Treasury may have planned to replace large, infrequent, regularly scheduled subscription offerings with small, frequent, discretionary auction offerings in order to "time" offerings to when demand for Treasury securities was strong and to stay out of the market when demand was weak.[b])

The table below shows the terms and results of the five auction offerings. The first offering was widely characterized as experimental, although the Treasury was reported to be ready to use the auction method more frequently if the offering succeeded.[c] The auction attracted tenders for $270 million of bonds and was viewed as a modest success.[d] The next two auctions attracted greater interest. The Secretary of the Treasury was quoted as being "very pleased" with the second and characterized the third as "very satisfactory."[e] The fourth offering fared a little worse than the second and third, and the fifth, in mid-August, received a distinctly less enthusiastic reception.[f]

Auction Offerings of Treasury Bonds, 1935

Auction Date	Issue	Quantity Bid (Millions of Dollars)	Range of Accepted Prices	Average Accepted Price
5/29	3 percent bonds of 6/15/48	270	103 1/32 to 103 26/32	103 4/32
6/26	3 percent bonds of 6/15/48	461	Not reported	103 18/32
7/17	2 7/8 percent bonds of 3/15/60	511	101 19/32 to 101 27/32	101 19/32
7/31	2 7/8 percent bonds of 3/15/60	321	101 7/32 to 101 24/32	101 18/32
8/14	2 7/8 percent bonds of 3/15/60	147	100 21/32 to 101 8/32	100 25/32

Sources: Federal Reserve Bank of New York circulars (1935, various dates); *New York Times* (1935, various issues).

Notes: All five auctions were for $100 million principal amount of bonds, reopened bonds previously sold in subscription offerings, and used a multiple-price format. Competitive bids below 100 and noncompetitive bids were not accepted.

[a] "Treasury Plans Large Refinancing," *New York Times*, May 28, 1935, p. 39 ("[Secretary of the Treasury Morgenthau] said that the plan of issuing securities at only the quarterly financing periods of June 15, Sept. 15, Dec. 15 and March 15 had been abandoned and the issues would be ordered when it appeared that the Treasury needed the money").

[b] "Treasury Retains Bond Auction Plan," *New York Times*, September 14, 1935, p. 14, and U.S. Treasury (1940).

[c] "Treasury Plans Large Refinancing," *New York Times*, May 28, 1935, p. 39 (auction offering "a feeler"), and "A Treasury Experiment," *New York Times*, May 29, 1935, p. 20.

[d] "New Bond Bids Treble Offering," *New York Times*, May 31, 1935, p. 25.

[e] "Subscriptions of $461,341,000 Are Received for $100,000,000 Offer of Treasury Bonds," *New York Times*, June 28, 1935, p. 31, and "New Federal Issue Subscribed 5 Times," *New York Times*, July 19, 1935, p. 25.

[f] "Treasury Bond Sale Sets Premium Mark," *New York Times*, August 2, 1935, p. 26, and "Bids Show Decline on Federal Bonds," *New York Times*, August 16, 1935, p. 23.

investors and dealers expressed dissatisfaction with the auction process. In particular, the Treasury's practice of announcing and holding auctions on short notice and on no regular schedule made participation risky for dealers, dealers believed the profit opportunities did not justify the risks of participation, and banks and investors outside of the largest financial centers were reluctant to participate because they believed the auctions favored market professionals.[16] The failure of an auction offering of Treasury-guaranteed federal agency bonds in late August 1935 was widely noted[17] and led the Treasury to abandon the auction method.[18]

Responding to Anderson's analysis, Friedman (1960, pp. 64-5) noted that the analysis implicitly assumed that notes and bonds would be auctioned the same way as bills: in a multiple-price format, where a successful tender is invoiced at its bid price.[19] (The 1935 bond auctions had used this format.) Friedman claimed (p. 64) that the multiple-price format established a "strong tendency for the [primary] market to be limited to specialists" and suggested that small investors would be more willing to participate if the Treasury adopted a single-price format, where all accepted tenders pay the stop-out price.

Following Friedman's suggestion for single-price auctions, the Treasury faced a choice among three methods for selling securities: fixed-price offerings (already used for notes and bonds), single-price auctions, and multiple-price auctions (already used for bills). Friedman's principal point was that fixed-price offerings were inferior to either of the two auction alternatives.[20] He recommended the single-price auction format in lieu of the multiple-price format primarily to counter the Treasury's claim that small investors would not participate in auction offerings of notes and bonds.[21]

5. The 1963 Syndicate Auctions

In 1963, the Treasury tried to combine the benefits of an auction with a fixed-price format that would preserve direct participation by small investors. Emulating contemporary market practice in the sale of some municipal and power company bonds, it twice offered long-term bonds in all-or-none auctions to syndicates of securities dealers, where the winning syndicate was required to reoffer the bonds to public investors on a fixed-price basis (at a price of the syndicate's choosing). The Treasury hoped that moving the locus of bond pricing to competing dealer syndicates would enhance the efficiency of the primary market without jeopardizing the benefits of fixed-price offerings for small investors. It characterized the new program as a "trial" intended to "explore the practicality" of syndicate auctions for selling bonds "at the lowest possible interest cost."[22]

In 1963, the Treasury tried to combine the benefits of an auction with a fixed-price format that would preserve direct participation by small investors.

The first offering of $250 million of thirty-year bonds on January 8, 1963, attracted bids from four syndicates; the second offering of $300 million of thirty-one-year bonds on April 9 attracted three bids. Bidding was extraordinarily competitive. In both cases, less than 1 basis point separated the yield on the winning bid from the yield on the third-best bid. The Treasury stated that the results of the first auction were "highly satisfactory" and indicated that the auction "provided the base for the potential development of an important new instrument for debt management."[23]

The first offering was also a success for the members of the winning syndicate: the public reoffering sold out within a matter of hours.[24] The second reoffering, however, was not well received. Less than half of the issue was sold by the close of trading on the auction day and few, if any, additional bonds were sold before the winning syndicate disbanded in late April.[25] Market participants suggested that a third offering would produce a wider distribution of bids than the first two and that participating syndicates were certain to try to protect themselves by building larger underwriting spreads into their bids.[26] Robert Roosa, Treasury Under Secretary for Debt Management, remarked that the next auction offering was "a long time" off.[27] The Treasury never again sold securities through syndicate auctions.

6. A Renewed Effort to Auction Coupon-Bearing Securities

After the demise of the 1963 attempt, the Treasury had twice tried to implement regular auction offerings of long-term bonds and had twice failed. Nevertheless, Friedman's basic criticism, that fixed-price offerings were inefficient, remained.[28] The inefficiencies became more apparent as interest rate volatility increased in the mid- and late 1960s. As shown in the bottom panel of Table 1, the standard deviation of the daily change in yield on a five-year note increased from about 1 basis point in 1963 to almost 6 basis points in 1970. Volatility in the three-year and ten-year sectors increased similarly. Treasury officials recognized that heightened volatility increased the likelihood that a fixed-price offering might fail and increased the likelihood that the Treasury would overpay on a new issue (Baker 1979, p. 204). A Treasury economist later summarized why the Treasury found auctions increasingly attractive by the end of the 1960s (Baker 1979, p. 204): "Auction pricing . . . eliminated the awkward delays in pricing and subscribing for the issue, allowed the market itself to determine the price, and thus removed the Treasury from the necessity of having to guess the price and the likely course of the market until the financing was complete."

In late 1970, the Treasury decided to try yet again to auction coupon-bearing debt on a regular basis, but this time it

Table 1
Level and Volatility of Treasury Yields, 1963-70

Year	Three-Year Note	Five-Year Note	Ten-Year Bond
Average yield during calendar year (percent per annum)			
1963	3.67	3.83	4.00
1964	4.03	4.07	4.19
1965	4.22	4.25	4.28
1966	5.23	5.11	4.93
1967	5.03	5.10	5.07
1968	5.68	5.70	5.64
1969	7.02	6.93	6.67
1970	7.29	7.38	7.35
Standard deviation of yield change over one business day (basis points)			
1963	1.32	1.07	0.92
1964	1.43	1.07	0.84
1965	1.76	1.58	1.11
1966	4.59	3.59	3.24
1967	4.27	3.96	3.31
1968	4.66	4.16	3.34
1969	5.46	4.59	4.13
1970	6.44	5.89	5.53

Source: Author's calculations, based on data from Federal Reserve Statistical Release H.15 (various years).

designed the auctions to resemble its successful and widely accepted bill auctions. This decision gave dealers a familiar starting point from which to develop the risk management and sales programs needed to support auction bidding for notes and bonds. Additionally, the Treasury borrowed from its experience with introducing longer term bill auctions in 1958 and 1959: it first auctioned short-term notes, then progressively longer notes and bonds. This sequencing gave dealers an opportunity to develop their risk management and sales programs gradually.

6.1 The November 1970 Refunding

The November 1970 refunding[29] got off to an unexceptional start when the Treasury announced on October 22 that it was prepared to exchange either a three-and-a-half-year note or a five-and-three-quarter-year note for $6.0 billion of Treasury securities maturing on November 15. Following the close of the subscription books, the Treasury announced that investors had tendered $5.3 billion of the maturing securities, leaving $0.7 billion to be redeemed in cash. However, rather than financing the attrition with a subscription offering, the Treasury announced that it would auction $2.0 billion of 6 3/4 percent eighteen-month notes.

The auction was held on November 5 and followed closely the format of a bill auction. In light of the failure of the syndicate auction scheme seven years earlier, the Treasury was careful to remind participants that it was not doing anything novel: "the use of the auction method of sale represents an adaptation of the technique used successfully for many years in marketing Treasury bills" and "bidding and other procedures

In light of the failure of the syndicate auction scheme [in 1963], the Treasury was careful to remind participants that it was not doing anything novel.

[will] very closely follow the standard procedures used in regular Treasury bill auctions."[30] Auction participants could submit one or more competitive tenders or a single noncompetitive tender (limited to $200,000) that would be filled at the average accepted competitive bid. Competitive tenders had to specify a bid price of at least 99.76 percent of principal value and were accepted in order of declining price until all of the notes were accounted for or all of the tenders were filled. Tenders specifying bid prices in excess of the stop-out price received the full amount sought and were invoiced at their respective bid prices. The remaining notes were distributed among those who bid at the stop-out price in proportion to the quantities sought. The Treasury characterized the auction as a "test," part of a "continuing effort . . . to develop more efficient debt management techniques."[31]

On November 6, the Treasury announced that it had received tenders for $5.2 billion of notes—2.6 times the amount offered. It accepted bid prices ranging from 100.93 (to yield 6.09 percent) down to a stop-out price of 100.69 (to yield 6.26 percent), where there was a 32 percent allocation. The average accepted competitive price was 100.76 (to yield 6.21 percent).

6.2 Subsequent Early Auctions

The Treasury followed up its successful auction of eighteen-month notes with additional auction offerings, but it initially used auctions sparingly and only to sell short-term notes. This infrequent and limited use of the auction method contrasts sharply with the 1935 attempt, where five issues of thirteen- and twenty-five-year bonds were auctioned in a two-and-a-half-month interval, and with the 1963 attempt, where two auctions of long-term bonds came only three months apart. As shown in Table 2, the second auction (of sixteen-month notes) took place in June 1971, more than seven months after the first auction, and the third auction (in August 1971) was another offering of eighteen-month notes.

The Treasury followed up its successful auction of eighteen-month notes with additional auction offerings, but it initially used auctions sparingly and only to sell short-term notes.

After the August auction, the Treasury increased the frequency and maturities of its auction offerings. By the end of 1971, it had conducted six successful auctions of notes maturing in as much as five years. The Under Secretary of the Treasury for Monetary Affairs, Paul Volcker, characterized auction sales of short- and intermediate-term coupon-bearing debt as a "striking innovation" in debt management: "I cannot claim that the approach has yet been fully tested in adversity, but I can say it has met or surpassed every expectation so far, to the advantage of the Treasury and the market. I am confident it will pass further testing with larger amounts and longer maturities."[32]

6.3 Pushing the Envelope

The Treasury continued to expand its use of auction sales in 1972. As Table 3 shows, the Treasury auctioned midquarter refunding issues for the first time in May; in October, it began to auction two-year notes on a regular basis. (The latter was the first series of regular note offerings to be auctioned from inception.)

In late 1972, the Treasury announced the first auction offering of long-term bonds since 1963: $625 million of twenty-year bonds. In a striking departure from prior practice, it adopted the single-price format recommended by Friedman more than a decade earlier, observing that "This procedure will provide an incentive to bid at prices sufficiently high to be sure of awards, while also assuring

In late 1972, the Treasury announced the first auction offering of long-term bonds since 1963: $625 million of twenty-year bonds.

TABLE 2
Auction Offerings of Treasury Notes, 1970-71

Auction Date	Issue	Term	Quantity Offered (Billions of Dollars)	Quantity Bid (Billions of Dollars)	Range of Accepted Yields (Percent)	Average Accepted Yield (Percent)
11/5/70	6 3/4 percent notes of 5/15/72	Eighteen months	2.00	5.2	6.09 to 6.26	6.21
6/22/71	6 percent notes of 11/15/72	Sixteen months	2.25	4.0	5.71 to 6.05	6.00
8/5/71	6 1/2 percent notes of 2/15/73	Eighteen months	2.50	4.1	6.44 to 6.59	6.54
8/31/71	6 1/4 percent notes of 11/15/76	Five years, two months	1.25	3.4	5.92 to 6.02	5.98
10/15/71	5 7/8 percent notes of 2/15/75	Three years, four months	2.00	4.6	5.46 to 5.61	5.58
11/9/71	4 7/8 percent notes of 2/15/73	Fifteen months	2.75	4.0	4.79 to 4.96	4.91

Source: Federal Reserve Bank of New York circulars (1970-71, various dates).

Table 3
Auction Offerings of Treasury Notes and Bonds, 1972

Auction Date	Issue	Term	Quantity Offered	Quantity Bid	Range of Accepted Yields	Average Accepted Yield
			(Billions of Dollars)		(Percent)	
3/28	5 7/8 percent notes of 5/15/75	Three years	1.75	3.8	5.69 to 5.80	5.78
5/2	4 3/4 percent notes of 5/15/73	One year	1.25	3.3	4.23 to 4.47	4.44
5/2	6 3/8 percent bonds of 2/15/82	Nine years, nine months	0.50	1.3	6.23 to 6.32	6.29
10/11	6 percent notes of 9/30/74	Two years	2.00	4.8	5.77 to 5.89	5.86
11/1	6 1/4 percent notes of 11/15/76	Four years	3.00	7.1	6.16 to 6.21	6.20
12/20	5 7/8 percent notes of 12/31/74	Two years	2.00	5.6	5.72 to 5.85	5.83

Source: Federal Reserve Bank of New York circulars (1972, various dates).

each bidder that, if he bids at a price within the range of accepted prices, he will be awarded bonds at the same price as every other bidder."[33] In response to complaints that the single-price format would deprive dealers of an opportunity to buy bonds slightly cheaper than other auction participants, a Treasury official pointed out that "the objective is to encourage widespread and confident bidding," and a "broader distribution of our securities. We're appealing to a type of investor who will be able to bid what he thinks the bond is worth to him without worrying about whether somebody else may get it cheaper."[34] Over the next fifteen months, the Treasury offered long-term bonds in single-price auctions five more times (Table 4). However, the single-price format never became popular with dealers. Henry Kaufman, a well-known economist at Salomon Brothers, stated that the single-price format "provides no incentives to . . . dealers to help in the distribution process."[35]

7. Fine-Tuning the Auction Process

By mid-1973, auction sales of notes and bonds had replaced fixed-price offerings. The Treasury had not announced a subscription offering since August 1970 and the last mid-quarter refunding to rely on an exchange offering was in February 1973. However, the form of the auction process did not remain unchanged, evolving first in response to the only outright failure of a Treasury auction offering and then to simplify and enhance the efficiency of the process.

Table 4
Auction Offerings of Long-Term Treasury Bonds in a Single-Price Format, 1973-74

Auction Date	Issue	Term	Quantity Offered	Quantity Bid	Yield (Percent)
			(Billions of Dollars)		
1/4/73	6 3/4 percent bonds of 2/15/93	Twenty years	0.63	1.7	6.79
5/2/73	7 percent bonds of 5/15/98	Twenty-five years	0.65	1.2	7.11
8/1/73	7 1/2 percent bonds of 8/15/93	Twenty years	0.50	0.3	8.00
10/31/73	7 1/2 percent bonds of 8/15/93	Nineteen years, nine months	0.30	1.3	7.35
2/7/74	7 1/2 percent bonds of 8/15/93	Nineteen years, six months	0.30	1.1	7.46
5/8/74	8 1/2 percent bonds of 5/15/94	Twenty-five years	0.30	0.9	8.23

Source: Federal Reserve Bank of New York circulars (1972-74, various dates).

7.1 A Failed Auction

The first setback in the Treasury's third attempt to auction coupon-bearing securities on a regular basis occurred in the August 1973 refunding. To refinance $4.7 billion of maturing notes and bonds, the Treasury announced on July 25 that it would auction $2.0 billion of 7 3/4 percent four-year notes, $500 million of 7 1/2 percent twenty-year bonds, and $2.0 billion of thirty-five-day bills.

Fixed-income securities prices declined sharply in late July 1973. Between July 16 and July 30, the yield on five-year notes rose from 7.21 percent to 7.80 percent and the yield on twenty-year bonds rose from 7.21 percent to 7.56 percent. On July 31, the Treasury received tenders for only $2.1 billion of its new four-year notes, barely more than the amount offered. It accepted all bids above 99.01 (the lowest price it had said it would accept) and 75 percent of the bids at 99.01. On the following day, the auction of twenty-year bonds failed: the Treasury received public tenders for only $260 million of the bonds. It accepted all of the tenders submitted at or above 95.05, the lowest price it had said it would accept. The balance of the offering went into "Government Accounts."[36]

7.2 Modification of the Auction Process

The failure of the August bond sale did not deter the Treasury from continuing to auction securities, but it did lead to some important changes in auction procedures. Immediately after the failure, the Treasury began to announce the coupon rate on a forthcoming issue after the announcement of the issue itself and closer to the time of the auction. For example, on August 20, 1973, the Treasury announced that it would auction two-year notes on August 24, but it did not announce the coupon rate on the new notes until August 22. This action reduced (but did not eliminate) the likelihood that the Treasury would offer another bond with a substantially off-market coupon.

The Treasury continued to delay coupon announcements on new notes and bonds until September 1974, when—in a further modification of prior practice—it replaced bidding in terms of price (on a security with a specified coupon) with bidding in terms of yield (on a security with no specified coupon). In the new framework, competitive tenders were accepted in order of increasing yield until all of the securities not taken by noncompetitive bidders were accounted for. Following the auction, the Treasury set the coupon rate at the highest rate—in increments of one-eighth of a percent—that gave an average price on the accepted competitive tenders not greater than par. Each accepted tender was then invoiced at its own bid yield. Noncompetitive tenders were invoiced at the average accepted competitive price. The Treasury remarked that "The new bidding method will permit pricing close to par and eliminate the risk of setting a coupon which, because of a

The failure of the August bond sale did not deter the Treasury from continuing to auction securities, but it did lead to some important changes in auction procedures.

change in the market between the coupon announcement date and the auction date, would result, on the one hand, in a price so far above par as to discourage bidders or, on the other hand, result in a price so low that the sale would have to be canceled."[37]

7.3 The End of Single-Price Auctions

In mid-1974, the Treasury switched its long-term bond auctions to a multiple-price format—thus putting all of its auctions in a common format. The Treasury did not state publicly the reason for the change. However, one money market newsletter reported at the time that "Debt managers found no evidence that [the single-price format] was attracting enough additional or different bidders for the bonds to make its use worthwhile."[38] Under Secretary of the Treasury for Monetary Affairs, Jack Bennett, subsequently stated that "The Secretary of the Treasury at that time, William E. Simon, made the decision to discontinue the [single-price format] as a result of his judgment, based on his extensive experience in the market for Treasury securities, that the [single-price format] would bring in fewer dollars to the Treasury."[39]

7.4 Removal of Restrictions on When-Issued Trading

When-issued, or "WI," trading is trading in an unissued security for settlement on the issue date. Beginning with the first note auction in 1970 and continuing until early 1975, the Treasury effectively precluded WI trading in notes and bonds prior to the close of bidding. Bidders were required to agree "not to buy or sell, or to make any agreements with respect to the purchase or sale or other disposition of any [securities] of this issue at a specific rate or price, until [after the auction close]."[40] The restriction continued a similar restriction on WI trading in connection with subscription offerings that dated back to 1940.[41] The Treasury did not generally prohibit WI trading in bills prior to the close of an auction.

Market participants found pre-auction WI trading in bills useful for two reasons. First, public dissemination of the discount rate at which a new bill was trading in the WI market provided information about the market's collective appraisal of the prospective value of the bill and enhanced the efficiency of the bidding process. A 1992 study (U.S. Treasury Department et al. 1992, p. A-6) pointed out that WI trading "reduces uncertainties surrounding Treasury auctions by serving as

In early 1975, the Treasury removed the restriction on pre-auction [when-issued] trading in notes and bonds . . . . This was an important step in enhancing the efficiency of auction bidding and facilitating the distribution of new issues.

a price discovery mechanism. Potential . . . bidders look to when-issued trading levels as a market gauge of demand in determining how to bid at an auction." Additionally, pre-auction WI sales facilitated distribution of a bill. The 1992 study noted (p. 9) that WI trading "benefits the Treasury by . . . stretching out the actual distribution period for each issue."

In early 1975, the Treasury removed the restriction on pre-auction WI trading in notes and bonds in the course of revising its offering circulars to eliminate "obsolete" provisions.[42] This was an important step in enhancing the efficiency of auction bidding and facilitating the distribution of new issues.[43]

8. Conclusion

The Treasury's success in institutionalizing regular auction sales of notes and bonds in the early 1970s was surprising. Two prior attempts, in 1935 and 1963, had failed and the third attempt came at a time when fixed-income securities prices had become more volatile. That the Treasury even made a third attempt testifies to the significance of Friedman's (1960, pp. 64-5) criticism of fixed-price offerings. However, the two failed attempts demonstrated that the advantages of market-driven auctions were not enough to guarantee that regular auction offerings would succeed: the process of moving from fixed-price offerings to auction sales also had to be managed carefully.

There were three important differences between the coupon-bearing securities auctions of the early 1970s and the 1935 and 1963 auctions. First, the auctions of the early 1970s were closely patterned on the successful and familiar bill auctions and did not introduce any novel bidding rules (as in 1963) or issuance patterns (as in 1935). This structure gave dealers a familiar base for developing their sales and risk management programs.

Second, auctions of coupon-bearing debt in the early 1970s were extended gradually to securities of increasing maturity and did not immediately offer long-term bonds. The extension gave dealers an opportunity to build up their risk management and sales programs gradually.

Finally, the Treasury was willing to modify the auction process when experience suggested that the existing structure could be improved. Most prominently, following the failure of the twenty-year bond auction in August 1973, the Treasury first began to delay announcement of the coupon rate on a new issue until closer to the auction day and then switched to a yield auction format. Similarly, in 1975, the Treasury removed the restriction on when-issued trading before an auction to enhance bidding efficiency and new-issue distribution.

Endnotes

1. Beginning in 1960, the Treasury sometimes refinanced maturing debt by issuing new debt in one or more subscription offerings and using the proceeds to redeem the maturing debt. These operations were called "cash refundings." See Gaines (1962, pp. 174-6) and Banyas (1973, pp. 8-10, 27-30). The subscription offerings in a cash refunding were not different from the subscription offerings used to raise new money.

2. Gaines (1962, pp. 156-7, 165) briefly describes the consultative process. Also see the detailed description in Committee on Government Operations (1956).

3. Banyas (1973, p. 7) and Gaines (1962, p. 82). Prior to World War II, the Treasury was required to sell bonds at par and notes at not less than par (Cecchetti 1988, p. 1119). This requirement precluded fine-tuning bond offerings, and made it difficult to fine-tune note sales because investors were sometimes reluctant to purchase notes at a premium (Banyas 1973, p. 7). Legislation enacted at the beginning of World War II allowed the Treasury to sell bonds at prices other than par and to sell notes at a discount (Banyas 1973, p. 7). The first nonpar bond offering came in June 1958 (U.S. Treasury Department 1959, p. 24; Hallowell and Williamson 1961, p. 82). The first discount note offering came in January 1959 (U.S. Treasury Department 1960, pp. 22-3).

4. Faced with the prospect of an undersubscribed offering, officials sometimes pressured banks and dealers to take up the slack. See "The Under-Subscribed Loan," *New York Times*, September 1, 1935, p. 8 (reporting that "voluntary subscriptions [to a 1931 Treasury bond offering] did not cover the full amount, and official pressure had to be applied to the larger banks to make up the deficiency"), and "Bids Fall Short on U.S. Bond Issue," *New York Times*, August 2, 1973, p. 49 (reporting that "heavy official pressure had been applied to dealers [to increase their subscriptions] on some issues in 1969-70").

5. See, for example, "Treasury Offers $100,000,000 Issue in Financing Test," *New York Times*, May 27, 1935, p. 1 ("under the policy of selling [Treasury] bonds at [fixed prices] it has been necessary for the Treasury so to gauge the market's appetite as to assure the success of an offering, with the result that the interest rate usually has been slightly above the market"), and Gaines (1962, p. 184, "the rate of interest selected should be somewhat above current market rates").

6. See "New Bond Bids Treble Offering," *New York Times*, May 31, 1935, p. 25 ("a profit has usually been realized by those who speculate in Treasury bond offerings, as [the bonds] usually have commanded a premium in the open market immediately after their sale"), Childs (1947, pp. 389-93), Gaines (1962, pp. 171-2, 293), and Friedman (1960, p. 64; 1964, p. 513).

7. The Treasury introduced the option for a holder to choose any of several alternative issues in 1953, following Roosa's (1952, p. 234) suggestion that "Treasury might . . . be able to vary its offering arrangements, and perhaps minimize the risks of miscalculating investor response in some situations, by using a package offering of several issues, thereby spreading the impact of a given operation over several sectors of the market." See also Hallowell and Williamson (1961, p. 82).

8. Federal Reserve Bank of New York Circular no. 6582, July 29, 1970.

9. On at least two occasions, the Federal Reserve directly supported floundering exchange offers. In November 1955, the Treasury offered a one-year certificate of indebtedness and a two-and-a-half-year note in exchange for $12.2 billion of securities maturing on December 15. When market conditions deteriorated sharply on the last day of the subscription period, the Federal Reserve purchased $167 million of the certificates on a when-issued basis. In July 1958, the Treasury offered a one-year certificate of indebtedness in exchange for $16.3 billion of maturing securities. When market conditions became "disorderly" during the subscription period, the Federal Reserve purchased $110 million of the maturing securities and $1,090 million of the certificates on a when-issued basis (Hallowell and Williamson 1961, p. 84).

10. Cecchetti (1988, p. 1117). Hallowell and Williamson (1961, p. 82) state that the Treasury introduced the option to choose any of several new issues specifically to limit attrition: "Treasury runs less risk of attrition on an exchange with a choice, because all its eggs are not in one basket."

11. Hallowell and Williamson (1961, p. 82) remark that "The rights to the long-term issue are likely to be largely in the hands of . . . short-term investors and have to be transferred through the market to those who want them." Gaines (1962, pp. 163-4) points out that, in practice, dealers bought maturing securities, sold the new securities for when-issued settlement, and covered their delivery obligations on the new securities by tendering the old securities in exchange for the new ones.

12. See also Gaines (1962, p. 174) (the decision of investors in June 1958 to exchange $7.4 billion out of $9.6 billion of maturing debt for an intermediate-term bond rather than a one-year certificate of

indebtedness resulted in an "over-issue" of bonds and precipitated a "disorderly market collapse"), and Federal Reserve Bank of Richmond (1961, p. 4) (in the June 1958 refunding, "holders of rights . . . set the size of the respective issues, and . . . took far more of the longer obligation than they wished for investment purposes only").

13. The Treasury did not auction bills on a discount-rate basis until April 1983 ("Treasury Bill Auctions to Use New Bidding Method Effective April 18, 1983," *Treasury News*, March 15, 1983).

14. The Treasury did not auction bills in a single-price format until October 1998 ("Treasury Offers 13-Week and 26-Week Bills," *Treasury News*, October 29, 1998).

15. See also Eckstein and Kareken (1959), Carson (1959, p. 441) (auctions would relieve the Treasury of responsibility for "determining an interest rate which will clear the market . . . [and] eliminate attrition arising from inaccurate estimation of what the market will accept"), and Goldstein (1962, p. 386) ("the auction technique . . . has the virtue of freeing the Treasury from the task of having to set the effective yield on its obligations").

16. U.S. Treasury Department (1940, p. 1157). Dealer unhappiness with the auction process was reported in "New Federal Issue Subscribed 5 Times," *New York Times*, July 19, 1935, p. 25, and "Treasury Retains Bond Auction Plan," *New York Times*, September 14, 1935, p. 14.

17. "Federal Bond Sale Fell Short of Goal," *New York Times*, August 30, 1935, p. 1, "The Under-Subscribed Loan," *New York Times*, September 1, 1935, p. 8, and "Borah Sees Danger Signal," *New York Times*, September 2, 1935, p. 22.

18. "Treasury Announces $50,000,000 Bill Issue," *New York Times*, October 25, 1935, p. 31 (stating that "it was learned . . . today that the Treasury intends to drop, for the time being at least, the auction method of selling bonds"), and "Debt Over $300,000,000 as Treasury Announces Financing of $1,318,000,000," *New York Times*, December 22, 1935, p. 1 (stating that the failed federal agency issue had "brought the use of the [auction] method into question").

19. See also Friedman's testimony before the Joint Economic Committee (Joint Economic Committee 1959b, pp. 3023-6).

20. Friedman (1964, p. 513) ("the [fixed-price] method now used to sell long-term securities . . . makes the Treasury's cost . . . appreciably higher than it would be under either alternative method of bidding").

21. Friedman (1960, p. 65) ("Treasury's published objections to using the auction method for long-term securities all derive from the assumption that the [multiple-price] technique would be used and would be met fully by the [single-price] technique"). As noted earlier, the Treasury's objections were generally matters of small investor participation in the primary market. The subsequent development of the Treasury auction literature focused on the different question of whether the Treasury would derive greater revenue by auctioning securities in a single-price format or in a multiple-price format. See Smith (1966, 1967), Bolten (1973, 1975), Boatler (1975), Goldstein and Kaufman (1975), Tsao and Vignola (1977), Reinhart (1992), Simon (1994), Malvey, Archibald, and Flynn (1995), and Malvey and Archibald (1998).

22. Federal Reserve Bank of New York Circular no. 5224, September 14, 1962.

23. Federal Reserve Bank of New York Circular no. 5282, January 8, 1963.

24. "Treasury Experiment," *New York Times*, January 11, 1963, p. 6.

25. "Treasury Raises $300 Million in Auction of Long-Term Bonds," *New York Times*, April 10, 1963, p. 51, "Bonds: Market Unsettled by $300,000,000 Long-Term Offering by U.S. Treasury," *New York Times*, April 10, 1963, p. 56, "Bond Syndicate Being Broken Up," *New York Times*, April 26, 1963, p. 47, and "Bonds: Treasury's New Issue Declines after Restrictions End," *New York Times*, April 27, 1963, p. 32.

26. "Reception Is Cool to U.S. Bond Issue," *New York Times*, April 14, 1963, sec. 3, p. 1, and "U.S. to Try Again on Underwriting," *New York Times*, April 21, 1963, sec. 3, p. 1.

27. "Bond Syndicate Being Broken Up," *New York Times*, April 26, 1963, p. 47.

28. See, for example, "Auctioning U.S. Debt," *New York Times*, February 19, 1969, p. 61 ("there would appear to be no reason . . . why [Treasury] obligations of any maturity could not be sold at auction").

29. By the late 1950s, a large fraction of Treasury notes and bonds matured in mid-February, mid-May, mid-August, or mid-November. The midquarter maturities were intended to reduce "the number of times each year that Treasury financing interferes with other borrowers such as corporations, States, and municipalities," and to facilitate the execution of monetary policy (U.S. Treasury Department

Note 29 continued
1959, pp. 25-6). Exchange offerings to refinance these issues were commonly called "midquarter refundings."

30. Federal Reserve Bank of New York Circular no. 6629, October 30, 1970, and Circular no. 6631, November 2, 1970.

31. Federal Reserve Bank of New York Circular no. 6629, October 30, 1970. The Treasury limited bids to not less than 99.76 to preclude the possibility that different blocks of the notes might be taxed differently and would therefore not be fungible with each other. (This phenomenon occurred when the Treasury reopened the 3 7/8 percent note of August 13, 1965, in April 1964. See Banyas [1973, p. 8].) The original issue discount (OID) rule in effect at the time provided that if a fixed-income security was issued at a discount to principal value in excess of the number of full years to maturity times .25, the discount would be taxed as ordinary income rather than as a capital gain. An eighteen-month note has one full year to maturity, so the OID threshold was 99.75.

32. "Proposals on Reform of Debt Management Offered by Volcker," *New York Times*, March 8, 1972, p. 57.

33. Federal Reserve Bank of New York Circular no. 7071, December 27, 1972.

34. "Prices of Treasury Bonds Decline in Light Trading," *New York Times*, December 29, 1972, p. 39.

35. Kaufman (1973, p. 170).

36. Federal Reserve Bank of New York Circular no. 7201, August 2, 1973, and "Bond Prices Drop in Gloomy Market," *New York Times*, August 1, 1973, p. 51. The lowest prices the Treasury said it would accept were marginally above the OID thresholds of 99.00 for a four-year note and 95.00 for a twenty-year bond. See also Baker (1976, p. 148).

37. Federal Reserve Bank of New York Circular no. 7456, September 16, 1974. See also Carson (1959, p. 441) and Baker (1976, p. 148; 1979, p. 206).

38. *The Goldsmith-Nagan Bond and Money Market Letter*, August 3, 1974.

39. Subcommittee on Securities of the Committee on Banking, Housing, and Urban Affairs (1991, p. 409). Baker (1979, pp. 205-6) discusses in some detail the decision to adopt a single-price format in 1973 but does not comment on why the Treasury abandoned that format in mid-1974. Two papers (Tsao and Vignola 1977; Simon 1994) subsequently examined whether the Treasury received more aggressive bids in the six single-price auctions or the ten multiple-price auctions of long-term bonds held between February 1973 and August 1976. Neither paper comments on why the Treasury abandoned the single-price format. Chari and Weber (1992, p. 4) state that the Treasury "abandoned the experiment [with single-price auctions] as largely inconclusive," but do not cite a source. The Treasury returned to the single-price format for two- and five-year note auctions in 1992 and for the balance of its auction offerings in 1998.

40. Tender for 6 3/4 percent Treasury notes dated November 16, 1970, and due May 15, 1972.

41. The December 11, 1940, offering of five-year notes was the first offering to require that a subscriber certify that "no arrangements have been or will be made for the sale or other disposition of this subscription, or of the securities which may be allotted thereon, prior to the closing of the subscription books" (tender for three-quarter percent notes, series B-1945, National Defense Series, dated December 18, 1940, due December 15, 1945). The restriction subsequently appeared on some, but not all, subscription offerings of coupon-bearing securities during World War II. Childs (1947, pp. 372-3, 375-6, 389-92) recounts the origins of the restriction and states that it was intended to limit free-riding. The Treasury did not make any subscription offerings from 1946 to 1951 and it did not explicitly impose the restriction in connection with any subscription offerings from 1952 to 1958. However, the restriction appears on every subscription offering beginning with the January 1959 offerings of sixteen-month notes and twenty-one-year bonds.

42. The characterization of the restriction on WI trading as "obsolete" appears in a Treasury statement reprinted in Federal Reserve Bank of New York Circular no. 8147, July 15, 1977.

43. The Treasury reimposed the restriction in July 1977, "after monitoring the development and expansion of trading in Treasury securities prior to the actual auctions, and in some cases, prior even to the announcement of an offering" and after concluding that when-issued trading "does not contribute to the efficient marketing of

new . . . issues and may, in fact, facilitate undesirable speculative activity in Treasury securities” (Federal Reserve Bank of New York Circular no. 8147, July 15, 1977). However, greater volatility of interest rates after October 1979 and a rapidly growing federal deficit led to renewed suggestions from the dealer community that pre-auction WI trading would facilitate price discovery and new-issue distribution (author’s conversation with Mark Stalnecker, Deputy Assistant Secretary for Federal Finance, 1981-82). The Treasury removed the restriction a second time in August 1981, characterizing it as “an unnecessary regulation which is believed to hinder the efficient adjustment of market prices to announcements of Treasury financing” (Federal Reserve Bank of New York Circular no. 9128, August 17, 1981).

References

Baker, C. 1976. "Auctioning Coupon-Bearing Securities: A Review of Recent Experience." In Y. Amihud, ed., Bidding and Auctioning for Procurement and Allocation, 146-51. New York: New York University Press.

———. 1979. "The Basis and Practice of Treasury Debt Management." In M. Dooley, H. Kaufman, and R. Lombra, eds., The Political Economy of Policy-Making, 175-218. Beverly Hills, Calif.: Sage Publications.

Banyas, L. 1973. "New Techniques in Debt Management from the Late 1950's through 1966." In Joint Treasury-Federal Reserve Study of the U.S. Government Securities Market, Staff Studies—Part 3. Washington, D.C.: Board of Governors of the Federal Reserve System.

Boatler, R. 1975. "Treasury Bill Auction Procedures: An Empirical Investigation: Comment." Journal of Finance 30, no. 3 (June): 893-4.

Bolten, S. 1973. "Treasury Bill Auction Procedures: An Empirical Investigation." Journal of Finance 28, no. 3 (June): 577-85.

———. 1975. "Reply." Journal of Finance 30, no. 3 (June): 900-1.

Carson, D. 1959. "Treasury Open Market Operations." Review of Economics and Statistics 41, no. 4 (November): 438-42.

Cecchetti, S. 1988. "The Case of the Negative Nominal Interest Rates: New Estimates of the Term Structure of Interest Rates during the Great Depression." Journal of Political Economy 96, no. 6 (December): 1111-41.

Chari, V., and R. Weber. 1992. "How the U.S. Treasury Should Auction Its Debt." Federal Reserve Bank of Minneapolis Quarterly Review 16, no. 4 (fall): 3-12.

Childs, C. 1947. Concerning U.S. Government Securities. Chicago, Ill.: C. F. Childs and Company.

Committee on Government Operations. 1956. "Debt Management Advisory Committees (Treasury Department)." Hearings before a Subcommittee of the Committee on Government Operations. U.S. House of Representatives, 84th Cong., 2nd Sess., June 5 and 7.

Eckstein, O., and J. Kareken. 1959. "A Background Memo on the Use of the Auction Technique for Marketing Treasury Securities." Memorandum prepared for the Joint Economic Committee. Reprinted in Joint Economic Committee (1959a, pp. 1257-8).

Federal Reserve Bank of Richmond. 1961. "The Longer She Stands the Shorter She Grows." Federal Reserve Bank of Richmond Monthly Review, April: 2-5.

Friedman, M. 1960. A Program for Monetary Stability. New York: Fordham University Press.

———. 1964. Comment on "Collusion in the Auction Market for Treasury Bills." Journal of Political Economy 72, no. 5 (October): 513-4.

Gaines, T. 1962. Techniques of Treasury Debt Management. Glencoe, Ill.: Columbia University Graduate School of Business Administration and the Free Press of Glencoe.

Goldstein, H. 1962. "The Friedman Proposal for Auctioning Treasury Bills." Journal of Political Economy 70, no. 4 (August): 386-92.

Goldstein, H., and G. Kaufman. 1975. "Treasury Bill Auction Procedures: Comment." Journal of Finance 30, no. 3 (June): 895-9.

Hallowell, B., and K. Williamson. 1961. "Debt Management's Contribution to Monetary Policy." Review of Economics and Statistics 43, no. 1 (February): 81-4.

Joint Economic Committee. 1959a. "Employment, Growth, and Price Levels, Part 6A—The Government's Management of Its Monetary, Fiscal, and Debt Operations." Hearings before the Joint Economic Committee. U.S. Congress, 86th Cong., 1st Sess., July 24, 27, 28, 29, and 30.

———. 1959b. "Employment, Growth, and Price Levels, Part 9A—Constructive Suggestions." Hearings before the Joint Economic Committee. U.S. Congress, 86th Cong., 1st Sess., October 26-30.

Kaufman, H. 1973. "Federal Debt Management: An Economist's View from the Marketplace." In Issues in Federal Debt Management, 155-74. Boston, Mass.: Federal Reserve Bank of Boston.

References (Continued)

Malvey, P., and C. Archibald. 1998. "Uniform-Price Auctions: Update of the Treasury Experience." U.S. Treasury Department. Available at <http://www.ustreas.gov/offices/domestic-finance/debt-management/auctions-study/upas2.pdf>.

Malvey, P., C. Archibald, and S. Flynn. 1995. "Uniform-Price Auctions: Evaluation of the Treasury Experience." U.S. Treasury Department. Available at <http://www.ustreas.gov/offices/domestic-finance/debt-management/auctions-study/final.pdf>.

Reinhart, V. 1992. "An Analysis of Potential Treasury Auction Techniques." Federal Reserve Bulletin 78, no. 6 (June): 403-13.

Roosa, R. 1952. "Integrating Debt Management and Open Market Operations." American Economic Review 42, no. 2 (May): 214-35.

Simon, D. 1994. "The Treasury's Experiment with Single-Price Auctions in the Mid-1970s: Winner's or Taxpayer's Curse?" Review of Economics and Statistics 76, no. 4 (November): 754-60.

Smith, V. 1966. "Bidding Theory and the Treasury Bill Auction: Does Price Discrimination Increase Bid Prices?" Review of Economics and Statistics 48, no. 2 (May): 141-6.

_____. 1967. "Experimental Studies of Discrimination versus Competition in Sealed-Bid Auction Markets." Journal of Business 40, no. 1 (January): 56-84.

Subcommittee on Securities of the Committee on Banking, Housing, and Urban Affairs. 1991. "The Activities of Salomon Brothers, Inc. in Treasury Bond Auctions." Hearings before the Subcommittee on Securities of the Committee on Banking, Housing, and Urban Affairs. U.S. House of Representatives, 102nd Cong., 1st Sess., September 11 and 12.

Tsao, C., and A. Vignola. 1977. "Price Discrimination and the Demand for Treasury's Long-Term Securities." Unpublished paper, U.S. Treasury Department.

U.S. Treasury Department. 1940. "Selling U.S. Government Direct and Guaranteed Issues by Tender." Staff memorandum. Reprinted in Joint Economic Committee (1959a, pp. 1156-61).

———. 1959. Annual Report for the Fiscal Year Ended June 30, 1958. Washington, D.C.: U.S. Government Printing Office.

———. 1960. Annual Report for the Fiscal Year Ended June 30, 1959. Washington, D.C.: U.S. Government Printing Office.

———. 1972. Annual Report for the Fiscal Year Ended June 30, 1972. Washington, D.C.: U.S. Government Printing Office.

U.S. Treasury Department, Securities and Exchange Commission, and Board of Governors of the Federal Reserve System. 1992. "Joint Report on the Government Securities Market." Washington, D.C.: U.S. Government Printing Office.

Brian Sack and Robert Elsasser

Treasury Inflation-Indexed Debt: A Review of the U.S. Experience

- Treasury inflation-indexed securities (TIIS) have yet to live up to one of their primary goals: reducing the U.S. Treasury's expected financing costs.
- Since 1997, yields on TIIS have been surprisingly high relative to yields on comparable nominal Treasury securities, with the spread between yields falling, on average, well below survey measures of long-run inflation expectations.
- This study attributes this "valuation puzzle" to several factors: investor difficulty adjusting to a new asset class, divergent supply trends between TIIS and nominal Treasuries, and the lower liquidity of TIIS. In addition, investors may have had a benign outlook for inflation and inflation risks.
- More recently, the liquidity and breadth of investor participation in the TIIS market have increased notably, and the valuation of these securities appears to have improved.

1. Introduction

In January 1997, the U.S. Treasury began issuing Treasury inflation-indexed securities (TIIS)—debt securities with coupon and principal payments that adjust in line with a measure of consumer prices. Through 2003, the Treasury had issued $172 billion of these securities, with maturity dates ranging from 2002 to 2032. By the end of 2003, the amount of TIIS outstanding (including inflation accrual) totaled approximately $176 billion, or nearly 7 percent of all outstanding Treasury notes and bonds.

Inflation-indexed debt held the promise of providing benefits to both investors and the Treasury. Investors could benefit, it was argued, from access to a new type of asset that reduces the risks associated with inflation. By purchasing inflation-indexed securities, they could lock in a real rate of return—measured in terms of the amounts of goods and services that can be purchased—over the maturity of the security, thereby protecting themselves against the possibility that an unexpected rise in inflation would erode the real return on a nominal debt security.[1] Moreover, the Treasury's willingness to issue TIIS could provide a benchmark that would spur private issuance of inflation-indexed securities.

The Treasury would also benefit, some argued, because the issuance of inflation-indexed debt would likely reduce its

Brian Sack is chief of the Monetary and Financial Market Analysis section of the Board of Governors of the Federal Reserve System; Robert Elsasser is a vice president in the Markets Group of the Federal Reserve Bank of New York.
<brian.sack@frb.gov>
<robert.elsasser@ny.frb.org>

This article has benefited from numerous conversations with Jim Clouse and Doug Elmendorf, as well as with other members of the Board of Governors of the Federal Reserve System, the Federal Reserve Bank of New York, and the U.S. Treasury Department. We thank Patrick Dwyer, Bill English, Michael Fleming, Kenneth Garbade, Jeff Huther, Dino Kos, Deborah Perelmuter, Vincent Reinhart, and David Wilcox for valuable comments, and Stephanie Sam for statistical assistance. The views expressed are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

financing costs. The rationale was that investors typically demand a higher return on nominal debt securities to compensate for the risks associated with future inflation. By issuing inflation-indexed debt, the Treasury would eliminate that risk for investors and therefore avoid having to pay this "inflation risk premium," which would also lower its financing costs.[2]

In addition, some argued that issuing indexed debt would offer ancillary benefits by providing policymakers and market participants with a useful reading of real interest rates. In that case, comparing the yields on TIIS with those on nominal securities would provide a measure of the amount of compensation that investors demand to offset future inflation and the associated risks—a potentially useful gauge for monetary policymakers.

This article describes the U.S. experience with inflation-indexed debt, including the evolution of activity in the TIIS market since its inception and the valuation of those securities relative to nominal Treasury issues. We show that despite the potential appeal of TIIS, their yields have been surprisingly high relative to those on comparable nominal Treasury securities. Indeed, the spread between ten-year yields on nominal securities and TIIS has, on average, fallen about 50 basis points below the long-run inflation expectations reported in the Survey of Professional Forecasters, conducted by the Federal Reserve Bank of Philadelphia. We analyze several explanations for this "valuation puzzle" as well as offer evidence that bears on those explanations.

Despite the potential appeal of TIIS [Treasury inflation-indexed securities], their yields have been surprisingly high relative to those on comparable nominal Treasury securities.

One possibility is that the low relative valuation of TIIS has reflected investor difficulty adjusting to a new asset class. Over much of the period examined, participation in the TIIS market has been quite limited, although the investor base appears to have broadened considerably in recent years.

A second possibility is that divergent trends in supply affected the relative values of TIIS and nominal Treasury securities over this period. The market had to digest fairly rapid growth in the supply of TIIS at a time when investor participation was subdued, which may have put upward pressure on the yields of those securities. The robust expansion in outstanding TIIS contrasted with substantial declines in the supply of nominal Treasury notes and bonds from 1997 to early 2002.

A third possibility is that the low relative valuation of TIIS has reflected the lower liquidity of those securities. TIIS liquidity was particularly poor during the first several years of the securities' existence. Liquidity has improved in recent years as participation in the market has expanded, but TIIS will likely never achieve the same liquidity as nominal Treasury debt, largely because of the different roles that the two types of securities play in financial markets. As we discuss, TIIS are held primarily by "end users," or investors that tend to buy and hold the instruments. By contrast, nominal Treasury securities, especially recently issued ones, are to a large extent used as hedging and trading instruments, with primary dealers playing a very active role in the market.[3]

Factors such as the difficulty of launching a new asset class, supply trends, and the lower liquidity of indexed debt clearly have weighed on the valuation of TIIS over parts of our study period. However, even after adjusting for the influence of these factors, we argue that the observed valuation of TIIS relative to nominal Treasury securities suggests that investors simply had a very benign outlook for inflation over this period and did not demand much, if any, of an inflation risk premium for holding nominal securities.

Because of the low valuation of TIIS relative to nominal securities, inflation-indexed debt has not yet lived up to its purpose of reducing financing costs for the Treasury.[4] Our results suggest that based on inflation through mid-2003, the TIIS program has cost the Treasury nearly $3 billion more than the issuance of comparable nominal securities. Moreover, we find that future consumer price index (CPI) inflation would have to come in at about 1.7 percent for the Treasury to break even on the outstanding TIIS securities. According to the Survey of Professional Forecasters, long-run inflation is expected to be about 2.5 percent. If that forecast proves accurate, the Treasury would pay roughly 80 basis points of additional financing costs on the outstanding TIIS relative to comparable nominal securities.

Nevertheless, the TIIS market seems to be evolving. Anecdotal evidence suggests that investor participation in the market has widened considerably in recent years and that the liquidity of TIIS has increased noticeably. Moreover, these developments appear to have coincided with some improvement in the relative valuation of TIIS, although the evidence is still quite tentative to date.

2. The Mechanics of TIIS

Treasury inflation-indexed securities differ from nominal debt securities in the sense that payments on the TIIS adjust over time based on the rate of CPI inflation. More specifically, the principal amount of the TIIS increases daily by an amount determined by the increase in the CPI measure between the third and second preceding months—the minimum indexation lag possible given the timing of the CPI data release. Coupon payments on TIIS are determined as a fixed percentage of the indexed principal amount and therefore also increase in line with the CPI. Because of indexation, the principal and coupon payments on the TIIS are fixed in real terms—that is, on an inflation-adjusted basis. As a result, the quoted yield on a TIIS is approximately the real rate of return that an investor would earn by holding the security to maturity.[5]

The spread between the yield on a TIIS and that on a comparable nominal security—often called the rate of inflation compensation—is influenced by investors' views about future inflation. (See the appendix for a more formal discussion of the pricing of TIIS relative to nominal securities.) If investors were risk-neutral, the rate of inflation compensation would (approximately) equal the annualized cumulative rate of inflation that investors expect over the maturity of the security, up to an adjustment for convexity. The reason is that investors would demand the same expected return on the two securities, equal to the quoted yield for the nominal security or to the sum of the quoted yield on the TIIS and the expected inflation accrual.

As one might expect, this leaves open the issue of determining the appropriate nominal security to compare with the TIIS. The most common practice is to use a nominal coupon security with a similar maturity. However, the two securities have different payment flows: the nominal payments on the TIIS are much more back-loaded than those on a standard nominal coupon security; in real terms, the coupon payments on the nominal security decline over time, unlike the constant real coupon payments on a TIIS.[6] We explicitly take this issue into account later when calculating the relative cost of TIIS.

One complication with interpreting inflation compensation involves the adjustment for convexity. For a given level of the yield on a nominal security, uncertainty about future inflation increases the expected return on that security. This is a mechanical relationship that arises from the convexity of real returns in inflation—specifically, because higher inflation erodes the real return on the security at a slower rate than lower inflation boosts it (see the appendix). This point was originally made by Fischer (1975); a more recent description of the relationship between inflation compensation and future inflation can be found in McCulloch and Kochin (1998).

Although convexity tends to pull down inflation compensation relative to expected inflation, there may be an inflation risk premium that works in the opposite direction.

The spread between the yield on a TIIS and that on a comparable nominal security—often called the rate of inflation compensation—is influenced by investors' views about future inflation.

Indeed, investors are most likely not risk-neutral and hence will not expect to earn the same return on a TIIS and a nominal Treasury security. Because future inflation erodes the real payments on a nominal security but not those on a TIIS, one might expect risk-averse investors to demand a higher expected return on nominal securities when future inflation is uncertain. Such a risk premium would push up inflation compensation relative to expected inflation, thereby increasing the financing cost to the Treasury on nominal debt securities. Indeed, eliminating this additional cost was one of the primary arguments for issuing TIIS.

Unfortunately, the inflation risk premium is difficult to measure, and there is considerable uncertainty about its magnitude and even its sign. One estimate comes from Campbell and Shiller (1996), who use the historical behavior of inflation and real interest rates in a capital asset pricing model to estimate the inflation risk premium for the five-year nominal bond.[7] They estimate the inflation risk premium to be between 50 and 100 basis points.

A final consideration in valuing TIIS is that the securities offer deflation protection, in the sense that the cumulative adjustment to the principal amount of the inflation-indexed security at maturity cannot be negative. In terms of real returns, this feature gives investors a put option on cumulative inflation with a strike of zero. We ignore the value of this option in assessing the spread between nominal and inflation-indexed debt. Over most of our sample, the option was likely viewed as being sufficiently out-of-the-money so as to have little value.

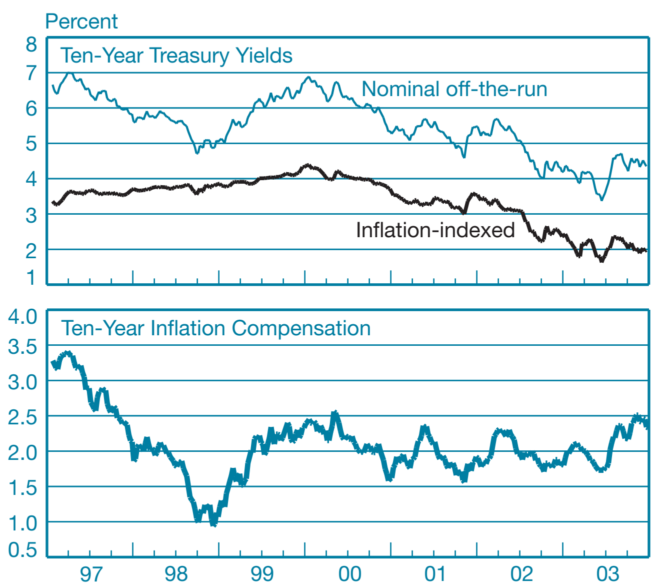
3. TIIS Market Developments

The TIIS program got off to an impressive start. The program's inaugural auction of a ten-year note in January 1997 was very well received by investors, creating a brief period of enthusiasm for the new asset class. The amount of bids at the first auction was impressive, with a bid-to-cover ratio (the amount of bids divided by the amount issued) equal to 5.3, compared with only 2.4 and 1.9 for the preceding and subsequent nominal ten-year-note auctions, respectively. Moreover, the stop-out rate (the yield at which the security was issued based on investor bidding) for the inaugural auction was 3.449 percent, which was more than 3 percentage points below the yields on comparable nominal Treasury securities.[8]

The spread between nominal and TIIS yields that prevailed over the first several months would in fact be the widest level observed during the TIIS program to date. Chart 1 shows the history of the yields on nominal and inflation-indexed ten-year Treasury securities, where an off-the-run nominal yield is used to limit the difference in the liquidity of the nominal and indexed securities.[9] (Off-the-run securities are previously issued securities, which are much less liquid than the most recently issued, or on-the-run, securities. The liquidity of off-the-run securities and TIIS is discussed in more detail below.)

Chart 1

Treasury Yields and Inflation Compensation



Source: Smoothed yield curves are estimated by the Board of Governors of the Federal Reserve System based on proprietary market quotes collected by the Federal Reserve Bank of New York.

Note: Inflation compensation is measured relative to off-the-run nominal Treasury securities.

The chart's bottom panel shows a measure of ten-year inflation compensation based on the difference between the nominal and indexed yields. We see that the inflation compensation measure averaged about 3 1/4 percent over the first several months of 1997, which was greater than the prevailing level of inflation expectations from various surveys. In response to the favorable valuation of indexed debt, the initial Treasury offering was followed by a flurry of other borrowers issuing inflation-indexed securities of their own. Between February and July 1997, fifteen different U.S. non-Treasury issuers offered a total of $2.3 billion of inflation-indexed securities.

The TIIS program got off to an impressive start. The program's inaugural auction of a ten-year note in January 1997 was very well received by investors, creating a brief period of enthusiasm for the new asset class.

The enthusiasm for inflation-indexed debt was not long-lived, though. Inflation compensation fell steadily over 1997 (Chart 1), reaching a level of about 2 percent during the first half of 1998. This decline may partly reflect the fact that the strongest demand for TIIS—by those investors willing to give up the largest amount of yield to hold inflation-indexed rather than nominal securities—was quickly saturated. In addition, the fall in inflation compensation may be partly attributed to a broad decline in inflation expectations. In 1997, various currency crises abroad and concerns about a global economic slowdown, particularly in Asia, dominated market attention. As commodity prices plummeted and the dollar surged, inflation indicators consistently fell below expectations. Chart 2 shows the actual headline CPI figure and the unexpected component of the monthly CPI release calculated from a Bloomberg survey of market participants. Throughout this period, inflation declined to very low levels and consistently surprised market participants to the downside. In this environment, investors apparently had little interest in purchasing the inflation protection offered by TIIS.

In the fall of 1998, financial market volatility abroad spread to U.S. financial markets, causing investors to place great value on the liquidity of their portfolios. The increased preference for liquidity at that time pushed down nominal yields relative to TIIS yields, given that nominal securities are more liquid (Chart 1). On-the-run nominal Treasury securities were viewed as the ultimate liquid instruments, but even off-the-run

Treasuries benefited, which contributed to the sharp decline in their yields. In contrast, yields on TIIS dipped only modestly, as trading activity in these securities was reportedly viewed as too limited to provide the flexibility needed in such unpredictable market conditions. As a result, inflation compensation fell to a remarkably low level, reaching a trough at around 1 percent in October 1998.

Over the first half of 1999, some of the factors that may have been limiting the appeal of TIIS began to unwind. CPI inflation turned higher and began to show some upward momentum (Chart 2), in part due to considerable increases in energy prices. In addition, investors' preference for liquidity, while still elevated, fell back from its extreme levels. In response, inflation compensation rose sharply over the first half of 1999.

Since 1999:2, movements in nominal and TIIS yields appear to have become more correlated, and inflation compensation has remained in a narrower range—typically between 1 1/2 and 2 1/2 percent—in contrast to the wide swings seen during the first two years of the TIIS program. Inflation compensation edged higher over most of 1999 as the economy grew at a rapid

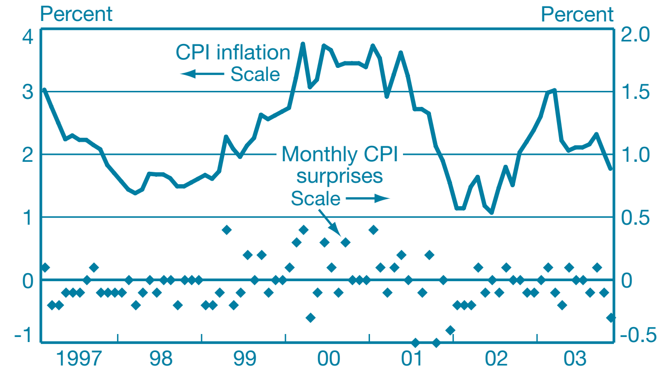
The spread between nominal and TIIS yields that prevailed over the first several months would in fact be the widest level observed during the TIIS program to date.

pace and reached a new peak at slightly more than 2 1/2 percent in May 2000, when concerns about inflation seemed to crest. TIIS yields also rose over this period as the tightening of monetary policy led to expectations of a higher path for real interest rates.

As the growth of the economy moderated over the latter part of 2000, real interest rates and inflation compensation drifted lower. Once it became apparent late in 2000 that the economy was slowing more rapidly, real interest rates and inflation compensation fell considerably, although inflation compensation retraced part of that decline after the Federal Reserve began to ease monetary policy in early 2001. Inflation compensation remained at fairly low levels on average through mid-2003, as the recession and the resulting slack in resource utilization damped inflation pressures. Real yields also fell dramatically, as the Federal Reserve cut the federal funds rate to 1 percent. More recently, inflation compensation again turned higher as investors became more optimistic about the economic outlook.

Additional information about real interest rates can be obtained by looking at the term structure of TIIS yields. Chart 3 presents several snapshots of the TIIS yield curve over the past four years. It shows that the curve shifted down somewhat from mid-2000 to early 2001, as investors came to expect slower economic growth and some easing of monetary policy. Realized policy easing through early 2002 was much more aggressive than expected, causing the TIIS curve to fall further and to steepen dramatically. Indeed, the yield on the TIIS maturing in 2002 declined all the way to, and even below, zero.[10] TIIS yields generally continued to move lower in 2003, as the economic recovery turned out to be more anemic than expected, although by the end of the sample they had risen off their lows reached earlier in the year.

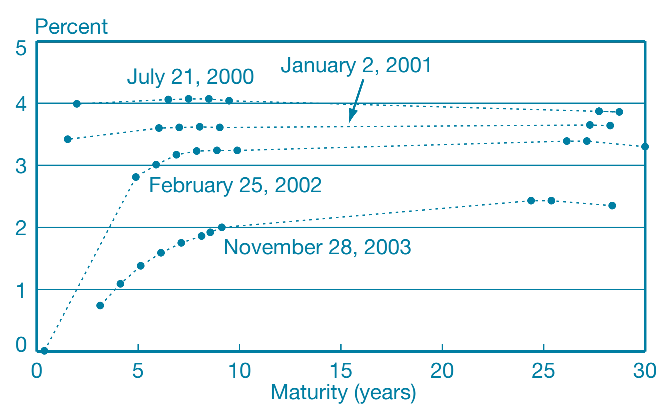
Chart 2
CPI Inflation and Expectation Errors



Sources: U.S. Department of Labor, Bureau of Labor Statistics (CPI); Bloomberg (CPI expectations).

Notes: Consumer price index (CPI) inflation is the twelve-month change in the nonseasonally adjusted overall index. Data are through November 2003.

Chart 3
Yield Curves of Treasury Inflation-Indexed Securities



Source: Bloomberg.

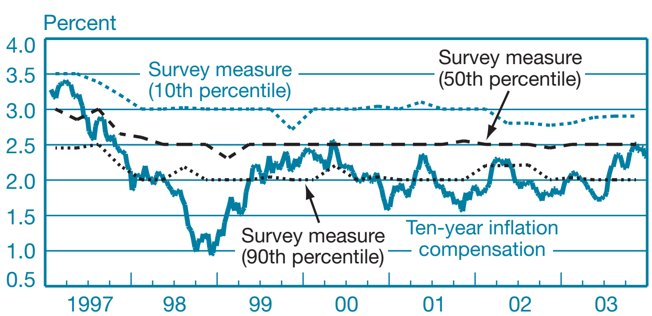
4. The Low Relative Valuation of TIIS

Although recent trends in TIIS and nominal Treasury yields seem reasonable given the changes in macroeconomic conditions that have taken place, the *level* of TIIS yields relative to nominal yields has been somewhat puzzling. In particular, the yields on TIIS have been quite high relative to nominal Treasury yields, so that the level of inflation compensation has consistently fallen below many survey measures of expected inflation. Chart 4 again shows the ten-year inflation compensation measure plotted with a measure of ten-year inflation expectations from the Survey of Professional Forecasters, conducted by the Federal Reserve Bank of Philadelphia. On average, market-based inflation compensation has been about 50 basis points below the median survey response. This average difference is only slightly smaller (45 basis points) if we focus only on the period since early 1999, when inflation compensation seemed to stabilize somewhat. Even more striking, the level of inflation compensation has often fallen around or below the responses of 90 percent of the survey participants.[11]

One consideration is whether the difference between inflation compensation and the survey measure can be explained by the convexity adjustment described earlier. This adjustment is likely not large enough to account for the difference. Under a reasonable estimate of uncertainty about future inflation (discussed in Section 5), the convexity effect decreases ten-year inflation compensation by 11 basis points or less—a small portion of the average 50-basis-point gap between inflation compensation and the survey.

Chart 4

Inflation Compensation and a Survey Measure of Inflation Expectations



Source: Federal Reserve Bank of Philadelphia, Survey of Professional Forecasters.

Note: The survey measure is expected ten-year consumer price index inflation.

The findings from Chart 4 suggest either that some special factors weighed on TIIS prices, or that investors had very low perceptions of future inflation and the associated risks. We now consider some of these possible interpretations.

4.1 Difficulty Adjusting to a New Asset Class

The low valuations of TIIS may, in part, reflect the difficulties associated with launching a new type of asset. The securities are somewhat complex and likely require a nontrivial investment in a potential buyer's infrastructure (such as accounting and trading systems), thereby hindering the expansion of the investor base. Furthermore, investors have had only a relatively short track record of evaluating the behavior of these securities, including the likely volatility of TIIS prices and their correlations with other asset prices. Given these considerations, one might expect it to take some time to build a sizable investor base for the TIIS market.

Data on the distribution of end users of TIIS are not available, but anecdotal reports suggest that the investor base for these securities has been much more concentrated than the base for nominal Treasuries. As expected, the primary participants in the market are large institutional investors such as pension funds and insurance companies—investors with significant amounts of long-term real liabilities that can be counterbalanced by holding long-term real assets.

Notably, the primary dealers, which are the major participants in the market for nominal Treasury securities, have generally been much less active in the TIIS market than they are in the nominal Treasury market. For the dealer activity present in the TIIS market, trading volume is concentrated among a small number of dealers. The share of total TIIS transaction volume among the top quintile of primary dealers averaged 80 percent in 2002, compared with 47 percent for nominal Treasury securities.

Importantly, however, investor interest in the TIIS market appears to have expanded significantly in the past couple of years. Large numbers of investors reportedly have entered the market, particularly after the Treasury reaffirmed its commitment to the TIIS program in February 2002 and indicated that it would seek ways to develop the market further.[12] Indeed, dealers report that their customer base has been expanding robustly, particularly among medium-sized institutional investors. Moreover, anecdotal reports suggest that several dealers began to increase their market-making activity in the TIIS market in late 2002 and 2003.

In addition, small investors appear to be increasing their holdings of TIIS. At least seven different companies currently offer mutual funds that hold inflation-indexed securities. The most recent data available from these funds indicate that the funds have a total of approximately $16 billion in assets. These holdings still represent only a modest portion of outstanding TIIS, but the funds are growing rapidly. In fact, the total amount of assets in the funds appears to have expanded five-fold since 2001.

Overall, the "newness" of TIIS was probably an important factor weighing on the valuations of the securities over the earlier parts of our study period. The fact that the breadth of investor participation in the market has continued to increase even recently suggests that it has taken some market participants quite a long time to incorporate TIIS into their investment strategies. At this point, however, any lingering effect of this adjustment process on the valuation of TIIS has probably diminished substantially. TIIS have now traded in the market for more than seven years, giving potential investors enough experience to understand and adjust to the asset class.

Investor interest in the TIIS market appears to have expanded significantly in the past couple of years.

4.2 Lower Liquidity of TIIS

Another factor that may have weighed on the value of TIIS is their lower liquidity relative to that of nominal Treasury debt.[13] As we observed, primary dealers are generally much less active in the TIIS market than they are in the nominal Treasury market. The inactivity of the primary dealers largely reflects the fact that TIIS do not play the same role as hedging and trading vehicles that nominal Treasuries do, in part because of the absence of private inflation-indexed debt that needs to be hedged. As a result, dealer positions in TIIS pale in comparison to those in nominal securities. Over 2002, for example, primary dealers in total had an average of $102 billion in long positions in nominal Treasury coupon securities and $164 billion in short positions. By comparison, those same dealers had on average only $7 billion in long positions in TIIS and $4 billion in short positions.

Instead, activity in the TIIS market is dominated by end users that might find the securities appealing as an investment vehicle (a buy-and-hold asset). This characteristic can be seen from Chart 5, which shows weekly trading volume in TIIS reported by primary dealers as a percentage of total outstanding TIIS (the turnover rate). Most of the trading in the TIIS market takes place between dealers and customers. Further evidence of the greater appeal of TIIS to institutional investors than to primary dealers is available from the awards at Treasury auctions. Over 2001 and 2002, an average of 77.5 percent of the awards of nominal ten-year Treasury notes went to primary dealers and only 8.2 percent went directly to institutional investors such as mutual funds, pension funds, and insurance companies. By contrast, 54.7 percent of the awards at ten-year TIIS auctions went to primary dealers while 30.5 percent went to institutional investors.[14]

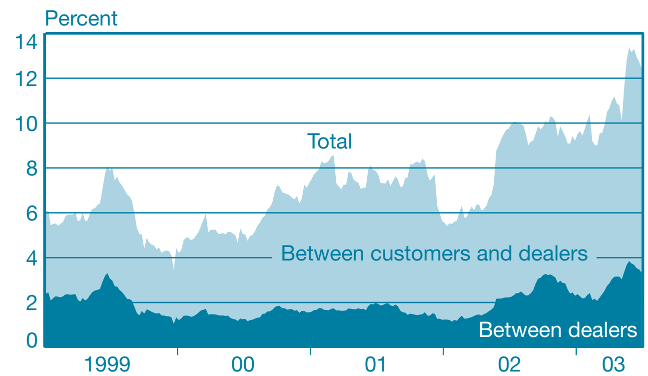
Given these differences in the composition of market participants and in the nature of trading activity, the liquidity of TIIS will likely never rival that of on-the-run nominal Treasury securities. Nevertheless, anecdotal reports suggest that TIIS liquidity has improved much in recent years and is currently not far below that of off-the-run nominal Treasuries.

These anecdotal reports are corroborated by the trading volumes depicted in Chart 5. As is evident, trading activity increased significantly over this period, with the weekly turnover rate reaching an average of about 11 percent over the first three quarters of 2003, compared with an average of less than 6 percent in 1999. In dollar terms, trading volume

Chart 5

Trading Turnover of Treasury Inflation-Indexed Securities

Weekly Trading Volume Relative to Outstanding Debt



Sources: Federal Reserve Bank of New York (trading volume); U.S. Treasury Department (outstanding amounts).

Notes: The series shown are thirteen-week moving averages. Data are through August 2003.

increased even faster, given that the supply of TIIS was expanding robustly over this period. This improvement has largely coincided with the greater participation of investors and dealers in the TIIS market.

The 11 percent turnover rate for TIIS is not far below the rate for some other types of fixed-income assets. Indeed, the average weekly turnover rate for agency debt securities over the same period was roughly 17 percent; for mortgage-backed securities, it was about 21 percent. Trading volume in nominal Treasury securities was instead much higher over that period, with an average weekly turnover rate of 82 percent across all outstanding coupon securities. It is important to note, though, that most of this trading took place in on-the-run issues, which turned over more than fourteen times per week on average and accounted for 74 percent of the total volume in Treasury coupon securities. Excluding on-the-run issues, we note that the turnover rate for all off-the-run Treasury coupon securities was approximately 22 percent—much closer to, although still above, the turnover rate for TIIS.

TIIS also appear to be somewhat less liquid than off-the-run nominal Treasury securities when liquidity is measured by transaction costs. Table 1 summarizes indicative bid-ask spreads observed for TIIS and for nominal Treasury securities. Bid-ask spreads on on-the-run nominal Treasuries are shown to be the narrowest, reflecting the remarkable liquidity of those issues. The spreads on TIIS are closer to those on off-the-run nominal securities, although the TIIS spreads are still wider. Moreover, the market for nominal Treasuries appears to be deeper than the TIIS market, in the sense that a larger volume of securities can be traded at posted bid and ask prices.[15]

Table 1

Typical Bid-Ask Spreads for Treasury Securities
1/32nds of Price

Type	Maturities of Five Years or Less	Maturities of Five to Ten Years	Maturities beyond Ten Years
On-the-run nominal	1/4 to 1/2	1/2	NA
Off-the-run nominal	1/2 to 1	1/2 to 1	2
Inflation-indexed	1 to 2	2	4 to 16

Source: Federal Reserve Bank of New York (informal survey of dealers conducted in mid-2003).

Notes: Bid-ask spreads are measured in 1/32s of a point, where a point roughly equals 1 percent of the security's par value. Spreads are for trades of approximately $25 million for Treasury inflation-indexed securities and up to $100 million for nominal Treasuries.

Overall, TIIS appear to be somewhat less liquid than off-the-run nominal securities—a factor that could boost TIIS yields and reduce measured inflation compensation. However, at least in recent years, the difference in liquidity has been sufficiently limited that, judging from observed liquidity premia in other markets, the difference would have had a fairly modest effect on the relative valuations of nominal and indexed securities.[16]

4.3 Relative Supply

From March 1997 through March 2002, the Treasury on net paid down $688 billion of nominal Treasury coupon securities, or 26 percent of the outstanding stock. In contrast, the supply of TIIS increased from zero at the beginning of 1997 to more than $145 billion (including inflation accrual) by March 2002. The divergent trends for supply may have affected the relative pricing of these securities. Indeed, the transition to a smaller nominal Treasury market at times seemed to result in a heightened premium for nominal Treasuries relative to other fixed-income securities.

While supply considerations at times may have weighed on the valuation of TIIS relative to nominal Treasury securities, any such effects have likely weakened substantially in recent years.

However, the paydown of Treasury debt has reversed in recent years, and the Treasury has been forced to implement sizable increases in its issuance of nominal securities. Indeed, it issued $96 billion in nominal ten-year Treasury notes over 2003—an amount well above the $47 billion of gross issuance in 1997. By comparison, gross issuance of ten-year TIIS increased less dramatically over that period, from $15 billion to $26 billion (and gross issuance of all TIIS has actually fallen over this period). Thus, while supply considerations at times may have weighed on the valuation of TIIS relative to nominal Treasury securities, any such effects have likely weakened substantially in recent years.

4.4 What Is the Total Effect of These Factors?

In general, the three factors we described—the difficulty adjusting to a new asset class, the lower liquidity of TIIS relative to nominal Treasury securities, and changes in the relative supply—may have weighed on the relative values of TIIS over the earlier parts of the period examined. However, those effects have probably weakened substantially in recent years. It therefore may be informative to focus on changes over time in the valuation of TIIS relative to nominal Treasury securities.

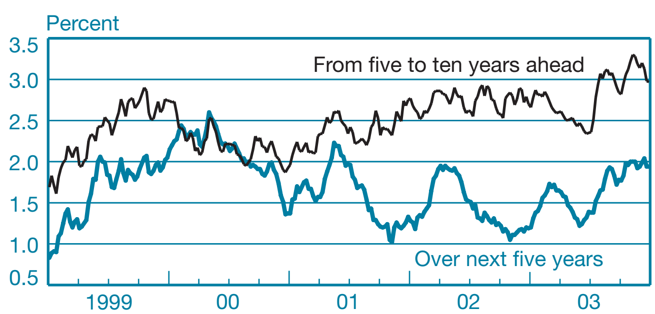
One difficulty in conducting such an exercise, however, arises because the economy weakened in the latter part of the study period, resulting in a decline in near-term inflationary pressures that presumably pulled down inflation compensation. This cyclical influence would likely have the largest effect on inflation expectations over the next several years and would fade at longer horizons. In contrast, the three factors considered above would likely be felt at all maturities, given that they influence the demand for all TIIS. Thus, one way to remove some of the cyclical effect and focus on the influence of these factors is to look at a *forward rate* of inflation compensation.

More specifically, the ten-year inflation compensation measure depicted in our charts can be decomposed into the rate of inflation compensation over the next five years and the forward rate of inflation compensation from five to ten years ahead.[17] (The average of these two rates will approximately equal the ten-year measure.) These measures are shown in Chart 6 for the period since 1999, which is as far back as the measures are computed.[18] As expected, the five-year measure fell to fairly low levels over the past few years, which in turn held down ten-year inflation compensation. However, the forward rate of inflation compensation from five to ten years ahead generally trended up over the period, despite the weakening economy.

The rising pattern of the forward inflation compensation rate provides some tentative evidence of an improvement in the relative valuation of TIIS over time that might be associated with some unwinding of the three factors discussed above. However, this evidence must be viewed with some caution. As one might expect, the forward rate is a very crude measure of the influence of these factors, as it is also influenced by changes to long-run inflation expectations and the inflation risk premium.

Overall, the total magnitude of the influence of these factors is difficult to quantify. The upward trend in forward inflation compensation appears to be on the order of 50 basis points or more, suggesting that these factors were having a fairly sizable effect earlier in the period.[19] It also seems likely that the effects of these factors had largely disappeared by the end of the sample. Indeed, our discussion suggests that the influence of the newness of TIIS and supply trends should have largely unwound and that the premium associated with remaining liquidity differences between TIIS and off-the-run nominal Treasuries should be relatively small.

Chart 6
Inflation Compensation Measures



Source: Smoothed yield curves are estimated by the Board of Governors of the Federal Reserve System based on proprietary market quotes collected by the Federal Reserve Bank of New York.

Note: Inflation compensation is measured relative to off-the-run nominal Treasury securities.

4.5 A Benign View of Inflation and Associated Risks

Even assuming that the three factors we identified depressed inflation compensation by 50 basis points on average over the period since 1999, their effects would just offset the average gap between the ten-year inflation compensation measure and survey expectations (see Chart 4). As we discussed, based on Campbell and Shiller's analysis (1996), one might expect the inflation risk premium to be between 50 and 100 basis points.[20] For these factors to be consistent with that hypothesis, they would have required a much larger effect—between 100 and 150 basis points—which we view as implausibly large. Thus, we are left to conclude that the low level of inflation compensation observed over this period to a large extent reflects investors' very benign outlook for inflation and the associated risks of holding nominal securities.[21]

5. The Cost of TIIS to the Treasury

The seemingly low valuation of TIIS relative to nominal debt securities has important implications for the relative cost of those securities to the Treasury. We now provide estimates of the cost of issuing the outstanding TIIS relative to the cost incurred by the Treasury had it instead issued nominal securities.

While the previous analysis compared TIIS yields with yields on off-the-run nominal securities, the relevant comparison from the perspective of financing costs is between TIIS and on-the-run nominal issues. The Treasury benefits from a liquidity premium that tends to lower the yields on its on-the-run nominal issues. This liquidity premium thus provides a cost advantage to nominal debt relative to TIIS.

The difficulty in obtaining cost estimates occurs in specifying the counterfactual, or the issuance strategy that the Treasury would have followed in the absence of TIIS. Because the payment flows on nominal and inflation-indexed securities differ considerably, there is no obvious choice of a nominal security for comparison to the TIIS. One might be tempted to compare TIIS with nominal debt securities having the same maturity, but the nominal coupon security has declining real coupon payments that give it a shorter duration than the TIIS. To minimize the effect of differences in payments, we instead compare the cost of each outstanding TIIS with the cost of a portfolio of hypothetical on-the-run zero-coupon nominal securities that replicate the back-loaded payments on the TIIS.[22] To be sure, the Treasury would not follow such a strategy in the absence of TIIS, but would instead likely increase its issuance of a variety of on-the-run securities. Nevertheless, this approach effectively captures the cost of replacing issuance of TIIS with issuance of nominal on-the-run securities, while minimizing any effects arising from differences in their payment streams.[23]

The seemingly low valuation of TIIS relative to nominal debt securities has important implications for the relative cost of those securities to the Treasury.

The first step in our analysis is to calculate break-even inflation rates for each TIIS auction, or the rate of inflation at which the cost to the Treasury of issuing a TIIS will exactly equal the cost of raising the same amount of funds by issuing the comparable nominal security (the portfolio of zero-coupon securities).[24] If inflation exceeds the break-even rate, the TIIS will be more costly than the nominal security, and vice versa. (The break-even inflation rate is the same concept as the inflation compensation rate discussed earlier, but here it is measured relative to on-the-run nominal securities rather than off-the-run securities.)

The break-even inflation rates for all auctions (including reopenings) of TIIS to date are shown in Table 2, column 5. The highest break-even inflation rates are for the first two auctions of inflation-indexed securities (both of which are the ten-year note maturing in 2007). As we observed, this result could reflect the fact that investors with the strongest demand for inflation protection were among the first to purchase TIIS. The lowest break-even inflation rates are for those securities issued around the financial market turbulence in the fall of 1998, perhaps because of the heightened preference for liquidity at that time. For auctions since April 1999, break-even inflation rates have remained in a narrower range, between 1.48 and 2.36 percent.

The cost of each TIIS issue to date depends on the difference between actual inflation and the break-even inflation rate. Column 6 of Table 2 shows the inflation rate realized over the period since each auction, adjusted for the indexation lag and expressed on an annualized basis. Deviations of actual inflation from the break-even inflation rate generate a stream of differences in payments on the nominal and inflation-indexed securities over the maturity of those issues. In our computations, we express the relative cost of the TIIS as the present value of all past and future differences in the payments on the two securities.[25]

Column 7 presents this cost measure for each outstanding TIIS as of June 30, 2003, based on realized inflation through that date. As we see, the largest cost savings to the Treasury occurred at the first two TIIS auctions, which together saved the Treasury more than $1 billion. By contrast, the TIIS issued at all auctions since October 1997 have been more expensive than comparable nominal securities.[26] The relative cost is especially high for those securities issued in October 1998 and January 1999. Summing across all securities, we estimate that the excess cost of all outstanding TIIS based on inflation to date is just under $3 billion.[27]

While these calculations account only for realized inflation to date, it may also be useful to estimate the total cost of the program under an assumption about inflation going forward. We find that future inflation would have to come in at about 1.7 percent for the Treasury to make up its realized costs to date and to break even on outstanding TIIS (in present-value terms). Of course, most economic forecasts project that CPI inflation will come in well above this level. For example, the Survey of Professional Forecasters discussed earlier expects inflation to be around 2.5 percent in the long run. In that case, it appears that the Treasury will pay nearly 80 basis points of additional yield on TIIS than it would have paid on comparable nominal debt.

Under the assumption that inflation will edge up to 2.5 percent by 2005 and remain at that level thereafter, we can compute the total cost of the TIIS program, or the present value of the differences in all past and future payments on the securities.[28] The results in Table 2, column 8, indicate that the Treasury will incur a higher relative cost on all but the first three TIIS auctions. The total cost of the inflation-indexed securities outstanding is estimated to be about $12 billion under the assumed path of inflation.

We obtain similar results if we instead consider an alternative exercise in which the Treasury follows a dynamic strategy for issuing coupon-bearing nominal securities. The basic insight of this approach is that the accrual of inflation compensation on indexed debt is similar to the issuance of additional debt, in the sense that it increases the principal and all future coupon payments. In fact, the Treasury can employ a strategy in which it issues the nominal coupon security with the same maturity date as the TIIS every six months so as to replicate all of the payments of the indexed security up to its maturity date. The relative cost of nominal and indexed debt is then captured entirely by the single difference in the payments on the maturity date. Under this approach, the estimated cost of outstanding TIIS (not shown) is very close to the cost found in Table 2.[29]

Table 2

Estimated Costs of Treasury Inflation-Indexed Securities (TIIS)

Auction	Auction Date (1)	Maturity Date (2)	Coupon Rate (Percent) (3)	Par Amount Issued (Billions of Dollars) (4)	Break-Even Inflation (Percent) (5)	Actual Inflation (Percent) (6)	Cost to Date (Millions of Dollars) (7)	Total Cost (Millions of Dollars) (8)
1	1/29/1997	1/15/2007	3 3/8	7.0	3.20	2.33	-586	-838
2	4/8/1997	1/15/2007	3 3/8	8.0	3.26	2.33	-697	-1,005
3	7/9/1997	7/15/2002	3 5/8	8.0	2.40	2.34[a]	-38	-38
4	10/8/1997	7/15/2002	3 5/8	8.0	2.34	2.39[a]	23	23
5	1/8/1998	1/15/2008	3 5/8	8.0	1.75	2.40	381	668
6	4/8/1998	4/15/2028	3 5/8	8.0	2.17	2.49	185	740
7	7/8/1998	4/15/2028	3 5/8	8.0	1.93	2.50	307	1,281
8	10/7/1998	1/15/2008	3 5/8	8.0	0.69	2.55	894	1,632
9	1/6/1999	1/15/2009	3 7/8	8.0	0.83	2.59	810	1,632
10	4/7/1999	4/15/2029	3 7/8	7.0	1.59	2.69	427	1,820
11	7/7/1999	1/15/2009	3 7/8	7.0	1.87	2.58	271	526
12	10/6/1999	4/15/2029	3 7/8	7.0	1.94	2.64	253	1,119
13	1/12/2000	1/15/2010	4 1/4	6.0	2.36	2.60	73	107
14	7/12/2000	1/15/2010	4 1/4	5.0	2.03	2.43	82	236
15	10/11/2000	4/15/2029	3 7/8	5.0	1.83	2.35	92	833
16	1/10/2001	1/15/2011	3 1/2	6.0	1.58	2.25	121	544
17	7/11/2001	1/15/2011	3 1/2	5.0	1.80	1.87	6	269
18	10/10/2001	4/15/2032	3 3/8	5.0	1.98	2.07	7	568
19	1/9/2002	1/15/2012	3 3/8	6.0	1.67	2.41	75	493
20	7/10/2002	7/15/2012	3	9.0	1.79	2.33	52	591
21	10/9/2002	7/15/2012	3	7.0	1.48	2.71	66	681
22	1/8/2003	7/15/2012	3	6.0	1.69	3.08	41	456
Total							2,846	12,337

Sources: U.S. Treasury Department (columns 1-4); authors' calculations (columns 5-8).

Notes: Columns 7 and 8 are the amount by which the cost of TIIS exceeds the cost of comparable nominal securities, where the cost is measured by the present value of the differences in the payments on the TIIS and the nominal securities. All cost figures are measured as of June 30, 2003. Column 7 shows the cost based on inflation through that date, accounting for the indexation lag. Column 8 presents the total cost if future inflation follows the path assumed by Congressional Budget Office (2003). Par amounts issued exclude securities issued to the Federal Reserve.

[a]Actual inflation for the July 15, 2002, security is measured only through its maturity date.

Although the above calculations suggest that TIIS appear to have been an expensive form of borrowing for the Treasury in expected terms, the actual (ex-post) cost of TIIS will depend on the realized level of CPI inflation over the life of those issues. Given the difficulties involved in making long-run economic forecasts, realized inflation can deviate substantially from expected inflation. If inflation was to come in above expectations, the ex-post cost of TIIS would be higher than these estimates. Conversely, if inflation was to come in far enough below the expectations assumed above, the outstanding TIIS could result in a lower financing cost than the cost of nominal debt. We estimate that each 0.01 percentage point of additional inflation adds about $150 million to the total cost of the TIIS program.

It is difficult to calibrate the uncertainty involved in predicting long-run inflation. A reasonable estimate, based on simulations of the Federal Reserve's FRB/US model and the past prediction errors reported by the Congressional Budget Office, is that the standard deviation of annualized ten-year inflation is somewhere between 0.5 and 1.5 percentage points.[30] If the average level of inflation in the long run is around 2.5 percent, as assumed above, then this range of uncertainty suggests that the probability of breaking even on outstanding TIIS is approximately between one-sixth and one-third. Of course, the probability of breaking even would increase if the average level of inflation is below 2.5 percent.

6. Conclusion

Over the first seven years of its existence, Treasury inflation-indexed debt has not appeared to be a less expensive form of financing for the Treasury. To some extent, the high relative cost of these securities to date may reflect the difficulties associated with launching a new type of asset, the lower liquidity of indexed debt relative to nominal Treasury securities, and the considerable growth in the supply of indexed debt. Furthermore, we argue that TIIS investors over the period appear to have had a very benign outlook for inflation and the associated risks of holding nominal securities.

In recent years, however, some of the factors that may have weighed on the relative value of TIIS have likely weakened. By now, investors have had ample time to adjust to the new security, and investor participation in the TIIS market has expanded considerably; liquidity appears to have improved noticeably with the increased market participation; and supply trends have become less favorable for nominal Treasury securities. Perhaps for these reasons, there is some tentative evidence that the relative valuation of TIIS has improved in recent years, although additional time and data will be needed for that conclusion to become more decisive.

Although the TIIS program thus far has appeared to be expensive, the Treasury has indicated its intention to sustain its issuance of indexed debt and to encourage the development of the market. In general, the Treasury pursues a more complicated debt management strategy than simply minimizing its current financing costs.[31] For example, the Treasury currently issues securities with maturities out to ten years, even though it pays a larger term premium at the margin on the longer maturities than it does on short-term debt. Instead, the Treasury likely takes into account the relationship between its borrowing needs and the costs of issuing different types of debt over time. Indeed, tax revenues might tend to increase with inflation, in which case the Treasury may be better able to absorb inflation risk than investors. Given these considerations, the optimal debt structure for the Treasury could contain some indexed debt.[32]

In addition, the Treasury likely recognizes that the TIIS market is still evolving and that the ultimate borrowing costs associated with these securities relative to nominal Treasury securities remain very uncertain. The behavior of the TIIS market going forward will therefore be of considerable interest.

Appendix: The Pricing of TIIS

As we describe in Section 2, the payments on Treasury inflation-indexed securities (TIIS) increase in line with the consumer price index (CPI). Specifically, the value of the principal on a given day is scaled up by an index ratio determined by dividing the reference CPI for that day by the reference CPI at the time of issuance. The reference CPI on the first of the month is the nonseasonally adjusted CPI index published by the Bureau of Labor Statistics for the third preceding calendar month, and its value within the month is determined by linear interpolation. This is the minimum indexation lag possible given the timing of the CPI data release.

Because of this indexation, the nominal payments on the indexed security are back-loaded relative to those on a nominal security, assuming that the rate of inflation is positive. An indexed security issued at time *t* with a coupon rate of *c*, a maturity of *N* years, and a par value of $100 has coupon payments after *n* years of $c \cdot 100 \cdot P_{t+n} / P_t$, where P_{t+n} is the reference CPI at time *t*+*n*, and a principal payment after *N* years of $100 \cdot P_{t+N} / P_t$. (For notational simplicity, we assume that coupons are paid annually and ignore semiannual compounding.) This back-loaded pattern allows the real coupon payments, $c \cdot 100$, to be constant.

If future inflation were known, the price of the inflation-indexed security at time *t*, B_t, would be determined by the sum of future nominal payments multiplied by the value of those payments, as follows:

$$\text{(A1)} \qquad B_t = \sum_{n=1}^{N} c \cdot 100 \cdot (P_{t+n} / P_t) \cdot \delta_t(n) + 100 \cdot (P_{t+N} / P_t) \cdot \delta_t(N),$$

where $\delta_t(n)$ is the discount function, which equals the value at time *t* that investors place on a nominal payment *n* periods into the future.[33] The discount function is determined by the term structure of nominal interest rates $\delta_t(n) = 1/(1+i_t^n)^n$, where i_t^n is the *n*-period zero-coupon nominal interest rate at time *t*. Rewriting the index ratio P_{t+n} / P_t as $(1+\pi_t^n)^n$, where π_t^n is the average annualized rate of inflation over the next *n* periods, and writing out the discount function, equation A1 becomes

$$\text{(A2)} \qquad B_t = \sum_{n=1}^{N} \frac{c \cdot 100 \cdot (1+\pi_t^n)^n}{(1+i_t^n)^n} + \frac{100 \cdot (1+\pi_t^N)^N}{(1+i_t^N)^N}.$$

To derive a simpler equation for TIIS, we define the *n*-period zero-coupon real interest rate r_t^n by the following:[34]

$$\text{(A3)} \qquad (1+r_t^n) = \frac{(1+i_t^n)}{(1+\pi_t^n)}.$$

Using this definition, equation A2 becomes

$$\text{(A4)} \qquad B_t = \sum_{n=1}^{N} \frac{c \cdot 100}{(1+r_t^n)^n} + \frac{100}{(1+r_t^N)^N},$$

which states that the TIIS is valued like a regular bond with a fixed coupon of *c*, only discounted using real interest rates rather than nominal rates. Note that the real payments on the TIIS security are independent of inflation, so that equation A3 holds regardless of whether future inflation is known. In practice, the quoted yield on a TIIS is the real yield to maturity on the security, which is the constant real interest rate r^{ytm} ($r^n = r^{ytm}$ for all *n*) for which equation A4 holds.

The spread between the yield on a TIIS and the yield on a comparable nominal security will reflect investors' views about future inflation. If future inflation is known, the *N*-period returns on two investments—one making a real payment in *N* periods and one making a nominal payment—must be equal, which implies that

$$\text{(A5)} \qquad (1+r)^N = \left[\frac{(1+i)}{(1+\pi)}\right]^N.$$

(We drop the subscripts and superscripts for notational simplicity.) This equation will be approximately satisfied if $i - r = \pi$. Thus, in this case, the yield spread between comparable nominal and indexed zero-coupon securities should (approximately) equal the future rate of inflation.

Equation A5 would hold for zero-coupon yields, and hence for the valuation of all the individual payments on the TIIS. The relationship is more complicated for the yields to maturity on coupon-bearing bonds. For those securities, the choice of the appropriate nominal security to compare with the TIIS is not obvious. The most common practice is to use a nominal coupon security with the same maturity as the TIIS. However, those two securities have different payment flows: the nominal payments on the TIIS are much more back-loaded than those on a standard nominal coupon security; in real terms, the coupon payments on the nominal security decline over time, unlike the constant real coupon payments on a TIIS.

Sack (2000) instead derives a measure of inflation compensation based on a portfolio of nominal zero-coupon securities (read off an estimated yield curve) constructed to match the back-loaded payments of the TIIS. Under the additional assumption that inflation is expected to be relatively stable around some level π, the following relationship still holds:

$$(1 + r^{ytm}) = \frac{(1 + i^{ytm})}{(1 + \pi)}, \tag{A6}$$

where i^{ytm} is the nominal yield that investors would demand on a security with the same back-loaded payment stream as the TIIS. Nevertheless, as demonstrated in the Sack paper, the resulting measure differs only modestly from a simple yield spread based on a nominal coupon security. Sack argues that a more important factor is choosing a nominal security with a level of liquidity comparable to that of the TIIS—as we do here by using off-the-run rather than on-the-run nominal securities.

One complication with interpreting inflation compensation measures involves uncertainty about future inflation. If investors are risk-neutral, then they will demand the same expected real return on nominal and inflation-indexed zero-coupon securities. In that case, equation A5 becomes:

$$(1 + r)^N = E_t\left[\frac{(1 + i)^N}{(1 + \pi)^N}\right], \tag{A7}$$

which can be rewritten approximately as follows:

$$i - r = \frac{1}{E_t\left[\frac{1}{(1 + \pi)^N}\right]^{1/N}} - 1\,. \tag{A8}$$

According to equation A8, inflation uncertainty tends to pull inflation compensation down relative to the expected rate of inflation. To see that, note that Jensen's inequality implies that

$$E_t\left[\frac{1}{(1 + \pi)^N}\right] > \left[\frac{1}{(1 + E_t \pi)^N}\right]. \tag{A9}$$

As a result, the yield spread will be less than the expected rate of inflation,

$$i - r < E_t \pi, \tag{A10}$$

by an amount that increases with the uncertainty surrounding future inflation. For a coupon-bearing security, the total effect is a bit more complicated—equation A8 shows the effect of uncertainty on the value of any single payment, and those effects have to be aggregated across all payments on the security.

While convexity tends to pull down inflation compensation relative to expected inflation, there may be an inflation risk premium that works in the opposite direction. If investors are not risk-neutral, they will generally not demand the same expected return on the two securities. Because future inflation erodes the real payments on a nominal security but not on a TIIS, one might expect investors to demand a higher expected return on nominal securities when future inflation is uncertain. Such a risk premium would push the yield spread $i - r$ up relative to expected inflation, thereby increasing the financing cost to the Treasury on nominal debt securities. Indeed, as we observe in this article, this was one of the primary arguments for issuing Treasury inflation-indexed securities.

Endnotes

1. Investors cannot precisely lock in a real return because of taxes and the indexation lag on TIIS.

2. Another argument for issuing inflation-indexed debt is that it might help commit the government to maintaining low inflation. However, this incentive mechanism is generally seen as less important at this time for the United States.

3. For a broad overview of the Treasury securities market, see Dupont and Sack (1999).

4. In part for this reason, in May 2001, the Treasury Advisory Committee of the Bond Market Association recommended that the Treasury discontinue issuance of inflation-indexed securities (see “Report to the Secretary of the Treasury from the Treasury Advisory Committee of the Bond Market Association,” May 1, 2001, available at <http://www.treas.gov/offices/domestic-finance/debt-management/adv-com/reports/index.html>).

5. The yield to maturity on a TIIS is calculated from the standard bond pricing formula, only assuming that there will be no additional inflation accrual from the quote date forward.

6. Sack (2000) instead derives a measure of inflation compensation based on a portfolio of nominal zero-coupon securities (read off an estimated yield curve) constructed to match the back-loaded payments of the TIIS. Nevertheless, as demonstrated in that paper, the resulting measure differs only modestly from a simple yield spread based on a nominal coupon security.

7. Similarly, Kopcke and Kimball (1999) evaluate the role of TIIS in efficient investor portfolios.

8. The behavior of TIIS over the first several months following the first auction is described in more detail in Wilcox (1998).

9. The indexed yield shown is the yield on the most recently issued ten-year TIIS, with a small adjustment made to keep its maturity fixed at ten years (see endnote 18). The nominal yield shown is the ten-year par yield read from a smoothed nominal yield curve estimated using the Svensson method to fit outstanding off-the-run notes and bonds.

10. Note that there is no zero bound on the yield on TIIS, as there is on the yields on nominal securities, because the inflation compensation can result in a positive nominal return even when the real yield is negative. The yield on the 2002 TIIS fell well below zero after the date shown.

11. An alternative measure, the Michigan Survey Research Center’s Survey of Households, asks about the expected level of inflation over the next five to ten years. On average, the median response has been about 32 basis points *above* the Philadelphia Fed survey, thus increasing the discrepancy with inflation compensation.

12. See the Treasury’s February 2002 Quarterly Refunding Statement (available at <http://www.treas.gov/offices/domestic-finance/debt-management/remarks/index.html>) and the comments by Brian Roseboro, the Treasury’s Assistant Secretary for Financial Markets.

13. The effect of liquidity on the relative valuation of TIIS is discussed in Shen and Corning (2001).

14. Some of the bidding by primary dealers is intended to cover short positions that they have established by selling the security in the when-issued market. Thus, a portion of their auction awards is essentially passed on to other investors.

15. In 2003:1, TIIS were also added to TradeWeb, an electronic trading platform widely used by large institutional investors. This addition likely lowered transaction costs for those investors.

16. For example, Lonstaff (2002) calculates that liquidity premia on Refcorp zero-coupon securities relative to Treasury zero-coupon securities are roughly 10 to 15 basis points. The difference in liquidity between those securities is presumably greater than the difference in liquidity between TIIS and off-the-run nominal securities.

17. We compute a five-year real rate and a forward real rate five to ten years ahead by smoothing a yield curve through outstanding TIIS. The TIIS yield curve is estimated using the Nelson-Siegel method, and securities with maturities of around five and ten years are given additional weight to force the curve to fit well at those horizons. We then compare these measures with their counterparts from the smoothed nominal Treasury yield curve to obtain the two inflation compensation measures.

18. It is difficult to estimate a TIIS yield curve before 1999, given the limited number of securities outstanding. In fact, the measures presented are probably better estimated over the period since 2001, when the maturities of outstanding securities have been closer to the five-year maturity range.

19. The forward rate seems to have increased from a typical level of around 2 1/2 percent from 1999 to 2001 to about 3 percent in recent months. The forward rate was even lower than 2 1/2 percent in early

Note 19 continued
1999—when investors may have still placed a very high premium on liquidity—and in 2000 and early 2001, when nominal Treasuries may have commanded a scarcity premium.

20. The authors' estimate was for a five-year nominal Treasury security. It is not clear how to extend this estimate to a ten-year security, although many market participants believe that the long end of the yield curve is the most sensitive to inflation expectations.

21. It is difficult to parse the rate of inflation compensation into its two components—expected inflation and the inflation risk premium. If one takes the survey measure as expected inflation, then the inflation risk premium would have been near zero. If one believes that expected inflation was lower than the survey measure, then the inflation risk premium would have been positive but small.

22. We do not consider the fact that the yields on nominal securities might have been higher if the Treasury had issued them in place of TIIS. However, it is unlikely that this consideration would fully offset the magnitude of the cost difference, which is estimated below to be around 80 basis points.

23. The values of the hypothetical zero-coupon securities are derived from the constant-maturity yield curve estimated by the Treasury, which is based primarily on the yields of on-the-run securities. We thank the Treasury for providing the zero-coupon data for the relevant dates. One concern is that this yield curve may be poorly estimated because of the limited number of data points.

24. This is strictly true only if inflation is constant over the maturity of the security. Allowing for a time-varying path of inflation would require additional assumptions.

25. This method discounts future payment differences and compounds past payment differences using our estimated off-the-run yield curve.

26. Interestingly, the Treasury roughly broke even on the only TIIS to have matured—the July 2002 note. As can be seen, it saved $38 million from its first auction of the issue but paid an extra $23 million on the reopening, leaving a net saving of $15 million.

27. One consideration that we ignore is that the Treasury recovers some of the additional interest it pays in the form of taxation on interest income.

28. More specifically, we assume that inflation follows the path assumed in Congressional Budget Office (2003), extrapolating the 2.5 percent level beyond the projection horizon in that report.

29. See the July 2002 working paper version of this article (available at <http://www.federalreserve.gov/pubs/feds/2002/200232/200232pap.pdf>) for more details on this approach and a comparison of the results to the static issuance strategy described here.

30. See the July 2002 working paper version of this article (available at <http://www.federalreserve.gov/pubs/feds/2002/200232/200232pap.pdf>) for estimates underlying this range. The FRB/US model is described in Reifschneider, Tetlow, and Williams (1999).

31. In a speech delivered on March 14, 2002, Under Secretary of the Treasury Peter Fisher stated that the objective of debt managers is to "meet the financing needs of the federal government at the lowest cost over time." This objective could allow for issuance of securities that are currently more costly if doing so would lower future borrowing costs.

32. The academic literature on optimal debt structure focuses on the objective of smoothing tax rates, which in some cases argues for issuing debt with stable real payments. See Barro (1997) and Bohn (1990) for a discussion.

33. We scale the security to produce an index ratio of 1 at time *t*. Otherwise, all payments would be scaled up by P_t / P_i , where P_i is the reference CPI at the time of issuance. We also assume that the first coupon payment is exactly one period away. Otherwise, equation A1 would represent the "dirty" price of the security, which we would have to adjust for accrued interest and inflation compensation to arrive at the quoted ("clean") price.

34. Note that this equation implicitly defines a real discount function $\delta^r(n) = \delta(n) \cdot (1 + \pi^n)$.

References

Barro, Robert J. 1997. "Optimal Management of Indexed and Nominal Debt." NBER Working Paper no. 6197, September.

Bohn, Henning. 1990. "Tax Smoothing with Financial Instruments." American Economic Review 80, no. 5 (December): 1217-30.

Campbell, John Y., and Robert J. Shiller. 1996. "A Scorecard for Indexed Government Debt." In Ben S. Bernanke and Julio Rotemberg, eds., NBER Macroeconomics Annual 1996, 155-97. Cambridge: MIT Press.

Congressional Budget Office. 2003. "The Budget and Economic Outlook: Fiscal Years 2004-2013." January 30.

Dupont, Dominique, and Brian Sack. 1999. "The Treasury Securities Market: Overview and Recent Developments." Federal Reserve Bulletin 85, no. 12 (December): 785-806.

Fischer, Stanley. 1975. "The Demand for Index Bonds." Journal of Political Economy 83, no. 3 (June): 509-34.

Kopcke, Richard W., and Ralph C. Kimball. 1999. "Inflation-Indexed Bonds: The Dog That Didn't Bark." Federal Reserve Bank of Boston New England Economic Review, January-February: 3-24.

Lonstaff, Francis A. 2002. "The Flight-to-Liquidity Premium in U.S. Treasury Bond Prices." NBER Working Paper no. 9312, November.

McCulloch, J. Huston, and Levis A. Kochin. 1998. "The Inflation Premium Implicit in the U.S. Real and Nominal Term Structures of Interest Rates." Ohio State University Department of Economics Working Paper no. 98-12, August.

Reifschneider, David, Robert Tetlow, and John Williams. 1999. "Aggregate Disturbances, Monetary Policy, and the Economy: The FRB/US Perspective." Federal Reserve Bulletin 85, no. 1 (January): 1-19.

Sack, Brian. 2000. "Deriving Inflation Expectations from Nominal and Inflation-Indexed Treasury Yields." Journal of Fixed Income 10, no. 2 (September): 1-12.

Shen, Pu, and Jonathan Corning. 2001. "Can TIPS Help Identify Long-Term Inflation Expectations?" Federal Reserve Bank of Kansas City Economic Review, fourth quarter: 61-87.

Wilcox, David W. 1998. "Policy Watch: The Introduction of Indexed Government Debt in the United States." Journal of Economic Perspectives 12, no. 1 (winter): 219-27.