Creating an Integrated Payment System: The Evolution of Fedwire

Adam M. Gilbert, Dara Hunt, and Kenneth C. Winch

The following paper is adapted from remarks given by Adam M. Gilbert before the Seminar on Payment Systems in the European Union*. The seminar, sponsored by the European Monetary Institute, was held in Frankfurt, Germany, on February 27, 1997.*

On January 1, 1999, the countries participating in the European Union are expected to adopt a single currency and monetary policy. To support the creation of an integrated money market and the conduct of a unified monetary policy, the European Monetary Institute (EMI) and the national central banks in the European Union are developing a new payment system, the Trans-European Automated Real-Time Gross Settlement Express Transfer (TARGET) system. TARGET will interlink the advanced payment systems that the central banks of the European Union have agreed to implement in their own countries. This linkage will enable the banking sector to process cross-border payments in the new currency, the euro.

As the European Union moves forward with TARGET, it is an appropriate time to reconsider the U.S. experience with Fedwire, the large-dollar funds and securities transfer system linking the twelve district Banks of the Federal Reserve System. (See the box for a brief overview of Fedwire.) Just as TARGET is designed to ease the flow of funds among financial institutions throughout Europe, Fedwire allows U.S. financial institutions to send and receive funds anywhere in the country through accounts at their local Reserve Banks.

This paper traces the evolution of Fedwire from twelve separate payment operations, linked only by an interdistrict communications arrangement, to a more unified and efficient system. Our account highlights both the difficulties the Federal Reserve encountered as it sought to standardize and consolidate payment services and the lessons it drew from its experience. These lessons may prove useful to the European Union and to other nations undertaking a similar integration of payment systems.

Origins of the Fedwire System

The motives for linking the payment systems of the twelve Reserve Banks in the early part of this century were not unlike the current goals of TARGET. Prior to and immediately following the creation of the Federal Reserve System in 1913, exchange rates governed payments across regions in the United States. Like foreign exchange rates under a gold standard, the regional exchange rates for the U.S. dollar moved in a narrow band established by the costs of shipping gold or currency—costs that included freight charges and the interest lost during the time it took for payments to be received (Garbade and Silber 1979, pp. 1-10).

FEDWIRE: THE FEDERAL RESERVE WIRE TRANSFER SERVICE

The Federal Reserve Fedwire system is an electronic funds and securities transfer system. Depository institutions that maintain a reserve or clearing account with the Federal Reserve may use the system.

Fedwire provides real-time gross settlement for funds transfers. Each transaction is processed as it is initiated and settles individually. Settlement for most U.S. government securities occurs over the Fedwire book-entry securities system, a real-time delivery-versus-payment gross settlement system that allows the immediate and simultaneous transfer of securities against payments.

Operationally, Fedwire has three components: data processing centers that process and record funds and securities transfers as they occur, software applications that operate on the computer systems, and a communication network that electronically links the Federal Reserve district Banks with depository institutions.

To address the regional differences in the value of the U.S. dollar and their perceived negative effect on business, the Federal Reserve took two steps shortly after its establishment. First, to eliminate the transit costs in payments, the Federal Reserve created the Gold Settlement Fund. Thereafter, commercial banks could settle both intradistrict and interdistrict transfers through their local Reserve Bank, which in turn would settle with other Reserve Banks through the Gold Settlement Fund. The arrangement permitted interdistrict balances to settle through book-entry transfers—a method of effecting settlements whereby debits and credits are posted to accounts—and made the physical shipment of gold or currency unnecessary. Second, the Federal Reserve inaugurated leased-wire communications among the Reserve Banks and transferred funds daily over the wire at no cost to member banks. This practice eliminated the interest losses that occurred during the time it took to transfer funds. By 1918, these two services helped abolish regional exchange rates and formed the basic structure of the modern Fedwire system (Garbade and Silber 1979, p. 10).

NEW CHALLENGES: FEDWIRE IN RECENT DECADES

Over the years, Fedwire grew more sophisticated as advances in technology were applied, but it remained structured as a system that linked twelve operationally unique units. The widely held view that each Reserve Bank could best serve the specific needs of institutions in its district helped to perpetuate a decentralized approach. In addition, because statutory prohibitions on interstate banking kept banks from crossing Federal Reserve districts, the lack of consistency in payment services was not regarded as a problem by many Fedwire participants.

Despite these considerations, by the 1960s the need to standardize services had become increasingly apparent to the Federal Reserve. The existing system for the interdistrict and intradistrict transfer of funds was inefficient. Although the payment units at the various Reserve Banks were required to originate and receive transfer messages using a common format, each unit maintained its own funds software, data processing center, and computer programmers. As a consequence, enhancements to Fedwire were time-consuming to execute; before a change could be implemented, the twelve individual systems and the electronic interlinks among them had to be tested. In addition, enhancements had to be introduced on a staggered basis, or a single cutoff date had to be worked out among all the Reserve Banks. Coordinating these efforts proved difficult. Along with creating inefficiencies, this multisystem environment introduced greater operational risk to the task of revising and upgrading services.

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In response to these problems, a decision was made in the 1970s to develop standard software for each key payment service. By the early 1980s, a standard software application had been developed for the Fedwire funds transfer service. The individual Reserve Banks then implemented copies of this application on their local mainframes. The single common application was more efficient to develop, maintain, and modify.

Unfortunately, during the 1980s, the standard software applications became increasingly less standard. To meet the perceived desires of local customers, the Reserve Banks made modification upon modification to the common applications. In addition to trying to satisfy customers, the Reserve Banks made changes to meet internal reporting and system interfacing requirements. The components altered at the local level ranged from peripheral aspects of Fedwire, such as the type of reports generated, to core elements of the system, such as communication links. The end result was an erosion of the standard applications and the introduction of the same problems experienced earlier. The system became difficult to update, and the risk of operational problems grew.

By the late 1980s, the Federal Reserve was aware of the limitations and potential problems created by the locally modified applications. At the same time the operations at the Reserve Banks were becoming more individualized, the need for standard services was becoming more pronounced. This need was particularly apparent from the perspective of Federal Reserve customers as the boundaries and distinctions between districts blurred. One reason for this blurring was that bank holding companies increasingly operated separate subsidiary banks in multiple Federal Reserve districts. In addition, as differences in business practices and financial markets in regions throughout the United States diminished, the demands of Fedwire customers became more homogeneous. Customers also became increasingly concerned about inequalities in the service provided to institutions in different districts.

It is important to note that the Reserve Banks never deliberately made Fedwire less customer friendly. In fact, the Reserve Banks modified their systems with precisely the opposite intention—to improve the services for customers. Nevertheless, with twelve organizations working independently to improve their local service, a system arose that as a whole did not fully meet the needs of emerging regional and national banks. Business managers tried to address these problems by eliminating district modifications, but their efforts met with limited success.

Turning from Fedwire's electronic funds transfers to its securities transfers, we find even more striking inconsistencies in the services provided by different Reserve Banks. In fact, despite an effort to develop standard software, two completely distinct applications came into operation. The New York and Philadelphia Reserve Banks used software called BESS, designed as a high-speed application that could handle large volumes, while the other ten Federal Reserve districts used software called SHARE. Because local modifications were made to these two unique applications, the difficulties experienced for funds transfers were exacerbated for Fedwire securities services. In addition, during the 1980s, new types of securities, such as mortgage-backed obligations, were added to Fedwire at a rapid pace, creating the need to update and modify the system constantly.

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The communication network linking the computer systems of the Federal Reserve Banks and depository institutions also presented problems. The network technology available in the 1960s was relatively inefficient. As a result, all Fedwire interdistrict messages had to pass through a single hub, in Culpeper, Virginia. In addition, if a district temporarily lost its connection to Culpeper, it could not communicate with the entire system.

In the 1980s, the Federal Reserve incorporated advances in network technology to address these shortcomings. A new network consisting of a common backbone with unique local networks was implemented. Each of the twelve Federal Reserve Banks maintained an independent local network; switch-routing software linked the networks for interdistrict messages. Although an improvement over the central hub model, this network configuration had its own weaknesses. In particular, the existence of twelve unique local networks greatly complicated the diagnosis and resolution of technical problems.

Current Strategies for Consolidating Systems

Recognizing the need for further refinements of Fedwire, the Federal Reserve is now standardizing and consolidating software, data processing centers, and communications networks for both funds and securities throughout the System. The software applications that were modified by the Reserve Banks to meet the needs of local customers are being replaced by a single application for funds transfers and a single application for book-entry securities transfers. In addition, the twelve district data processing centers and their four backup locations have been consolidated into three sites: one primary processing center for Fedwire and other critical national electronic payment and accounting systems, and two backup sites. The individual Reserve Banks will continue to maintain their own balance sheets, and customer relations will be handled locally. Although the conversion to a more centralized system has gone very smoothly to date, the relationship of Fedwire customers to the Reserve Banks and consolidated processing sites is still in transition. Over time, it will become more difficult for Reserve Banks to maintain their technical expertise as responsibility for automated operations is ceded to centralized offices.

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In addition to making these changes in software and data processing, the Federal Reserve recently converted the network linking computer systems at the Reserve Banks and depository institutions to a unified communications network with common standards and equipment. The new network, known as FEDNET, is linked with the main processing center in New Jersey and the two contingency centers and is used to process both transactions within a single district and those between districts. Because FEDNET has standard connection equipment at depository institutions, it simplifies diagnostic testing and provides improved service and enhanced disaster recovery capabilities.

Benefits of Consolidation

Several important benefits should arise from the initiatives undertaken in recent years:

- The Federal Reserve will be able to provide uniform payment services throughout the country. Customers have repeatedly asked for standard services to eliminate unnecessary inconvenience and expense and to ensure that institutions are treated equitably regardless of their location.
- Redundant resources will be eliminated, and costs will be reduced. At the start of the year, with consolidation almost complete, the Federal Reserve was able to reduce the fee for Fedwire funds transfers by 10 percent. Given the competitive environment facing both the Federal Reserve and its customers, the ability to reduce costs without compromising the integrity of the system is of utmost importance.
- In the future, it will be possible to modify payment systems more quickly and with less risk.
- The designation of multiple backup facilities for critical payment systems will enhance contingency processing capabilities, while the move from twelve sites to one will improve security.

As noted, standardizing Fedwire should make it easier to modify the system quickly. In this regard, a number of changes are currently being implemented or considered. The message format for Fedwire funds transfers is being modified to make it similar to both the CHIPS and the S.W.I.F.T. message formats.[1] This change should provide significant efficiencies for customers by reducing the need for manual intervention when transactions are processed and by eliminating the truncation of payment-related information when payment orders received via CHIPS and S.W.I.F.T. are forwarded to Fedwire. Another change, scheduled to occur in December 1997, will expand the Fedwire funds processing day to eighteen hours. The extended hours will give customers additional flexibility and should create an improved environment for reducing foreign exchange settlement risk. The Federal Reserve is also studying extending the hours of the book-entry system. Most important, whatever changes the Federal Reserve elects to make, they will be easier to implement in a standardized and consolidated environment.

Introducing changes such as these should also be easier because the management of Fedwire services has been centralized along with the automated operations themselves. Payment personnel started out with a diffuse management approach that relied on a series of committees with representation from each Reserve Bank. They have now structured management responsibilities by establishing systemwide product offices for wholesale payments, retail payments, cash, and fiscal services. These offices report to a six-member policy committee made up of presidents and first vice presidents from the Reserve Banks. The product offices also consult with Reserve Bank staff and staff of the Board of Governors of the Federal Reserve System, as well as other interested parties.

The Federal Reserve has coordinated its consolidation of the payment system with changes in Reserve Bank risk management designed to meet the challenges of a rapidly evolving financial landscape. For example, with the elimination of barriers to interstate banking in June of this year, each interstate bank will be given a single account at the Federal Reserve. Thus, even though a bank based in San Francisco might have a branch in New York City making payments and transferring securities over Fedwire, those transfers will be posted to the books of the San Francisco Reserve Bank. This arrangement allows a single risk manager at the Reserve Bank with the primary account relationship to monitor the Reserve Bank's credit exposure to a particular customer. In connection with this change, efforts are also under way to improve the Reserve Banks' risk management by developing standard operating procedures for lending at the discount window and by setting uniform standards on the acceptability and valuation of collateral for securing credit from the Reserve Banks.

Lessons from the U.S. Experience

Three major lessons have emerged from the Federal Reserve's experience with Fedwire. First, an effective payment system must be able to respond to changes in financial markets and technology. It must be flexible enough to adapt in many areas, including software applications, data processing, networking, account relationships, risk management, and management structure. Moreover, any modifications must be handled effectively from the perspective of both the central bank and its customers. The central bank's responsiveness to change is especially important when the bank operates in conjunction with private-sector payment and settlement mechanisms. If the central bank is unable to adapt its services, it may perpetuate risks and inefficiencies in the market.

A central bank must consider how customers will evaluate its payment services and policies relative to alternative payment mechanisms.

Second, central banks are likely to feel pressure to meet the evolving demands of customers and internal constituents. Unless these pressures are managed, central banks may respond by modifying systems locally. The resulting differences may compromise the effectiveness and adaptability of the system as a whole. The local differences may also influence where a banking organization chooses to locate or how it elects to structure its operations.

Finally, a central bank must consider how customers will evaluate its payment services and policies relative to alternative payment mechanisms. Payment services are, of course, a banking business. If the potential response of customers is not given adequate consideration, a market reaction could occur that is inconsistent with the central bank's business or policy objectives. If a central bank makes its systems too expensive or difficult to use, or does not provide the services market participants demand, customers may well go elsewhere. The implications of such a development must be carefully considered.

This paper has outlined some of the challenges the Federal Reserve has faced in establishing a payment system and the ways in which it has responded. To be sure, this response is still evolving. As the countries participating in the European Union develop their own integrated payment system, they will undoubtedly find unique solutions to the problems they confront. Nevertheless, the Federal Reserve's experience with Fedwire may serve as a helpful reference in the European effort.

ENDNOTES

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1. CHIPS (Clearing House Interbank Payments System) is a private funds transfer system that settles on a net basis through the Federal Reserve Bank of New York. S.W.I.F.T. (Society for Worldwide Interbank Financial Telecommunication) is a private network for transferring payment messages; the exchange of funds (settlement) subsequently takes place over a payment system or through correspondent banking relationships.

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The Round-the-Clock Market for U.S. Treasury Securities

Michael J. Fleming

The U.S. Treasury securities market is one of the most important financial markets in the world. Treasury bills, notes, and bonds are issued by the federal government in the primary market to finance its budget deficits and meet its short-term cash-management needs. In the secondary market, the Federal Reserve System conducts monetary policy through open market purchases and sales of Treasury securities. Because the securities are near-risk-free instruments, they also serve as a benchmark for pricing numerous other financial instruments. In addition, Treasury securities are used extensively for hedging, an application that improves the liquidity of other financial markets.

The Treasury market is also one of the world's largest and most liquid financial markets. Daily trading volume in the secondary market averages $125 billion.[1] Trading takes place overseas as well as in New York, resulting in a virtual round-the-clock market. Positions are bought and sold in seconds in an interdealer market, with trade sizes starting at $1 million for notes and bonds and $5 million for bills. Competition among dealers and interdealer brokers ensures narrow bid-ask spreads for most securities and minimal interdealer brokerage fees.

Despite the Treasury market's importance, size, and liquidity, there is little quantitative evidence on its intraday functioning. Intraday analysis of trading volume and the bid-ask spread is valuable, however, for ascertaining how market liquidity changes throughout the day. Such information is important to hedgers and other market participants who may need to trade at any moment and to investors who rely on a liquid Treasury market for the pricing of other securities or for tracking market sentiment. Intraday analysis of price volatility can also reveal when new information gets incorporated into prices and shed light on the determinants of Treasury prices. Finally, analysis of price behavior can be used to test the intraday efficiency of the Treasury market by determining, for example, whether overseas price changes reflect new information that is subsequently incorporated into prices in New York.

This article provides the first detailed intraday analysis of the round-the-clock market for U.S. Treasury securities. The analysis, covering the period from April 4 to August 19, 1994, uses comprehensive data on trading activity among the primary government securities dealers.[2] Trading volume, price volatility, and bid-ask spreads are examined for the three major trading locations—New York, London, and Tokyo—as well as for each half-hour interval of the global trading day. Price efficiency across trading locations is also tested by examining the relationship between price changes observed overseas and overnight price changes in New York.

The Treasury market is . . . one of the world's largest and most liquid financial markets. Daily trading volume in the secondary market averages $125 billion.

The analysis reveals that trading volume and price volatility are highly concentrated in New York trading hours, with a daily peak between 8:30 a.m. and 9 a.m. and a smaller peak between 2:30 p.m. and 3 p.m. Bid-ask spreads are found to be wider overseas than in New York and wider in Tokyo than in London. Despite lower overseas liquidity, overseas price changes in U.S. Treasury securities emerge as unbiased predictors of overnight New York price changes.

The Structure of the Secondary Market

Secondary trading in U.S. Treasury securities occurs primarily in an over-the-counter market rather than through an organized exchange.[3] Although 1,700 brokers and dealers trade in the secondary market, the 39 primary government securities dealers account for the majority of trading volume (Appendix A).[4] Primary dealers are firms with which the Federal Reserve Bank of New York interacts directly in the course of its open market operations. They include large diversified securities firms, money center banks, and specialized securities firms, and are foreign- as well as U.S.-owned. Over time, the number of primary dealers can change, as it did most recently with the addition of Dresdner Kleinwort Benson North America LLC.

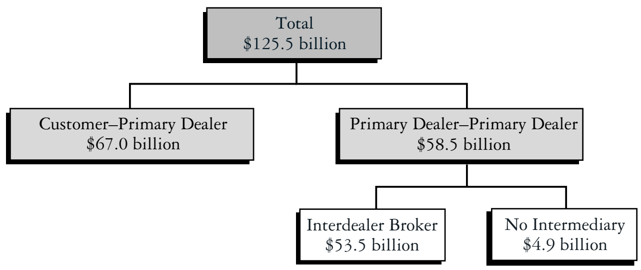
Among their responsibilities, primary dealers are expected to participate meaningfully at auction, make reasonably good markets in their trading relationships with the Federal Reserve Bank of New York's trading desk, and supply market information to the Fed. Formerly, primary dealers were also required to transact a certain level of trading volume with customers and thereby maintain a liquid secondary market for Treasury securities. Customers include nonprimary dealers, other financial institutions (such as banks, insurance companies, pension funds, and mutual funds), nonfinancial institutions, and individuals. Although trading with customers is no longer a requirement, primary dealers remain the predominant market makers in U.S. Treasury securities, buying and selling securities for their own account at their quoted bid and ask prices.

Primary dealers also trade among themselves, either directly or through interdealer brokers.[5] Interdealer brokers collect and post dealer quotes and execute trades between dealers, thereby facilitating information flows in the market while providing anonymity to the trading dealers. For the most part, interdealer brokers act only as agents. For their service, the brokers collect a fee from the trade initiator: typically $12.50 per $1 million on three-month bills (1/2 of a 100th of a point), $25.00 per $1 million on six-month and one-year bills (1/2 and 1/4 of a 100th of a point, respectively), and $39.06 per $1 million on notes and bonds (1/8 of a 32nd of a point).[6] The fees are negotiable, however, and can vary with volume.

The exchange of securities for funds typically occurs one business day after agreement on the trade. Settlement takes place either on the books of a depository institution or between depository institutions through the Federal Reserve's Fedwire securities transfer system. Clearance and settlement activity among primary dealers and other active market participants occurs primarily through the Government Securities Clearance Corporation (GSCC). The GSCC compares and nets member trades, thereby reducing the number of transactions through Fedwire and decreasing members' counterparty credit risk.

The level of trading activity among the various Treasury securities market participants is extremely high (see exhibit). Between April and August of 1994—the period examined in this article—trades involving primary dealers in the secondary market averaged about $125 billion per day.[7] More than half the volume involved primary dealer trades with customers, with the remainder involving trades between primary dealers. The vast majority of the $58.5 billion interdealer volume occurred through interdealer brokers. Activity data from these brokers form the basis of much of the analysis in this article (see box).

DAILY TRADING VOLUME OF U.S. TREASURY SECURITIES
APRIL TO AUGUST 1994



Source: Author's calculations, based on data from the Board of Governors of the Federal Reserve System.

Notes: The exhibit shows the mean daily volume of secondary trading in the cash market as reported to the Federal Reserve by the primary dealers. Because the reporting data changed in July 1994, all figures are estimated based on full-year 1994 activity. The figures are also adjusted to eliminate double counting (trades between primary dealers are counted only once).

TRADING HOURS AND LOCATIONS

Trading hours for U.S. Treasury securities have lengthened in line with the growth of the federal debt, the increase in foreign purchases of Treasuries, and the globalization of the financial services industry.[8] Trading now takes place twenty-two hours a day, five days a week (Chart 1).[9] The global trading day for U.S. Treasury securities begins at 8:30 a.m. local time in Tokyo, which is 7:30 p.m. New York daylight saving time (DST).[10] Trading continues until roughly 4 p.m. local time in Tokyo (3 a.m. New York), when trading passes to London, where it is 8 a.m.

INTERDEALER BROKER DATA

This article analyzes interdealer broker data obtained from GovPX, Inc., a joint venture of the primary dealers and several interdealer brokers set up under the guidance of the Public Securities Association (an industry trade group).[a] GovPX was formed in 1991 to increase public access to U.S. Treasury security prices (*Wall Street Journal* 1991).

GovPX consolidates and posts real-time quote and trade data from five of the six major interdealer brokers, which together account for about two-thirds of the interdealer broker market. Posted data include the best bids and offers, trade price and size, and aggregate volume traded for all Treasury bills, notes, and bonds. GovPX data are distributed electronically to the public through several on-line vendors such as Bloomberg, Knight-Ridder, and Reuters.

The data for this article include the quote and trade data for all "when-issued" and "on-the-run" securities in the cash market. When-issued securities are securities that have been announced for auction but not yet issued. On-the-run securities (also called active or current) are the most recently issued securities of a given maturity. Off-the-run (or inactive) securities, by contrast, are issued securities that are no longer active. Daily volume data obtained from GovPX reveal that 64 percent of interdealer trading is in on-the-run issues, 12 percent is in when-issued securities, and 24 percent is in off-the-run securities.

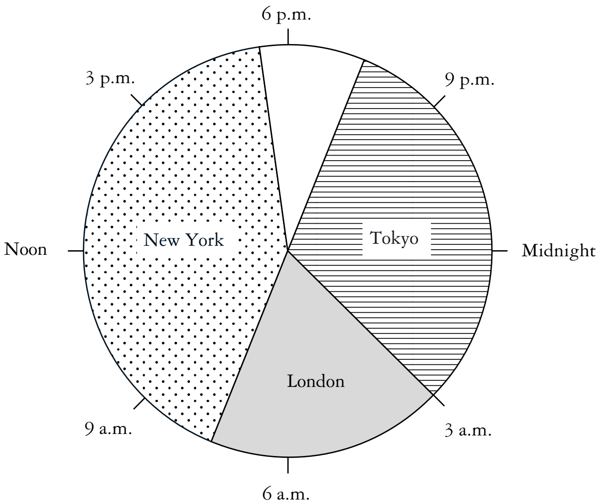
The period examined is April 4 to August 19, 1994. After holidays and missing data are excluded, ninety days from this twenty-week period are left for analysis.[b] An average of 2,702 trades a day were posted by GovPX in the sample period, along with 9,888 bid-ask spreads. For tractability purposes, the day is divided into half-hour periods. Trading locations are also assigned on the basis of the time of day a quote or trade was made (Chart 1). Appendix B discusses the data in more detail, including data cleaning and processing.

[a]The Public Securities Association has since changed its name to PSA, The Bond Market Trade Association.

[b]The market was closed in New York on three days, in Tokyo on four days, and in London on an additional two days during this period. One day was dropped because of missing data. End-of-day New York prices are used, when applicable, for the six overseas holidays to maintain as large a sample as possible.

Chart 1

TRADING TIMES FOR U.S. TREASURY SECURITIES



Notes: The chart shows the breakdown by location of interdealer trading over the global trading day. Crossover times are approximate because interdealer trading occurs over the counter and may be initiated from anywhere. All times are New York daylight saving time.

At about 12:30 p.m. local time in London, trading passes to New York, where it is 7:30 a.m. Trading continues in New York until 5:30 p.m.

Although it is convenient to think of trading occurring in three distinct geographic locations, a trade may originate anywhere. For example, business hours among the locations overlap somewhat: traders in London may continue to transact in their afternoon while morning activity picks up in New York. Traders may also transact from one location during another location's business hours. In fact, some primary dealers have traders working around the clock, but all from a single location (Stigum 1990, p. 471).

Regardless of location, the trading process for U.S. Treasuries is the same. The same securities are traded by the same dealers through the same interdealer brokers with the same brokerage fees. Trades agreed upon during overseas hours typically settle as New York trades do—one business day later in New York through the GSCC.[11]

TRADING ACTIVITY BY LOCATION

Although the U.S. Treasury securities market is an over-the-counter market with round-the-clock trading, more than 94 percent of that trading occurs in New York, on average, with less than 4 percent in London and less than 2 percent in Tokyo (Table 1).[12] While each location's share of daily volume varies across days, New York hours always comprise the vast majority (at least 87.5 percent) of daily trading.[13] This is not particularly surprising since Treasury securities are obligations of the U.S. government: most macroeconomic reports and policy changes of relevance to Treasury securities are announced during New York trading hours, and most owners of Treasury securities are U.S. institutions or individuals.[14]

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The share of U.S. Treasuries traded overseas, while small, can vary substantially. London reached its

Table 1

TRADING VOLUME OF U.S. TREASURY SECURITIES BY LOCATION

April 4 to August 19, 1994

	Tokyo	London	New York
Mean	1.84	3.50	94.66
Standard deviation	1.06	1.40	2.08
Minimum	0.14	0.55	87.53
Maximum	6.61	7.93	98.75

Source: Author's calculations, based on data from GovPX, Inc.

Note: The table reports the percentage distribution of daily interdealer trading volume by location for on-the-run and when-issued securities.

highest share of daily volume (7.9 percent) in the sample period on Friday, August 19, 1994. Tokyo reached its highest share (6.6 percent) on Friday, July 1, 1994. News reports indicate that dollar-yen movements drove overseas activity on both days. Overseas activity was also *relatively* high on July 1 because of a shortened New York session ahead of the July 4 weekend.

A more thorough examination of news stories on days when the overseas locations were particularly active or volatile suggests several reasons why U.S. Treasuries trade overseas:

- late afternoon New York activity spills over to the overseas trading locations (April 6);
- overnight activity in the foreign exchange market impacts the Treasury market (June 24);
- other overnight events occur—for example, comments are made by a government official during overseas hours (June 8);
- news is *released* during overnight hours—for instance, a U.S. newspaper article appears during overseas hours (June 21);
- overseas investors are active during overseas hours (August 17);
- central bank intervention occurs during overseas hours (May 10).

Overseas locations thus allow traders to adjust positions in response to overnight events and give foreign investors and institutions the opportunity to trade during their own business hours.

On a typical weekday, trading starts at 7:30 p.m. New York DST with relatively low volume throughout Tokyo hours (Chart 2). Volume picks up somewhat when London opens at 3 a.m. (New York DST) and remains fairly steady through London trading hours. Volume jumps higher in the first half hour of New York trading (7:30 a.m. to 8 a.m.), then spikes upward in the next half hour of trading. Volume reaches a daily peak between 8:30 a.m. and 9 a.m. Except for a small peak from 10 a.m. to 10:30 a.m., volume generally falls until the 1 p.m. to 1:30 p.m. interval. Volume rises again to a peak between 2:30 p.m. and 3 p.m., then quickly tapers off, with trading ending by 5:30 p.m. New York DST.

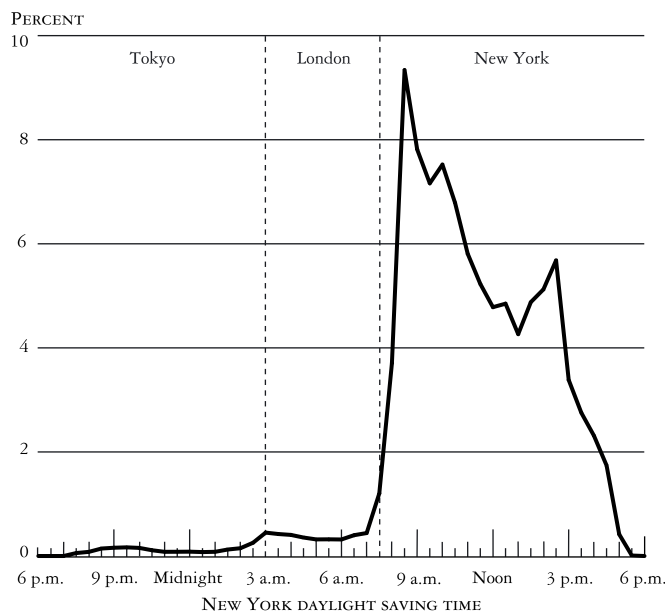
> *Overseas locations . . . allow traders to adjust positions in response to overnight events and give foreign investors and institutions the opportunity to trade during their own business hours.*

The pattern of U.S. Treasuries trading between 8:30 a.m. and 3 p.m. parallels that of equity markets trading. Several studies of equity securities (such as Jain and Joh [1988] and McInish and Wood [1990]) have found

Chart 2

TRADING VOLUME OF U.S. TREASURY SECURITIES BY HALF HOUR

APRIL 4 TO AUGUST 19, 1994



Source: Author's calculations, based on data from GovPX, Inc.

Notes: The chart shows the mean half-hourly interdealer trading volume as a percentage of mean daily interdealer trading volume for on-the-run and when-issued securities. The times on the horizontal axis indicate the beginning of intervals (for example, 9 a.m. for 9 a.m. to 9:30 a.m.).

that daily volume peaks at the opening of trading, trails off during the day, then rises again at the close. Jain and Joh (1988) speculate that news since the prior close may drive morning volume, while afternoon volume may reflect the closing or hedging of open positions in preparation for the overnight hours.

In the U.S. Treasury securities market, the daily peak between 8:30 a.m. and 9 a.m. is at least partially explained by the important macroeconomic reports (including employment) released at 8:30 a.m. (Fleming and Remolona 1996). The opening of U.S. Treasury futures trading at 8:20 a.m. on the Chicago Board of Trade (CBT) is probably also a factor in this peak. The slight jump in volume between 10 a.m. and 10:30 a.m. may be a response to the 10 a.m. macroeconomic reports. The peak in volume between 2:30 p.m. and 3 p.m. coincides with the closing of U.S. Treasury futures trading at 3 p.m. There is little evidence that activity picks up during the Federal Reserve's customary intervention time (11:30 a.m. to 11:45 a.m.)[15] or during the announcement of Treasury auction results (typically 1:30 p.m. to 2 p.m.).

Trading Activity by Maturity

To this point, the volume statistics have been examined without regard to the particular issues making up the total volume. However, there is significant variation in trading activity by maturity for the most recently issued, or on-the-run, Treasury securities (Chart 3). The five-year note is the most actively traded security, accounting for more than one-fourth (26 percent) of on-the-run volume. The two- and ten-year notes are close behind, with shares of 21 percent and 17 percent, respectively, while the three-year note accounts for 8 percent.[16] The one-year bill accounts for 10 percent, the three-month bill for 7 percent, the six-month bill for 6 percent, and the occasionally issued cash-management bill for 1 percent.[17] The bellwether thirty-year bond accounts for less than 3 percent of total on-the-run volume.[18]

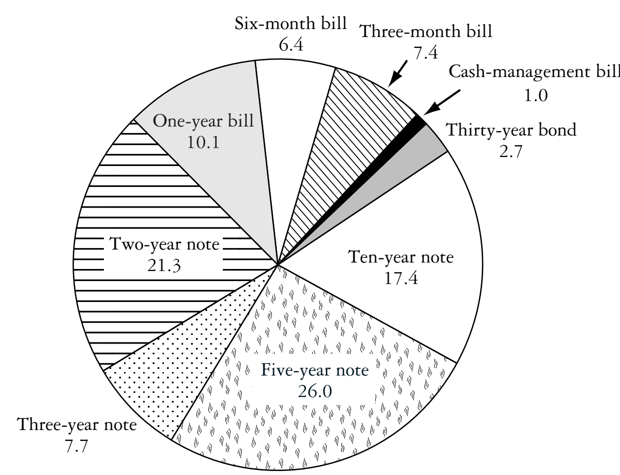
There is significant variation in trading activity by maturity for the most recently issued, or on-the-run, Treasury securities.

A breakdown of trading volume by maturity for each of the three locations reveals that the most significant difference across locations is the dearth of U.S. Treasury bill trading overseas.

The value of outstanding on-the-run securities by maturity cannot explain the level of trading by maturity. Auction sizes over the period examined were reasonably similar by maturity with three-month, six-month, five-year, ten-year, and thirty-year auctions running in the

Chart 3

Trading Volume of U.S. Treasury Securities by Maturity
April 4 to August 19, 1994



Source: Author's calculations, based on data from GovPX, Inc.

Note: The chart shows the mean interdealer trading volume by maturity as a percentage of the mean total interdealer trading volume for on-the-run securities.

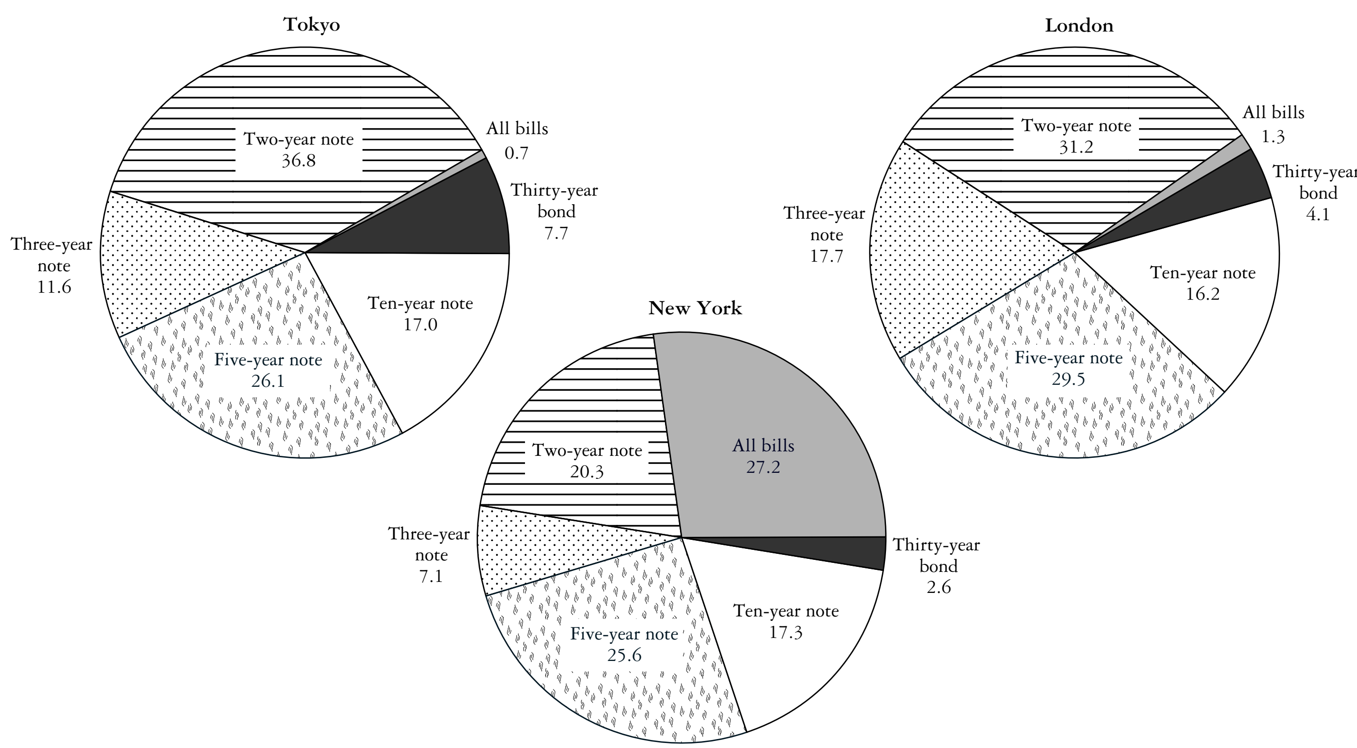
$11.0 billion to $12.5 billion range and one-, two-, and three-year auctions running in the $16.5 billion to $17.5 billion range. When the auctions that were reopenings of previously auctioned securities are taken into account, volume outstanding is actually higher for the relatively lightly traded three-month, six-month, and thirty-year securities.

A breakdown of trading volume by maturity for each of the three locations reveals that the most significant difference across locations is the dearth of U.S. Treasury bill trading overseas (Chart 4). Although Treasury bills (the one-year, six-month, three-month, and cash-management issues) represent 27 percent of trading in New York, they represent just 1 percent of trading in both London and Tokyo. On most days, in fact, not a single U.S. Treasury bill trade is brokered during the overseas hours. The distribution of overseas trading in Treasury notes is reasonably similar to that of New York, although the two-year note is the most frequently traded overseas (as opposed to the five-year note in New York) and heavier relative volume is evident in the three-year note. The thirty-year bond is traded more intensively overseas relative to total volume—particularly in Tokyo, where it represents nearly 8 percent of total volume.

A distributional breakdown of trading in each maturity by location (Table 2) confirms that bill volume is extremely low overseas. London trades less than 0.4 percent of the total daily volume for each bill (on average) and Tokyo trades less than 0.2 percent. In contrast, London trades 3 to 6 percent of daily volume for the two-, five-, ten-, and thirty-year securities, and more than 9 percent for the three-year note. Tokyo trades 2 to 4 percent of daily

Chart 4

TRADING VOLUME OF U.S. TREASURY SECURITIES BY LOCATION AND MATURITY
APRIL 4 TO AUGUST 19, 1994



Source: Author's calculations, based on data from GovPX, Inc.

Note: The chart shows the mean interdealer trading volume by maturity as a percentage of the mean total interdealer trading volume in each location for on-the-run securities.

volume for each of the notes, and more than 6 percent for the thirty-year bond. Although volumes vary substantially across trading locations, a plot of daily volume by half hour (not shown) would reveal a very similar intraday pattern for each of the notes and bonds. Like bill trading, when-issued trading is low overseas and particularly so in Tokyo. Because of the limited overseas trading in bills and when-issued securities, the remainder of the analysis will treat on-the-run notes and bonds exclusively.

PRICE VOLATILITY

Analyzing intraday price volatility leads to an improved understanding of the determinants of Treasury prices. As noted by French and Roll (1986), price volatility arises not only from public and private information that bears on prices but also from errors in pricing. The authors show, however, that pricing errors are only a small component of equity security volatility. This article contends that pricing errors are probably an even smaller component of Treasury security volatility because of the market's greater liquidity.

The vast majority of price discovery is found to occur during New York hours, with relatively little price discovery in Tokyo or London.

Table 2
TRADING VOLUME OF U.S. TREASURY SECURITIES BY MATURITY AND LOCATION
April 4 to August 19, 1994

Security Type	Tokyo	London	New York
Cash-management bill			
Mean	0.00	0.00	100.00
Standard deviation	0.00	0.00	0.00
Three-month bill			
Mean	0.15	0.03	99.82
Standard deviation	1.06	0.27	1.11
Six-month bill			
Mean	0.03	0.40	99.57
Standard deviation	0.25	1.69	1.70
One-year bill			
Mean	0.01	0.23	99.76
Standard deviation	0.12	1.00	1.01
Two-year note			
Mean	3.87	5.85	90.27
Standard deviation	3.60	3.60	5.85
Three-year note			
Mean	3.07	9.23	87.71
Standard deviation	2.67	6.33	7.27
Five-year note			
Mean	2.13	4.48	93.40
Standard deviation	1.41	1.87	2.70
Ten-year note			
Mean	2.07	3.64	94.29
Standard deviation	1.48	2.09	2.99
Thirty-year bond			
Mean	6.37	5.95	87.68
Standard deviation	5.99	4.72	8.81
When-issued bills			
Mean	0.02	0.28	99.70
Standard deviation	0.16	2.51	2.52
When-issued notes and bonds			
Mean	0.92	1.80	97.28
Standard deviation	1.29	2.16	2.75

Source: Author's calculations, based on data from GovPX, Inc.

Note: The table reports the percentage distribution of daily interdealer trading volume by location and security type for on-the-run and when-issued securities.

The examination of price volatility is therefore largely an examination of price movements caused by the arrival of information. The process by which Treasury prices adjust to incorporate new information is referred to in this article as *price discovery.*

Price volatility is examined across days, trading locations, and half-hour intervals of the day. Daily price volatility is calculated as the absolute value of the difference between the New York closing bid-ask midpoint and the previous day's New York closing bid-ask midpoint.[19] Price volatility for each trading location is calculated as the absolute value of the difference between that location's closing bid-ask midpoint and the closing bid-ask midpoint for the previous trading location in the round-the-clock market. Half-hour price volatility is calculated as the absolute value of the difference between the last bid-ask midpoint in that half hour and the last bid-ask midpoint in the previous half hour.[20] Volatility is not calculated for two different securities of similar maturity (there is a missing observation when the on-the-run security changes after an auction).

The vast majority of price discovery is found to occur during New York hours, with relatively little price discovery in Tokyo or London (Table 3). For example, the five-year note's expected price movement during Tokyo hours is 6/100ths of a point, during London hours 6/100ths of a point, and during New York hours 27/100ths of a point. By contrast, the daily expected price movement is 28/100ths of a point. For other securities as well, volatility is similar for Tokyo and London but much higher for New York.

Like the findings for trading volume, these results are not too surprising. Treasury securities are obligations of the U.S. government, and most macroeconomic reports and policy changes of relevance to the securities are announced during New York trading hours. Studies of the foreign exchange market have also found price volatility to be generally greater during New York trading hours, albeit to a lesser extent than found here (Ito and Roley 1987; Baillie and Bollerslev 1990).

An examination of price volatility by half-hour interval (Chart 5) reveals that volatility is fairly steady from the global trading day's opening in Tokyo (7:30 p.m. New York DST) through morning trading hours in London (7 a.m. New York). Volatility picks up in early afternoon London trading right before New York opens (7 a.m. to 7:30 a.m. New York). It then increases in the first hour of New York trading (7:30 a.m. to 8:30 a.m.) and spikes higher to reach its daily peak between 8:30 a.m. and 9 a.m. A general decline is observed until the 12:30 p.m. to 1 p.m. period, although there is a spike in the 10 a.m. to 10:30 a.m. period. Volatility then picks up again, reaches a peak between 2:30 p.m. and 3 p.m., and falls off quickly after 3 p.m. to levels comparable to those seen in the overseas hours. The intraday volatility pattern is similar across maturities.

In their study of intraday price volatility in the CBT's Treasury bond futures market, Ederington and Lee (1993) find that volatility peaks between 8:30 a.m. and 8:35 a.m. and is relatively level the rest of the trading day (the trading day runs from 8:20 a.m. to 3 p.m.). The authors observe, however, that price volatility shows no increase between 8:30 a.m. and 8:35 a.m. on days when no 8:30 a.m. macroeconomic announcements are made. These

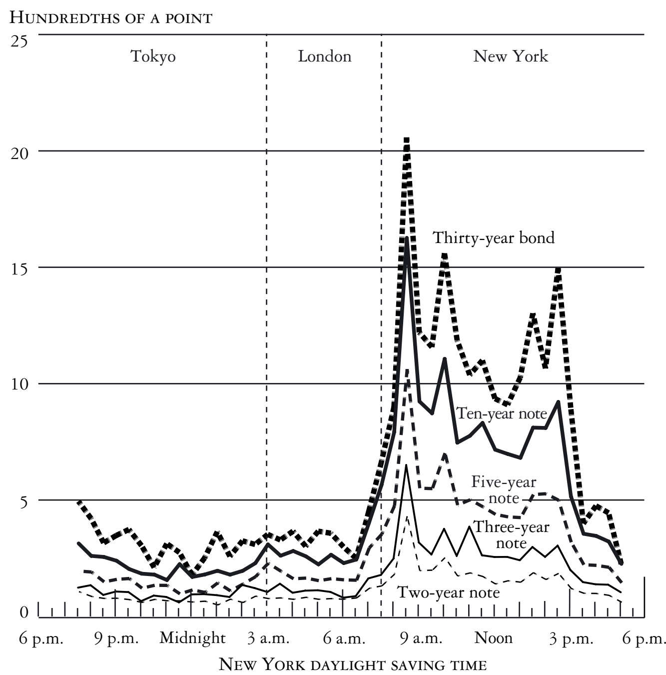
Table 3
PRICE VOLATILITY OF U.S. TREASURY SECURITIES
April 4 to August 19, 1994

Security Type	Daily	Tokyo	London	New York
Two-year note				
Mean	10.68	2.91	2.12	9.94
Standard deviation	9.91	2.61	2.00	9.39
Three-year note				
Mean	16.60	3.91	3.38	15.61
Standard deviation	13.64	3.78	3.45	12.99
Five-year note				
Mean	28.08	6.10	5.69	26.63
Standard deviation	23.43	5.55	5.93	22.19
Ten-year note				
Mean	43.40	8.00	8.73	43.10
Standard deviation	37.22	8.30	8.66	35.93
Thirty-year bond				
Mean	58.28	11.35	10.32	56.53
Standard deviation	50.45	11.33	11.93	48.62

Source: Author's calculations, based on data from GovPX, Inc.

Notes: The table reports price volatility for on-the-run notes and bonds. Values are in hundredths of a point. Daily price volatility is calculated as the absolute value of the difference between the New York closing bid-ask midpoint and the previous day's New York closing bid-ask midpoint. Price volatility for each trading location is calculated as the absolute value of the difference between that location's closing bid-ask midpoint and the closing bid-ask midpoint for the previous trading location in the round-the-clock market.

Chart 5
PRICE VOLATILITY OF U.S. TREASURY SECURITIES BY HALF HOUR
APRIL 4 TO AUGUST 19, 1994



Source: Author's calculations, based on data from GovPX, Inc.

Notes: The chart shows the mean half-hourly price volatility for on-the-run notes and bonds. Volatility is calculated as the absolute value of the difference between the last bid-ask midpoint in that half hour and the last bid-ask midpoint in the previous half hour. For the 7:30 p.m. to 8 p.m. interval, the previous interval is considered 5 p.m. to 5:30 p.m. The times on the horizontal axis indicate the beginning of intervals (for example, 9 a.m. for 9 a.m. to 9:30 a.m.).

findings give strong support to the hypothesis that the 8:30 a.m. to 9 a.m. volatility in the cash market is driven by these announcements.[21]

The intraday pattern of price volatility has also been studied for equity and foreign exchange markets. Equity market studies (such as Wood, McInish, and Ord [1985] and Harris [1986]) find volatility peaking at the markets' opening, falling through the day, and rising somewhat at the end of trading. Again, we see a similar pattern for U.S. Treasury securities if we limit our examination to the 8:30 a.m. to 3 p.m. period. Outside of this period, price volatility is relatively low.

By contrast, the intraday volatility pattern in the foreign exchange market is markedly different. Although price volatility does peak in the morning in New York, the second most notable peak is seen in the morning in Europe and no volatility peak occurs in the New York afternoon (Baillie and Bollerslev 1990; Andersen and Bollerslev forthcoming). Although there is no official closing time for the U.S. Treasury securities market, the market behaves in some ways as if there were one, apparently because of the fixed trading hours of Treasury futures and the predominance of U.S. news and investors in determining prices.

Although there is no official closing time for the U.S. Treasury securities market, the market behaves in some ways as if there were one, apparently because of the fixed trading hours of Treasury futures and the predominance of U.S. news and investors in determining prices.

The similarities in the Treasury market between intraday price volatility (Chart 5) and intraday volumes (Chart 2) are striking. Both peak between 8:30 a.m. and 9 a.m., a period encompassing the 8:30 a.m. macroeconomic announcements and following, by just ten minutes, the opening of CBT futures trading. Both peak again between 2:30 p.m. and 3 p.m., the last half hour of CBT futures trading. Both show small peaks in the 10 a.m. to 10:30 a.m. period, when less significant macroeconomic announcements are made. Volatility seems to jump slightly in periods of Fed intervention (then 11:30 a.m. to 11:45 a.m.) and when auction announcements are made (typically 1:30 p.m. to 2 p.m.), but these movements are secondary.

The relationship between trading volume and price changes has also been studied extensively in other financial markets.[22] These studies consistently find trading volume and price volatility positively correlated for a variety of trading intervals. Most models attribute this relationship to information differences or differences of opinion among traders. New information or opinions become incorporated in prices through trading, leading to the positive volume-volatility relationship.

The volume-volatility relationship for U.S. Treasury securities is depicted in Chart 6. The five-year note's trading volume is plotted against price volatility (as calculated in Chart 5) for every half-hour interval in the sample period.[23] The upward slope of the regression lines demonstrates a positive relationship between volume and price volatility. A positive relationship is also indicated by the positive correlation coefficients (.57 for all trading locations combined, .24 for Tokyo, .22 for London, and .51 for New York), all of which are significant at the .01 level. The same positive correlation between trading volume and price volatility documented in other financial markets holds for the U.S. Treasury market.

BID-ASK SPREADS

U.S. Treasury investors who may need to trade at any moment or who rely on the market for pricing other instruments or gauging market sentiment are concerned with market liquidity. The bid-ask spread, which measures a major cost of transacting in a security, is an important indicator of market liquidity. The spread is defined as the difference between the highest price a prospective buyer is willing to pay for a given security (the bid) and the lowest price a prospective seller is willing to accept (the ask, or the offer). In looking across days, trading locations, and half-hour intervals, this article calculates spreads as the mean difference between the bid and the offer price for all bid-ask quotes posted.[24]

Four components of the bid-ask spread have been identified in the academic literature: asymmetric information, inventory carrying, market power, and order processing.[25] Asymmetric information compensates the market maker for exposure to better informed traders; inventory carrying accounts for the market maker's risk in holding a security; market power is that part of the spread attributable to imperfect competition among market makers; order processing allows for the market maker's direct costs of executing a trade.

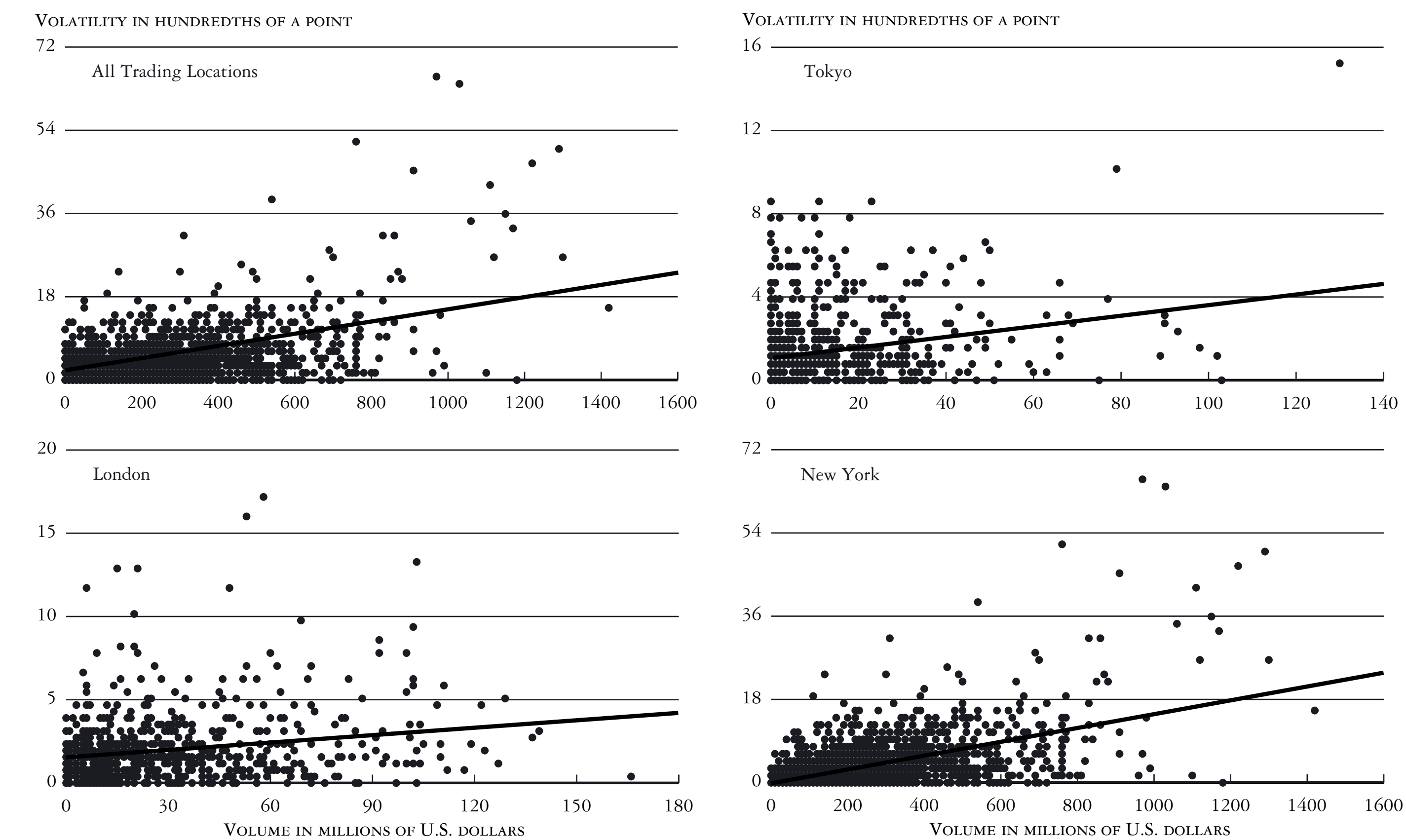
Treasury market bid-ask spreads are extremely narrow and increase with maturity (Table 4). The daily spread averages 0.8/100ths of a point for the two-year security, 1.7/100ths for the three-year, 1.5/100ths for the five-year, 2.5/100ths for the ten-year, and 6.3/100ths for the thirty-year.[26] The increase in spread with maturity is not surprising given the positive relationship between price volatility and maturity (Table 3).[27] The higher spread on more volatile securities compensates the market

Treasury market bid-ask spreads are extremely narrow and increase with maturity.

Chart 6

Correlation of Trading Volume and Price Volatility for Five-Year U.S. Treasury Note

April 4 to August 19, 1994



Source: Author's calculations, based on data from GovPX, Inc.

Note: The chart plots half-hourly price volatility against GovPX trading volume for the on-the-run U.S. Treasury note for all trading locations and by location.

maker for increased asymmetric information and inventory-carrying costs. The exception to this pattern—the five-year note, which has a lower spread than the three-year note—is likely attributable to the greater volume transacted in the five-year note (Chart 3). Higher volume in a security leads to economies of scale in order processing and is probably associated with greater market maker competition.

Bid-ask spreads in the U.S. Treasury market are comparable to those in the foreign exchange market but significantly lower than those in the equity markets. Bessembinder (1994) finds interbank bid-ask spreads of 0.064 percent for dollar-yen transactions and 0.062 percent for dollar-pound transactions—roughly the size of the spread on a thirty-year Treasury bond. Mean equity market spreads are found to vary from 1.4 to 3.1 percent (Amihud and Mendelson 1986; Stoll 1989; Laux 1993; Affleck-Graves, Hegde, and Miller 1994), a range roughly 50 to 200 times greater than that for on-the-run U.S. Treasury securities. The substantially lower bid-ask spreads in the Treasury market probably reflect lower asymmetric information costs, lower order-processing costs, and lower market-power costs. Market making for U.S. Treasuries is extremely competitive, with a high number of trades, large trade sizes, and limited private information.

New York spreads are lower than overseas spreads for every U.S. Treasury note, and London spreads are narrower than those in Tokyo. For example, the five-year note's spread is 1.5/100ths of a point in New York, 2.0/100ths in London, and 2.5/100ths in Tokyo. The New York differences from Tokyo are statistically significant (at the .01 level) for every note, and the New York differences from London are statistically significant (at the .01 level) for the two-, five-, and ten-year notes. The London-Tokyo differences are statistically significant for the two- and three-year notes (at the .01 level) and to a lesser extent for the five-year note (at the .05 level).

Bid-ask spreads in the U.S. Treasury market are comparable to those in the foreign exchange market but significantly lower than those in the equity markets.

Spreads are similar across trading locations for the thirty-year bond. The mean spread is 6.4/100ths of a point in New York, 6.3/100ths in London, and 5.9/100ths in Tokyo. However, two cautions regarding the spreads are in order: First, spreads are often not posted during the overseas hours, particularly in Tokyo.[28] Second, the spreads give no indication of the associated quantities bid or offered, which may be lower in the overseas locations (but are not part of this study's data set).[29] Cautions notwithstanding, the higher relative volume of the thirty-year bond in Tokyo might be expected to result in smaller spread differences. Another factor may be the CBT's evening and overnight hours in the futures market—a market dominated by the thirty-year bond.

Examining bid-ask spreads by half-hour intervals,

Table 4
BID-ASK SPREADS ON U.S. TREASURY SECURITIES
April 4 to August 19, 1994

Security Type	All Locations	Tokyo	London	New York
Two-year note				
Mean	0.83	1.37	1.12**	0.78 ** ##
Standard deviation	0.14	0.58	0.38	0.15
Three-year note				
Mean	1.68	2.47	1.79**	1.65**
Standard deviation	0.30	1.06	0.77	0.31
Five-year note				
Mean	1.53	2.48	2.04 *	1.47 ** ##
Standard deviation	0.23	1.90	0.59	0.24
Ten-year note				
Mean	2.50	3.83	3.73	2.39 ** ##
Standard deviation	0.36	1.21	1.13	0.38
Thirty-year bond				
Mean	6.30	5.93	6.27	6.36
Standard deviation	1.11	2.12	2.86	1.15

Source: Author's calculations, based on data from GovPX, Inc.

Notes: The table reports interdealer bid-ask spreads for on-the-run notes and bonds. Values are in hundredths of a point. Spreads are calculated daily as the mean difference between the bid and the offer for all bid-ask quotes posted during that location's (or during all locations') trading hours.

* Significantly different from Tokyo at the .05 level based on two-sided t-test.

** Significantly different from Tokyo at the .01 level based on two-sided t-test

Significantly different from London at the .05 level based on two-sided t-test.

Significantly different from London at the .01 level based on two-sided t-test.

this article finds that the general pattern exhibited by the three-, five-, and ten-year notes (and to a lesser extent the two-year note) is of a triple "u" shape (Chart 7). The bid-ask spread begins at its daily high with the start of trading in Tokyo (7:30 p.m. New York DST). The spread drops quickly, levels out, and rises toward the end of trading in Tokyo (2 a.m. to 3 a.m. New York). The spread declines from this early morning peak as London trading gets under way, then rises again to a peak when trading passes to New York (7 a.m. to 8 a.m.). The spread then falls again, remains roughly level throughout the late morning and early afternoon, and rises in the late afternoon as trading drops off (4:30 p.m. to 5:30 p.m.).

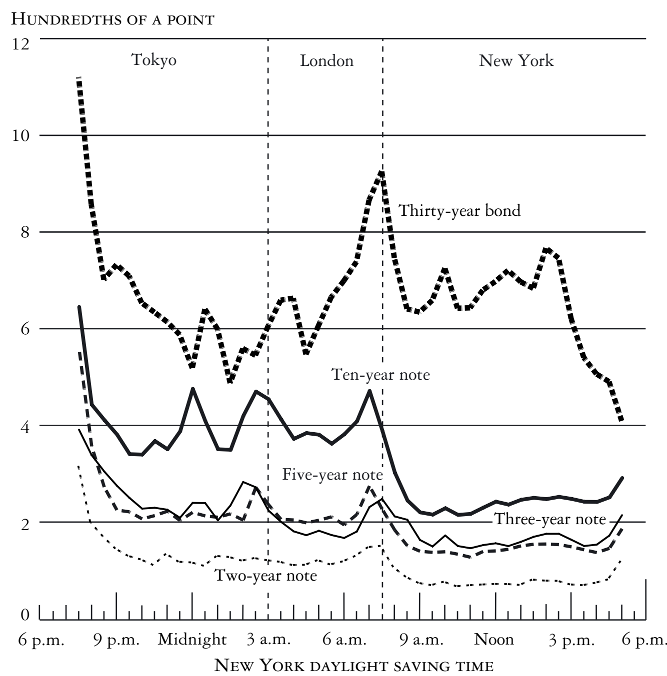
This pattern is quite different from that found in the foreign exchange market, but similar in some ways to that in the equity markets. Bollerslev and Domowitz (1993) find that the deutsche mark–dollar spread peaks during the Far Eastern lunch break and reaches a low during morning trading in Europe. U.S. equity market studies (such as McInish and Wood [1992] and Brock and Kleidon [1992]) have found that bid-ask spreads are highest at the markets' opening, fall through the day, and rise again at the end of trading. U.S. Treasury notes follow the same pattern in New York, but also seem to replicate it overseas. The result is the triple-u-shaped pattern of Chart 7.

The pattern for the thirty-year bond is somewhat different. Like the note spreads, the thirty-year bond spread peaks at the opening in Tokyo and also peaks in the morning, when New York opens. Unlike the note spreads, however, the bond spread does not peak at the Tokyo close. More striking is the afternoon behavior of the bond spread in New York: it peaks between 1:30 p.m. and 2 p.m., then declines during the rest of the afternoon. The CBT futures market's 3 p.m. closing may help explain this pattern. Note, too, that the thirty-year bond is the only security examined for which a substantial number of observations are missing in the late afternoon of New York.[30]

Examining bid-ask spreads by half-hour intervals, this article finds that the general pattern exhibited by the three-, five-, and ten-year notes (and to a lesser extent the two-year note) is of a triple "u" shape.

Chart 7

BID-ASK SPREADS ON U.S. TREASURY SECURITIES BY HALF HOUR
APRIL 4 TO AUGUST 19, 1994



Source: Author's calculations, based on data from GovPX, Inc.

Notes: The chart shows the mean half-hourly interdealer bid-ask spread for on-the-run notes and bonds. Spreads are calculated daily as the mean difference between the bid and the offer for all bid-ask quotes posted during that half hour. The times on the horizontal axis indicate the beginning of intervals (for example, 9 a.m. for 9 a.m. to 9:30 a.m.).

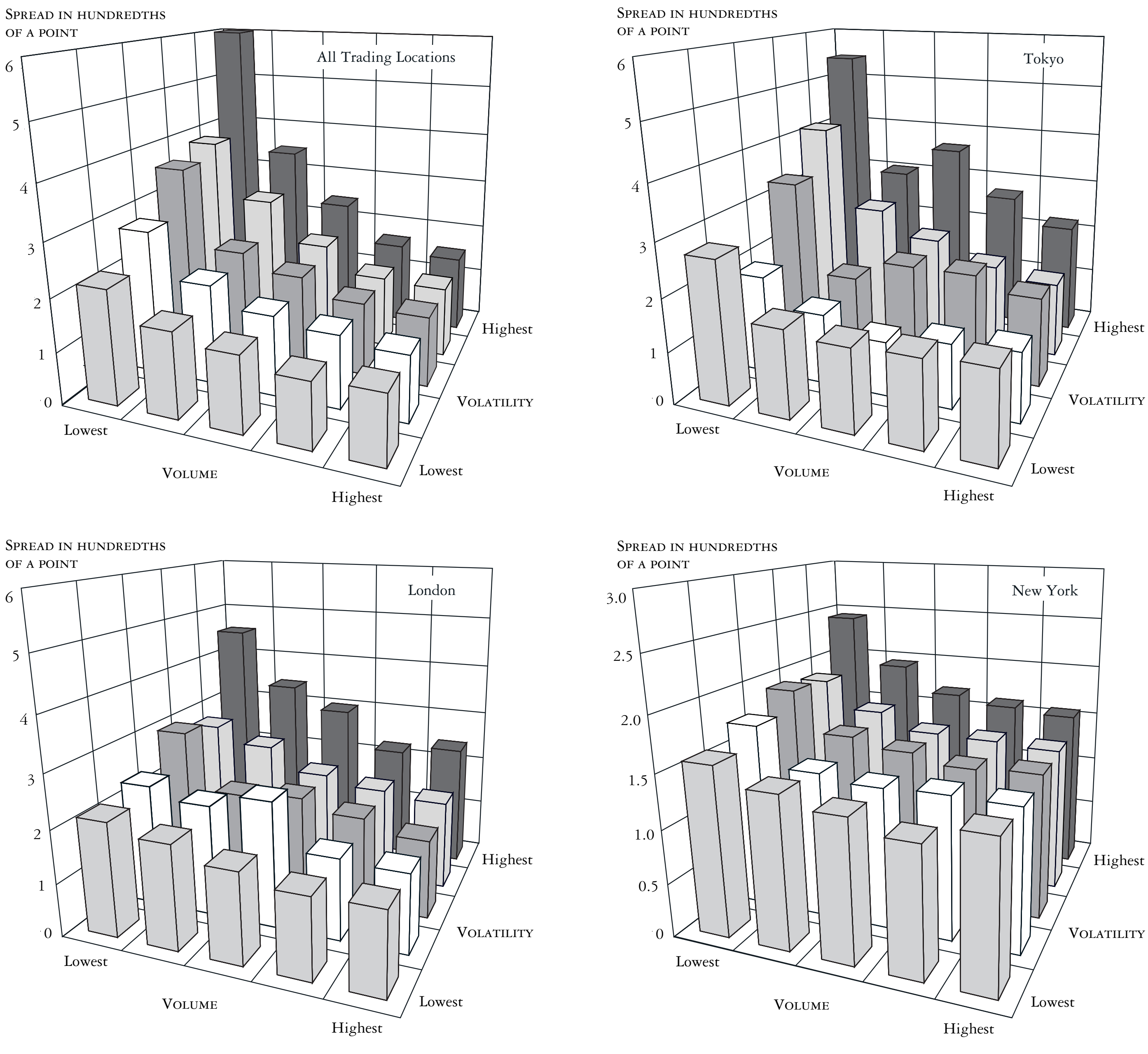
Numerous studies have related bid-ask spreads to trading activity and price volatility for a variety of financial markets.[31] These studies generally find a negative relationship between volume and bid-ask spreads and a positive relationship between price volatility and bid-ask spreads. The volume-spread relationship probably reflects decreasing order-processing costs, decreasing inventory-carrying costs, and increasing market maker competition as volume increases. The volatility-spread relationship likely reflects increasing inventory-carrying costs and increasing asymmetric information costs as volatility increases.

This relationship for the U.S. Treasury securities market is illustrated in Chart 8. Half-hour price volatility and trading volume are grouped into quintiles as defined for the relevant trading location. The plots show the mean of the mean half-hourly bid-ask spread for every volume-volatility quintile combination for the five-year note. The

Chart 8

Relationship of Bid-Ask Spread to Trading Volume and Price Volatility for Five-Year U.S. Treasury Note

April 4 to August 19, 1994



Source: Author's calculations, based on data from GovPX, Inc.

Notes: The chart plots the mean half-hourly mean bid-ask spread against the half-hour trading volume quintile and price volatility quintile for the on-the-run U.S. Treasury note for all trading locations and by location. Volume and volatility quintiles are defined separately for each panel.

chart reveals that higher price volatility is associated with higher bid-ask spreads, and higher trading volume is associated with lower bid-ask spreads. These simple relationships are confirmed by highly significant correlation coefficients.[32]

PRICE EFFICIENCY REGRESSIONS

With low overseas trading volume, low overseas price discovery, and high overseas bid-ask spreads, it is reasonable to ask whether the overseas trading locations are efficient. That is, are the price changes observed overseas a response to new information that later becomes incorporated in prices in New York? Or does the relative illiquidity of the overseas markets make price changes there an unreliable guide to the path of future prices? Those who have studied the U.S. Treasury market report that large trades are not easily transacted overseas without significant price concessions (Madigan and Stehm 1994; Stigum 1990). Furthermore, work by Neumark, Tinsley, and Tosini (1991) uncovers evidence that overseas price changes of U.S. equity securities are not efficient.[33] They argue that higher overseas transaction costs are a barrier to the transmission of small (but not large) price signals.

However, overseas price efficiency might be expected for several reasons. While volume is relatively low overseas, a typical day still sees interdealer volume of more than $450 million during Tokyo hours and nearly $900 million

Table 5
OVERNIGHT PRICE RESPONSE OF U.S. TREASURY SECURITIES TO TOKYO PRICE MOVEMENTS
April 4 to August 19, 1994

	Two-Year Note	Three-Year Note	Five-Year Note	Ten-Year Note	Thirty-Year Bond
Intercept	0.00	0.00	0.00	0.00	0.00
(Standard error)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\hat{\beta}$	0.97	0.89	0.85	0.89	0.94
(Standard error)	(0.14)	(0.10)	(0.10)	(0.11)	(0.05)
Adjusted R-squared	0.50	0.39	0.36	0.30	0.58
Durbin-Watson statistic	1.61	2.00	1.76	1.70	1.90
Number of observations	86	82	85	87	83

Source: Author's calculations, based on data from GovPX, Inc.

Notes: The table reports regression estimates of New York overnight price response to price movements during Tokyo hours for on-the-run notes and bonds. Reported standard errors are heteroskedasticity-consistent.

Table 6
OVERNIGHT PRICE RESPONSE OF U.S. TREASURY SECURITIES TO LONDON PRICE MOVEMENTS
April 4 to August 19, 1994

	Two-Year Note	Three-Year Note	Five-Year Note	Ten-Year Note	Thirty-Year Bond
Intercept	0.00	0.00	0.00	0.00	0.00
(Standard error)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$\hat{\beta}$	0.98	0.95	1.05	1.10	1.04
(Standard error)	(0.07)	(0.06)	(0.07)	(0.08)	(0.05)
Adjusted R-squared	0.78	0.71	0.80	0.78	0.84
Durbin-Watson statistic	1.87	1.69	1.95	1.37	1.64
Number of observations	85	87	87	88	84

Source: Author's calculations, based on data from GovPX, Inc.

Notes: The table reports regression estimates of New York overnight price response to price movements during London hours for on-the-run notes and bonds. Reported standard errors are heteroskedasticity-consistent.

during London hours.[34] In addition, the same market participants are transacting overseas and in New York. Furthermore, while spreads may be relatively high overseas, they are still low in an absolute sense, and brokerage fees are the same overseas as in New York. Overseas departures from price efficiency would seem to be easily exploited with trades that could be reversed for a profit just a few hours later.

This article follows the Neumark, Tinsley, and Tosini (1991) methodology. If overseas trading locations are efficient, overseas prices should reflect the evolving value of Treasury securities as news arrives during the overnight hours. If high-frequency price movements of U.S. Treasury securities can be characterized as a martingale process,[35] overseas price movements should provide an unbiased prediction of overnight price changes in New York. The regression of the overnight New York price change on the Tokyo price change,

$$(1) \quad (NY_t^o - NY_{t-1}^c)/NY_{t-1}^c = \alpha + \beta^*(TK_t^c - NY_{t-1}^c)/NY_{t-1}^c + \varepsilon_t \ ,$$

and the regression of the overnight New York price change on the London price change,

$$(2) \quad (NY_t^o - NY_{t-1}^c)/NY_{t-1}^c = \alpha + \beta^*(LN_t^c - NY_{t-1}^c)/NY_{t-1}^c + \varepsilon_t \ ,$$

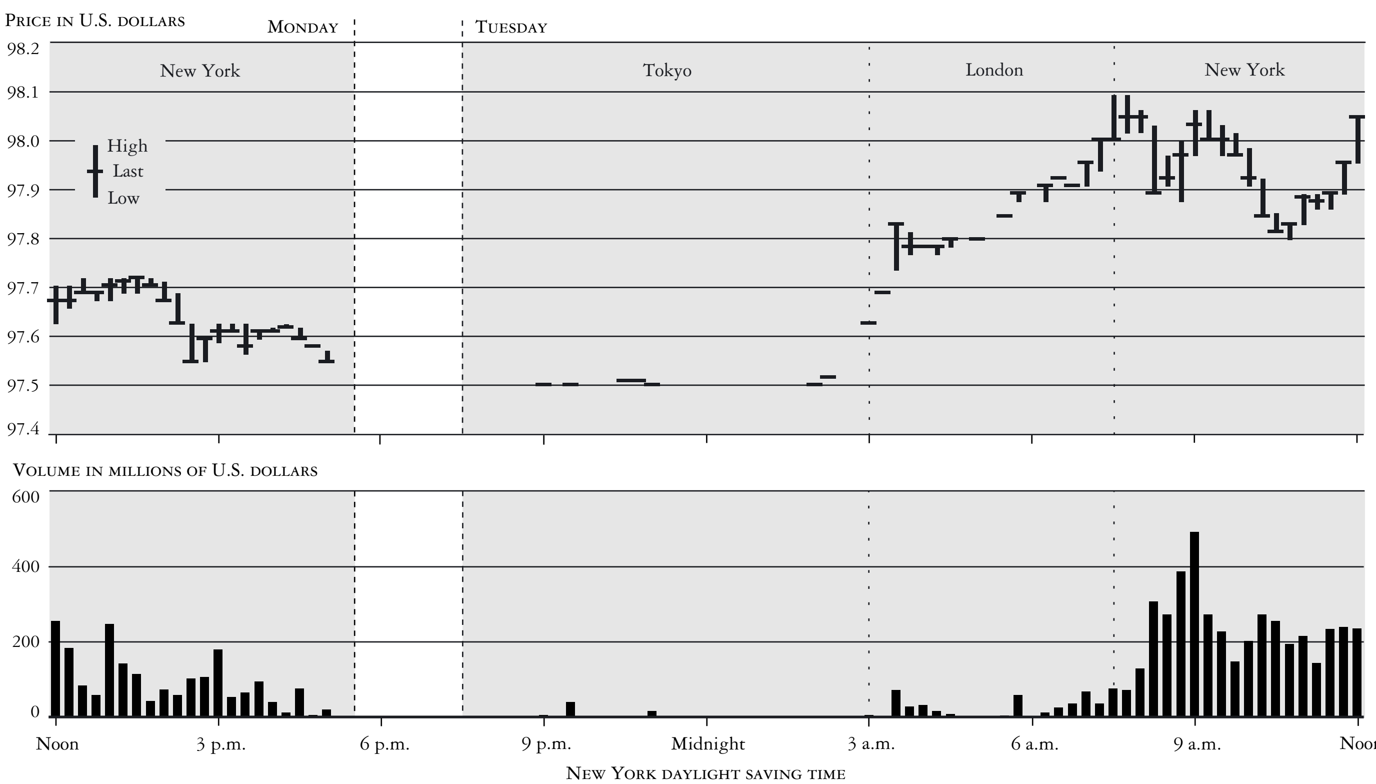
should have slope coefficients (β) equal to 1.0.

The regressions exclude crossover times in order to get "clean" prices that are more easily attributable to a particular location. Sample times are 5:30 p.m. for the

Chart 9

London Price Change as a Predictor of Overnight Price Change in New York

May 9 (Noon) to May 10 (Noon) 1994



Source: Author's calculations, based on data from GovPX, Inc.

Note: The chart shows the interdealer price path and the associated GovPX trading volume for the on-the-run five-year U.S. Treasury note by quarter hour.

New York close, 2:30 a.m. (3:30 p.m. Tokyo time) for the Tokyo close, 7 a.m. (noon London time) for the London close, and 8 a.m. for the New York opening. Observations are included only when all prices refer to the same security (there is a missing observation when the on-the-run security changes).

The Tokyo price movement regressions reveal that the slope coefficient is insignificantly different from 1.0 in all five maturities (Table 5). There is, therefore, insufficient evidence to reject the null hypothesis that Tokyo price changes are unbiased predictors of overnight price changes in New York. Furthermore, the slope coefficient is significantly different from zero (at the .01 level) in all five maturities. U.S. Treasury security price movements in Tokyo thus reflect new information that is subsequently incorporated in New York prices.

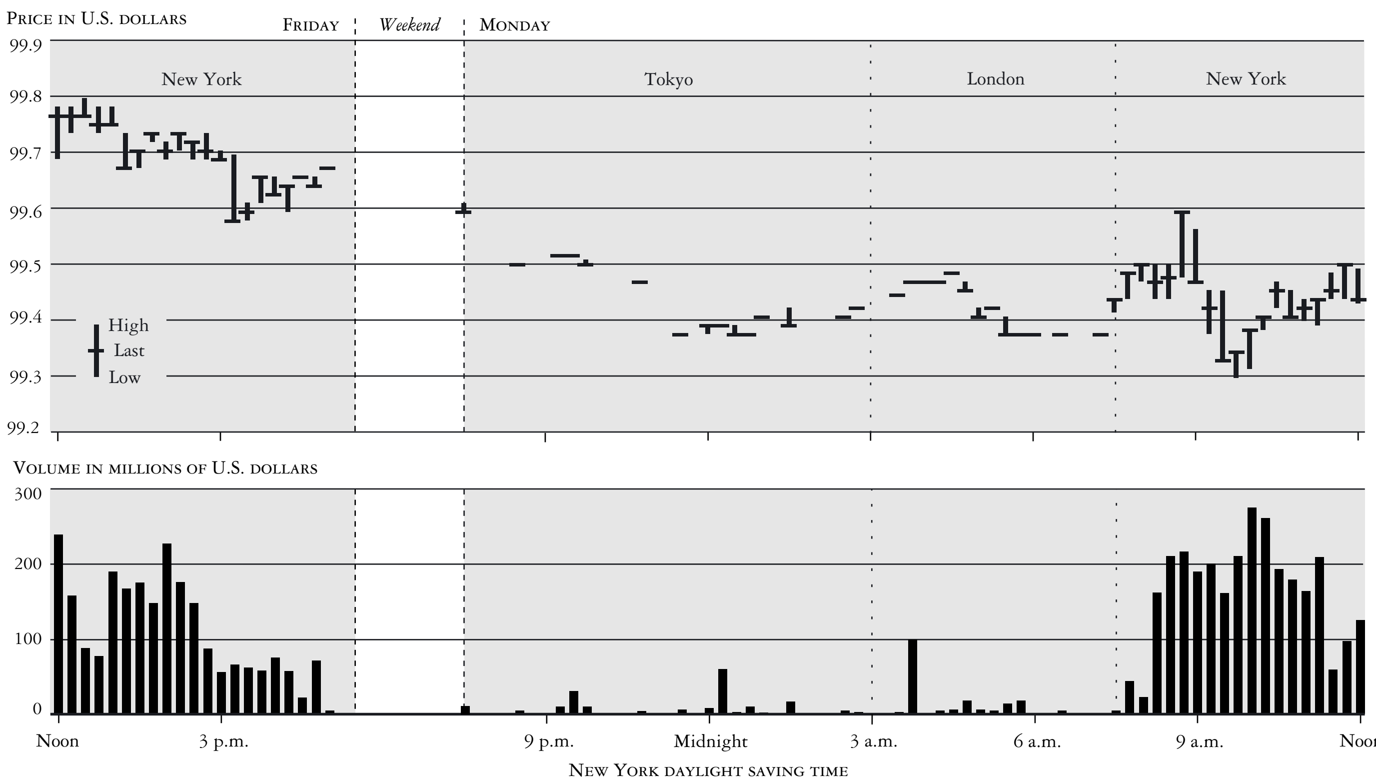
Unsurprisingly, given the Tokyo results, the slope coefficient for the London price movement regressions is also insignificantly different from 1.0 in all five maturities (Table 6). There is insufficient evidence to reject the null hypothesis that London price changes are unbiased predictors of overnight price changes in New York. In addition, the slope coefficient is significantly different from zero (at the .01 level) in all five maturities. U.S. Treasury security price movements in London (from the New York close) therefore reflect new information that is later incorporated in New York prices.

Price Efficiency Case Studies

Two case studies now illustrate how large overseas price changes in U.S. Treasury securities may be accurate indicators of overnight New York price changes. The first study

Chart 10

Tokyo Price Change as a Predictor of Overnight Price Change in New York
June 24 (Noon) to June 27 (Noon), 1994



Source: Author's calculations, based on data from GovPX, Inc.

Note: The chart shows the interdealer price path and the associated GovPX trading volume for the on-the-run five-year U.S. Treasury note by quarter hour.

examines the largest price change observed in London hours during the sample period—Tuesday, May 10, 1994, when news reports suggested that European central banks and Middle Eastern investors were purchasing U.S. Treasury securities during London trading hours.

The global trading day opened quietly on May 10 with little activity in Tokyo (Chart 9). The five-year note then rallied in London, jumping 48/100ths of a point from the last Tokyo price to the last London price. The price change was thus eight times the magnitude of the expected price change during London hours (Table 3) and nearly twice as large as the typical daily change. The London price change was maintained when New York opened at 7:30 a.m. While there was some price slippage later in the morning, it is clear that the bulk of the London price movement was not reversed when New York opened.

The second study examines the largest price change observed in Tokyo hours during the sample period—June 27, 1994. Japanese Prime Minister Tsutomu Hata resigned on Saturday, June 25. On Monday, June 27, the dollar declined in the foreign exchange market to a new post–World War II low of 99.50 yen. News stories indicated that U.S. Treasury securities were sold by dealers and overseas investors on fears that the Fed would boost interest rates to halt the dollar's fall.

The five-year note opened on June 27 down slightly from the June 24 close (Chart 10). The price made two further downward jumps: in the 8:30 p.m. to 8:45 p.m. and the 11:30 p.m. to 11:45 p.m. (New York time) intervals. The note finished in Tokyo down 25/100ths of a point, a drop that was four times the magnitude of the expected price change during Tokyo hours and about as large as a typical daily change. It fell a few more hundredths in late morning London before New York opened. While the price rose slightly in early New York trading, most of the Tokyo price movement was maintained.

Conclusion

Although the secondary market for U.S. Treasury securities operates around the clock, it behaves more like U.S. equity markets, with limited trading hours, than like the round-the-clock foreign exchange market. Trading volume and price volatility are highly concentrated during New York trading hours, with a daily peak between 8:30 a.m. and 9 a.m. and a smaller peak between 2:30 p.m. and 3 p.m. During these hours, the u-shaped patterns of trading volume, price volatility, and the bid-ask spread are similar to patterns found in the equity markets (but not in the foreign exchange market). The preponderance of relevant news during New York trading hours and the fixed hours of the CBT's futures market seem to be the most likely determinants of these intraday patterns.

Trading volume outside of New York hours is relatively low, with less than 2 percent of round-the-clock volume attributable to Tokyo hours and less than 4 percent attributable to London hours. Although prices have at times moved significantly during the overseas hours, price volatility tends to be significantly lower overseas than in New York. Bid-ask spreads are higher overseas than in New York and higher in Tokyo than in London. The spreads exhibit a triple u pattern across the global trading day corresponding to the start and stop of trading in the three trading locations.

Despite the relatively low trading volume, low price discovery, and high bid-ask spreads during the overseas hours, overseas price changes of U.S. Treasury securities can effectively predict overnight price changes in New York. Lower liquidity notwithstanding, the overseas trading locations provide important information on the path of U.S. Treasury security prices.

APPENDIX A: PRIMARY GOVERNMENT SECURITIES DEALERS

The primary government securities dealers as of June 6, 1997, were as follows:

BA Securities, Inc.
Bear, Stearns & Co., Inc
BT Securities Corporation
BZW Securities Inc.
Chase Securities Inc.
CIBC Wood Gundy Securities Corp.
Citicorp Securities, Inc.
Credit Suisse First Boston Corporation
Daiwa Securities America Inc.
Dean Witter Reynolds Inc.
Deutsche Morgan Grenfell/C.J. Lawrence Inc.
Dillon, Read & Co. Inc.
Donaldson, Lufkin & Jenrette Securities Corporation
Dresdner Kleinwort Benson North America LLC.
Eastbridge Capital Inc.
First Chicago Capital Markets, Inc.
Fuji Securities Inc.
Goldman, Sachs & Co.
Greenwich Capital Markets, Inc.
HSBC Securities, Inc.
Aubrey G. Lanston & Co., Inc.
Lehman Brothers Inc.
Merrill Lynch Government Securities Inc.
J.P. Morgan Securities, Inc.
Morgan Stanley & Co. Incorporated
NationsBanc Capital Markets, Inc.
Nesbitt Burns Securities Inc.
The Nikko Securities Co. International, Inc.
Nomura Securities International, Inc.
Paine Webber Incorporated
Paribas Corporation
Prudential Securities Incorporated
Salomon Brothers Inc.
Sanwa Securities (USA) Co., L.P.
SBC Warburg Inc.
Smith Barney Inc.
UBS Securities LLC
Yamaichi International (America), Inc.
Zions First National Bank

Source: Federal Reserve Bank of New York (1997).

APPENDIX B: DATA DESCRIPTION

GovPX, Inc., supplies real-time market information through on-line vendors by sending out a digital ticker feed, daily backup copies of which are used in this study. The data contained in the feed provide a precise history of the trading information sent to GovPX subscribers. Any posting errors made by the interdealer brokers that are not filtered out by GovPX are included in the backup files. Additionally, since the purpose of the digital feed is to refresh vendors' screens, the data must be processed before they can be effectively analyzed.

When a trade occurs, two pieces of information are typically transmitted by GovPX. First, during the "workup stage," when traders are jumping into a transaction, GovPX posts the news that a bid is being "hit" or that an offer is being lifted (a "take"); it also posts price and volume information. Seconds later, the total volume of the trade(s) is posted. Transactions occurring through the same interdealer broker at the same price and virtually the same time are thus counted as a single transaction. Occasionally, there are several lines of data per transaction, but sometimes there is only a single line.

For this analysis, the volume data are processed to ensure that each trade is counted only once. The aggregate daily volume provided with each trade is helpful in this regard. Aggregate daily volume data provided separately from the ticker feed are also useful in ensuring data accuracy. The study identifies 243,222 unique transactions over the ninety-day sample period, or an average of 2,702 per day.

Prices in U.S. Treasury notes and bonds are quoted in 32nds and can be refined to 256ths. Transaction prices, as well as bids and offers, are converted to decimal form for this analysis. Pricing errors are also screened from the data set using a two-step procedure. First, large trade-to-trade price movements that revert a short time later and are clearly erroneous are screened out. Second, prices that are more than ten standard deviations from the daily price mean or daily bid-ask midpoint mean are screened out. Just over one price per day is dropped, leaving an average of 2,701 prices per day.

A multistep procedure is used to screen quotes from the data set:

- Bids are first screened for large quote-to-quote movements that revert a short time later. This first screen drops an average of 4 quotes per day.
- As offers in the data set are quoted off of the bids, large positive spreads are indistinguishable from small negative ones. Spreads calculated to be greater than 0.9 (but less than 1.0) are likely to be negative spreads that existed only momentarily when quotes arrived from two different brokers. These quotes (an average of 115 per day) are dropped.
- One-sided quotes (a bid *or* an offer, but not both) are occasionally posted by dealers. This study makes no use of these bids (an average of 366 per day) or offers (an average of 287 per day).
- Finally, spreads with bid-ask midpoints more than ten standard deviations from the daily bid-ask midpoint mean or daily price mean are dropped, as are spreads more than ten standard deviations from the daily spread mean. This process screens out an average of 9 quotes per day.

As spreads posted by the interdealer brokers do not include the brokerage fee charged to the transaction initiator, zero spreads are common and can persist for lengthy periods. Quotes calculated to be zero are therefore kept in the data set. The data set retains 889,936 quotes from the sample period, or an average of 9,888 per day.

Once the data are cleaned, they are summarized by half-hour period using the digital feed's minute-by-minute time stamp. The final data set contains market information on each security for each half hour of the sample period, including volume, last price, and mean bid-ask spread. Because information on market participants and trading location is not available, the trading location is assigned according to the time the information is posted (Chart 1).

ENDNOTES

The author thanks GovPX, Inc., for its data. Mitch Haviv, Jean Helwege, Frank Keane, Jim Mahoney, Amy Molach, Stavros Peristiani, Anthony Rodrigues, and Jeff Stehm provided helpful comments, as did Federal Reserve Bank of New York workshop and seminar participants. The research assistance of Ray Kottler and Irene Pedraza is gratefully acknowledged.

1. In contrast, trading volume on the New York Stock Exchange averages only about $9.7 billion per day (New York Stock Exchange 1995).

2. Initially, data for the period March 1–August 31, 1994, were obtained from the data provider, GovPX, Inc. However, the period was shortened to April 4–August 19 to eliminate differences in the data format and to ensure that daylight saving time did not go into effect during the sample period.

3. Although Treasuries *are* listed on the New York Stock Exchange, trading volume of all debt issues there (corporate bonds as well as U.S. government securities) averaged just $28.6 million per day in 1994 (New York Stock Exchange 1995). Odd-lot trading of Treasuries takes place on the American Stock Exchange, with an average volume of just $14 million per day in 1994 (American Stock Exchange 1996).

4. See U.S. Department of the Treasury et al. (1992). More information on the structure of the secondary market can be found in this source and in Bollenbacher (1988), Madigan and Stehm (1994), Stigum (1990), and U.S. General Accounting Office (1986).

5. The major interdealer brokers are Cantor Fitzgerald Inc., Garban Ltd., Hilliard Farber & Co. Inc., Liberty Brokerage Inc., RMJ Securities Corp., and Tullett and Tokyo Securities Inc.

6. These are the fees reported by Stigum (1990). Communication with market participants suggests that these fees are very similar today.

7. It is estimated that primary dealers also trade $18.3 billion per day in U.S. Treasury futures, $6.1 billion in forwards, and $7.8 billion in options. Primary dealers' outstanding financing transactions (repurchase agreements, loaned securities, and collateralized loans) averaged $850 billion to $875 billion over this period.

8. The debt stood at $4,645.8 billion on June 30, 1994, $3,051.0 billion of which existed in the form of marketable securities; foreign investors accounted for 20.5 percent ($633.2 billion) of the $3,088.2 billion held by private investors (Board of Governors of the Federal Reserve System 1995).

9. Trading increases to twenty-three hours per day when New York switches to eastern standard time. There is no trading on weekends. Other sources on overseas activity in U.S. Treasury securities include Madigan and Stehm (1994) and Stigum (1990).

10. All of the intraday data examined in this study fall within a period when New York and London times are daylight saving time. Japan has not adopted daylight saving time.

11. Financing transactions involving U.S. Treasury securities are also conducted in New York, regardless of the trading time for or location of the associated cash trade.

12. As explained in the data description sections (see box and Appendix B), trading locations are assigned according to the time of day a trade was made. For example, a trade at 7:45 a.m. is considered to be a New York trade even though it may have originated in London (or elsewhere). This convention may bias the summary statistics for the individual trading locations. The similarity of this article's findings to earlier estimates reported by Stigum (1990)—93 percent for New York, 4 to 5 percent for London, 1 to 2 percent for Tokyo—suggests that the distribution of trading activity by location has been relatively stable in recent years.

13. Similarly, Barclay, Litzenberger, and Warner (1990) find negligible trading volume in Tokyo for U.S. stocks listed on the Tokyo Stock Exchange.

14. As noted earlier, foreign investors accounted for 20.5 percent of the U.S. Treasury securities held by private investors on June 30, 1994; this amount increased to 30.3 percent as of September 30, 1996 (Board of Governors of the Federal Reserve System 1995 and 1997).

15. In January 1997, the customary intervention time was moved forward one hour to around 10:30 a.m.

16. Madigan and Stehm (1994) believe that the high level of intermediate note activity is driven by hedging activity for swap transactions and underwritings.

17. Cash-management bills are very short-term bills (maturing in, say, fourteen days) issued on an unscheduled basis to meet immediate cash flow needs.

18. Because data from one of the six interdealer brokers are not available for the analysis, the figures may present a biased picture of the interdealer market. In particular, the excluded broker is regarded as being stronger in the longer term issues than the other interdealer brokers.

19. Although volatility results based on actual trade prices are similar, use of the bid-ask midpoint results in many fewer missing observations

Note 19 continued
in the overseas half-hour intervals. In addition, although volatility is calculated in terms of nominal price changes, percentage price change numbers look very similar. This similarity occurs because Treasury notes and bonds are issued at a price close to 100 and the on-the-run securities examined in this study are recently issued securities, by definition.

20. For the 7:30 p.m. to 8 p.m. interval, the previous interval is considered to be 5 p.m. to 5:30 p.m.

21. More recent findings for the cash market also support this hypothesis (Fleming and Remolona 1996, 1997).

22. Karpoff (1987) reviews the literature. Recent studies in this area include Bessembinder and Seguin (1993) and Jones, Kaul, and Lipson (1994).

23. The five-year note is chosen for this and subsequent analyses because it is the security that is most actively traded between the primary dealers. Results are similar for other securities.

24. Although spreads are calculated as the nominal difference between the bid and the ask prices, percentage bid-ask spreads look very similar. Treasury notes and bonds are issued at a price close to 100 and the on-the-run securities examined in this study are recently issued securities, by definition. None of the spread calculations incorporates interdealer broker fees.

25. McInish and Wood (1992) review the components of the bid-ask spread and cite much of the relevant literature.

26. As noted earlier, data from one of the six interdealer brokers are not included in the analysis. The daily spread averages may therefore be somewhat inaccurate—particularly in the longer term issues, in which the excluded broker is considered to be more active than the other interdealer brokers.

27. The relationship between spread and maturity for U.S. Treasury securities has also been documented in Tanner and Kochin (1971), Garbade and Silber (1976), and Garbade and Rosey (1977).

28. No bid-ask quote for the thirty-year bond is recorded for 40 percent of the Tokyo half-hour periods in the sample.

29. Average trade sizes for notes and bonds are similar in the three trading locations (although slightly *lower* in New York), however, suggesting that bid and offer quantities are similar.

30. For example, the 4:30 p.m. to 5 p.m. mean bid-ask spread is based on eighty-eight days of data for the two-, three-, five-, and ten-year notes, but only seventy-five days of data for the thirty-year bond.

31. Equity market studies include Demsetz (1968), Tinic (1972), Tinic and West (1972), Benston and Hagerman (1974), and Branch and Freed (1977). Foreign exchange market studies include Bollerslev and Domowitz (1993), Bollerslev and Melvin (1994), and Bessembinder (1994). Treasury market studies include Garbade and Silber (1976) and Garbade and Rosey (1977). Both Treasury market studies use daily data and do not have volume figures.

32. The spread-volume correlation coefficients are -.26 (all locations), -.22 (Tokyo), -.24 (London), and -.14 (New York), all significant at the .01 level. The spread-volatility coefficients are .00 (all locations), .27 (Tokyo), .32 (London), and .18 (New York), all significant at the .01 level with the exception of the "all locations" coefficient. The insignificant coefficient for "all locations" results from low spreads in New York in spite of high price volatility.

33. The authors regress overnight price changes in New York on overseas price changes from the New York close. They find that overseas price changes are generally biased predictors of overnight New York price changes, but that they were unbiased immediately after the October 1987 stock market crash.

34. Mean trading volumes of $470 million (Tokyo) and $893 million (London) for on-the-run and when-issued securities were calculated using data from GovPX, which covers roughly two-thirds of the interdealer broker market.

35. When each successive price observation depends only on the previous one plus a random disturbance term, the price series is said to follow a *random walk*. Generally speaking, a martingale process is a random walk that allows price volatility to vary over time. A martingale is therefore a process in which past prices have no information beyond that contained in the current price that is helpful in forecasting future prices.

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Market Returns and Mutual Fund Flows

Eli M. Remolona, Paul Kleiman, and Debbie Gruenstein

The 1990s have seen unprecedented growth in mutual funds. Shares in the funds now represent a major part of household wealth, and the funds themselves have become important intermediaries for savings and investments. In the United States, more than 4,000 mutual funds currently hold stocks and bonds worth a total of more than $2 trillion (Chart 1). Household investment in these funds increased more than fivefold in the last ten years, making it the fastest growing item on the household financial balance sheet. Most of this growth came at the expense of more traditional forms of savings, particularly bank deposits.

With the increased popularity of mutual funds come increased concerns—namely, could a sharp drop in stock or bond prices set off a cascade of redemptions by fund investors and could the redemptions exert further downward pressure on asset markets? In recent years, flows into funds have generally been highly correlated with market returns. That is, mutual fund inflows have tended to accompany market upturns and outflows have tended to accompany downturns. This correlation raises the question whether a positive-feedback process is at work here, in which market returns cause the flows at the same time that the flows cause the returns. Observers such as Hale (1994) and Kaufman (1994) fear that such a process could turn a decline in the stock or bond market into a downward spiral in asset prices.[1]

In this study, we use recent historical evidence to explore one dimension of the broad relationship between market returns and mutual fund flows: the effect of short-term market returns on mutual fund flows. Research on this issue has already confirmed high correlations between market returns and aggregate mutual fund flows (Warther 1995). A positive-feedback process, however, requires not just correlation but two-way causation between flows and returns, in which fund investors react to market movements while the market itself moves in response to the investors' behavior.

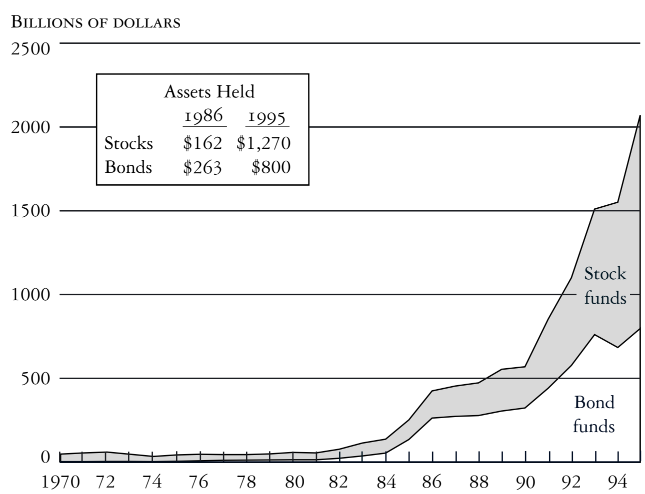
Previous studies of causation have focused on the effects of past performance on flows into individual mutual funds, typically with a one-year lag separating cause and effect. In this article, however, we examine the effect of market-wide returns on aggregate mutual fund flows within a month, a level of aggregation and a time horizon that seem more consistent with the dynamics of a downward spiral in asset prices. Our statistical analysis uses instrumental variables, a technique that is particularly well suited for measuring causation when observed variables are likely to be determined simultaneously. The technique has not been applied before to mutual fund flows and market returns.

Despite market observers' fears of a downward spiral, our study suggests that the short-term effect of market returns on mutual fund flows typically has been too weak to sustain a spiral.

Despite market observers' fears of a downward spiral, our study suggests that the short-term effect of market returns on mutual fund flows typically has been too weak to sustain a spiral. During unusually severe market declines, stock and bond movements have prompted proportionately greater outflows than under normal conditions, but even at these times, the effect has not seemed strong enough to perpetuate a sharp fall in asset prices.

Chart 1

GROWTH OF MUTUAL FUND NET ASSETS



Source: Investment Company Institute.

We begin by describing the nature of mutual funds and characterizing their recent growth. Next, we examine the data on aggregate mutual fund flows by dividing them into expected and unexpected components and investigating their correlations with market returns. The effects of returns on flows are then estimated using instrumental variables. Finally, we test the robustness of our estimates by looking at the flows during severe market declines.

THE NATURE AND GROWTH OF MUTUAL FUNDS

Mutual funds operate as tax-exempt financial institutions that pool resources from numerous shareholders to invest in a diversified portfolio of securities.[2] Unlike closed-end funds, which issue a fixed number of shares, open-end mutual funds are obligated to redeem shares at the request of the shareholder. When a shareholder redeems shares, he or she receives their net asset value, which equals the value of the fund's net assets divided by the number of shares outstanding. An investment manager determines the composition of the fund's investment portfolio in accordance with the fund's return objectives and risk criteria.

INVESTMENT OBJECTIVES AND FEE STRUCTURES

Mutual funds vary widely in their investment objectives. The Investment Company Institute (ICI)—the industry trade group whose membership includes almost all registered U.S. mutual funds—classifies mutual funds according to twenty-one investment objectives (Appendix A). For instance, some funds aim to provide a steady stream of income while others emphasize capital appreciation; some funds specialize in U.S. common stocks while others specialize in U.S. bonds or in foreign stocks and bonds. It is important to gauge a fund's performance relative to its investment objective because the different objectives represent trade-offs between risk and return. Some objectives aim for high returns at high risk, others for more modest returns but at less risk.

Mutual funds also differ in their fee structures, which can affect the sensitivity of flows to a fund's short-term performance. Many mutual funds charge an up-front sales fee, called a *load*, that is typically around 5 percent of the initial investment. The desire to spread the cost of the load over time may make a shareholder reluctant to sell in the short run. For example, Ippolito (1992) finds that poor performance leads to half as many withdrawals from load funds as from no-load funds. Chordia (1996) also provides evidence that such fees discourage redemptions. At the end of 1995, 62 percent of the assets in stock mutual funds and 66 percent of the assets in bond mutual funds were in load funds.[3] Although no-load funds impose no up-front fees, many collect back-end fees, called contingent deferred sales charges, when shares are redeemed. These fees generally decline the longer the shares are held and thus also discourage investors from selling in the short run.

Mutual funds vary widely in their investment objectives. . . . It is important to gauge a fund's performance relative to its investment objective because the different objectives represent trade-offs between risk and return.

The Growth of Mutual Funds

Although mutual funds have existed in the United States since 1924, truly significant amounts of money did not start flowing into the funds until the mid-1980s. A decline in deposit rates in the early 1990s marked the beginning of explosive growth in the funds. As a result, mutual funds as a group have become important financial intermediaries and repositories of household wealth. Households in 1995 held 10 percent of their net financial wealth in mutual fund shares directly and 3 percent indirectly through pension funds (Table 1). At the end of 1995, the net assets of mutual funds were 60 percent as large as the assets held by commercial banks, a leap from only 27 percent at year-end 1986 (Table 2). Such rapid growth has prompted Hale (1994) to suggest that the rise of mutual funds is creating a whole new financial system.

Much of the growth in mutual funds can be attributed to the influx of retirement money driven by long-term demographic forces. Morgan (1994) shows that changes in the share of household assets held in stocks and

Table 1
MAJOR HOUSEHOLD FINANCIAL ASSETS
Billions of Dollars

Asset Type	1986	1995
Deposits (check, time, savings)	2,650	3,258
Pension reserves	2,265	5,510
Life insurance	264	542
Money market shares	229	452
Total securities,	2,497	7,436
of which:		
Corporate equities	1,453	4,313
Mutual funds	334	1,265
Memo:		
Mutual fund assets as a percentage of total securities	13	17
Mutual fund assets as a percentage of net financial wealth	7	10

Source: Board of Governors of the Federal Reserve System, Flow of Funds Accounts.

Table 2
TOTAL ASSETS OF MAJOR FINANCIAL INTERMEDIARIES

	1986		1995	
Intermediary	Assets (Billions of Dollars)	Percentage of Intermediary Assets	Assets (Billions of Dollars)	Percentage of Intermediary Assets
Commercial banks	2,620	32	4,501	28
Thrift institutions	1,539	19	1,326	8
Insurance companies	1,260	15	2,832	18
Pension plans	1,723	21	4,014	25
Finance companies	421	5	827	5
Mutual funds	717	9	2,598	16
TOTAL	8,280	100	16,097	100

Source: Board of Governors of the Federal Reserve System, Flow of Funds Accounts.

Note: Mutual funds include short-term funds.

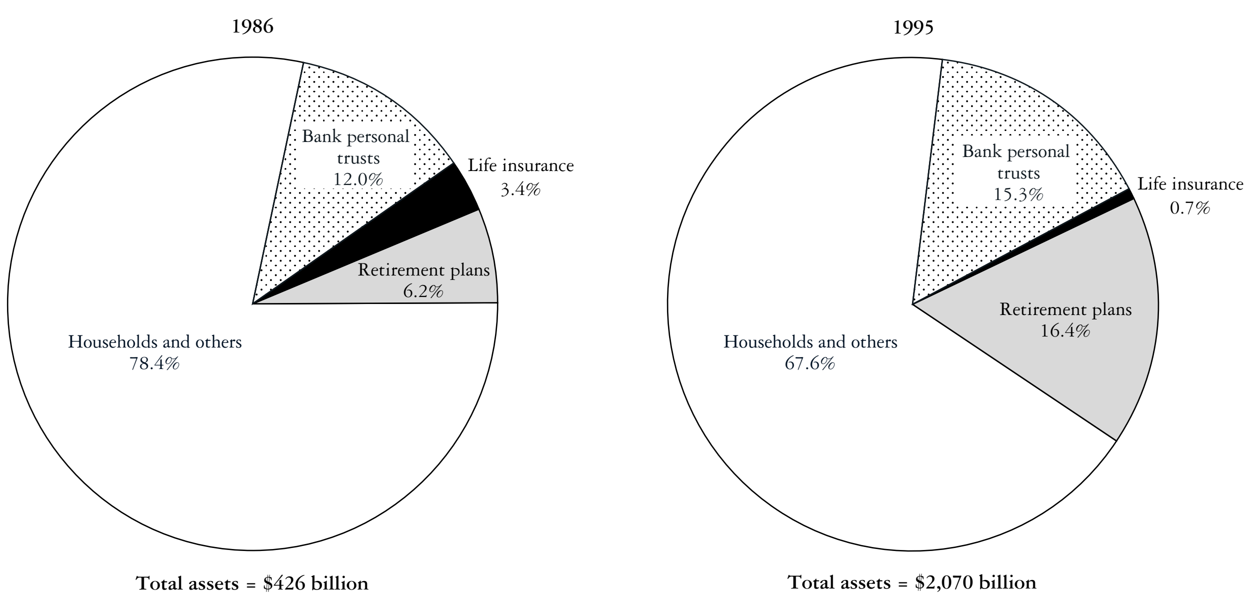
bonds are explained by the proportion of workers thirty-five years of age or older. Workers reaching thirty-five years of age tend to earn enough to start saving for retirement, and mutual fund shares represent a way to invest their savings. Households also save through retirement plans, life insurance policies, and trust accounts with banks. Among these investments, retirement plans have been acquiring mutual fund shares at the highest rate: the share of mutual fund assets held by retirement plans expanded from 6.2 percent in 1986 to 16.4 percent in 1995 (Chart 2). Life-cycle motives for investing in mutual funds—such as saving for retirement—can make certain flows insensitive to short-term returns, and much of these flows would be predictable on the basis of past flows. Hence, this analysis will distinguish between long-term trends and short-term fluctuations in mutual fund flows.

As large as the recent flows have been, mutual funds still hold relatively small shares of the markets in which they invest.

As large as the recent flows have been, mutual funds still hold relatively small shares of the markets in which they invest. At the end of 1995, they held 16 percent of the capitalization of the municipal bond market, 12 percent of the corporate equity market, 7 percent of the corporate and foreign bond market, and 5 percent of the U.S. Treasury and agency securities market (Chart 3). These fairly small shares limit the potential impact of the flows on asset prices. Estimates by Shleifer (1986) suggest that an exogenous decline in mutual funds' demand for stocks by one dollar would reduce the value of the market by one dollar. Such estimates imply that selling pressure by mutual funds alone is unlikely to cause a sharp market decline.

Chart 2

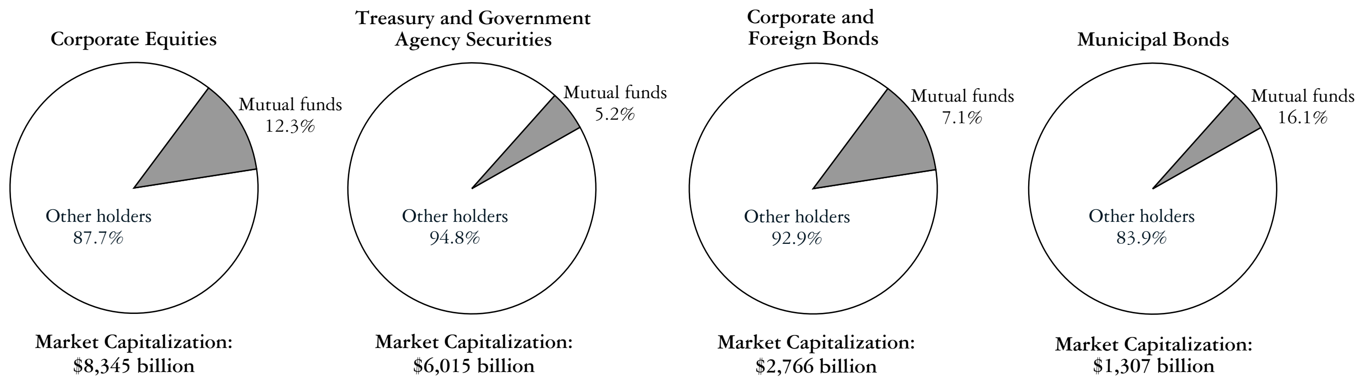
Sources of Flows: Holders of Stock and Bond Mutual Funds



Sources: Board of Governors of the Federal Reserve System, Flow of Funds Accounts; Investment Company Institute (1995); authors' estimates.

Chart 3

SHARE OF SECURITIES HELD BY MUTUAL FUNDS, 1995



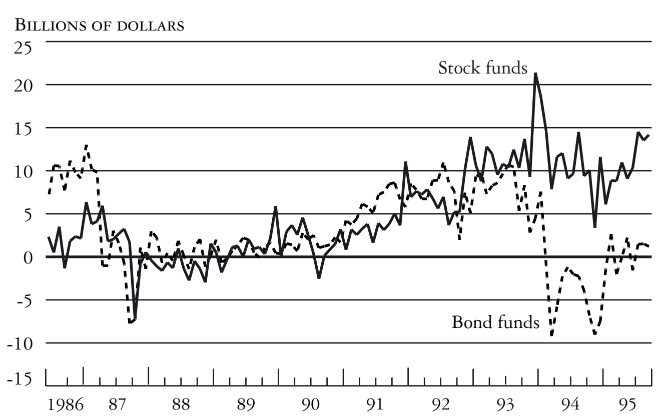
Source: Board of Governors of the Federal Reserve System, Flow of Funds Accounts.

THE CORRELATION BETWEEN RETURNS AND FLOWS

The recent movements of large mutual fund flows suggest a strong correlation between market returns and the flows. In the early 1990s, the flows into stock and bond mutual funds were equally strong (Chart 4). However, when the Federal Reserve started to raise its target federal funds rate in February 1994, the bond market became bearish and the flows shifted sharply from bond to stock funds. More recently, the equity bull market in 1995 was accompanied by record flows into stock funds. Such correlations between aggregate fund flows and marketwide returns suggest a positive-feedback process in which the market returns cause the fund flows at the same time that the flows cause the returns.

Chart 4

MONTHLY FLOWS INTO STOCK AND BOND MUTUAL FUNDS



Source: Investment Company Institute.

For our analysis, it is important to distinguish among various notions of correlations between flows and returns. For instance, Warther (1995) has documented strong correlations between *monthly* market returns and *monthly* aggregate mutual fund flows. The question then arises, Do such monthly correlations reflect causation between returns and flows? If they do, could they lead to a strong positive-feedback process? Note that the correlations that Kaufman (1994) and Hale (1994) have in mind may be quite different. Kaufman, for example, emphasizes that the average investor in mutual funds has never experienced a prolonged bear market. In such a market, investors may suddenly react by redeeming their shares heavily.[4] The correlation would therefore be between returns over an unspecified period and flows over a somewhat shorter period. Our analysis examines only monthly flow-return correlations from 1986 to 1996, a period for which there may not have been a bear market of long enough duration to test Kaufman's hypothesis.

MEASURING MUTUAL FUND FLOWS

To measure mutual fund flows, we use monthly ICI data on cash flows into and out of mutual funds from July 1986 to April 1996.[5] In the ICI data, cash flows are computed for each of the twenty-one groupings of funds by investment objective. Within each group, cash flows are further broken down into total sales, redemptions, exchange sales, and exchange redemptions. Total sales and redemptions represent outside flows, while exchange sales and exchange redemptions represent flows between funds within a fund family. We compute net flows as total sales minus redemptions, plus exchange sales minus exchange redemptions.

The expected flows . . . reflect a relatively smooth and slow process, while the unexpected flows show a great deal more short-run volatility.

We make several adjustments to the mutual fund categories by either aggregating categories or excluding some from our study. We exclude money market mutual funds and precious metal funds because they do not seem to be subject to the same risks as stock and bond funds. We also exclude various hybrid funds (flexible portfolio, income mixed, balanced, and income bond) because of the lack of an appropriate market price index. We combine aggressive growth and growth stock funds, income and growth-and-income stock funds, and global and international stock funds. Hence, we collapse six equity categories into three: growth, income, and global stock funds. We also combine long-term municipal bond and state municipal bond funds into a single category of municipal bond funds. We retain four other bond fund categories: government bond, corporate bond, Government National Mortgage Association (GNMA) bond, and high yield bond. We use growth stock funds as the benchmark stock fund and government bond funds as the benchmark bond fund.

To control for the flows' strong rising trend during the period, we normalize the flows by dividing them by the funds' net asset value in the previous month. Flows are thus stated as a percentage of a fund category's net assets. (The data analyzed in this study are summarized in Table 3.) Over the period, global stock funds and corporate bond funds received the largest net flows relative to net assets, while government bond funds received the smallest. Global stock funds and GNMA bond funds had the most volatile net flows, while income stock funds had the most stable flows. All the flows exhibit high autocorrelations, with government bond funds and GNMA bond funds showing the most persistent flows. These autocorrelations imply that large components of the flows are predictable on the basis of past flows.

To divide the flows into expected and unexpected components, we regress flows on three months of lags and on a time trend (Appendix B).[6] The predicted values from the regressions then serve as our expected flows and the residuals as our unexpected flows. The expected flows for growth stock funds and government bond funds reflect a

Table 3

SUMMARY STATISTICS FOR STOCK AND BOND MUTUAL FUND FLOWS

Fund Group	Number of Observations	Mean Flows (Percent)	Standard Deviation (Percent)	First Order Autocorrelations
Stock funds				
Growth	118	1.0	1.3	0.34
Global equity	118	1.4	2.2	0.70
Income	118	1.1	0.9	0.69
Bond funds				
Government	118	0.4	1.8	0.90
Corporate	118	1.4	1.7	0.75
GNMA	118	0.4	2.2	0.84
High yield	118	1.1	2.0	0.36
Municipal	118	1.1	1.5	0.67

Sources: Investment Company Institute; authors' calculations.

Notes: Monthly flows into mutual funds over the July 1986–April 1996 period are computed as the sum of 1) total sales minus redemptions and 2) exchanges into a fund minus exchanges out of a fund. The flow into each group is divided by that fund's net asset value from the previous month. The fund groups are drawn from the Investment Company Institute (ICI) classification of mutual funds by objective. Some groups combine two ICI categories: *growth stock funds* includes growth and aggressive growth stock funds; *global equity funds*, global equity and international stock funds; *income stock funds*, equity income and growth-and-income stock funds; *municipal funds*, national and state municipal bond funds.

relatively smooth and slow process, while the unexpected flows show a great deal more short-run volatility (Chart 5).[7]

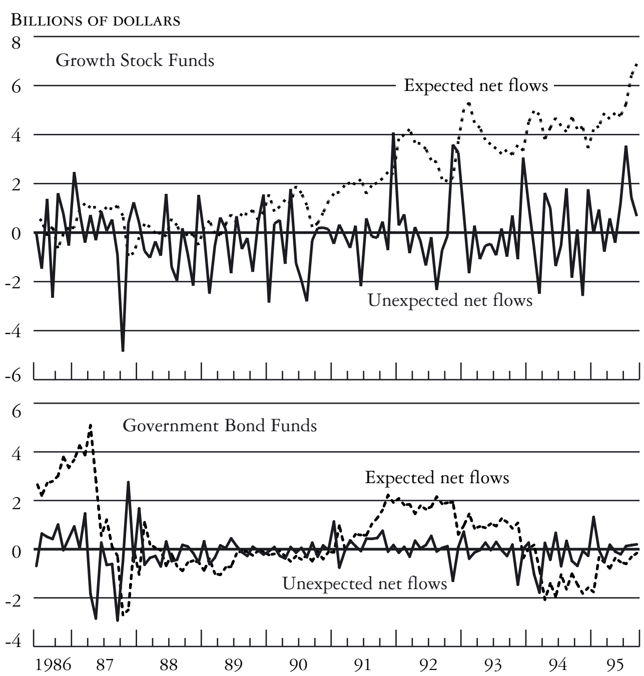
Measuring Market Returns

To measure market returns, we select market price indexes to gauge the performance of the markets in which the funds in each group invest (Table 4). Within each group, some funds will do better than others, and flows may shift to the best performers. However, we are more interested in the aggregate flows, which depend not on the performance of specific portfolios but on that of whole market sectors. In choosing among the various market indexes, it is not critical that we select precisely the right index because the various stock market indexes tend to be highly correlated, as do the bond market indexes.

We compute returns as the changes in the logarithms of the end-of-month market indexes and annualize them by multiplying by twelve. As a result, the annualized return for market *i* for month *t* would be given by $R_{it} = 12\ (log\ P_{it} - log\ P_{i,t-1})$, where P_{it} represents that market's index at the end of month *t.* We then compute excess returns as the difference between this market return and the yield on prime thirty-day commercial paper (CP) in the previous month. The CP rate tracks returns on money market mutual funds, which are the natural alternative for an investor not wishing to invest in stock or bond funds.

Chart 5

Comparison of Expected and Unexpected Flows



Source: Authors' calculations.

Table 4

Mutual Fund Return Indexes

Fund Group	Index
Stock funds	
Growth	Russell 2000
Income	Russell 1000
Global equity	Morgan Stanley Capital International Index (World)
Bond funds	
Government	Lehman Brothers Composite Treasury Index
Corporate	Merrill Lynch Corporate Master
GNMA	Merrill Lynch GNMA Index
High yield	Merrill Lynch High Yield Bond Index
Municipal	Standard and Poor's Municipal Index (One Million)

Sources: DRI/McGraw-Hill; Datastream International Limited; Haver Analytics.

Correlations between Returns and Flows

In general, net flows into the various mutual fund groups are highly correlated with market performance (Table 5). The correlations between net flows and market returns range from 12 percent for government bond funds to 72 percent for high yield bond funds. In most cases, these correlations can be attributed almost entirely to the *unexpected* component of net flows. The correlations between returns and the unexpected components range from 31 percent for GNMA bond funds to 71 percent for growth stock funds. In Chart 6, we plot these correlations for government bond funds and growth stock funds, which serve as our benchmark bond and stock funds. In contrast, the correlations between returns and the *expected* components of net flows are by and large not statistically different from zero. These findings are consistent with those of Warther (1995), who looked at similar flow data covering the period from January 1984 through December 1992. Combining all the stock funds into one category, Warther found a correlation of 73 percent between stock returns and unexpected net flows into stock funds and a correlation of -10 percent between stock returns and expected net flows.

Correlation versus Causation

High correlations between flows and returns do not necessarily mean that a strong positive-feedback process is at work. There are at least two ways in which such correlations can arise in the absence of this process. First, a third factor—such as investor sentiment—may be driving both flows and returns. An optimistic sentiment may encourage investment in mutual funds at the same time that it pushes up asset prices.[8] In this case, the resulting correlation between flows and returns would not imply any kind of self-sustaining market mechanism. Second, the correlation may arise from a causal relationship in only one direction: flows may cause returns but not vice versa. Even when flows are small relative to the size of the markets, flows may cause returns if other investors observing the flows take large positions in the belief that the flows convey useful investment information. The correlation arising from such one-way causation, however, still does not imply a positive-feedback process, which requires that the causation operate in both directions.

Table 5

Correlations between Mutual Fund Flows and Excess Market Returns

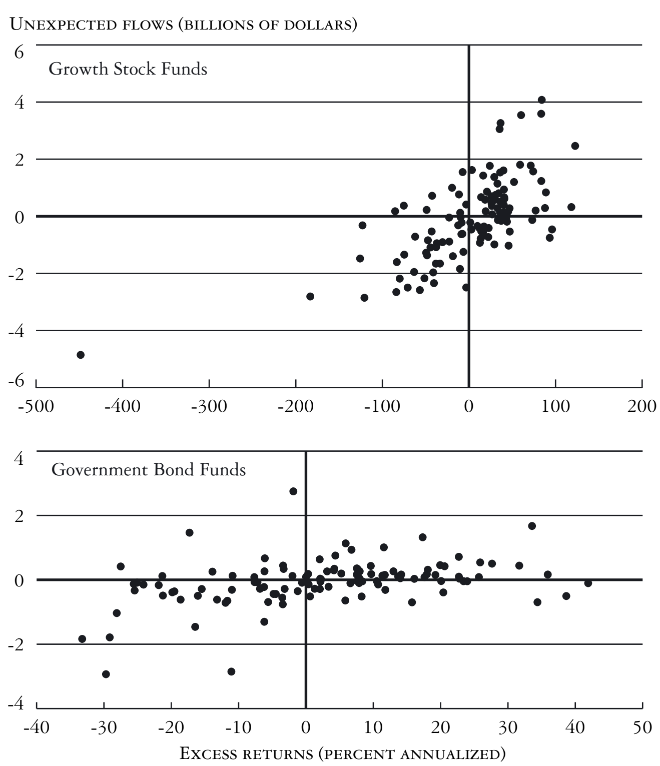
Fund Group	Total Flow	Expected Flow	Unexpected Flow
Stock funds			
Growth	0.61	0.02	0.71
Income	0.36	0.05	0.49
Global equity	0.31	-0.08	0.55
Bond funds			
Government	0.12	-0.07	0.41
Corporate	0.47	0.02	0.68
GNMA	0.21	0.12	0.31
High yield	0.72	0.19	0.70
Municipal	0.48	-0.05	0.69

Sources: Investment Company Institute; authors' calculations.

Notes: Monthly flows into mutual funds over the July 1986–April 1996 period are computed as the sum of 1) total sales minus redemptions and 2) exchanges into a fund minus exchanges out of a fund. The flow into each group is divided by that fund's net asset value from the previous month. The fund groups are drawn from the Investment Company Institute (ICI) classification of mutual funds by objective. Some groups combine two ICI categories: *growth stock funds* includes growth and aggressive growth stock funds; *global equity funds*, global equity and international stock funds; *income stock funds*, equity income and growth-and-income stock funds; *municipal funds*, national and state municipal bond funds. Excess market returns are computed by subtracting the thirty-day commercial paper rate from the return index.

Chart 6

Correlation between Unexpected Flows and Market Returns



Source: Authors' calculations.

Do Short-Term Returns Cause Short-Term Flows?

Timing and Aggregation

Previous studies of causation have typically examined the effect of returns on current flows into individual funds over a period longer than a month. For example, Ippolito (1992), Sirri and Tufano (1993), and Patel, Zeckhauser, and Hendricks (1994) use annual data to show that investors shift their money to funds that performed well in the previous year. For our purposes, however, it is important to examine effects with lags much shorter than a year and to examine the flows at an aggregate level. Short lags are necessary for the kind of positive-feedback process that could lead to a self-sustaining decline. Therefore, we look at the effects of market returns on flows within a month. This period is too short for most investors to know precisely how their own funds have performed relative to other funds, but they will be able to surmise how the funds, including their own, have performed on average. At the same time, shifts in flows from one individual fund to another that do not change aggregate flows are unlikely to move prices in the market as a whole. Hence, we measure the effects of market returns on aggregate flows for funds within a given investment objective.

The Instrumental-Variable Approach

To measure whether returns cause flows, we rely on so-called instrumental variables. Such variables have not been used before to analyze causation between mutual fund flows and market returns. The purpose of these variables is to isolate a component of returns that we are confident could not have been caused by flows. We can then estimate the effect of this component on flows to obtain a measure of the independent effect of returns on flows. It is therefore important to identify instrumental variables that are not only independent of flows, but also relevant to returns. Specifically, the instruments should be sufficiently correlated with returns to capture a component large enough to allow a reliable measure of the component's effect on flows. If the instruments are weak, some bias will distort the estimates. With biased estimates, the measured effects will fall somewhere between the ordinary least squares (OLS) estimates and the true effects.

We derive our instrumental-variable estimates in two stages. First, we regress stock and bond market excess returns on the instruments. The predicted values from the first-stage regression then represent a component of returns that we can consider not to be attributable to mutual fund flows. Second, we regress mutual fund flows on the predicted values from the first-stage regression. The coefficients from the second-stage regression then measure the independent effect of returns on flows.[9]

Note that our application of instrumental variables leaves two issues unaddressed. First, although we can examine the possible effects of market returns on aggregate mutual fund flows, we cannot measure the effects in the opposite direction, because we lack good instrumental variables for flows. Second, our instrumental-variable analysis does not allow us to determine the possible effects of longer term returns on flows, such as those of bull or bear markets that last longer than two months. Hence, this analysis is limited to testing a positive-feedback hypothesis based on causation from only two months of returns.

Instruments for Stock and Bond Returns

We use four macroeconomic variables as instruments for stock and bond excess returns: capacity utilization, the consumer price index, domestic employment, and the Federal Reserve's target federal funds rate. We chose these variables because we may reasonably assume that none are affected by mutual fund flows in the short run. Moreover, the variables are significantly correlated with excess stock and bond returns.[10] By their nature, such excess returns would be hard to predict on the basis of lagged data because stock and bond markets are so quick to reflect any available information. Instead of using lagged data for instruments, however, we use contemporaneous data on macroeconomic variables—that is, data for the same month over which we measure returns. The contemporaneous correlations between the instruments and returns arise because the stock and bond markets react to the macroeconomic variables as the information is released. The F-statistics and Nelson and Startz's TR^2 statistics all suggest that the instruments have significant explanatory power.[11] Nonetheless, the coefficients may still be biased because the first-stage F-statistics tend to be less than 10.[12] If the estimates are biased because of poor instruments, we know that they will be biased toward the OLS estimates. It will therefore be useful to compare the instrumental-variable estimates with the OLS estimates.

The Effect of Short-Term Returns on Flows

Our instrumental-variable regressions control for changing volatilities and for conditions in markets other than the ones in which particular funds invest. (The complete regressions are reported in Appendix C.) Specifically, each regression includes as explanatory variables two months of excess returns and two months of conditional volatilities in the corresponding market and the same four variables in the alternative market. For flows into stock funds, the alternative market is the government bond market; for flows into bond funds, it is the market for growth stocks (Table 4). The same-month returns are modeled using the instrumental variables, while the lagged-month returns are not. The conditional volatilities are based on an estimated process that allows the volatilities to vary over time.[13] Warther (1995) runs OLS regressions that include two lags of monthly returns but not volatilities or returns in other markets. We find that our specification of explanatory variables results in stronger estimated effects of short-term returns on fund flows.[14]

Our regressions suggest that short-term market returns have little to no effect on mutual fund flows (Table 6). In the case of the three stock funds examined, the estimated effect of market returns on flows in the same month is statistically no different from zero at conventional significance levels. For the five bond funds examined, the estimated same-month effect is significant for government bond, corporate bond, and municipal bond funds and is insignificant for GNMA bond and high yield bond funds. Even when the effect is statistically significant, however, it is very small. A market decline of 1 percentage point would lead to outflows of less than 1/10 of 1 percent of the net assets of funds of a given type. In most cases, market returns in the month before have the opposite effect or no effect on flows. The exceptions are the government bond and GNMA bond funds, but even here the combined effect of two months of returns remains small.

Remarkably, our instrumental-variable estimates also suggest that the funds with the more conservative investment objectives are also the ones most vulnerable to outflows.[15] That is, the bond funds' flows are more sensitive to market returns than the stock funds' flows are. Among the bond funds, the government, corporate, and municipal bond funds show larger outflows for a given market decline than do the GNMA and high yield bond funds. The largest effect we find involves municipal bond funds, for which a fall of 1 percentage point in the market leads to unexpected outflows of 0.084 percent of these funds' net assets. For the stock funds, none of the estimated effects is statistically significant, but the point estimates suggest that income funds are more subject to outflows than growth and global stock funds. Investors seem to self-select in such a way that the more risk-averse ones are also more sensitive to short-term performance.

Table 6
REGRESSION OF UNEXPECTED FLOWS ON MARKET RETURNS

Dependent Variable	Instrumental-Variable Coefficient on Excess Returns, Same Month	Instrumental-Variable Coefficient on Excess Returns, Two Months Combined	Ordinary Least Squares Coefficient on Excess Returns, Same Month	Ordinary Least Squares Coefficient on Excess Returns, Two Months Combined
Stock funds				
Growth	0.006	0.005	0.013**	0.010**
	(1.25)		(12.74)	
Income	0.016	0.014	0.005**	0.013
	(1.68)		(2.20)	
Global equity	0.010	0.008	0.015**	0.003
	(0.92)		(6.27)	
Bond funds				
Government	0.033**	0.043**	0.015**	0.027**
	(2.21)		(3.92)	
Corporate	0.049**	0.045**	0.041**	0.038**
	(3.40)		(9.18)	
Municipal	0.084**	0.075**	0.053**	0.053
	(3.96)		(9.08)	
GNMA	0.013	0.031**	0.016**	0.042**
	(0.71)		(2.67)	
High yield	0.023	0.016	0.082**	0.065**
	(0.39)		(10.04)	

Source: Authors' estimates.

Notes: The regressions control for excess returns in an alternative market (the government bond market for stock funds and the growth stock market for bond funds) and for conditional volatility in the markets. The t-statistics are in parentheses.
* Significant at the 90 percent level.
** Significant at the 95 percent level.

POSSIBLE BIASES

To the extent that our instrumental-variable estimates are still biased, the true effects would serve to strengthen our conclusions about the relationship between the funds' flow reactions and the apparent riskiness of their investment objectives. Although the standard statistical gauges suggest that our instruments are adequate, the instruments may still not be good enough to rule out biased estimates, which would tend to bring the instrumental-variable estimates closer to the OLS estimates. Interestingly, our comparison of the estimates suggests that when the estimated effects are relatively small, the true effects may be smaller still, and when the estimated effects are relatively large, the true effects may be even larger (Table 6).

Recall that within the class of stock funds or bond funds, the funds with the riskier investment objectives show smaller flow reactions than the more conservative ones. At the same time, the instrumental-variable estimates for the growth and global stock funds are smaller than the OLS estimates, suggesting that the true effects may be even smaller than our measures indicate. For the income stock funds, the instrumental-variable estimates are larger than the OLS estimates, suggesting that the true effects may be even larger. For the GNMA and high yield bond funds, the estimates fall short of the OLS estimates, suggesting that the true effects may be even smaller, while the opposite holds true for the government, corporate, and municipal bond funds.

Mutual funds' fee structures may be one reason for the generally weak effects of short-term returns on funds' flows and for the relatively weaker effects of returns on the more aggressive mutual funds.

Fee Structures and Effects of Returns on Flows

As we noted earlier, the mutual funds' fee structures may be one reason for the generally weak effects of short-term returns on funds' flows and for the relatively weaker effects of returns on the more aggressive mutual funds. Although some fund groups discourage short-run redemptions by limiting the number of exchanges between funds within a calendar year, for the most part, funds seem to rely on loads and redemption fees to discourage fund investors from selling in the short run. In examining these issues, Ippolito (1992) finds that poor returns lead to smaller outflows from load funds than from no-load funds, while Chordia (1996) finds that aggressive funds are more likely to rely on these fees to discourage redemptions.

The Effect of Major Market Declines

To characterize the effects of market returns on mutual fund flows, it is important to examine whether large shocks have special effects. Our instrumental-variable analysis assumes that the effects on flows are proportional to the size of the shocks. We now assess this assumption by taking a closer look at mutual fund flows during five episodes of unusually severe market declines (Table 7).[16] We also look for evidence that the flows perpetuated the declines. The market declines were most pronounced in the bond market in April 1987 and February 1994, in the stock market in October 1987, in the stock and high yield bond markets in October 1989, and in the municipal bond market in November 1994.[17] Although these were the markets most affected, price movements in other markets also tended to be significant; therefore, we also take these markets into account. Finally, we examine whether the funds' investment managers tended to panic and thus exacerbate the selling in the markets.

The Bond Market Plunge of April 1987

In the spring of 1987, Japanese institutional investors pulled out of the U.S. stock and bond markets after the threat of a trade war between the United States and Japan precipitated a sharp dollar depreciation (*Economist* 1987). In April, government bond prices plunged an average of 2.3 percent, while stock prices and other bond prices also fell. Taking into account the decline in the government

Table 7
EFFECT OF MAJOR MARKET DECLINES ON MUTUAL FUND FLOWS

Market	Episode	Size of Decline (Percentage of Net Assets)	Predicted Outflow (Percentage of Net Assets)	Actual Outflow (Percentage of Net Assets)
Government bond	April 1987	2.27	1.23	1.79
Growth stock	October 1987	37.67	1.13	4.58
Growth stock	October 1989	6.22	0.34	1.44
High yield bond	October 1989	1.59	1.34	2.94
Government bond	February 1994	2.07	0.85	0.91
Municipal bond	November 1994	1.43	1.25	1.44

Source: Authors' calculations.

bond and stock markets, our instrumental-variable estimates would have predicted unexpected outflows from government bond funds of 1.2 percent of net assets (Table 7). Actual unexpected outflows were 1.8 percent, much greater than predicted but still bearing little resemblance to a run. Although there is some evidence that the flows served to perpetuate the decline, the magnitudes were still too small for a self-sustaining decline. In May, the unexpected outflows from government bonds rose to 2.9 percent of net assets, while bond prices continued to fall. However, flows and prices recovered in June.

The Stock Market Break of October 1987

The largest single market decline in our sample was the stock market break of October 1987. The crash hit growth stocks the hardest, with prices falling an average of 37.7 percent in the month or about seven times their volatility. The Federal Reserve reacted by announcing a readiness to provide liquidity, and the bond market led a modest stock market recovery. On the basis of stock and bond price movements, we would have predicted unexpected outflows from growth stock funds of 1.1 percent of net assets. In fact, unexpected outflows were four times greater, 4.6 percent. Even so, the outflows were still quite manageable given the funds' liquidity levels, which averaged 9.4 percent of net assets. A moderation trend followed as unexpected outflows from growth stock funds abated in November and stock prices started to recover in December.

The Stock Market Decline of October 1989

The decline of October 1989 signaled the end of the leveraged buyout wave of the 1980s. Previously, stock prices of many companies had been boosted by premiums reflecting the possibility of future buyouts at favorable prices. Although the high yield bond market had been the main source of financing for the buyouts, it had been weakened by a series of defaults (*Economist* 1989). In October, the management of United Airlines turned to several international banks to finance their leveraged takeover of the airline. The deal failed when some of the banks refused. Many investors then realized that buyouts would no longer be as likely as they had thought. Takeover premiums vanished overnight, and prices of growth stocks fell by 6.2 percent during the month while those of high yield bonds fell by 1.6 percent. Our estimates would have predicted unexpected outflows of 0.3 percent of net assets from growth stock funds and 1.3 percent from high yield bond funds. The actual unexpected outflows were 1.4 percent and 2.9 percent, respectively—much greater than predicted but still far from constituting a run on mutual funds. The funds saw flows return in November.

The Bond Market Decline of February 1994

In February 1994, the Federal Reserve raised its target federal funds rate 25 basis points. The increase, the first in a series, was not altogether a surprise, but prices of government bonds still fell by about 2.1 percent. Stock prices also fell. Given these developments, we would have predicted unexpected outflows from government bond funds of 0.8 percent of net assets, an estimate that is close to the actual figure of 0.9 percent. Unexpected outflows rose in March and bond prices continued to decline, but the magnitudes remained unimpressive. Prices started to stabilize in April.

> *Faced with heavy redemptions and the possibility that current outflows could lead to more outflows in the near future, the fund managers took the reasonable step of adding to their liquid balances.*

The Market Declines of November 1994

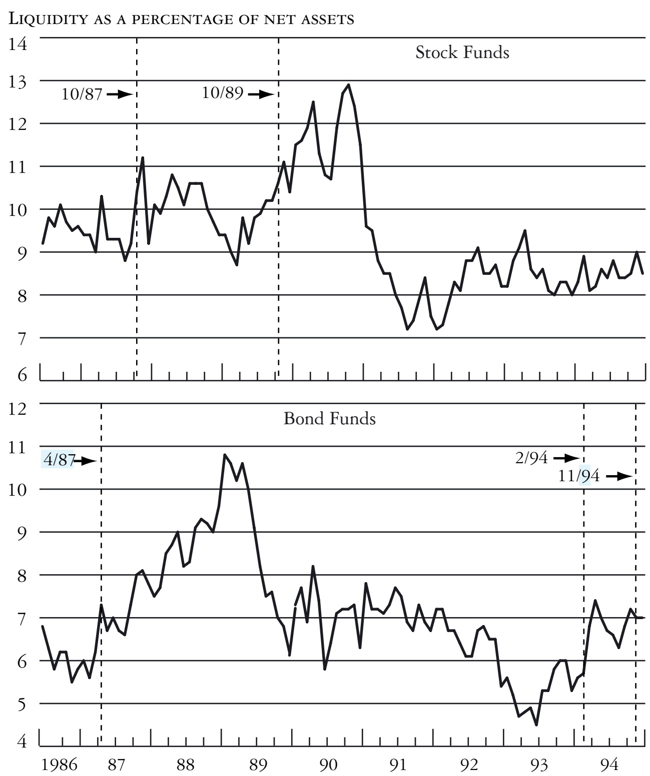
In November 1994, the Federal Reserve again raised its target federal funds rate—this time by 75 basis points, a larger increase than most investors had anticipated. In addition, the troubles of the Orange County municipal investment pool came to light later in the month. Stock and bond markets experienced substantial declines, with municipal bond prices falling by 1.4 percent during the month. Taking these market movements into account, we would have predicted unexpected outflows from municipal bond funds of 1.2 percent of net assets, yet actual unexpected outflows were 1.4 percent. The inflows in December exceeded the outflows in November.

Fund Managers' Reactions

Fund managers may react sharply to abrupt market declines and thus could exacerbate the effects of the outflows. For instance, to meet redemptions, they may either draw on their funds' liquid balances or sell off portions of the portfolio. Or they may go further still by selling more securities than they need to meet the redemptions. Indeed, in four of the five episodes summarized, average liquidity ratios rose in the month of the market decline, indicating that the fund managers sold more than they needed to meet redemptions (Chart 7). In three episodes, the liquidity ratio continued to rise in the following month. Nevertheless, the reactions of fund managers fell well short of a panic. Faced with heavy redemptions and the possibility that current outflows could lead to more outflows in the near future, the fund managers took the reasonable step of adding to their liquid balances. Moreover, in the five episodes of market decline, the average liquidity ratio never rose by more than 2 percent of net assets and never exceeded the highest levels reached in periods without major market declines.

Chart 7

Market Declines and Mutual Fund Liquidity Ratios



Source: Investment Company Institute (1996).

Conclusion

Can the recent high monthly correlations between aggregate mutual fund flows and market returns be at least partially attributed to short-term market returns' strong effect on flows? If returns have such an effect on flows and flows also have a strong effect on returns, then the implied positive-feedback process may lead to a self-sustaining decline in asset prices. However, our instrumental-variable analysis suggests that, on average, the effects of short-term returns on mutual fund flows have been weak.

To the extent that the effects of returns on flows are present, they seem to be stronger for the funds with relatively conservative investment objectives, such as government bond funds and income stock funds, than for those with relatively risky objectives, such as growth stock funds, GNMA bond funds, and high yield bond funds. We also find that these effects have been stronger in certain episodes of major market declines, although still not strong enough to sustain a downward spiral in asset prices.

Appendix A: Types of Mutual Funds by Investment Objective

Aggressive growth funds seek maximum capital appreciation; current dividend income is not a significant factor. Some funds invest in out-of-the-mainstream stocks, such as those of struggling companies or stocks of companies in new or temporarily out-of-favor industries. Some may also use specialized investment techniques, such as option writing or short-term trading.

Balanced funds generally try to achieve moderate long-term growth of capital, moderate income from dividend and/or interest payments, and moderate stability in an investor's principal. Balanced funds invest in a mixture of stocks, bonds, and money market instruments.

Corporate bond funds purchase primarily bonds of corporations based in the United States; they may also invest in other fixed-income securities, such as U.S. Treasury bonds.

Flexible portfolio funds generally invest in a variety of securities such as stocks, bonds, or money market instruments. They seek to capture market opportunities in each of these asset classes.

Global bond funds seek a high level of interest income by investing in the debt securities of companies and countries worldwide, including those of issuers in the United States.

Global equity funds seek capital appreciation by investing in securities traded worldwide, including those of issuers in the United States.

GNMA funds seek a high level of interest income by investing primarily in mortgage securities backed by the Government National Mortgage Association (GNMA).

Growth-and-income stock funds invest mainly in the common stock of companies that offer potentially increasing value as well as consistent dividend payments. Such funds attempt to provide investors with long-term capital growth and a steady stream of income.

Growth funds invest in the common stock of companies that offer potentially rising share prices. These funds aim to provide capital appreciation, rather than steady income.

High yield bond funds seek a high level of interest income by investing at least two-thirds of their assets in lower rated corporate bonds (rated Baa or lower by Moody's and BBB or lower by Standard and Poor's).

Income bond funds seek a high level of income by investing in a mixture of corporate and government bonds.

Income equity funds seek a high level of income by investing mainly in stocks of companies with a consistent history of dividend payments.

Income mixed funds seek a high level of interest and/or dividend income by investing in income-producing securities, including equities and debt instruments.

International equity funds seek capital appreciation by investing in equity securities of companies located outside the United States (these securities at all times represent two-thirds of the fund portfolios).

National municipal bond funds (long-term) seek dividend income by investing primarily in bonds issued by states and municipalities.

Precious metal funds seek capital appreciation by investing at least two-thirds of their fund assets in securities associated with gold, silver, and other precious metals.

State municipal bond funds (long-term) seek dividend income by investing primarily in bonds issued by states and by municipalities of one state.

Taxable money market mutual funds seek the highest income consistent with preserving investment principal. Examples of the securities these funds invest in include U.S.

Treasury bills, commercial paper of corporations, and large-denomination bank certificates of deposit.

Tax-exempt money market funds (national) seek the highest level of federal tax-free dividend income consistent with preserving investment principal. These funds invest in short-term municipal securities.

Tax-exempt money market funds (state) seek the highest level of federal tax-free dividend income consistent with preserving investment principal. These funds invest primarily in short-term municipal securities from one state.

U.S. government income funds seek income by investing in a variety of U.S. government securities, including Treasury bonds, federally guaranteed mortgage-backed securities, and other U.S.-government-backed issues.

APPENDIX B

VECTOR AUTOREGRESSION RESULTS FOR CURRENT MONTHLY MUTUAL FUND FLOWS

Fund Group	Constant	Lag 1	Lag 2	Lag 3	Time Trend	Adjusted R-Squared
Stock funds						
Growth	0.00082	0.191	0.077	0.230	0.000074	0.26
	(0.38)	(2.16)**	(0.87)	(2.64)**	(1.97)*	
Global equity	-0.00062	0.618	-0.058	0.184	0.000071	0.54
	(-0.22)	(6.87)**	(-0.56)	(2.12)**	(1.54)	
Income	0.00102	0.465	0.075	0.290	0.0000123	0.54
	(0.75)	(5.11)**	(0.75)	(3.23)**	(0.71)	
Bond funds						
Government	-0.00024	0.851	-0.130	0.162	0.000001	0.80
	(-0.144)	(9.04)**	(-1.05)	(1.75)*	(0.03)	
Corporate	0.001805	0.592	-0.039	0.238	0.000009	0.54
	(0.74)	(6.43)**	(-0.37)	(2.69)**	(0.30)	
GNMA	-0.00075	0.665	0.114	0.085	0.000010	0.71
	(-0.35)	(7.27)**	(1.03)	(1.03)	(0.34)	
High yield	0.00238	0.249	0.123	0.116	0.000044	0.12
	(0.64)	(2.63)**	(1.27)	(1.27)	(0.86)	
Municipal	0.00460	0.511	0.040	0.131	-0.000029	0.42
	(1.78)*	(5.43)**	(0.39)	(1.45)	(-0.93)	

Source: Authors' estimations.

Notes: Monthly flows into mutual funds over the July 1986–April 1996 period are computed as the sum of 1) total sales minus redemptions and 2) exchanges into a fund minus exchanges out of a fund. The flow into each group is divided by that fund's net asset value from the previous month. The fund groups are drawn from the Investment Company Institute (ICI) classification of mutual funds by objective. Some groups combine two ICI categories: growth stock funds includes growth and aggressive growth stock funds; global equity funds, global equity and international stock funds; income stock funds, equity income and growth-and-income stock funds; municipal funds, national and state municipal bond funds. The t-statistics are in parentheses.

* Significant at the 90 percent level.

** Significant at the 95 percent level.

Appendix C

Instrumental Variable Regressions

	Dependent Variable: Unexpected Flows as a Percentage of Assets							
	Stock Funds			Bond Funds				
Independent Variable	Growth	Income	Global Equity	Government	Corporate	Municipal	GNMA	High Yield
Funds' own market								
Same-month excess return	0.006	0.016	0.010	0.033**	0.049**	0.084**	0.013	0.023
	(1.25)	(1.68)	(0.92)	(2.21)	(3.40)	(3.96)	(0.71)	(0.39)
Lagged excess return	-0.002	-0.001	-0.002	0.01*	-0.004	-0.009	0.018**	-0.007
	(-0.67)	(1.68)	(-0.67)	(1.80)	(-0.72)	(-0.98)	(2.57)	(-0.45)
Same-month conditional volatility	-0.081	0.001	0.045	-0.100	-0.005	-0.005	0.030	0.016
	(-0.33)	(-0.53)	(1.23)	(-1.64)	(0.06)	(-0.03)	(0.24)	(0.45)
Lagged conditional volatility	-0.040	0.001	-0.013	-0.001	0.029	0.001	0.084	-0.003
	(-0.23)	(1.44)	(-0.40)	(-1.64)	(0.35)	(0.52)	(0.66)	(-0.11)
Alternative market								
Same-month excess return	0.037**	-0.008	0.009	-0.004	0.001	0.000	0.002	0.009
	(2.18)	(0.83)	(0.34)	(-0.87)	(0.24)	(0.21)	(0.42)	(0.36)
Lagged excess return	-0.017**	0.003	0.005	-0.004	-0.004*	-0.002	-0.002	0.001
	(-2.61)	(-1.03)	(0.49)	(-0.19)	(-1.75)	(-0.81)	(-1.06)	(0.38)
Same-month conditional volatility	-0.042	-0.001	-0.178*	0.341	-0.207	-0.003	0.222	0.068
	(-0.62)	(-0.37)	(-1.67)	(1.58)	(-0.98)	(-1.21)	(0.82)	(0.11)
Lagged conditional volatility	-0.044	-0.000	-0.161*	0.274*	-0.148	-0.002	0.132	0.114
	(-0.64)	(-0.08)	(-1.67)	(1.79)	(-0.96)	(-1.15)	(0.67)	(0.29)
Adjusted R-squared	0.350	0.050	0.251	-0.070	0.460	0.370	0.180	0.280
F-statistic	3.060	1.170	1.882	3.670	6.350	4.840	2.980	1.740

Source: Authors' estimates.

Notes: The same-month returns are based on the following instruments: capacity utilization, the Federal Reserve's target federal funds rate, nonfarm employment, and the consumer price index. For stock funds, the alternative market is government bond funds. For bond funds, the alternative market is growth funds. The t-statistics are in parentheses.

* Significant at the 90 percent level.

** Significant at the 95 percent level.

APPENDIX D

REGRESSIONS BASED ON WARTHER'S EXPLANATORY VARIABLES

	Dependent Variable: Unexpected Flows as a Percentage of Assets							
	Growth Stock Funds				Government Bond Funds			
Independent Variable	Ordinary Least Squares Regressions		Instrumental-Variable Regressions		Ordinary Least Squares Regressions		Instrumental-Variable Regressions	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
FUNDS' OWN MARKET								
Same-month excess return	0.012**	0.012**	0.011**	0.011**	0.017**	0.017**	0.029**	0.029**
	(11.51)	(11.38)	(3.73)	(3.55)	(4.25)	(4.27)	(3.16)	(3.15)
Excess return lagged one month	-0.003**	-0.003**	-0.003**	-0.003**	0.012**	0.012**	0.009*	0.010**
	(-2.99)	(-2.99)	(-2.39)	(-2.36)	(2.88)	(2.96)	(1.97)	(2.11)
Excess return lagged two months	-0.001	-0.001	-0.001	-0.001	-0.001	0.000	0.002	0.001
	(-0.68)	(-0.58)	(-0.73)	(-0.63)	(0.14)	(-0.01)	(0.41)	(0.24)
Excess return lagged three months		0.000		-0.001		-0.004		0.004
		(-0.43)		(-0.51)		(0.94)		(0.98)
Adjusted R-squared	0.538	0.535	0.534	0.529	0.209	0.208	0.141	0.149
F-statistic	45.240	33.730	5.711	4.474	11.048	8.497	7.972	6.147

Source: Authors' calculations.

Notes: The ordinary least squares regressions use the same explanatory variables as in Warther (1995). The instrumental-variable regressions also use the same variables as in Warther, but include instruments for the same-month excess returns. For the instrumental-variable regressions, the same-month returns are based on the following instruments: capacity utilization, the Federal Reserve's target federal funds rate, nonfarm employment, and the consumer price index. The t-statistics are in parentheses.
* Significant at the 90 percent level.
** Significant at the 95 percent level.

ENDNOTES

The authors thank Richard Cantor, John Clark, and Tony Rodrigues for helpful discussions. William May and Dan Nickolich provided valuable contributions at an early stage of our research.

1. The large mutual fund flows have caught the attention of the financial press. For example, see *Economist* (1995), Norris (1996), and Gasparino (1996).

2. The Internal Revenue Code of 1954 treats a mutual fund's shareholders as investors who directly hold the securities in the fund's portfolio. To maintain their status as tax-exempt conduits, the funds must satisfy certain standards for diversification and sources of income.

3. These statistics were provided by the Investment Company Institute. They are available upon request from the ICI.

4. Investors may have seen such a market in 1973 and 1974, when the stock market fell an average of 23.3 percent a year. Mutual funds apparently saw heavy outflows from 1972 to 1979 (based on an ICI data series that was discontinued in 1983). In addition, Shiller (1984) cites a decline in the number of investment clubs from a peak of 14,102 in 1970 to 3,642 in 1980.

5. Although the flow data are available from January 1984 on, our sample period does not begin until two and a half years later, when full data on market returns become available.

6. Alternatively, we could have controlled for the time trend at a later stage of the analysis, but the conclusions would have remained unchanged. In the analysis, we regress flows on measures of excess returns. Since these returns are uncorrelated with the time trend, excluding the trend from this later regression does not result in an omitted variable bias.

7. Statistically, we can define these unexpected flows as a stationary process that allows us to draw the appropriate inferences from regression estimates. More specifically, augmented Dickey-Fuller tests reject the presence of a unit root.

8. Lee, Shleifer, and Thaler (1991), for example, consider mutual fund flows and discounts on closed-end funds as measures of investor sentiment. However, Warther (1995) finds no correlation between such flows and discounts.

9. For a good textbook treatment of the use of instrumental variables, see Davidson and MacKinnon (1993, pp. 622-51).

10. The literature on the effects of macroeconomic variables on the stock and bond markets is extensive. See Fleming and Remolona (1997) for a survey.

11. Because of correlation among the instruments, some coefficients in the first-stage regression are individually not statistically significant. The significant coefficients have the expected signs (as discussed in Fleming and Remolona [1997], for example). We did not exclude the insignificant instruments, however, because our tests showed them to be jointly significant.

12. See Nelson and Startz (1990), Bound, Jaeger, and Baker (1993), and Staiger and Stock (1994) for discussions of the uses and limitations of instrumental variables.

13. More specifically, the conditional volatilities are based on an estimated generalized autoregressive conditional heteroskedastic (GARCH) process.

14. We report OLS and instrumental-variable regressions in Appendix D to show that the extra lag does not contribute explanatory power, while the volatilities and other-market returns serve to strengthen the measured short-term effects of own-market returns on flows.

15. Note that the more conservative funds also exhibit less volatile flows.

16. We also tried to test this assumption econometrically by including variables representing returns that are more than a standard deviation from either side of the mean. We found that these variables contributed no significant explanatory power. There were relatively few large shocks, and their effects were apparently too different to be captured statistically. We also tried to test the possibility of asymmetric effects by including variables representing only negative returns. Again, we found that these variables contributed no significant explanatory power.

17. Marcis, West, and Leonard-Chambers (1995) also look at mutual fund flows during market disruptions in 1994 and come to conclusions similar to ours.

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The Evolving External Orientation of Manufacturing: A Profile of Four Countries

José Campa and Linda S. Goldberg

Changes in exchange rates, shifts in trade policy, and other international developments can significantly influence the profitability and performance of a country's manufacturing industries. To understand and measure the exposure of domestic manufacturing industries to international events, one must first examine the channels that transmit such shocks to production activity and, ultimately, to the economy as a whole. Capturing a country's industrial reliance on international markets—which we refer to as the "external orientation" of its industries—involves measuring the extent to which manufacturers sell products to foreign markets, use foreign-made inputs, and, more indirectly, compete with foreign manufacturers in domestic markets through imports.

The growing internationalization of the production process and trade means that no single measure can capture the importance of the world economy to a given industry. Today, the most widely used indicator of an industry's exposure to world events is its "openness to trade," typically calculated as import plus export revenues of final products divided by domestic production revenues. This measure has been used extensively in studies addressing industry exposure to external shocks such as exchange rate movements and trade policies.

Although the openness to trade measure is useful in some contexts (for example, in understanding the reasons for growth in world trade),[1] it can be misleading because it fails to consider the growing use of foreign inputs in the manufacture of domestic goods. To some degree, the use of foreign inputs in domestic production works to offset the revenue exposure to foreign shocks that arises because of a manufacturer's dependence on foreign sales and the presence of import competition. Consider, for example, a shoe manufacturer in the United States that imports and exports small amounts of its finished product. Such a company would appear to have limited openness to trade. Suppose, however, that the same manufacturer relies heavily on imported leather as an input in production. An appreciation of the U.S. dollar would likely lead to a drop in the price of the imported leather used by the manufacturer and consequently an increase in profitability. The openness to trade measure would capture only the negative effect of the rising dollar on the manufacturer's profitability. Clearly, a broader assessment of industrial external orientation will prove informative to policymakers and economists seeking to understand the effects of external shocks on particular manufacturing industries.

This article presents four measures of external orientation using industry-specific and time-varying data for manufacturing industries in four countries—the United States, Canada, the United Kingdom, and Japan. For each of these countries, we report export revenue share, imports relative to consumption, and imported input share in production of all manufacturing industries identified by two digits in the Standard Industrial Classification system. We also report an overall measure, net external orientation, defined as the difference between industry export share and imported input share in production.[2] We present approximately twenty years of data for the industries in each country from the early 1970s to the mid-1990s.

Our discussion of the data and methodology used in constructing the external orientation measures is followed by country-specific histories of the export share, import share, imported input share, and net external orientation of each manufacturing industry. The country sections are followed by cross-country comparisons of industry trends in external orientation. The results we present are useful for predicting how particular international shocks will influence manufacturing industries over time.

Measures of External Orientation

The first of our four measures of external orientation is export share, the ratio of industry export revenues to industry shipments (χ_i). This measure captures the portion of a producer's revenues that is generated in foreign markets. Manufacturers with high export shares are likely to have total revenues that are more sensitive to international shocks than producers with low export shares. Our second measure, import share, or the ratio of imports to consumption (M_i), captures foreign penetration in a particular industry. Revenues are also likely to be more sensitive to international shocks when there is a high degree of foreign penetration in domestic markets. Thus, a manufacturer in an industry with a high ratio of imports to consumption may experience a larger change in its ability to compete in local markets—and have domestic revenues that are more vulnerable to an external shock. We construct the series for export share and import share by using industry sales, consumption, and trade data from country sources (see the appendix for data sources).

Imported input share—imported inputs as a share of the value of production (α_i)—is our third measure.

The growing internationalization of the production process and trade means that no single measure can capture the importance of the world economy to a given industry.

Because data on imported inputs are not available from country sources, we construct this series by combining industry import data with country input-output data that describe the expenditures on different categories of inputs by each manufacturing industry in each country (see box). In contrast to the other two measures, which provide guidance on the vulnerability of producer revenues to international forces, the imported input share measure provides a window into the potential sensitivity of a producer to shocks experienced through the cost side of its balance sheet. A manufacturer that relies very heavily on imported inputs will likely be more exposed to international shocks through costs than a producer that relies mostly on domestically produced inputs. Nevertheless, since revenue and cost exposures can offset each other, thereby smoothing the effects of external shocks on producer profits, a manufacturer with high imported input share will not necessarily have greater net exposure to international shocks than a producer with low imported input share.

Finally, we present a measure of net external orientation, defined as the difference between industry export share and imported input share ($\chi_i - \alpha_i$). An industry with positive net external orientation has a larger export share than imported input share. An industry with negative net external orientation has a greater imported input share than export share. This net measure is more indicative of the direction of an industry's exposure to an international shock than any other single measure. However, net external orientation does not provide a reliable measure of the degree of industry exposure to international events. To arrive at such a measure, observers should utilize, but not rely exclusively on, our measures of external orientation. Each type of shock can be expected to elicit different types of industry or market adjustments. Moreover, in some instances, export revenue sensitivity to a particular type of shock may differ from imported input cost sensitivity to the same shock. These sensitivities may also vary across industries and according to the particular type of imported inputs used in each industry's production.

We present the measures of external orientation from the early 1970s to the mid-1990s for all two-digit Standard Industrial Classification manufacturing industries in the United States, Canada, the United Kingdom, and Japan.[3] The industries examined—approximately twenty for each country—represent most manufacturing production categories, including food, textiles, chemicals, instruments and related products, electrical machinery, and nonelectrical machinery.[4] We identify broad external orientation patterns in industries and changes over time and document our findings in a series of summary tables. These tables show both the level of the individual external

Calculating Imported Input Share

Imported inputs as a share of the value of production provide a useful measure of an industry's cost-side external orientation. These data generally are not published by country data sources. To construct the series, we start with data drawn from the production input-output tables for each manufacturing industry of each country. These tables provide detailed information on industry expenditure, within a given year, on each type of final output of all manufacturing (and, in most cases, nonmanufacturing) industries. We then multiply the share of total industry expenditures attributable to specific input categories by the respective import-to-consumption ratios. We sum the resulting data to arrive at a measure of imported inputs in production. The methodology for constructing our imported input share series is based on Campa and Goldberg (1995).

The formula for the imported input share of an industry i is

$$\alpha_t^i = \frac{\sum_{j=1}^{n-1} m_t^j p_t^j q_{j,t}^i}{VP_t^i},$$

where i = index representing the output industry;

j = index representing the production input industry;

m_t^j = share of imports in consumption of industry j in period t;

$p_t^j q_{j,t}^i$ = value of inputs from industry j used in the production of industry i in period t.

VP_t^i = value of total production cost of industry i in period t; and

n = total number of product input categories. The nth input is labor.

The appendix describes the specific data sources and the features of the data used for the four countries. The imported input share series is useful for comparing industries within a particular country. The constructed series is not fully comparable across countries, however. Two important reasons exist for cross-country differences. First, for Canada and Japan, the measure includes imported inputs from agriculture, raw materials, and manufacturing. By contrast, for the United States and the United Kingdom the measure includes only manufacturing inputs. Second, the denominator, which represents the value of total production, differs across countries because of data availability.

orientation series for select years and the similarities over time in the ranking of industries according to particular measures. The evolution of each external orientation measure for each industry is shown in Charts A1-A12 in the appendix.

The similarities or differences in external orientation of industries over time, or at points in time across countries, are captured using Spearman rank correlation statistics. These statistics measure the correlation between two variables on the basis of the ordinal positions of the variables without explicitly adjusting for differences in their levels. For example, we use Spearman rank correlations to determine whether those industries with the highest export shares in the 1970s remained the most export-oriented industries across the 1980s and 1990s. Using data for specific years, we rank industries from low to high, according to the size of their export shares. The industry rankings are then correlated with each other across two different years. If the resulting Spearman rank correlation statistic is high and positive, then the industries that are relatively more focused on exports in one year are also the industries that are relatively export-oriented in the other year. Likewise, those industries that do not rely heavily on exports are the same in the different years.

Five key conclusions result from our analysis of industry external orientation:

1. In all the countries except Japan, the *levels* of three measures of external orientation of manufacturing industries—export share, import share, and imported input share—have increased considerably in the last two decades. The external orientation of industries in Canada and the United Kingdom is considerably higher than in the United States and Japan.

2. The *relative rankings* of manufacturing industries in terms of export share, import share, and imported input share have been very stable over time in each country. In other words, an industry with higher export share than other industries in the early 1970s remained relatively export-oriented into the mid-1990s. Similarly, industries with relatively high import share or imported input use in the early 1970s remained relatively dependent on imports and imported inputs through the mid-1990s.

3. Significant changes over time and differences across countries are evident in the *net* external orientation of industries. In the U.S. industries, levels of net external orientation shifted dramatically between the early 1980s and the early 1990s. By contrast, in Japan the net external orientation of industries has been very stable over the past two decades.

4. Export share tends to be high in the same industries—electrical machinery, nonelectrical machinery, transportation equipment, and instruments and related products—across the four countries. The main difference in industry export orientation is one of degree: while Canadian, U.K., and U.S. exports are produced by a broader range of manufacturing industries, most of Japan's exports are generated by the small subset of industries that export a very high percentage of their output.

5. Unlike export share rankings, the import share and imported input share rankings of industries are not highly correlated across countries. By the mid-1990s, only the imported input share rankings of manufacturing industries in the United States and the United Kingdom were positively correlated. Overall, the industries that rely most heavily on imported inputs differ sharply among the four countries.

U.S. Manufacturing Industries

All four measures of external orientation indicate that U.S. manufacturing industries have become increasingly integrated with the world economy in the period 1972-95. Despite a brief dip by some industries when the dollar peaked in 1985, the overall export share of U.S. manufacturing roughly doubled, from about 7.5 percent in the early 1970s to 13.4 percent by the mid-1990s (Table 1 and Chart A1). Indeed, in three industries—apparel and other textiles, furniture and fixtures, and leather and leather products—export share more than tripled over the past two decades.

When we compare the rankings of industries by export share at various points during the past two decades, we find that those industries with relatively high export shares in the mid-1970s were still the most export-oriented by the mid-1990s (Table 1, bottom row). Thus, despite the large increases in overall levels of export share across industries, the relative pattern of export orientation among the manufacturing industries in the United States has been very stable over time.

U.S. manufacturing industries have also experienced large expansions in imports as a share of consumption. The increase in the import share of total manufacturing is comparable to the growth in export share. In contrast to the developments in export shares, however, the extent to which import penetration has increased differs greatly across industries. In several industries, import share has risen to more than 20 percent of domestic consumption (that is, in apparel and other textiles, leather and leather products, industrial machinery and equipment, electronic and other electric equipment, transportation equipment, and instruments and related products). By contrast, import shares remain below 10 percent of U.S. consumption in seven of the twenty manufacturing industries (food and kindred products; tobacco products; textile mill products; printing and publishing; petroleum and coal products; stone, clay, and glass products; and fabricated metal products). By and large, the same industries maintained a relatively high import share from the early 1970s through the mid-1990s (Chart A1). But the difference in the levels of import share across industries with low and high import penetration has significantly widened.

U.S. manufacturing industries have also steadily increased their use of imported inputs in production, on average from about 4 percent in 1975 to more than 8 percent in 1995 (Table 1 and Chart A2). The increase in imported input use across manufacturing was greatest in the first half of the 1980s, when the U.S. dollar dramatically appreciated and reduced the cost of foreign-produced inputs relative to inputs produced domestically. By 1985, imported

Table 1
EXPORT SHARE, IMPORT SHARE, AND IMPORTED INPUT SHARE OF U.S. MANUFACTURING INDUSTRIES IN SELECTED YEARS

	1975			1985			1995		
Industry	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share
Food and kindred products	3.3	3.7	2.8	3.6	4.3	3.6	5.9	4.2	4.2
Tobacco products	6.9	0.6	1.4	8.1	0.5	1.6	14.9	0.6	2.1
Textile mill products	5.1	4.3	3.0	3.6	7.7	5.4	7.6	9.1	7.3
Apparel and other textiles	2.0	8.5	1.3	1.8	22.4	2.3	7.4	31.4	3.2
Lumber and wood products	7.2	6.9	2.2	5.3	10.5	3.5	7.6	10.3	4.3
Furniture and fixtures	1.3	3.0	3.6	1.6	9.2	5.3	5.5	14.1	5.7
Paper and allied products	5.9	5.9	4.2	4.3	7.1	5.1	9.0	10.0	6.3
Printing and publishing	1.6	1.0	2.7	1.2	1.2	3.0	2.4	1.6	3.5
Chemicals and allied products	10.1	3.6	3.0	11.7	6.5	4.5	15.8	11.0	6.3
Petroleum and coal products	1.7	9.7	6.8	3.1	9.5	6.8	3.9	5.7	5.3
Rubber and miscellaneous products	4.8	4.9	2.7	3.9	6.3	3.9	9.2	12.8	5.3
Leather and leather products	3.9	17.7	5.6	6.1	49.6	15.7	14.4	59.5	20.5
Stone, clay, and glass products	3.4	3.4	2.1	3.4	7.6	3.6	5.6	9.5	4.7
Primary metal products	5.1	9.8	5.0	3.7	16.6	9.2	11.2	17.4	10.6
Fabricated metal products	6.3	3.0	4.7	4.7	5.5	7.8	7.9	8.5	8.7
Industrial machinery and equipment	23.3	6.3	4.1	20.1	13.9	7.2	25.8	27.8	11.0
Electronic and other electric equipment	11.1	8.5	4.5	10.1	17.0	6.7	24.2	32.5	11.6
Transportation equipment	15.8	10.4	6.4	13.0	18.4	10.7	17.8	24.3	15.7
Instruments and related products	16.8	7.4	3.8	15.5	13.7	5.4	21.3	20.1	6.3
Other manufacturing	9.9	13.4	4.6	8.1	35.0	8.5	13.5	41.1	9.9
TOTAL MANUFACTURING	8.4	6.3	4.1	7.9	11.0	6.2	13.4	16.3	8.2
INDUSTRY RANK CORRELATIONS WITH 1975 VALUES	---	---	---	0.901	0.850	0.934	0.765	0.614	0.812

Source: Authors' calculations, based on annual data from U.S. Department of Commerce, Bureau of the Census, *Annual Survey of Manufactures,* and U.S. Department of Commerce, Bureau of Economic Analysis, "Benchmark Input-Output Accounts for the U.S. Economy, 1982," *Survey of Current Business,* July 1991.

inputs as a share of total costs in U.S. manufacturing industries had risen to about 6 percent. Even after the dollar depreciated in the second half of the 1980s, the presence of imported inputs continued to increase in the United States. Overall, imported input share has more than doubled in many manufacturing industries over the past two decades.

In the early to mid-1970s, sixteen of the twenty U.S. manufacturing industries registered a positive net external orientation—that is, their export shares exceeded their imported input shares (Table 2 and Chart A3). These sixteen industries were responsible for more than 85 percent of all manufacturing shipments. As a result, during this period most discussions of the effect of trade policies and dollar value movements focused on implications for export activity. By the early to mid-1980s, the balance of external orientation had shifted tremendously. In 1985, only eight U.S. manufacturing industries, accounting for slightly more than half of manufacturing shipments, retained a positive net external orientation. In 1986, only seven industries, which together were responsible for 45 percent of total shipments, had a positive net external orientation (Chart A3).

Today, U.S. manufacturing industries are even more exposed to international shocks through their export market sales than through their imported input use.

The pendulum gradually swung back over the course of the late 1980s and early 1990s. In the late 1980s, the growth of export share again exceeded that of imported input share. Today, U.S. manufacturing industries are even more exposed to international shocks through their export market sales than through their imported input use. By 1995, only five of the twenty manufacturing industries recorded negative net external orientation. Once again, industries with positive net external orientation accounted for more than 80 percent of all manufacturing shipments to both domestic and foreign markets.

Despite the relative stability of rankings of the export, import, and imported input shares (indicated by the Spearman rank correlation statistics), the scale of net external orientation for many industries has changed considerably over time in the United States. Net external orientation of manufacturing is a useful instrument for thinking about changes in potential industry exposure to exchange rate movements and other external shocks. The greater the negative net external orientation of an industry, for example, the more likely that a dollar appreciation will improve, rather than worsen, the industry's profitability.

Canadian Manufacturing Industries

Canadian manufacturing industries have also greatly increased all channels of external orientation and become

Table 2
NET EXTERNAL ORIENTATION OVER TIME: THE UNITED STATES

	1975		1985		1995	
Export Share Exceeds Imported Input Share by:	Number of Industries	Share of Manufacturing Shipments	Number of Industries	Share of Manufacturing Shipments	Number of Industries	Share of Manufacturing Shipments
More than 10 percent	2	11.3	2	11.8	4	23.9
5 to 10 percent	5	27.9	2	9.4	1	10.2
0 to 5 percent	9	48.5	4	37.2	10	49.2
0 to -5 percent	3	5.6	10	36.3	4	16.3
-5 to -10 percent	1	6.8	2	5.2	1	0.3
More than -10 percent	0	0.0	0	0.0	0	0.0

Source: Authors' calculations, based on annual data from U.S. Department of Commerce, Bureau of the Census, *Annual Survey of Manufactures,* and U.S. Department of Commerce, Bureau of Economic Analysis, "Benchmark Input-Output Accounts for the U.S. Economy, 1982," *Survey of Current Business,* July 1991.

more globally integrated. In the period 1974-93, Canada experienced more changes than any other country in our sample in the actual ranking of sectors according to export shares. By contrast, import share and imported input share rankings have been much more stable (Table 3 and Charts A4 and A5).

In most industries, growth in export share was tremendous. For total manufacturing, export share rose from 23 percent in 1974 to nearly 50 percent in 1993. For two industries, export share rose tenfold: furniture and fixtures grew from 4.6 percent to 49 percent, and chemicals and chemical products expanded from nearly 3 percent to 37 percent. In Canada, most industries that started from low initial export shares tripled or quadrupled their use of export markets between the mid-1970s and mid-1990s. Industries exporting more than 37 percent of their output in the early 1970s generally exported more than 60 percent by the mid-1990s. This shift in export orientation clearly shows that the Canadian economy is more closely linked to the world economy.

The import share for most Canadian manufacturing industries exceeded 10 percent of domestic consumption in the early 1970s (averaging 25 percent of total manufacturing). These figures rose across the board from the mid-1970s to the early 1990s. By the early 1990s, the minimum import penetration of Canadian manufacturing industries was about 20 percent. In most cases, however, an industry's import share was 50 percent or more.[5]

The imported input share of manufacturing industries in Canada has not shifted as dramatically as the shares for the other external orientation channels. Across all manufacturing industries, the average imported input share rose from 16 to 20 percent from 1974 to 1993. Although some industries did experience more rapid increases (for

Table 3
EXPORT SHARE, IMPORT SHARE, AND IMPORTED INPUT SHARE OF CANADIAN MANUFACTURING INDUSTRIES IN SELECTED YEARS

	1974			1984			1993		
Industry	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share
Food and beverages	8.2	10.3	6.6	8.0	11.0	5.7	18.6	18.4	6.6
Tobacco products	10.2	3.8	6.6	6.4	3.3	5.3	40.0	51.7	9.8
Rubber and plastic industries	6.4	29.0	11.0	16.3	25.6	10.8	34.4	41.9	16.6
Leather industries	4.7	31.3	12.6	6.2	41.3	12.3	22.8	72.4	21.8
Textile industries	6.2	34.2	14.9	9.4	33.5	14.2	25.4	49.3	20.2
Knitting mills	4.2	17.2	17.9	5.9	29.0	17.9	18.8	48.0	21.6
Wood industries	38.1	12.9	3.6	49.7	11.0	3.3	75.2	24.4	4.8
Furniture and fixtures	4.6	13.7	9.7	17.5	14.3	8.1	49.2	51.5	14.2
Paper and allied products	49.5	10.7	4.8	53.4	14.9	5.4	62.6	30.2	10.5
Printing and publishing	2.6	14.1	4.2	4.5	13.1	5.5	6.2	19.6	8.8
Primary metal products	37.2	25.9	14.7	28.4	20.7	11.6	53.2	38.1	11.4
Fabricated metal products	7.1	19.4	10.8	12.4	21.9	8.6	16.8	27.4	13.6
Machinery industries	35.2	65.9	17.7	64.5	83.6	21.9	110.8	104.0	26.6
Transportation equipment	55.8	62.1	29.1	78.1	77.7	37.0	94.4	93.5	49.7
Electrical machinery products	14.5	36.5	13.2	28.0	46.9	17.1	38.9	60.8	30.9
Nonmetallic mineral products	7.0	16.8	6.1	13.4	20.3	6.6	21.8	32.5	8.5
Petroleum and coal products	11.4	8.1	70.0	15.2	9.2	15.1	27.1	18.2	12.1
Chemicals and chemical products	2.7	26.4	9.03	3.5	25.5	8.8	37.2	46.9	15.1
TOTAL MANUFACTURING	23.0	25.5	15.9	30.3	30.6	14.4	48.4	46.7	20.2
INDUSTRY RANK CORRELATIONS WITH 1974 VALUES	---	---	---	0.841	0.957	0.938	0.688	0.687	0.754

Source: Authors' calculations, based on annual data from Statistics Canada, System of National Accounts, *The Input-Output Structure of the Canadian Economy.*

Note: Results for 1993 are preliminary estimates.

example, paper and allied products, printing and publishing, and electrical machinery products), imported input use declined in many cases. The use of imported inputs in petroleum and coal products declined precipitously from 70 percent in 1974 to 12 percent in 1993. The share of imported inputs also fell in primary metal products.

Unlike U.S. manufacturing industries, where the direction of net external orientation has swung back and forth, Canada's manufacturing industries have moved steadily toward greater positive net external orientation (Table 4 and Chart A6). In 1974, nine out of eighteen manufacturing industries, accounting for 67 percent of total manufacturing shipments, registered positive net external orientation. For five of these industries—which together account for 40 percent of all manufacturing shipments—the net orientation toward exports was well above 10 percent. By the mid-1990s, sixteen out of eighteen manufacturing industries in Canada held a positive net external orientation, representing more than 90 percent of manufacturing shipments. This increasing tendency toward positive net external orientation came as a result of substantial export growth.

U.K. Manufacturing Industries

The external orientation of the manufacturing industries in the United Kingdom grew significantly in the period 1970-93. For total manufacturing, the export share of total shipments increased from nearly 20 percent in 1974 to almost 30 percent by 1993 (Table 5 and Chart A7). The largest absolute increase in U.K. manufacturing export share was in professional goods. As in the United States and Canada, the industries that entered the 1970s as relatively large exporters continued to be relatively large exporters into the mid-1990s.

Even with the widespread expansion of export share, some manufacturing industries are exceptionally oriented toward external markets. For example, chemicals and allied products, nonelectrical machinery, electrical machinery, and professional goods all show export shares exceeding 45 percent of their total production for 1993. Like the high numbers for Canadian industry export shares, some of these U.K. numbers reflect a significant re-export phenomenon: certain products entering the country as imports are not destined for home market consumption. Because these products are re-exported to third markets, with varying degrees of value added by U.K. manufacturing industries, the export share measure may inflate the industry's external orientation.

The net external orientation of manufacturing industries in the United Kingdom . . . has varied considerably over the past two decades.

The import share of U.K. manufacturing industries also increased, from approximately 20 percent to

Table 4
NET EXTERNAL ORIENTATION OVER TIME: CANADA

Export Share Exceeds Imported Input Share by:	1974 Number of Industries	1974 Share of Manufacturing Shipments	1984 Number of Industries	1984 Share of Manufacturing Shipments	1993 Number of Industries	1993 Share of Manufacturing Shipments
More than 10 percent	5	40.5	6	45.3	12	78.7
5 to 10 percent	0	0.0	3	6.3	2	9.2
0 to 5 percent	4	26.8	4	31.9	2	5.5
0 to -5 percent	3	12.5	2	6.0	2	6.6
-5 to -10 percent	4	10.9	2	8.2	0	0.0
More than -10 percent	2	9.4	1	2.3	0	0.0

Source: Authors' calculations, based on annual data from Statistics Canada, System of National Accounts, *The Input-Output Structure of the Canadian Economy.*

Note: Results for 1993 are preliminary estimates.

34 percent of consumption. Tobacco products, chemicals and allied products, rubber products, nonelectrical machinery, and electrical machinery registered large gains in import share. The overall rise in import share, however, largely reflects a pre-established pattern of foreign penetration in certain domestic industries. In particular, industries with a high import share in the 1970s were also the industries with high import penetration in the 1990s. Thus, although the level of external exposure for particular industries may have increased, the United Kingdom did not experience a major shift in the composition of manufacturing industries facing foreign competition.

Imported input share rose in all U.K. manufacturing industries over the past two decades, from an average of more than 13 percent in 1974 to 22 percent in 1993 (Table 5 and Chart A8). The industries that exhibited the most significant increases in imported input use were the same ones that experienced significant gains in import share. This finding makes sense because manufacturing industries tend to use their own broad product groups as inputs in their production. The finding also reflects the re-export activity of some industries and underscores the value of focusing attention on both the net external orientation of manufacturing industries and the separate channels of external orientation.

The net external orientation of manufacturing industries in the United Kingdom, like the net orientation of U.S. industries, has varied considerably over the past two decades (Table 6 and Chart A9). In contrast to the strong positive net orientation observed in the 1970s, less than 60 percent of manufacturing shipments in the 1980s were in industries with a net external orientation favoring

Table 5
EXPORT SHARE, IMPORT SHARE, AND IMPORTED INPUT SHARE OF U.K. MANUFACTURING INDUSTRIES IN SELECTED YEARS

	1974			1984			1993		
Industry	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share
Food	5.8	21.4	8.4	7.3	18.1	8.6	9.6	18.9	9.1
Beverages	17.7	11.1	8.8	20.5	13.5	11.1	22.3	16.2	13.2
Tobacco products	10.6	3.4	8.3	24.9	23.2	10.0	8.0	58.7	10.0
Textiles and wearing apparel	18.3	20.1	15.7	22.5	35.8	26.7	30.9	29.1	24.2
Leather and leather products	16.7	18.0	15.0	25.7	42.0	24.7	33.8	73.2	35.6
Wood products	2.0	34.3	20.6	3.6	33.8	21.8	2.7	15.6	12.9
Furniture and fixtures	5.7	6.0	14.7	7.7	15.4	19.9	7.9	51.9	14.1
Paper and paper products	7.1	28.6	18.9	10.0	32.6	23.2	15.1	31.2	23.1
Printing and publishing	6.9	4.1	10.9	7.8	5.5	13.5	8.3	5.6	13.6
Chemicals and allied products	25.0	19.6	13.1	36.7	32.0	20.6	45.1	38.5	22.5
Petroleum and coal products	12.9	14.8	3.7	18.2	24.7	6.1	19.0	9.4	4.8
Rubber products	16.9	10.9	11.8	23.7	23.1	19.1	31.2	33.2	21.3
Plastic products	8.6	13.4	14.1	10.1	15.2	21.6	8.6	14.5	24.7
Nonmetallic products	11.7	8.3	7.8	9.8	9.8	13.0	11.8	11.7	13.8
Iron and steel	11.9	14.5	11.7	17.0	16.9	15.6	29.1	26.0	20.1
Nonferrous metals	29.1	38.6	29.1	39.6	47.7	36.9	37.6	51.8	40.1
Fabricated metal products	11.2	6.6	15.4	17.9	16.1	20.8	17.1	19.1	24.6
Nonelectrical machinery	35.6	26.9	16.1	44.5	43.1	24.9	51.1	52.5	31.3
Electrical machinery	18.4	17.6	14.9	24.0	30.0	23.6	47.0	51.7	34.6
Transport equipment	30.7	18.4	14.3	35.1	38.1	25.5	40.8	47.7	32.2
Professional goods	42.1	39.9	13.2	109.2	108.8	22.6	107.6	111.9	29.5
Other manufacturing	76.6	76.6	20.6	116.4	114.7	28.2	118.2	112.8	29.0
TOTAL MANUFACTURING	18.5	19.6	13.4	24.1	29.0	19.0	29.8	33.8	21.7
INDUSTRY RANK CORRELATIONS WITH 1974 VALUES	---	---	---	0.915	0.837	0.883	0.893	0.735	0.801

Source: Authors' calculations, based on data from Central Statistics Office of the United Kingdom, *1990 Input-Output Balances for the United Kingdom* (1993), and annual data from Organization for Economic Cooperation and Development, *Industrial Structure Statistics*.

Table 6
NET EXTERNAL ORIENTATION OVER TIME: THE UNITED KINGDOM

Export Share Exceeds Imported Input Share by:	1974 Number of Industries	1974 Share of Manufacturing Shipments	1984 Number of Industries	1984 Share of Manufacturing Shipments	1993 Number of Industries	1993 Share of Manufacturing Shipments
More than 10 percent	5	31.0	6	30.6	6	37.2
5 to 10 percent	3	10.7	2	12.1	5	22.4
0 to 5 percent	7	27.0	5	15.8	1	12.9
0 to -5 percent	3	20.6	4	26.6	4	7.7
-5 to -10 percent	2	2.4	1	2.9	4	15.4
More than -10 percent	2	8.3	4	12.1	2	4.4

Source: Authors' calculations, based on data from Central Statistics Office of the United Kingdom, *1990 Input-Output Balances for the United Kingdom* (1993), and annual data from Organization for Economic Cooperation and Development, *Industrial Structure Statistics.*

exports rather than imported input use. By the mid-1990s, the importance of industries with negative net external orientation—measured by their weight in total manufacturing shipments—declined significantly. Nonetheless, the actual number of industries with negative net external orientation actually rose. On the whole, these industries became a smaller portion of total U.K. manufacturing.

JAPANESE MANUFACTURING INDUSTRIES

The patterns of external orientation in Japanese manufacturing industries are markedly different from those in U.S., Canadian, and U.K. industries. First, both the levels and rankings of industry export share and import share have been very stable from 1974 to 1993 (Table 7 and Chart A10). Second, the bulk of Japanese industrial exports are concentrated in four industries with a heavy export orientation. Third, import share and imported input share are significantly lower in Japan than in the other countries.

Most of Japan's exports are concentrated in durable goods manufacturing industries, including ordinary machinery, electrical machinery, transportation equipment, and instruments and related products.[6] In 1993, the export share of these four industrial groups (accounting for 67 percent of total exports from Japan) represented approximately 20 to 30 percent of industry shipments. Although for the other countries the rank correlation of export share by industry across time has been very stable, export activity in Japan has actually become even more concentrated in the four main export industries over the past twenty years.

The import share of Japanese manufacturing industries has remained relatively low and stable. By the mid-1990s, import penetration averaged almost 6 percent of industrial consumption; much of this activity was related to raw materials imports. Considering the growth in levels of imported inputs in the other countries and the general pattern of globalization of manufacturing,[7] this lack of movement is striking. These external orientation measures will undoubtedly contribute to debates on whether the Japanese economy is relatively closed and shed light on the factors that might explain Japan's unique structure.

Even more surprising, most Japanese manufacturing industries have observed declines in imported input shares over time (Table 7 and Chart A11). The two industries that are strong users of imported inputs, and that dramatically pull up the overall averages for Japanese industries, are petroleum and coal products and nonferrous metal products. Without these two industries, imported input shares generally are below 5 percent across the board.

The patterns of external orientation in Japanese manufacturing industries are markedly different from those in U.S., Canadian, and U.K. industries.

The net external orientation of manufacturing industries in Japan reveals a highly stratified economy (Table 8 and Chart A12). Five industry groups—leather and leather products, ordinary machinery, electrical machinery, transportation equipment, and instruments and related products—representing 40 percent of manufacturing shipments, hold a positive net external orientation exceeding 10 percent. Because many other industries export very little of their output, about 30 percent of Japanese manufacturing is consistently more exposed internationally through the use of imported inputs than through exports. The absolute size of the negative net orientation of these industries has been declining over time because the export growth for even these industries exceeds the growth of imported inputs in production. These patterns of external orientation across Japanese manufacturing suggest that shocks to the economy—such as large changes in the value of the yen—will likely affect individual Japanese manufacturers in dramatically different ways.

CROSS-COUNTRY COMPARISONS OF EXTERNAL ORIENTATION

As the previous sections show, export shares of manufacturing industries have been growing in the United States, the United Kingdom, Canada, and Japan. This growth, however, is unevenly distributed across industries and countries. In all the countries except Japan, the import share and imported input share of the manufacturing industries have also been on the rise. This growth may reflect an increasingly integrated structure of production and common industry trends across industrialized countries. In this section, we ask: Are the countries becoming more similar over time in the degree to which their manufacturing industries are externally oriented?

The Spearman rank correlation coefficients are used to analyze the similarities and differences among the four countries over time. We construct the correlation coefficient in several steps. First, we give each manufacturing industry within a country a ranking (from lowest

Table 7
EXPORT SHARE, IMPORT SHARE, AND IMPORTED INPUT SHARE OF JAPANESE MANUFACTURING INDUSTRIES IN SELECTED YEARS

	1974			1984			1993		
Industry	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share	Export Share	Import Share	Imported Input Share
Food and beverages	1.1	6.4	10.0	1.11	7.0	7.1	0.6	8.0	4.3
Textile products	8.5	6.8	4.6	9.2	7.9	4.3	5.8	14.6	4.8
Lumber and wood products	0.8	5.2	7.4	1.0	6.7	5.5	0.6	12.0	6.0
Pulp, paper, and paper products	3.0	4.6	3.0	2.7	4.5	2.9	2.4	3.7	2.1
Printing and publishing	0.6	1.1	1.4	0.8	0.6	1.5	0.4	0.6	0.9
Chemical products	12.5	7.8	5.2	9.8	8.5	4.8	8.0	5.9	2.6
Petroleum and coal products	2.1	10.6	57.9	2.2	13.0	54.0	2.5	8.4	25.5
Leather and rubber products	12.5	5.5	3.6	14.8	7.2	3.5	12.6	8.2	2.6
Nonmetallic products	4.0	1.0	14.5	7.0	2.2	11.8	4.8	2.5	7.1
Iron and steel	15.0	1.5	4.6	11.0	2.3	4.9	7.4	2.3	3.1
Nonferrous metal products	10.0	17.9	24.0	8.6	25.7	18.7	7.9	18.9	9.8
Fabricated metal products	7.3	1.0	1.8	7.7	1.2	2.2	3.3	1.4	1.7
Ordinary machinery	12.3	4.3	2.1	18.3	2.7	1.9	20.8	3.9	1.8
Electrical machinery	15.5	4.0	3.1	24.6	4.0	3.4	24.9	6.9	2.9
Transportation equipment	24.4	2.5	1.8	32.8	3.2	2.4	25.0	3.7	2.8
Instruments and related products	27.7	16.7	4.7	34.0	11.9	4.1	31.9	17.3	3.7
Other manufacturing	7.8	5.7	3.3	7.6	5.1	3.2	11.9	14.8	4.4
TOTAL MANUFACTURING	10.5	4.9	8.2	13.5	5.5	7.3	12.1	6.3	4.1
INDUSTRY RANK CORRELATIONS WITH 1974 VALUES	---	---	---	0.978	0.968	0.976	0.929	0.858	0.831

Source: Authors' calculations, based on annual data from Ministry of Trade and Industry, International Trade and Industry Statistics Association, *Japan Input-Output Tables Extended Chart.*

Table 8
NET EXTERNAL ORIENTATION OVER TIME: JAPAN

Export Share Exceeds Imported Input Share by:	1974 Number of Industries	1974 Share of Manufacturing Shipments	1984 Number of Industries	1984 Share of Manufacturing Shipments	1993 Number of Industries	1993 Share of Manufacturing Shipments
More than 10 percent	5	43.7	5	39.1	5	38.8
5 to 10 percent	3	13.7	2	22.0	1	14.5
0 to 5 percent	2	9.2	2	8.5	4	18.7
0 to -5 percent	2	6.0	5	11.2	4	21.8
-5 to -10 percent	2	15.9	1	11.2	1	2.7
More than -10 percent	3	11.5	2	8.2	2	3.5

Source: Authors' calculations, based on annual data from Ministry of Trade and Industry, International Trade and Industry Statistics Association, *Japan Input-Output Tables Extended Chart.*

to highest) according to export share, import share, and imported input share for 1974, 1984, and 1993. Then, for each of these three measures of external orientation, we correlate the rankings of similar industries across pairs of countries. This comparison—or correlation—is performed for each external orientation measure and for each country pair (Table 9).[8] If the correlation statistic is high, the rankings of industries according to a particular orientation measure are similar across two countries. If the correlation statistic is negative, the industries with relatively strong external orientation in one country are more likely to have a relatively low external orientation in the second country. If the rank correlations for the manufacturing industries in two countries increase between two years, the implication is that the two countries are becoming more alike in terms of the particular external orientation measure.

The external orientation patterns of U.S. and U.K. industries are the most similar, and they are becoming increasingly alike.

Our main conclusion from this analysis, detailed below, is that the external orientation patterns of U.S. and U.K. industries are the most similar, and they are becoming increasingly alike. Other cross-country comparisons of external orientation rankings are more mixed, underscoring the need to consider the individual measures separately. In addition, we find that most of the external orientation rank correlations—reported in the bottom row of each of the country tables (Tables 1, 3, 5, and 7)—have been stable over time within each of the four countries.

EXPORT SHARE RANKINGS

Rankings of industries in terms of export share are highly positively correlated in the United States and the United Kingdom, suggesting that similar manufacturing industries in these two countries are the most oriented toward exporting. By contrast, Canadian industry rankings have little in common with the rankings of industries for the United States and the United Kingdom. Industries in Japan have moderate export share rank correlations with industries in the other countries. Similarities in export share across countries reflect the fact that all four countries share heavy export industries—the various machinery and equipment industries, transportation equipment, and instruments or professional equipment. Comparisons of the rank correlation statistics computed at different dates support these observations.

IMPORT SHARE RANKINGS

Industries in the United States and the United Kingdom are also the most alike in terms of import share. Although Canada was very similar to these countries in the 1970s, the Spearman rank correlation statistics show that this is no longer true. The similarities between Canadian industries and U.S. and U.K. industries have eroded over time, while Canadian and Japanese industries have maintained very different rankings of import share.

Over the past two decades, correlations between Japanese industry rankings by import share and the rankings of industries in the United States and the United Kingdom have turned negative. These results imply that those industries with a relatively high import share in Japan are likely to have a relatively low import share in the United States and the United Kingdom. This pattern may arise because the United States and the United Kingdom have seen considerable growth of import share in manufacturing industries that are also export-oriented, while the import penetration of Japanese industries has grown mainly in those industries that rely more heavily on imported inputs.

Imported Input Share Rankings

In terms of imported input share, the United States and the United Kingdom have the highest correlation among country rankings of industry. This correlation appears to be growing over time. In the 1970s, the Canadian rankings of imported input share were negatively correlated with the rankings of the United States and the United Kingdom, but from the late 1970s to the 1990s, the correlations turned positive. Japanese industry rankings are increasingly negatively correlated with the rankings of industries in the United States and the United Kingdom in terms of imported input use. Thus, industry use of imported inputs is becoming more similar over time across the manufacturing industries in the United States, the United Kingdom, and Canada. The manufacturing industries in

Manufacturing industries in Japan are becoming increasingly dissimilar to the U.K., U.S., and Canadian manufacturing industries in their use of imported inputs.

Table 9

Spearman Rank Correlations of Industries by External Orientation Measure in Selected Years

Export Share

	United Kingdom			Japan			Canada		
	1974	1984	1993	1974	1984	1993	1974	1984	1993
United States	0.65	0.63	0.72	0.28	0.43	0.47	0.19	0.23	0.01
Canada	0.10	0.10	0.01	0.21	0.34	0.31			
Japan	0.40	0.44	0.37						

Import Share

	United Kingdom			Japan			Canada		
	1974	1984	1993	1974	1984	1993	1974	1984	1993
United States	0.38	0.58	0.70	0.36	0.05	-0.31	0.51	0.59	0.11
Canada	0.30	0.39	0.21	0.04	0.16	0.15			
Japan	0.56	0.30	-0.27						

Imported Input Share

	United Kingdom			Japan			Canada		
	1974	1984	1993	1974	1984	1993	1974	1984	1993
United States	-0.03	0.44	0.70	0.00	-0.04	-0.31	-0.16	0.24	0.11
Canada	-0.04	0.13	0.21	-0.05	-0.09	0.15			
Japan	-0.11	-0.08	-0.27						

Source: Authors' calculations.

Japan, however, are becoming increasingly dissimilar to the U.K., U.S., and Canadian manufacturing industries in their use of imported inputs.

Conclusion

There are important differences in the external orientation of industries within and across countries. Nevertheless, the United States, Canada, Japan, and the United Kingdom share a set of manufacturing industries that are relatively strong exporters. These countries, however, differ substantially in terms of the import share and imported input shares of their manufacturing industries. Exports relative to domestic manufacturing production and imports relative to consumption are highest in Canada and the United Kingdom, followed by the United States and Japan. In the United States, these shares have increased sharply over time, whereas in Japan, external orientation measures have stayed relatively stable. The export share and imported input share of manufacturing industries in Canada and the United Kingdom are consistently greater than in the United States. Although Japan has fewer industries geared toward exporting, these industries register strong export shares without relying extensively on imported inputs in production.

Our results can be used by analysts estimating the effects of exchange rate changes on the profitability and activities of manufacturing industries.

Industries in the United States show the most volatile patterns in net external orientation. After remaining, on average, primarily export-oriented in the 1970s, U.S. industries experienced increased international exposure in the early to mid-1980s through their reliance on imported inputs in production. In the late 1980s and in the 1990s, export shares grew faster than imported input shares, raising the positive net external orientation of U.S. industries.

Canadian industries are more heavily oriented toward exporting than industries in the United States. In 1993, 80 percent of Canadian manufacturing industries held a very high positive net external orientation, compared with 40 percent of manufacturing industries in the early 1970s. U.K. and Japanese manufacturing sectors have exhibited relatively stable patterns of net external orientation, despite substantial changes in real exchange rates and demand conditions in these economies over the past two decades.

Japanese manufacturing industries are distinct from those in the other countries in a number of ways. First, a small group of relatively large industries accounts for the bulk of Japan's exports. Second, Japanese industries have relatively low import share and generally low imported input share. Nonetheless, because some industries export very little of their production, roughly a third of manufacturing output in Japan is in industries with a consistently negative net external orientation. Finally, over time, Japan has become less like the United States and the United Kingdom in industry import share and imported input use.

This article has reviewed the size and composition of the external orientation of manufacturing industries according to four measures—export share, import share, imported input share, and net external orientation. The results have many potential applications. Most important, our results can be used by analysts estimating the effects of exchange rate changes on the profitability and activities of manufacturing industries in these countries. Careful empiricism can track the extent to which industry performance—as measured by stock market returns, profits, growth, or any other measure of industry activity—is affected by international shocks.[9] The scope of these effects is likely to depend on the size and direction of the measures of external orientation we have identified. Ultimately, our broad measures of industry external orientation are important tools for analyzing the magnitude and significance of international shocks for economic activity within a country.

UNITED STATES

Industry sales data are from U.S. Department of Commerce, Bureau of the Census, *Annual Survey of Manufactures.* Data on exports to shipments (export share) and imports to new supply (import share) are from U.S. Department of Commerce, Bureau of Economic Analysis, "Benchmark Input-Output Accounts for the U.S. Economy, 1982," *Survey of Current Business*, July 1991 and April 1994. Imported input share, α^i, includes in the numerator imported inputs from manufacturing industries, assuming $p_t^j q_{j,t}^i = p_{82}^j q_{j,82}^i$ for all t, and $VP_t^i = \Sigma_j p_{82}^j q_{j,82}^i + w_t^i$, where w_t^i is wages and salaries in nominal dollars from the U.S. National Income and Product Accounts, deflated by the U.S. producer price index reported in *International Financial Statistics,* International Monetary Fund (Series 63), and expressed in 1982 dollars.

We construct the imported input share series using the two most recent years of input-output data—1982 and 1987—reported in the "Benchmark Input-Output Accounts for the U.S. Economy." Because the dollar was unusually strong in 1987, we offer the measures using the 1982 input-output structure as the more representative of U.S. manufacturing. When comparing the imported input series constructed from the two input-output years, we see only a couple of differences: the apparel and other textile industry shifts from purchasing heavily in chemicals and allied products to buying more semifinished textile products; the lumber and wood products industry reduces inputs from chemicals and allied products, petroleum and coal products, and rubber and miscellaneous products and buys much more from itself.

CANADA

Data on the input-output structure of production and the import and export shares of manufacturing are drawn from Statistics Canada, System of National Accounts, *The Input-Output Structure of the Canadian Economy*. These data cover the period 1974-93. This source also reports data on exports, imports, employee compensation, and total production for each industry. Canada's imported input series, α^i, is the ratio of imported inputs purchased from agriculture, mining, raw materials, and manufacturing industries to total inputs purchased from these industries plus industry labor costs.

UNITED KINGDOM

Because of data limitations, we use only one year of input-output data in our calculations. These data are reported in Central Statistics Office of the United Kingdom, *1990 Input-Output Balances for the United Kingdom* (1993). Annual data from 1970 to 1994 on manufacturing exports, imports, wages and salaries, employee social security costs, and total production are drawn from Organization for Economic Cooperation and Development, *Industrial Structure Statistics.* The imported input share, α^i, includes in the numerator imported inputs from manufacturing industries, assuming $p_t^j q_{j,t}^i = p_{90}^j q_{j,90}^i$ for all t, and in the denominator $VP_t^i = \Sigma_j p_{90}^j q_{j,90}^i$.

JAPAN

Data on the input-output structure of manufacturing are from Ministry of Trade and Industry, International Trade and Industry Statistics Association, *Japan Input-Output Tables Extended Chart*. Data cover the period 1974-93 and are reported in millions of yen. This source reports annual input-output information as well as exports, imports, employee compensation, material costs, and total production. Japan's imported input series, α^i, is the ratio of imported inputs purchased from agriculture, mining, raw materials, and manufacturing industries to total inputs purchased from these industries plus industry labor costs.

Specific information on industry concordances for the data series for each country is available on request from the authors.

Chart A1

EXPORT SHARE AND IMPORT SHARE OF MANUFACTURING BY INDUSTRY: UNITED STATES
Percent

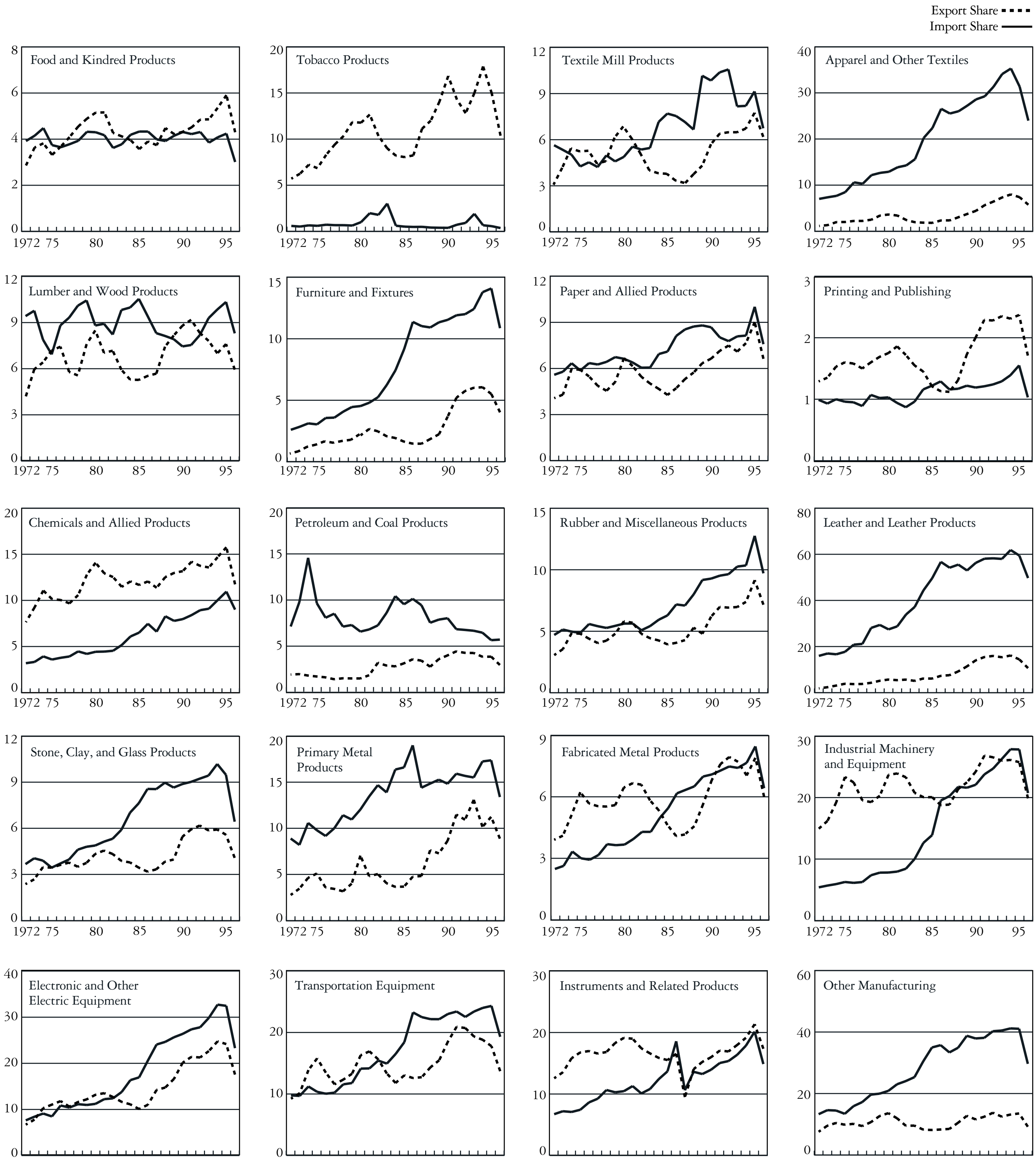


Chart A2

IMPORTED INPUT SHARE OF MANUFACTURING BY INDUSTRY: UNITED STATES

Percent

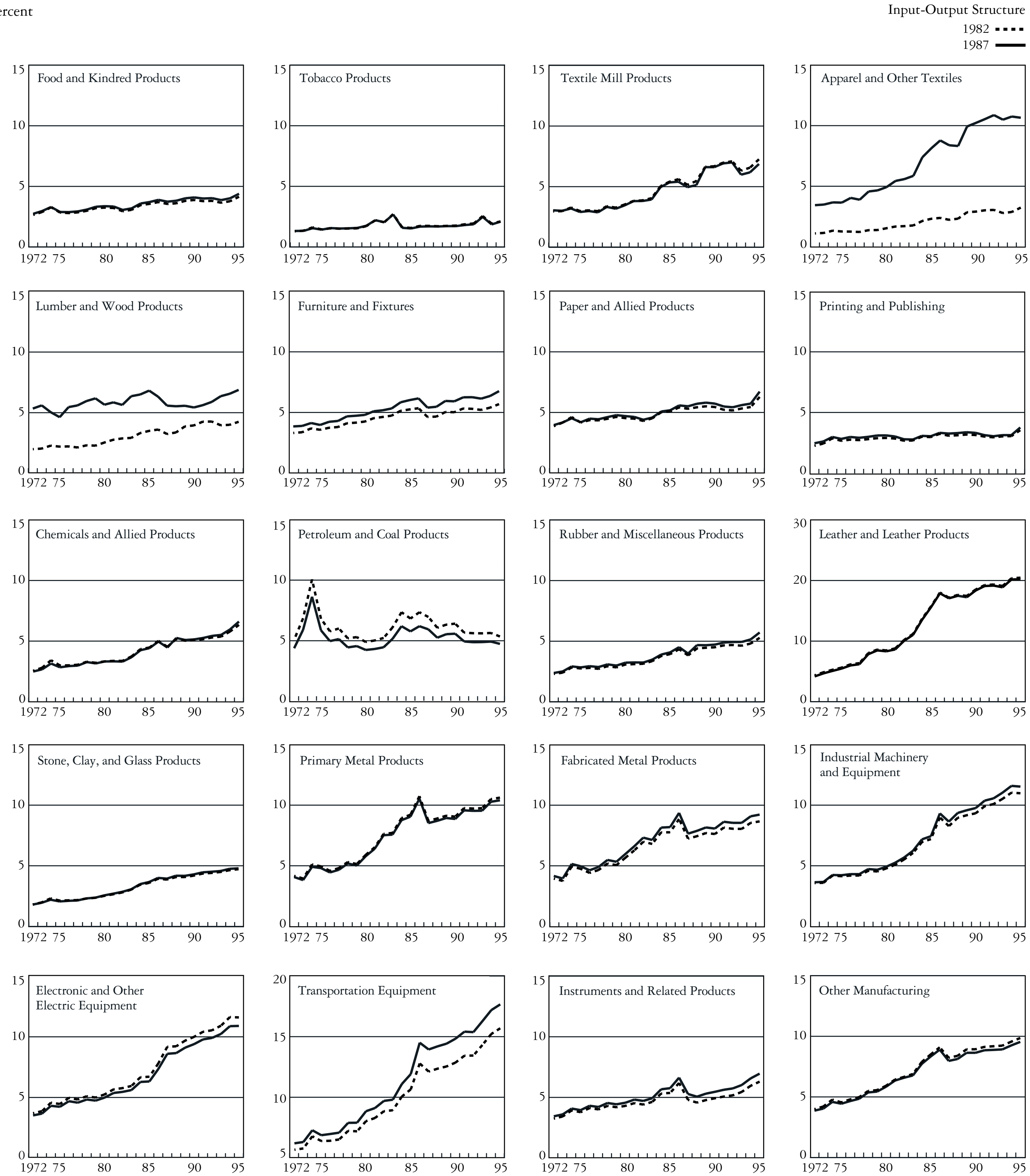


Chart A3

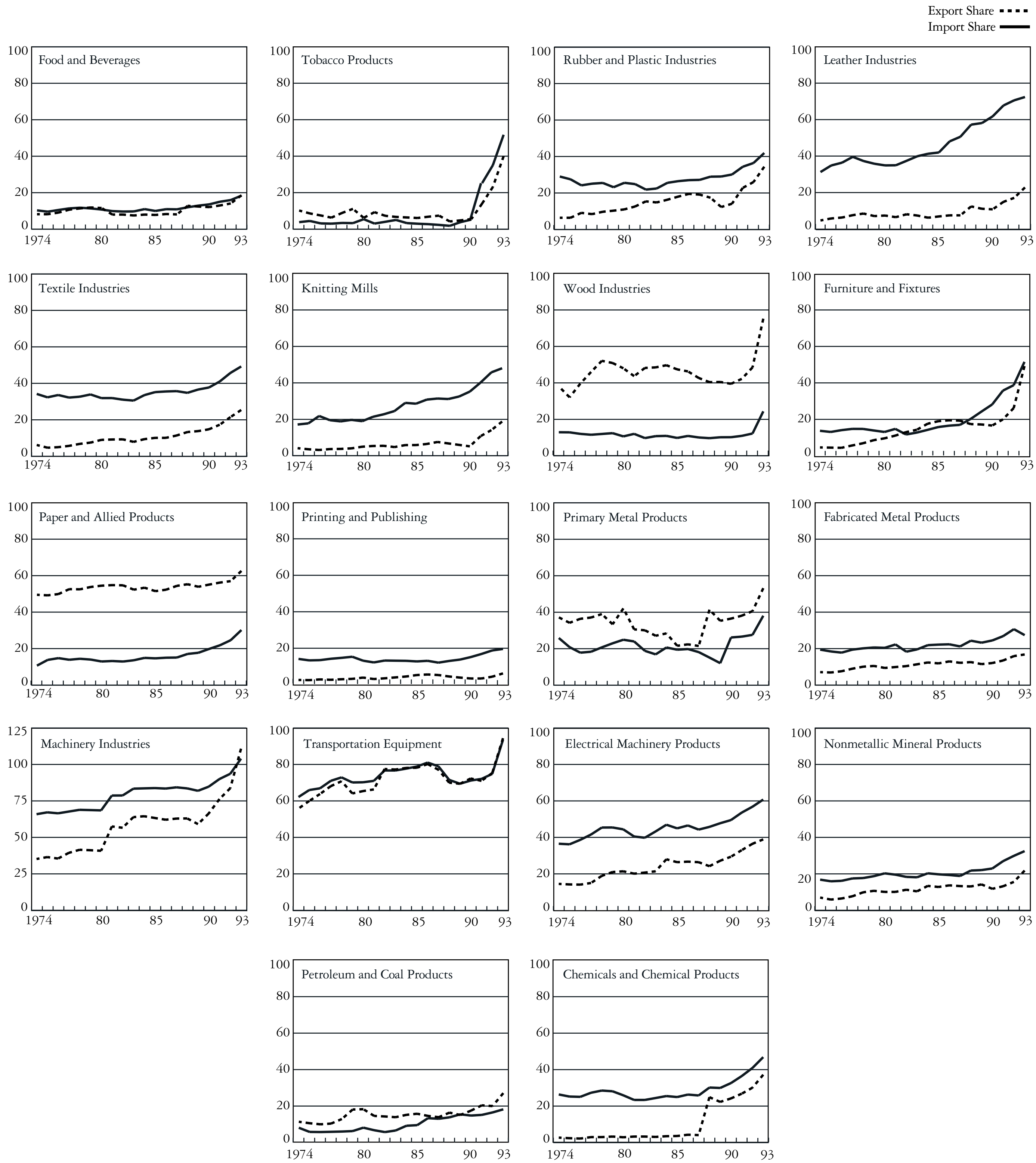
NET EXTERNAL ORIENTATION OF MANUFACTURING BY INDUSTRY: UNITED STATES

Percent

Chart A4

EXPORT SHARE AND IMPORT SHARE OF MANUFACTURING BY INDUSTRY: CANADA

Percent



Appendix: Data Sources and External Orientation Measure Results by Country *(Continued)*

Chart A5

Imported Input Share of Manufacturing by Industry: Canada
Percent

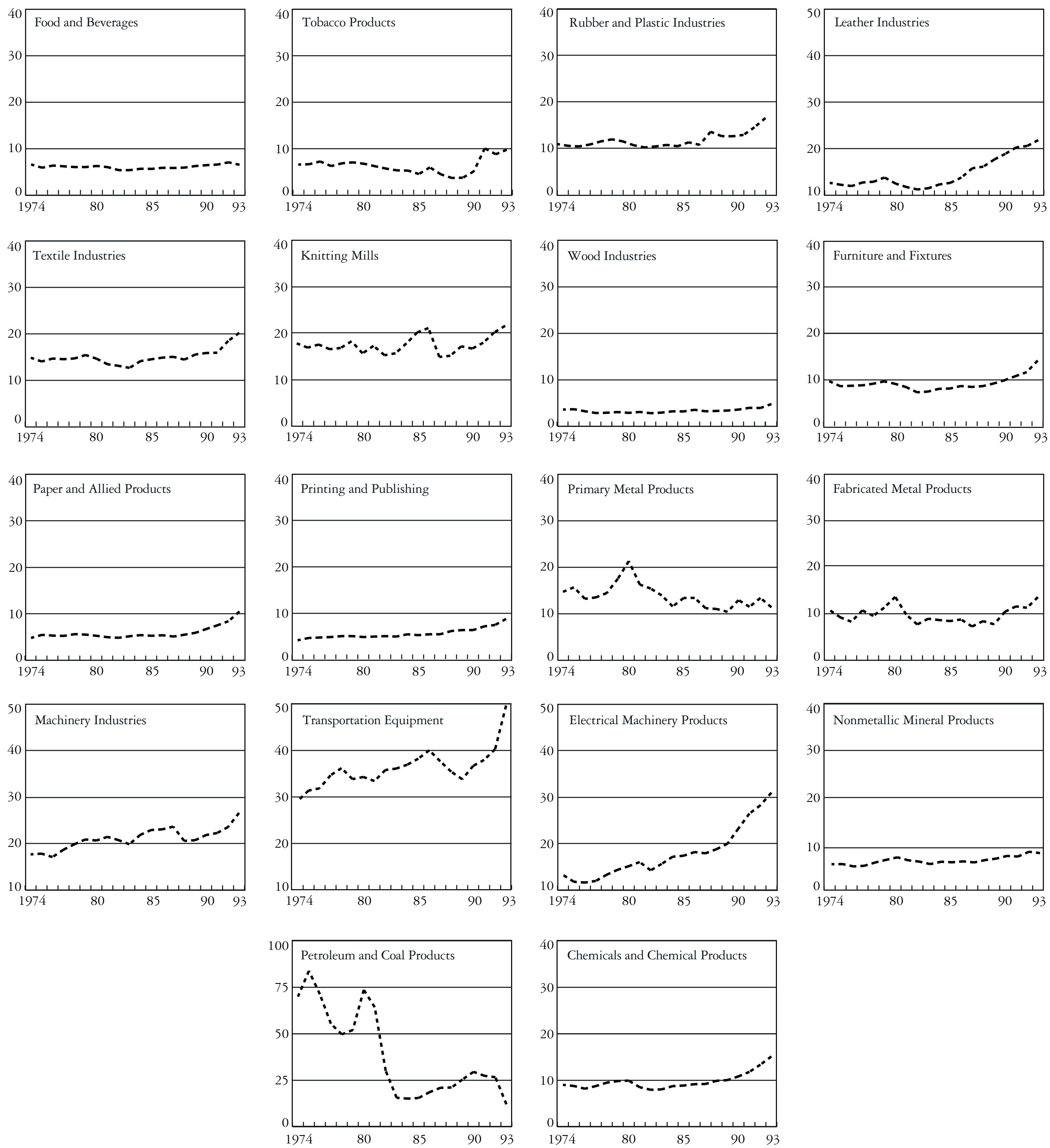


Chart A6

NET EXTERNAL ORIENTATION OF MANUFACTURING BY INDUSTRY: CANADA

Percent

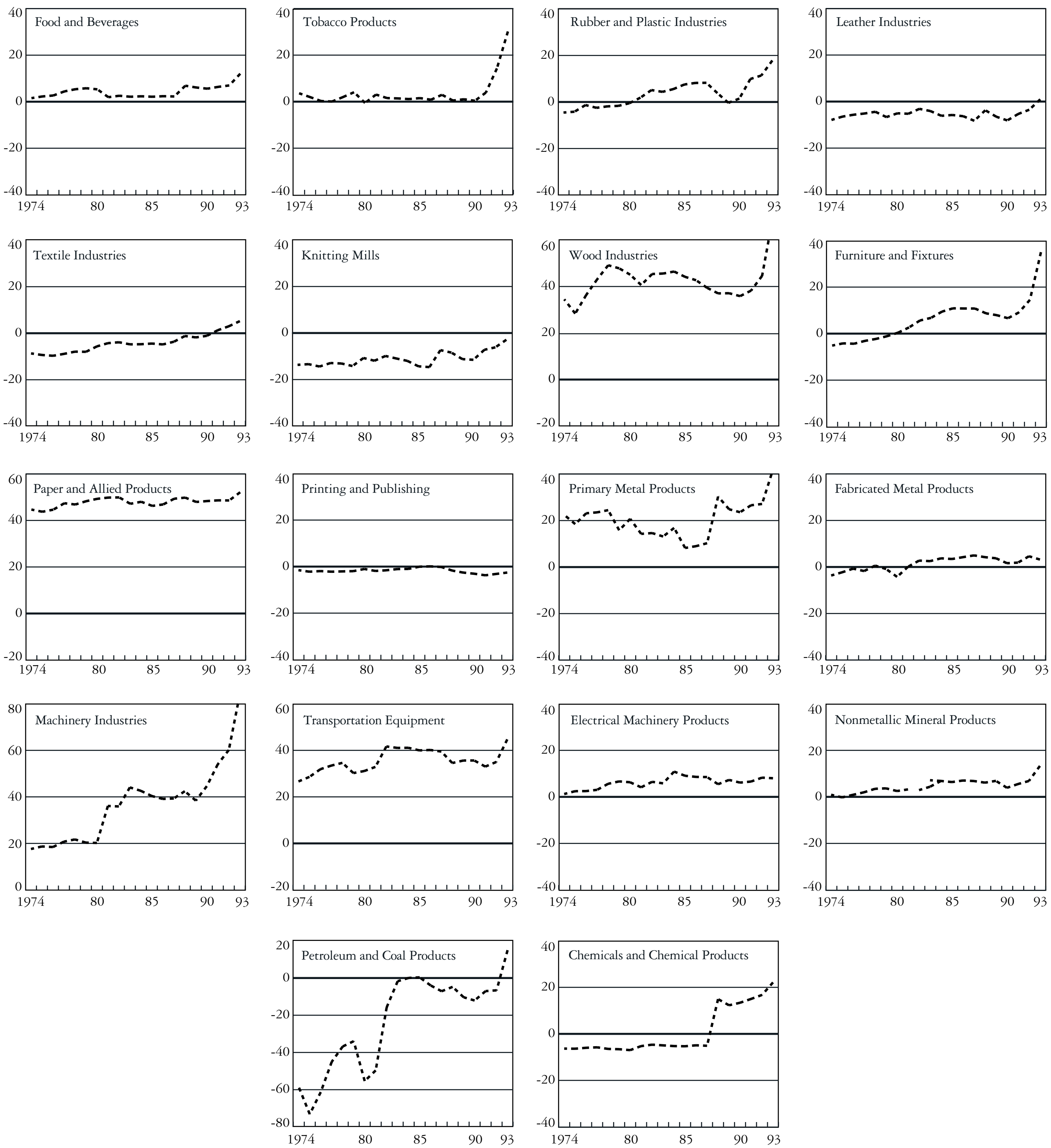


Chart A7

EXPORT SHARE AND IMPORT SHARE OF MANUFACTURING BY INDUSTRY: UNITED KINGDOM
Percent

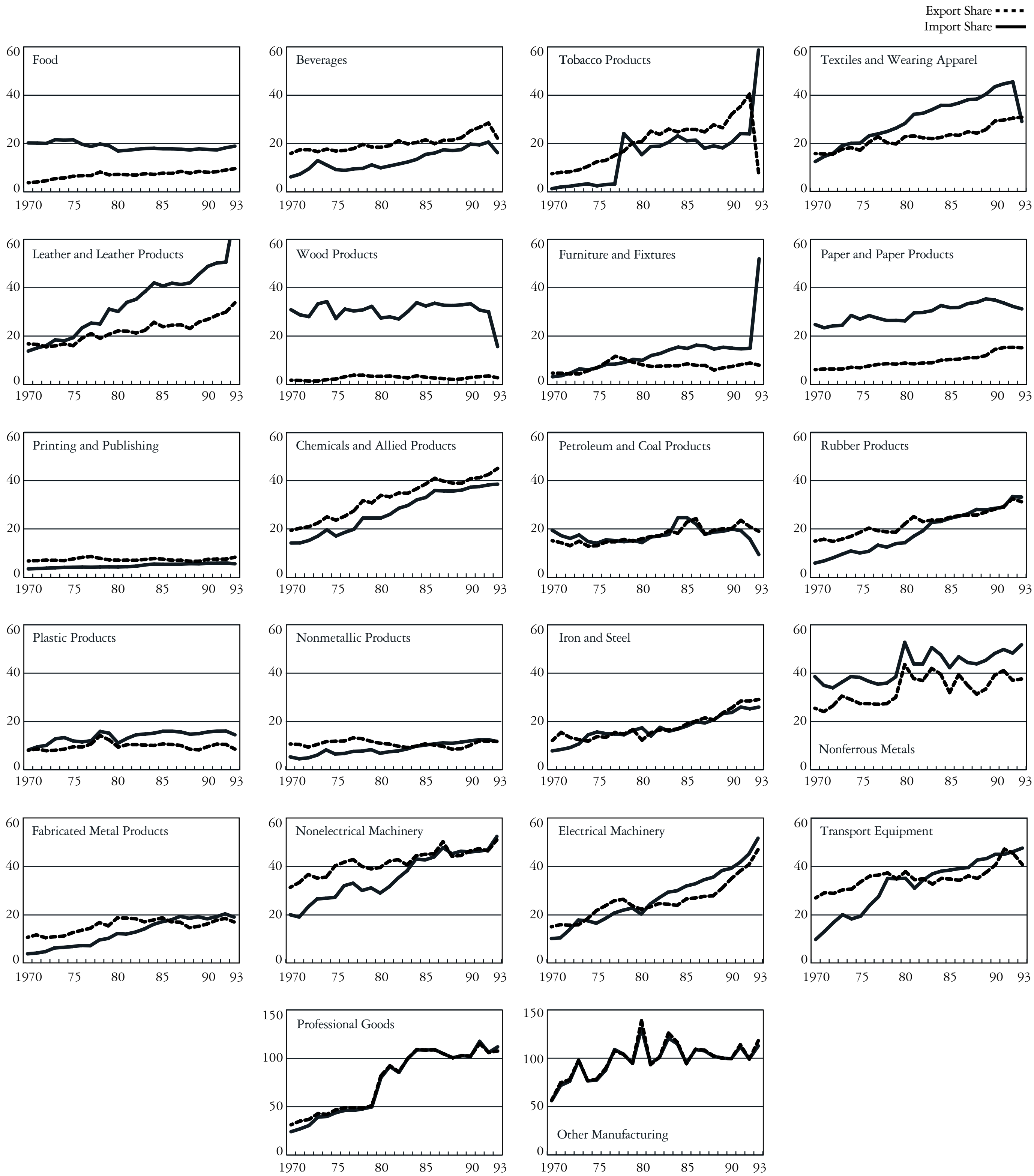


Chart A8

IMPORTED INPUT SHARE OF MANUFACTURING BY INDUSTRY: UNITED KINGDOM
Percent

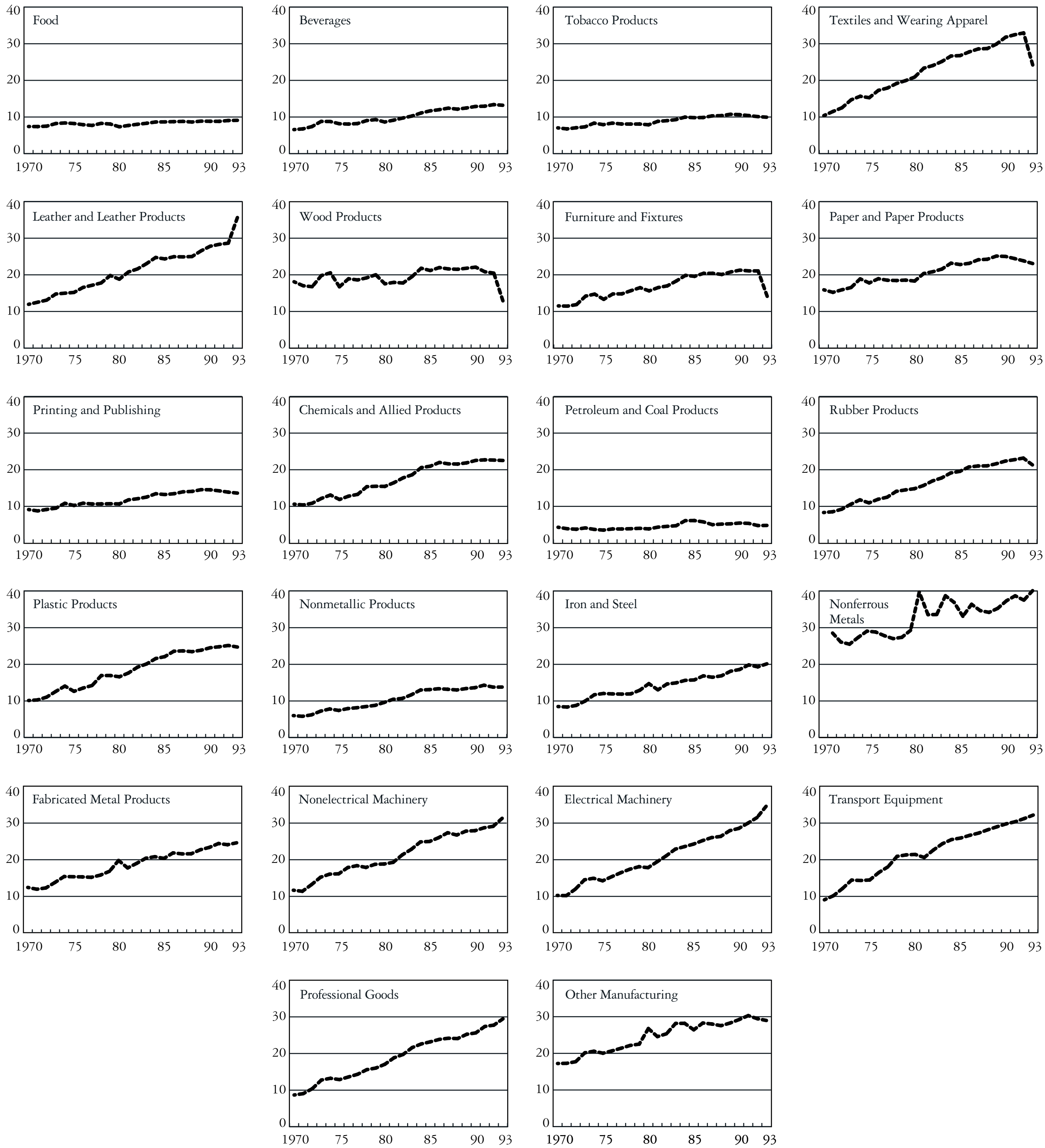


Chart A9

NET EXTERNAL ORIENTATION OF MANUFACTURING BY INDUSTRY: UNITED KINGDOM
Percent

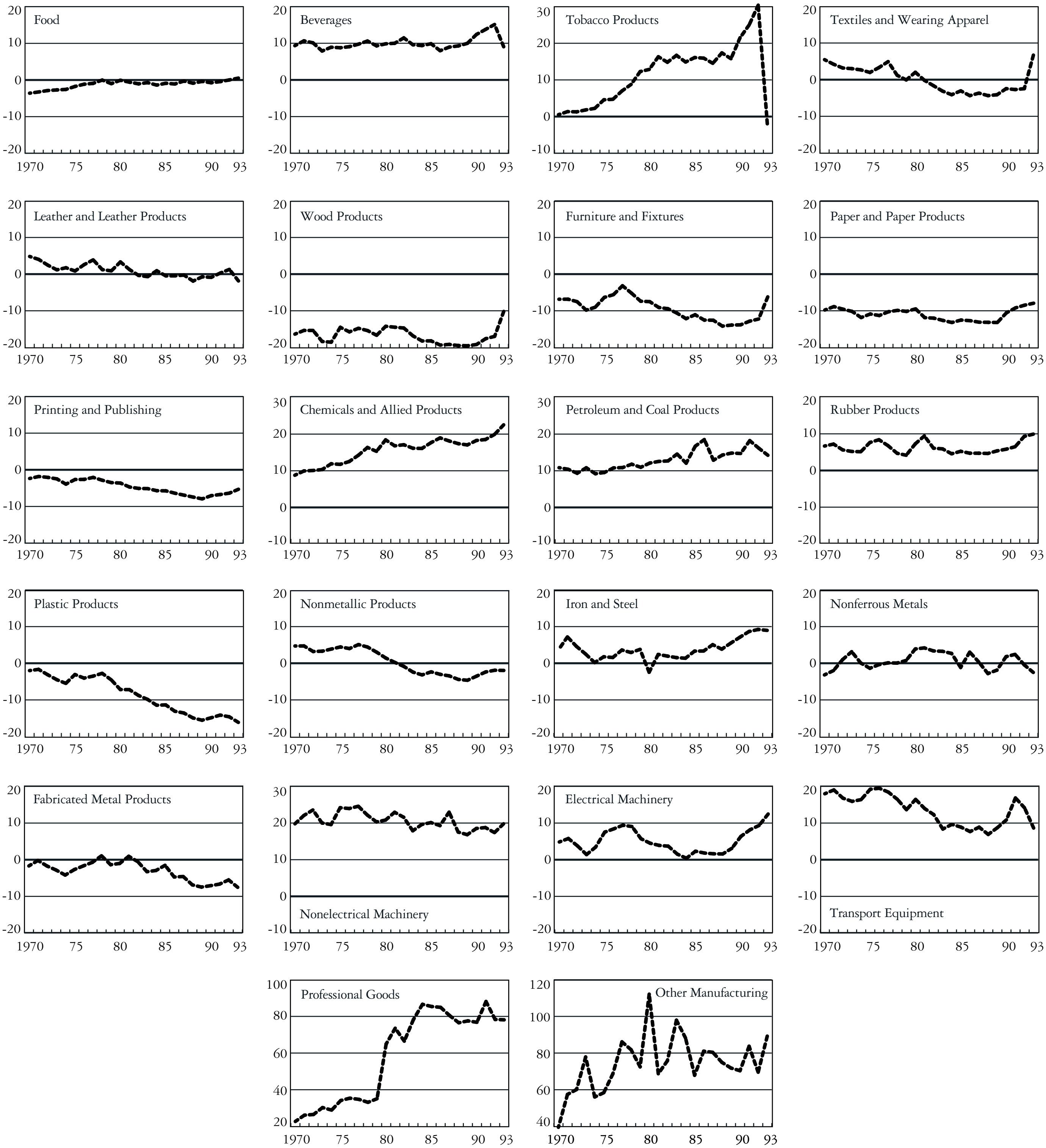
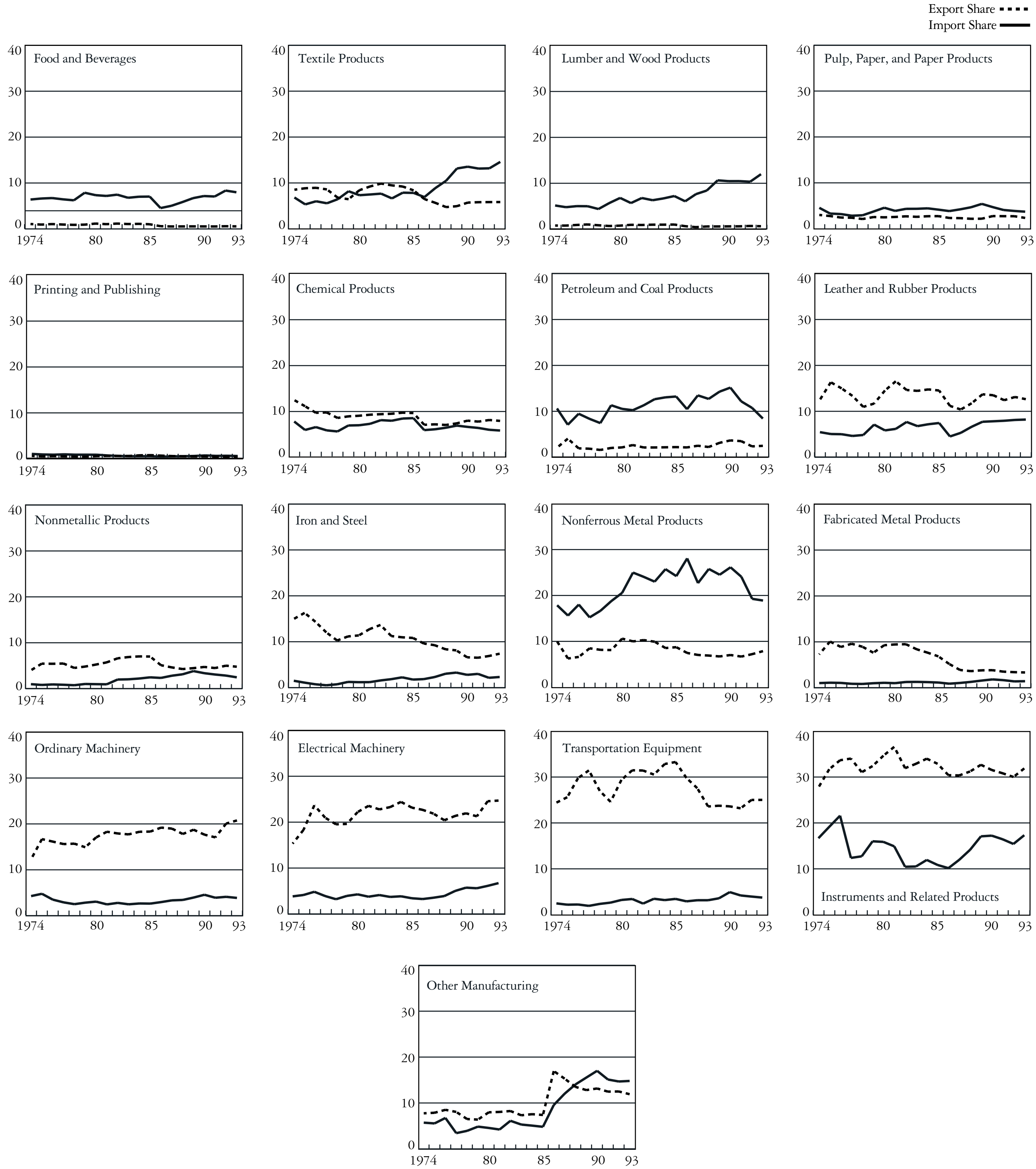


Chart A10

EXPORT SHARE AND IMPORT SHARE OF MANUFACTURING BY INDUSTRY: JAPAN
Percent



Appendix: Data Sources and External Orientation Measure Results by Country *(Continued)*

Chart A11

Imported Input Share of Manufacturing by Industry: Japan
Percent

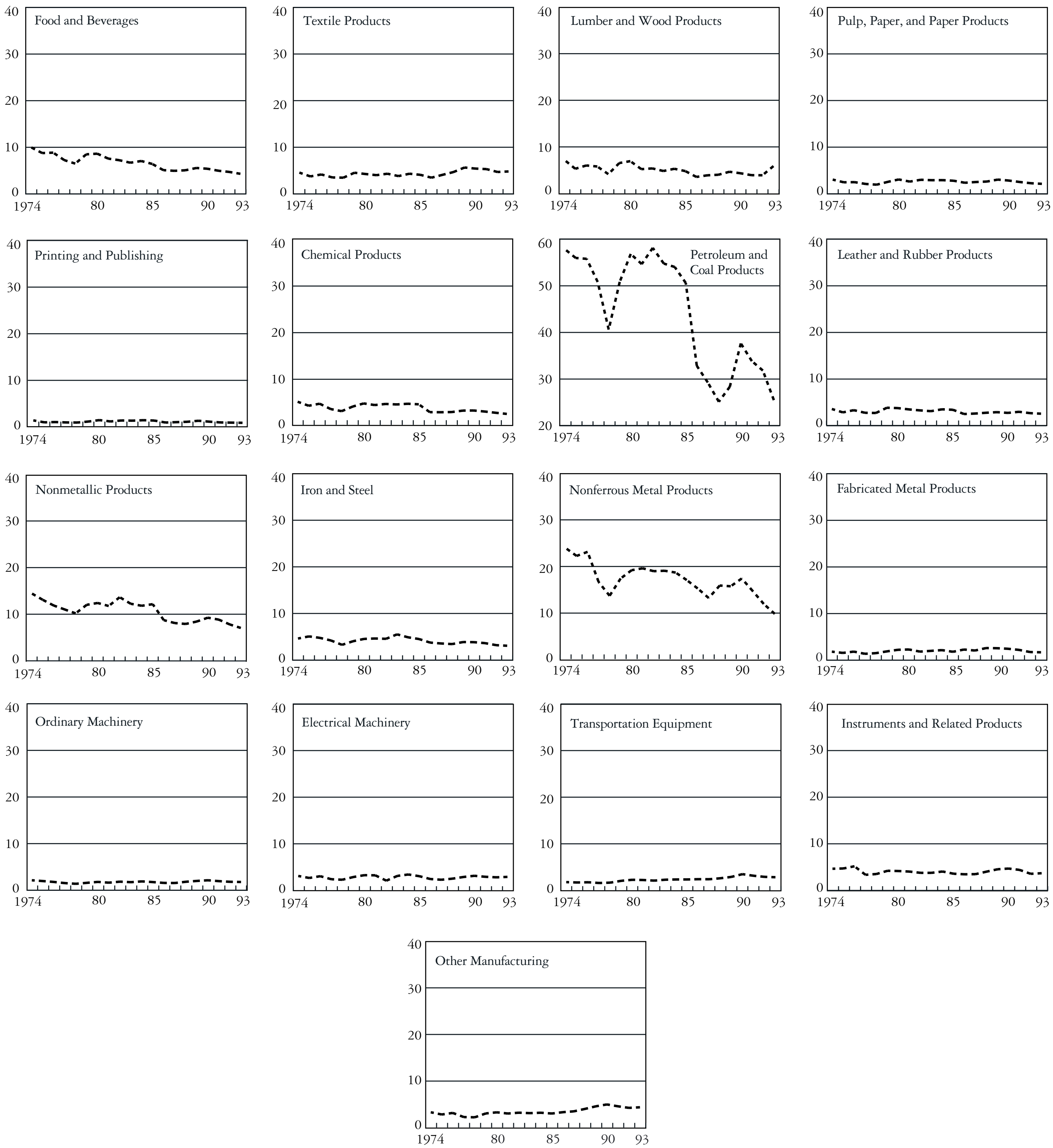
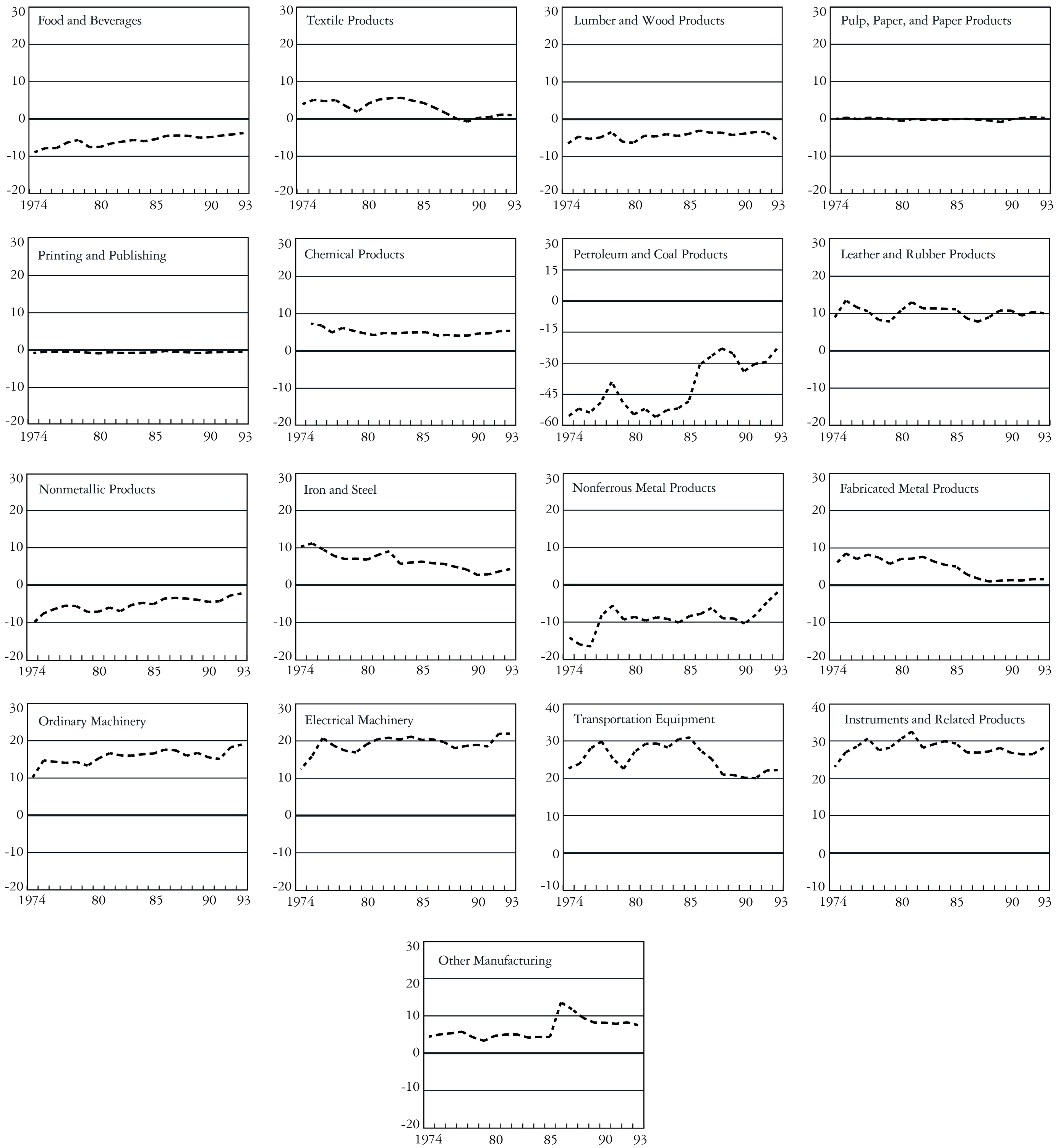


Chart A12

NET EXTERNAL ORIENTATION OF MANUFACTURING BY INDUSTRY: JAPAN
Percent



ENDNOTES

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1. Harrigan (1996) provides an overview of the literature on openness to trade and examples of the measure's application.

2. Our net measure does not explicitly address the role of multinational activity and long-term licensing arrangements in each industry. A priori, the relationship between foreign production and an industry's external orientation (and possibly exposure to exchange rate movements) is ambiguous. In some cases, foreign production substitutes for sales to foreign markets of domestically produced goods. In other cases, the presence of foreign production activity encourages increased trade of intermediate and related products.

3. Specific details regarding the data for each country are provided in the appendix. We use the latest available year of data for each country in our analysis, that is, 1995 for the United States, 1994 for the United Kingdom, and 1993 for Canada and Japan.

4. The measures of export share, imported input share, and net external orientation are shown in the charts in the appendix. Feenstra and Hanson (1996) combine import data and data on material purchases to calculate an alternative, but qualitatively similar, measure of imported inputs for U.S. industries.

5. For machinery industries, the export share and import share in 1993 were greater than 100 percent because of the re-export of imported goods. The re-export phenomenon, along with the practice of outsourcing various components, swells the size of imports relative to domestic consumption of particular goods categories.

6. As noted earlier, these four industries also have relatively high export shares in the United States, the United Kingdom, and Canada.

7. For Japan, one strong form of globalization occurs through foreign direct investment. Goldberg and Klein (1997) show that Japanese direct investment in Southeast Asian countries tends to increase both Japanese imports from these countries and Japanese exports to these countries. Japanese direct investment in Latin American economies does not appear to have the same effect.

8. To make comparisons across countries, we convert the original data for each country into a sample of fifteen uniformly defined industries across the four countries.

9. For example, see Campa and Goldberg (1995, 1996, and 1997), who examine the effects of real exchange rate movements on industry investment and labor market outcomes across the United States, the United Kingdom, Canada, and Japan.

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Credit, Equity, and Mortgage Refinancings

Stavros Peristiani, Paul Bennett, Gordon Monsen, Richard Peach, and Jonathan Raiff

Homeowners typically have the option to prepay all or part of the outstanding balance of their mortgage loan at any time, usually without penalty. However, unless homeowners have sufficient wealth to pay off the balance, they must obtain a new loan in order to exercise this option. Studies examining refinancing behavior are finding more and more evidence that differences in homeowners' ability to qualify for new mortgage credit, as well as differences in the cost of that credit, account for a significant part of the observed variation in that behavior. Therefore, individual homeowner and property characteristics, such as personal credit ratings and changes in home equity, must be considered systematically, along with changes in mortgage interest rates, in the analysis and prediction of mortgage prepayments.

Early research into the factors influencing prepayments focused almost exclusively on the difference between the interest rate on a homeowner's existing mortgage and the rates available on new loans. This approach arose in part because researchers most often had to rely on aggregate data on the pools of mortgages serving as the underlying collateral for mortgage-backed securities (for example, see Schorin [1992]). More recent research, however, has broadened the scope of this investigation through the utilization of loan-level data sets that include individual property, loan, and borrower characteristics.

This article significantly advances the literature on mortgage prepayments by introducing quantitative measures of individual homeowner credit histories to the loan-level analysis of the factors influencing the probability that a homeowner will refinance. In addition to credit histories, we include in the analysis changes in individual homeowner's equity and in the overall lending environment. Our findings strongly support the hypothesis that, other things being equal, the worse a homeowner's credit rating, the lower the probability that he or she will refinance. We also confirm the finding of other researchers that changes in home equity strongly influence the probability of refinancing. Finally, we provide evidence of a change in the lending environment that, all else being equal, has increased the probability that a homeowner will refinance.

These findings are important from an investment risk management perspective because they confirm that the responsiveness of mortgage cash flows to changes in interest rates will also be significantly influenced by the credit and equity conditions of individual borrowers. Moreover, evidence overwhelmingly indicates that these conditions are subject to dramatic changes. For example, although the sharp rise in personal bankruptcies since the mid-1980s (Chart 1) partly reflects changes in laws and attitudes, it nonetheless suggests that credit histories for a growing segment of the population are deteriorating. Furthermore, home price movements, the key determinant of changes in homeowners' equity, have differed considerably over time and in various regions of the country. Indeed, in the early to mid-1990s home price appreciation for the United States as a whole slowed dramatically while home prices actually fell for sustained periods in a few regions (Chart 2).

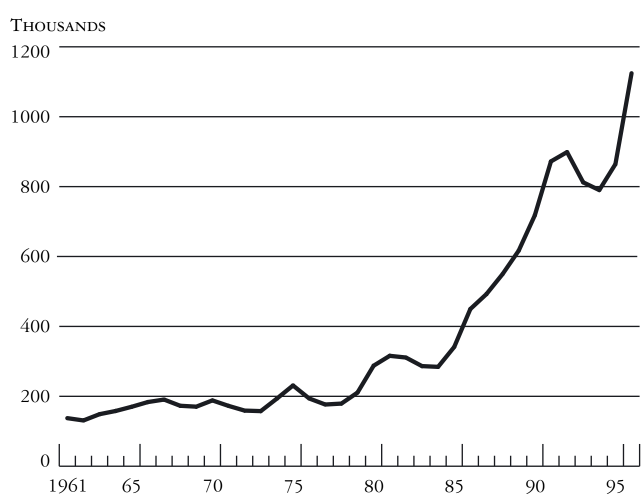
As mortgage rates fell during the first half of the 1990s, many households likely found it difficult, if not impossible, to refinance existing mortgages because of poor credit ratings or erosion of home equity.

In short, as mortgage rates fell during the first half of the 1990s, many households likely found it difficult, if not impossible, to refinance existing mortgages because of poor credit ratings or erosion of home equity.[1] Consequently, the prepayment experience of otherwise similar pools of mortgage loans may vary greatly depending on the pools' proportions of credit- and/or equity-constrained borrowers.

Our findings also contribute to an understanding of how constraints on credit availability affect the transmission of monetary policy to the economy (for example, see Bernanke [1993]). Fazzari, Hubbard, and Petersen (1988) and others have found that investment expenditures by credit-constrained businesses are especially closely tied to those firms' cash flows and are relatively insensitive to changes in interest rates, reflecting constraints on their ability to obtain credit. Analogously, we find credit- and/or equity-constrained homeowners to be less sensitive to changes in interest rates because of their limited access to new credit, thereby short-circuiting one channel through which lower interest rates improve household cash flows and stimulate the economy.

Chart 1

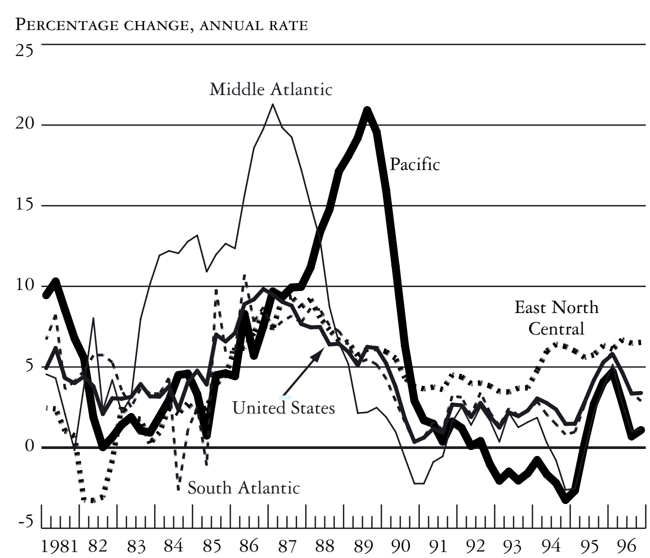
TOTAL PERSONAL BANKRUPTCIES



Source: Administrative office of the United States Courts.

Chart 2

RATE OF HOME PRICE CHANGE IN THE UNITED STATES AND SELECTED REGIONS, 1981-96



Source: Office of Federal Housing Enterprise Oversight.

Previous Loan-Level Research on Mortgage Prepayments

Recognition that individual loan, property, and borrower characteristics, in addition to changes in interest rates, play a key role in determining the likelihood of a mortgage prepayment has spawned a relatively new branch of research based on loan-level data sets. This research has generally focused on the three major underwriting criteria that mortgage lenders consider when deciding whether to extend credit: equity (collateral), income, and credit history.

However, past studies have only investigated the effects of changes in homeowners' equity and income on their ability to prepay. For example, Cunningham and Capone (1990)—using a sample of loans secured by properties in the Houston, Texas, area—estimated post-origination loan-to-value (LTV) ratios and post-origination payment-to-income ratios based on changes in regional home prices and incomes.[2] They concluded that post-origination equity was a key determinant of the termination experience of those loans (they found an inverse relationship for defaults and a positive relationship for refinancings and home sales), whereas post-origination income was insignificant. Caplin, Freeman, and Tracy (1993), using a sample of loans secured by properties in six states, also found evidence of the importance of home equity in influencing the likelihood of mortgage prepayment. They assessed the effect of post-origination equity by dividing their sample into states with stable or weak property markets (using transaction-based home price indexes for specific metropolitan statistical areas) and according to whether the loans had high or low original LTV ratios. Consistent with the hypothesis that changes in home equity play an important role in prepayments, the authors found that in states with weak property markets, prepayment activity was less responsive to declines in mortgage interest rates than in states with stable property markets.

In a related study, Archer, Ling, and McGill (1995) found that home equity had an important effect on the probability that a loan would be refinanced, and provided evidence that changes in borrower income are also a significant factor. The authors matched records from the 1985 and 1987 national samples of the American Housing Survey to derive a subsample of nonmoving owner-occupant households with fixed-rate primary mortgages, some of whom had refinanced, since the interest rate on their loan in 1987 was different from that reported in 1985. The authors' estimate of post-origination home equity was derived from the sum of the book value of a homeowner's entire mortgage debt, including second mortgages and home equity loans, divided by the owner's assessment of the current value of his or her property.[3] In addition, a post-origination mortgage payment-to-income ratio, derived from the homeowner's recollection of total household income, was included as an explanatory variable. The authors found that, along with changes in interest rates, post-origination home equity and income were significant and of the expected sign.

This article goes beyond the existing literature in several important respects. Ours is the first study to investigate systematically the effect of the third underwriting criterion: homeowners' credit histories. Ours is also the first study to estimate post-origination equity by using county-level repeat sales home price indexes.[4] These indexes are generally regarded as the best available indicator of movements in home prices over time. In addition, we employ a unique loan-level data set that not only provides information on credit history but also identifies the reason for prepayment: refinance, sale, or default (see box). The size of the data set allows very large samples to be drawn for major population centers as well as for the nation as a whole.

Ours is the first study to investigate systematically the effect of . . . homeowners' credit histories. Ours is also the first study to estimate post-origination equity by using county-level repeat sales home price indexes.

THE DATA SET AND SAMPLE CONSTRUCTION

The data for this study were provided by the Mortgage Research Group (MRG) of Jersey City, New Jersey, which in the early 1990s entered into a strategic alliance with TRW—one of the country's three largest credit bureaus—to provide data for research on mortgage finance issues. Until late 1996, MRG maintained a data base, arranged into "tables," of roughly 42 million residential properties located in 396 counties in 36 states. The primary table is the transaction table, which is based on the TRW Redi Property Data data base. This table is organized by properties, with a detailed listing of the major characteristics of all transactions pertaining to each property. For the roughly 42 million properties covered, information is provided on 150 million to 200 million transactions. For example, if a property is purchased, a purchase code is entered along with key characteristics of the transaction, including date of closing, purchase price, original mortgage loan balance, and maturity and type of mortgage (such as fixed-rate, adjustable-rate, or balloon).

The characteristics of any subsequent transactions are also recorded, such as a refinancing of the original mortgage, another purchase of the same property, and, for some counties, a default. The primary sources of this information are the records of county recorders and tax assessors, which are surveyed on a regular basis to keep the transaction data current.

A separate table contains periodic snapshots of the credit histories of the occupants of the properties. The data on credit histories are derived from TRW Information Services, the consumer credit information group of TRW. The data include summary measures of individuals' credit status as well as detailed delinquency information on numerous categories of credit sources. Individual records in the credit table can be linked to records in the transaction table on the basis of property identification numbers.

For our study, a sample from the larger data set was constructed in several stages: First, we selected groups of counties representing the 4 major regions of the country. In the East, we chose 4 counties surrounding New York City (Orange County in New York State, and Essex, Bergen, and Monmouth Counties in New Jersey). In the South, we chose 6 counties in central Florida (Citrus, Clay, Escambia, Hernando, Manatee, and Marion). In the Midwest, we chose Cook County and 5 surrounding counties in Illinois (Dekalb, DuPage, Kane, McHenry, and Ogle). In the West, we selected Los Angeles, Ventura, and Riverside Counties in California. Selecting these 4 diverse areas assured us that our statistical findings would be general rather than specific to a particular housing market. Furthermore, over the past decade, the behavior of home prices in the 4 regions has been quite different.

In the 19 counties examined, we identified for each property the most recent purchase transaction, going back as far as January 1984. The mortgages on some of these properties were subsequently refinanced, in some cases more than once, while other properties had no further transactions recorded through the end of our sample period, December 1994. (For multiple refinancings, we considered just the first one. In addition, we excluded from the sample loans that subsequently defaulted.) Thus, the sample consisted of loans that were refinanced and loans that were not refinanced as of the end of the sample period, establishing the zero/one, refinance/no-refinance dependent variable we then try to explain. (For refinanced loans, the new loan could be greater than, equal to, or less than the remaining balance on the old loan.) We limited our sample to fixed-rate mortgages outstanding for a year or more; the decision to refinance alternative mortgage types is more complex to model and is not treated in this study.

In the final step, MRG agreed to link credit records as of the second quarter of 1995 to a random sample of these properties. (Note that any information that would enable users of this data set to identify an individual or a property was masked by MRG.) The resulting sample consisted of 12,855 observations, of which slightly under one-third were refinanced.

Our sample is an extensive cross section, with each observation representing the experience of an individual mortgage loan over a well-defined time period. For example, assume that an individual purchased a house in January 1991 and subsequently refinanced in December 1993, an interval of 36 months. This window represents one observation or experiment in our sample. Our approach differs from that of most other studies on this topic in that the starting date, ending date, and time interval between refinancings are unique for each observation. Starting dates (purchases) range from January 1984 to December 1993, while time intervals (loan ages) range from 12 to 120 months. Therefore, our sample includes refinancings that occurred in the "refi wave" from 1986 to early 1987 as well as in the wave from 1993 to early 1994, although most are from the latter period. This diverse sample allows us to investigate whether the propensity to refinance has changed over time.

Modeling the Decision to Refinance

When a homeowner refinances, he or she exercises the call option imbedded in the standard residential mortgage contract. In theory, a borrower will exercise this option when it is "in the money," that is, when refinancing would reduce the current market value of his or her liabilities by an amount equal to or greater than the costs of carrying out the transaction. In fact, however, many borrowers with apparently in-the-money options fail to exercise them while others exercise options that apparently are not in the money. This heterogeneity of behavior appears to be due partly to differences in homeowners' ability to secure replacement financing. If an individual cannot qualify for a new mortgage, or can qualify only at an interest rate much higher than that available to the best credit risks, then refinancing may not be possible or worthwhile even though at first glance the option appears to be in the money.

While a decline in equity resulting from a drop in property value may rule out refinancing for some homeowners, refinancing may also not be possible or worthwhile because the homeowner's personal credit history is marginal or poor. This condition either prevents the borrower from obtaining replacement financing or raises the cost of that financing such that the present value of the benefits does not offset the transaction costs. Not only might the interest rate available exceed that offered to individuals with perfect credit ratings, but transaction costs might also be higher. In addition to paying higher out-of-pocket closing costs, the credit-impaired borrower may be asked to provide substantially more personal financial information and may face a substantially longer underwriting process.

Of course, other factors may explain this heterogeneity of refinancing behavior. For instance, homeowners often refinance when the option is not in the money in order to take equity out of the property. After all, mortgage debt is typically the lowest cost debt consumers can obtain, particularly on an after-tax basis. Conversely, some homeowners who are not equity-, credit-, or income-constrained choose not to exercise options that appear to be in the money. There are several possible reasons for such behavior. For instance, a homeowner who expected to move in the near future might not have enough time to recoup the transaction costs of refinancing.

In our model of refinancing, the dependent variable is a discrete binary indicator that assumes the value of 1 when the homeowner refinances and zero otherwise. We use logit analysis to estimate the effect of various explanatory variables on the probability that a loan will be refinanced. The explanatory variables may be categorized as (1) market interest rates and other factors in the lending environment affecting the cost, both financial and nonfinancial, of carrying out a refinancing transaction, (2) the credit history of the homeowner, and (3) an estimate of the post-origination LTV ratio. In addition, as in most prepayment models, we include the number of months since origination (or the "age" of the mortgage) to capture age-correlated effects not stemming from equity, credit, or the other explanatory variables. (See the appendix for further explanation of logit analysis and how it is applied in this case.) More details on the definition and specification of these variables follow; Table 1 presents summary statistics.

Table 1
Summary Statistics for Explanatory Variables

		Mean	
Explanatory Variable	Description	Refinancings	Nonrefinancings
WRSTNOW	Worst current credit status (1=good credit, 30, 60, 90, 120, 150, 180, 400=default)	26.5	42.5
WRSTEVER	Worst credit status ever (1=good credit, 30, 60, 90, 120, 150, 180, 400=default)	64.9	101.0
SPREAD	Coupon rate minus prevailing market rate (percentage points)	1.66	1.30
LTV	Current loan-to-value ratio (percent)	67.6	74.3
HSD	Historical standard deviation (percent)	0.11	0.11
AGE	Loan maturity (years)	4.90	5.44
LE	Lending environment measured by change in transaction costs (percent)	0.24	0.13
Memo:			
Related variables	Original purchase price of house (thousands of dollars)	150	129
	Original loan balance (thousands of dollars)	104	103

Source: Authors' calculations.

THE INCENTIVE TO REFINANCE

Theory suggests that homeowners will refinance if the benefits of doing so—that is, the reduction in after-tax mortgage interest payments over the expected life of the loan—exceed the transaction costs of obtaining a new loan. Accordingly, measuring the strength of the incentive to refinance involves a comparison of the contract rate on the existing mortgage with the rate that could be obtained on a new mortgage. In addition, account should be taken of transaction costs (such as discount points and assorted closing costs), the opportunity cost of the time spent shopping for and qualifying for a new loan, and interest rate volatility, which influences the value of the call option.[5]

There are many ways to measure the strength of the incentive to refinance, none of which is perfect (see, for example, Richard and Roll [1989]). In this study, we employ the simplest of them—the spread between the contract rate on the existing loan (C) and the prevailing market rate (R), that is:

$$SPREAD_t = C - R_t,$$

where (t) represents the time period. For all observations in our sample, C is the Freddie Mac national average commitment (contract) rate on fixed-rate loans for the month in which the existing loan closed.[6] This is the so-called A-paper rate, or the rate available to the best credit risks. Likewise, for those homeowners who did refinance, R is also the national average A-paper contract rate for the month in which the new loan closed.

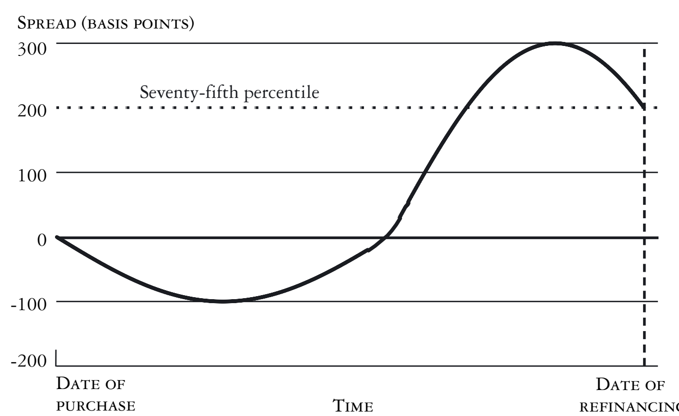
While SPREAD is a simple measure and tends to represent the way homeowners think about the refinancing decision, it has some drawbacks. First, it does not explicitly account for transaction costs, which are likely to vary across borrowers and over time. However, one could imagine that transaction costs create an implicit critical threshold of SPREAD, say 100 to 150 basis points, that must be exceeded to trigger a refinancing. Another drawback of SPREAD is that it does not take into account the fact that the financial benefit of refinancing is a function of the expected life of the new loan. However, experimentation with alternative measures that do explicitly account for transaction costs and holding period revealed that the effects of creditworthiness and home equity on the probability that a loan will be refinanced are insensitive to the measure employed.[7]

An important issue that arises when using SPREAD in cross-sectional analysis is the assignment of the value of R to those individuals who did not refinance. Several possible approaches exist for assigning a value, and there is a certain amount of arbitrariness in selecting any particular one.[8] In tackling this problem, we noted that those who did refinance rarely did so at the largest spread (the lowest value of R) that occurred over the period from their original purchase to the date they refinanced (Chart 3). If all the values of SPREAD observed over that period were ranked from highest to lowest, on average those who refinanced did so at about the seventy-fifth percentile. Accordingly, we assigned nonrefinancers the value of R associated with the seventy-fifth percentile of spreads observed over the period from the date of original purchase to the end of our sample period (December 1994).

Note that by basing C and R on the A-paper rate, we explicitly excluded from SPREAD any influences that individual borrower characteristics might have on the actual values of particular individuals. The effects of those individual characteristics are captured by the credit and equity variables, as well as by the error term. In addition, we ignored the fact that the values of C and R for any one individual are

Chart 3

SPREAD AT WHICH REFINANCING TYPICALLY OCCURS



Source: Authors' calculations.

likely to deviate somewhat from the national average because of regional differences in mortgage interest rates or differences in the shopping and bargaining skills of refinancers.

Volatility

As noted above, standard option theory suggests that there is value associated with *not* exercising the option to refinance that is increasing with the expected future volatility of interest rates. Assuming that one can correctly measure expected future volatility, theory also suggests that, when included in a model such as ours, volatility should have a negative sign. That is, higher volatility should reduce the probability that a loan will be refinanced. The expected effect of volatility has been found in some studies on this topic. For example, Giliberto and Thibodeau (1989), who measure volatility as the variance of monthly averages of mortgage interest rates over their sample period, find that greater volatility tends to increase the age of a mortgage (and decrease prepayments). In contrast, Caplan, Freeman, and Tracy (1993) find their measure of expected future volatility to be insignificant and drop it from their analysis.

Although the theoretical effect of expected future volatility on the probability that a loan will be refinanced is negative, actual volatility during a given time period should correlate positively with the probability of refinancing during that period. That is, if market interest rates during the relevant interval are relatively volatile, a homeowner will be more likely to observe an opportunity to refinance than if rates are relatively stable.

To capture this effect, we include as an explanatory variable the historical standard deviation (HSD) of market rates during the time interval from purchase to refinancing or from purchase to the end of the sample period. HSD is measured as the standard deviation of the ten-year Treasury bond rate. We expect this variable to be directly related to the probability that a loan will be refinanced.

Lending Environment

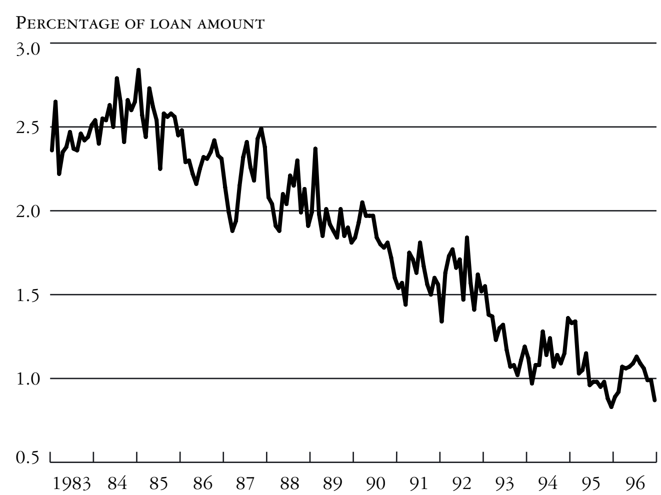
As noted by many industry experts, between the late 1980s and the early 1990s, the mortgage lending industry became more aggressive in soliciting refinancings. To encourage refinancing, mortgage servicers began contacting customers with spreads above some threshold, often as low as 50 basis points, and informing them of the opportunity and benefits of refinancing. Transaction costs declined as competing lenders reduced points and fees (Chart 4). Indeed, many lenders began offering loans with no out-of-pocket costs to borrowers. "Psychic" transaction costs were also reduced as lenders introduced mortgage programs that minimized the financial documentation required of borrowers ("no doc" or "low doc" programs) and drastically shortened the periods from application to approval and from approval to closing. This change in the lending environment likely increased the probability of a loan being refinanced, all else being equal.

Between the late 1980s and the early 1990s, the mortgage lending industry became more aggressive in soliciting refinancings.

To capture this effect, we introduce an explanatory variable termed lending environment (LE). LE is defined as the change in the average level of points and fees (expressed as a percentage of the loan amount) on conventional fixed-

Chart 4

Initial Fees and Charges on Conventional Loans Closed



Source: Federal Housing Finance Board.

rate loans closed between the time of the original purchase and either refinancing or the end of the sample period.

Personal Creditworthiness

Since credit history is a key determinant of mortgage loan approval, it clearly should have some bearing on the likelihood that a loan will be refinanced. However, because of a lack of data, this effect has never before been quantified. Our study is able to overcome this obstacle. The Mortgage Research Group (MRG)—the source of most of our data—has matched complete TRW credit reports to the individual property records that make up our sample of loans (see box). Using this matched data, we are able to test our hypothesis that, other things being equal, the worse an individual's credit rating, the lower the probability that he or she will refinance a mortgage, either because the homeowner cannot qualify for a new loan or because the interest rate and transaction costs at which he or she can qualify are too high to make it financially worthwhile.

The most general measure of an individual's credit history presented in the TRW reports is the total number of "derogatories."[9] A derogatory results from one of four events:

- a charge off: when a lender, after making a reasonable attempt to collect a debt, has deemed it uncollectible and has elected to declare it a bad debt loss for tax purposes. There are no hard and fast rules specifying when a lender can elect to charge off a debt or what represents a reasonable effort to collect. A charge off may result from a bankruptcy, but most often it is simply the result of persistent delinquency.
- a collection: when a lender has enlisted the services of a collection agency in an effort to collect the debt.
- a lien: a claim on property securing payment of a debt. A lien (for example, a tax lien or mechanics lien) is a public derogatory because it is effected through the courts and is a matter of public record.
- a judgment: a claim on the income and assets of an individual stemming from a civil law suit. Like a lien, a judgment is a public derogatory.

Somewhat more specific indicators of an individual's credit history are the worst now (WRSTNOW) and worst ever (WRSTEVER) summary measures across all credit lines. As the names imply, these variables capture an individual's worst payment performance across all sources of credit as of some moment in time (now) and over the individual's entire credit history (ever). At the extremes, either variable can take on a value of 1 (all credit lines are current) or a value of 400 (a debt has been charged off). Intermediate values capture the number of days a scheduled payment has been late: 30 (a scheduled payment on one or more credit lines is thirty days late), 60, 90, or 120.[10] Note that a 400 constitutes a derogatory, whereas some lesser indicator of credit deterioration, such as a 90 or 120, does not.

To clarify how the WRSTNOW and WRSTEVER measures are used to assess an individual's credit status, we offer the example of a homeowner who has three credit lines—a home mortgage, a credit card, and an auto loan (Table 2). At the beginning of the homeowner's credit history (t-11), all three credit lines are current, giving the

Table 2
Sample Credit History of Individual Homeowner

	t-11	t-10	t-9	t-8	t-7	t-6	t-5	t-4	t-3	t-2	t-1	t
Homeowner's credit lines												
Mortgage	1	1	1	30	1	30	30	30	30	1	1	1
Credit card	1	30	60	90	120	400	-	-	-	-	-	-
Auto loan	1	1	30	60	30	60	90	60	30	30	1	1
Summary measure of homeowner's credit history												
Worst ever	1	30	60	90	120	400	400	400	400	400	400	400
Worst now	1	30	60	90	120	400	90	60	30	30	1	1

Time

Source: Authors' calculations.

homeowner WRSTNOW and WRSTEVER values of 1. For some reason—perhaps loss of employment, illness, or divorce—this individual begins to experience some difficulty meeting scheduled payments on a timely basis. The credit card payment due becomes 120 days late in period t-7, prompting the lender to charge off that debt in period t-6, at which point both WRSTNOW and WRSTEVER take on a value of 400. Eventually, this individual gets all credit lines current again, bringing WRSTNOW down to 1 by period t-1. However, WRSTEVER remains at 400 because of the charge off of the credit card debt in period t-6. Indeed, once someone experiences credit difficulties, his or her credit history is likely to be affected for a long time.

We now examine a cross tabulation of the WRSTNOW and WRSTEVER values for all individuals in our sample (Table 3). For WRSTNOW, 85.5 percent of the sample have a value of 1 while 8.0 percent have a value of 400. Values from 30 to 120 represent just 6.5 percent of the total. In contrast, for WRSTEVER, 18.4 percent of the sample have a value of 400 while just 52.9 percent have a value of 1. Thus, although at any point in time nearly nine of every ten individuals have a perfect credit rating (WRSTNOW=1), at some time in their credit history roughly half the population experienced something less than a perfect credit rating (WRSTEVER>1). In fact, 8.0 percent have a WRSTNOW of 1 but a WRSTEVER of 400.[11]

The ideal data set for determining the effect of credit history on the probability that a loan will be refinanced would include a credit snapshot as of the date the home was originally purchased and periodic updates, perhaps once per quarter, as the loan ages. With this information, the researcher could determine whether the homeowner's credit history had deteriorated since the purchase of the home. Unfortunately, data sets that link property transaction data with credit histories are a relatively new phenomenon, so these periodic updates of the credit history are not yet available. As a second-best alternative, we use one credit snapshot—as of the second quarter of 1995—that includes both a current (WRSTNOW) and a backward-looking (WRSTEVER) credit measure. We included these measures of creditworthiness in numerous specifications of our logit model and, regardless of specification, found that they were both statistically and economically significant in determining refinancing probability. Moreover, by comparing WRSTNOW with WRSTEVER, we were able to identify cases where a mortgagor's credit history had improved over time, and found some evidence that improvement reduced, but did not completely overcome, the negative impact of a WRSTEVER value of 400.[12]

Table 3

CROSS TABULATION OF WORST NOW AND WORST EVER CREDIT HISTORIES FOR HOMEOWNERS IN THE SAMPLE

	Worst Now						
Worst Ever	1	30	60	90	120	400	Total
1	52.9	0.0	0.0	0.0	0.0	0.0	52.9
30	15.2	1.2	0.0	0.0	0.0	0.0	16.4
60	5.9	0.7	0.5	0.0	0.0	0.0	7.1
90	1.7	0.2	0.2	0.3	0.0	0.0	2.4
120	1.8	0.1	0.2	0.1	0.6	0.0	2.9
400	8.0	0.8	0.4	0.5	0.7	8.0	18.4
Total	85.5	3.0	1.3	0.9	1.3	8.0	100.0

Source: Authors' calculations.

Note: Figures in table represent the percentage of the sample that has the indicated combination of worst now and worst ever measures.

POST-ORIGINATION HOME EQUITY

In addition to a poor credit history, another factor that could prevent a homeowner from refinancing, regardless of how far interest rates have fallen, is a decline in property value that significantly erodes that owner's equity. For example, if a homeowner originally made a 20 percent down payment (origination LTV ratio=80 percent), a 15 percent decline in property value following the date of purchase would push the post-origination LTV ratio to nearly 95 percent, typically the maximum allowable with conventional financing. Loan underwriters would likely be concerned that the recent downward trend in property values would continue and therefore would be reluctant to approve such a loan.

In addition, an LTV ratio exceeding 80 percent would typically require some form of mortgage insurance, which would increase transaction costs and reduce the effective interest rate spread by as much as 25 to 50 basis points. If the original LTV ratio was greater than 80 percent, correspondingly smaller declines in property value would have similar effects. In contrast, increases in property value would likely raise the probability of refinancing. Greater equity simply makes it easier for homeowners to qualify for a loan since the lender is exposed to less risk. It may also increase the incentive to refinance for homeowners who wish to take equity out of their property (known as a cash-out refinancing). Furthermore, if price appreciation substantially lowers the post-origination LTV ratio, a borrower may be able to use refinancing to reduce or eliminate the cost of mortgage insurance, thereby increasing the effective interest rate spread.

To capture the effect of changes in home equity on the probability of refinancing, we enter an estimate of the post-origination LTV ratio as an explanatory variable. The LTV ratio's numerator is the amortized balance of the original first mortgage on the property, calculated by using standard amortization formulas for fixed-rate mortgages and the interest rate assigned to that loan, as discussed above.[13] The denominator is the original purchase price indexed using the Case Shiller Weiss repeat sales home price index for the county in which the property is located. While repeat sales home price indexes are not completely free of bias, they are superior to other indicators in tracking the movements in home prices over time. This approach allows us to calculate a post-origination LTV ratio for each month from the date of purchase to either the date of refinance or the end of the sample period.

In addition to a poor credit history, another factor that could prevent a homeowner from refinancing, regardless of how far interest rates have fallen, is a decline in property value that significantly erodes that owner's equity.

For loans that were refinanced, the post-origination LTV ratio used is the estimate for the month in which the refinance loan closed. However, as in the case of interest rate R, a value of the post-origination LTV ratio must be assigned to those observations that did not refinance. We noted that, on average, homeowners who refinanced did so at the forty-fifth percentile of values of the LTV ratio observed from the date of purchase to the date of refinance. On the basis of this observation, the LTV ratio assigned to those who did not refinance is the average over the entire period from the date of purchase to the end of the sample period.

We should note that virtually all of the movement in the LTV ratio is the result of changes in the value of the home. The amount of amortization of the original balance of a mortgage is relatively modest over the typical life of the mortgages in our sample. In contrast, over the time period represented by this sample, home price movements have been quite dramatic in some regions. For example, the Case Shiller Weiss repeat sales indexes suggest that home prices in the California counties included in our sample declined by roughly 30 percent from 1990 to 1995.

Age or "Burnout"

The actual prepayment performance of mortgage pools typically shows an increase in the conditional prepayment rate during roughly the first fifty to sixty months, at which point loans are described as being "seasoned." As the aging process continues, the remaining loans in a pool become quite resistant to prepayment, even with strong incentives—a phenomenon known as burnout. To capture this effect, most prepayment studies include the age of the loan or the number of months since origination as an explanatory variable.

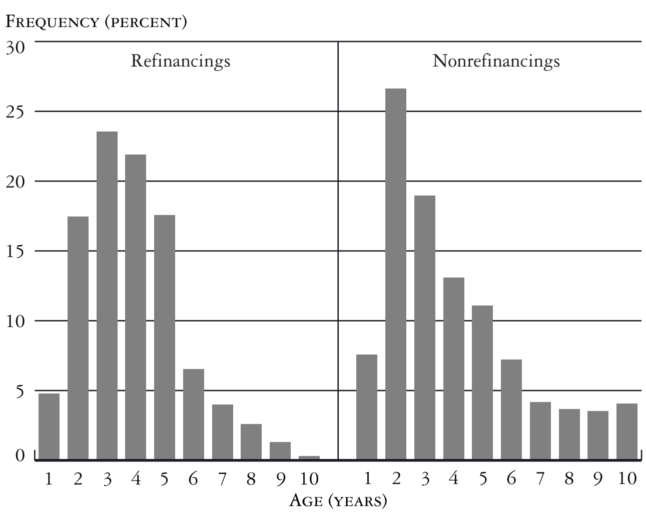
One explanation for burnout is that homeowners prevented from refinancing by credit, equity, and/or income constraints come to dominate mortgage pools over time as homeowners who are not similarly constrained refinance or sell their homes. To the extent that our equity and credit variables capture this effect, the age of the loan per se should be less important than it would be in a model that does not include those variables. However, recognizing that credit and equity may not capture all age-correlated effects, we also include AGE as an explanatory variable. Because the effect of aging may not be a simple linear one, we also include age squared (AGESQ). In comparing the frequency distribution of AGE for homeowners who refinanced with the corresponding distribution for homeowners who did not, we see that the general shape of these distributions is similar—although, as one would expect, the proportion of higher AGE values is greater for nonrefinancers than for refinancers (Chart 5).[14]

Empirical Findings

Logit estimations of our model for the entire sample—that is, all regions combined—appear in Table 4. We account for the effect of credit on the probability of refinancing by dividing the sample into three subsamples: individuals with values of WRSTNOW equal to 1 (good credits), individuals with WRSTNOW between 30 and 120 (marginal credits), and individuals with WRSTNOW equal to 400 (bad credits). We then estimate our model for each of the subsamples while dropping the credit history variable. We eliminate this variable because variations in market interest rates relative to the contract rate on a homeowner's existing mortgage would have a greater effect on the refinancing probability of a borrower with a perfect credit history than on one with serious credit difficulties. This variability in responsiveness suggests that there should be significant interactions between credit history and the other explanatory variables, particularly SPREAD.

Chart 5

Distribution of Sample of Mortgage Loans by Age



Source: Authors' calculations.

Note: Each number on the horizontal axis represents a one-year range. That is, "1" represents one to two years of age; "2," two to three years of age; and so on.

In addition, it is not clear whether the credit variables WRSTNOW and WRSTEVER should be viewed as continuous, such as crude credit scores, or as categorical.[15]

Our results confirm that credit history has a marked effect on the probability of refinancing. The coefficient on

Table 4

Logit Analysis of Factors Influencing the Decision to Refinance, by Credit Category: All Regions

Dependent variable: refinance=1, nonrefinance=0

Explanatory Variable	WRSTNOW=1	30 ≤ WRSTNOW <400	WRSTNOW=400
CONSTANT	1.187***	3.292***	2.245***
	(56.29)	(20.51)	(12.99)
SPREAD	0.585***	0.521***	0.266*
	(233.60)	(9.55)	(3.30)
LTV	-0.032***	-0.055***	-0.044***
	(470.89)	(64.29)	(58.26)
AGE	-0.172***	-0.548**	-0.273
	(10.18)	(5.94)	(1.77)
AGESQ	-0.059***	-0.022	-0.053***
	(140.52)	(1.12)	(7.76)
HSD	4.273***	4.872***	3.983**
	(94.51)	(8.27)	(5.28)
LE	4.445***	3.418***	4.798***
	(472.25)	(15.07)	(38.39)
DUM_IL	-0.387***	-0.971**	-1.039***
	(19.65)	(5.43)	(7.04)
DUM_FL	0.147**	0.836***	0.496**
	(5.99)	(9.65)	(4.11)
DUM_CA	0.417***	1.237***	0.694**
	(33.49)	(12.35)	(5.67)
Number of refinancings	3,522	177	218
Number of nonrefinancings	7,488	648	802
Pseudo R-squared[a]	0.248	0.259	0.244
Chi-square of model	2805.72	214.56	250.31
Concordant ratio (percent)	79.2	81.0	80.5

Source: Authors' calculations.

Note: Figures in parentheses are chi-square statistics.
[a]Pseudo R-squared is defined in Estrella (1997).
* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

SPREAD for good credits is approximately twice as large as it is for bad credits, with a corresponding sizable drop in statistical significance in the latter case. Similarly, we find that the coefficients on HSD are positive and highly significant, although slightly smaller and somewhat less significant for the WRSTNOW=400 subsample. While high values of HSD indicate more opportunities for a mortgagor's option to be in the money, such values have less impact on the refinancing probability of credit-constrained borrowers. As expected, we find that the coefficients of the variable SPREAD are uniformly significant and positive across the subsamples.

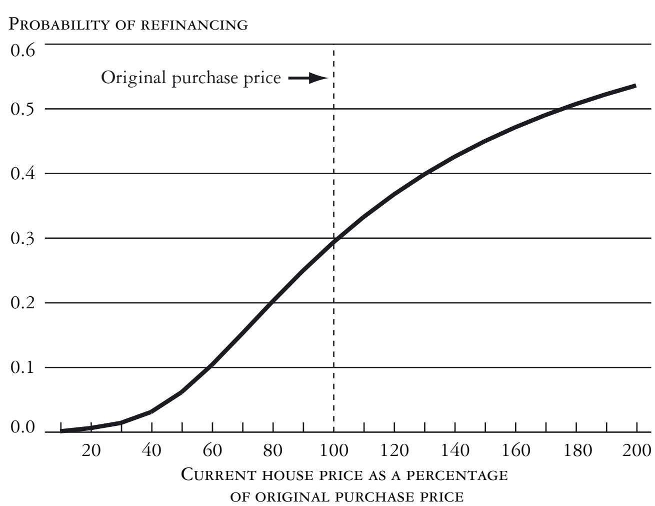
Changes in home equity also have an important influence on the probability of refinancing, as evidenced by the negative sign and high level of significance of the LTV ratio. We demonstrate the estimated effect of changes in house price by plotting simulated values of the probability of refinancing for different levels of the post-origination house price as a percentage of the original purchase price (Chart 6). Note that in Table 4, the coefficient on the LTV ratio is somewhat larger for the bad credit group, suggesting that to some extent there is a trade-off between equity and credit rating.

Lending environment is also significant and bears the predicted sign, suggesting that increased lender aggressiveness and consumer financial savvy have boosted the probability that a loan will be refinanced. Again note that the coefficient of LE is somewhat greater for bad credits than for good credits, suggesting that an important element of increased lender aggressiveness has been the increase in subprime credit quality lending, or lending to borrowers with credit histories worse than that required in the A-paper market. Finally, AGE and AGESQ are significant with negative signs, indicating that credit and equity do not explain all of the decline in probability of refinancing as a mortgage ages.

These results emphasize the dependence of estimates of interest rate sensitivities on credit factors. Pools of mortgages with relatively high proportions of borrowers with poor credit histories will experience significantly slower prepayment speeds, all else being equal. Investors in mortgage-backed securities are affected by the credit conditions of the households represented in the underlying pools of mortgages even though they may be insulated against homeowner default per se. Moreover, our results suggest that a change in the overall lending environment has occurred over the past decade, probably because lenders have become more aggressive and borrowers more sophisticated. All else being equal, this change has increased the probability that a homeowner will refinance.

Chart 6

EFFECT OF CHANGE IN HOUSE PRICE ON PROBABILITY OF REFINANCING



Source: Authors' calculations.

EFFECTS OF AN IMPROVEMENT IN CREDIT RATING

The summary measures of credit history used in this study suggest that the credit performance of many individuals in our sample has improved: for these individuals, WRSTNOW has a lower value than WRSTEVER. As Table 3 shows, 8.0 percent of the sample have a WRSTEVER of 400 (the worst credit classification) and a WRSTNOW of 1 (the best credit classification).

To investigate the extent to which improvement in a homeowner's credit history affects the probability of refinancing, we first select all those cases in which WRSTEVER is 400 (18.4 percent of the total sample). We then divide that group into three subsamples based on the extent of improvement: WRSTEVER=400, WRSTNOW=1; WRSTEVER=400, 1<WRSTNOW<400; and WRSTEVER=400, WRSTNOW=400. Next we estimate our model, absent the credit history variable, over these three subsamples. We find that the coefficients on SPREAD and HSD are larger for the subsample with the greatest improvement than for the subsample with no improvement. These results provide some support for the hypothesis that improvement in one's credit rating increases the probability of refinancing (Table 5).

Table 5
THE EFFECT OF CREDIT HISTORY IMPROVEMENT

Explanatory Variable	WRSTEVER=400 WRSTNOW=1	WRSTEVER=400 1<WRSTNOW<400	WRSTEVER=400 WRSTNOW=400
CONSTANT	2.860***	3.455***	2.245***
	(18.43)	(5.76)	(12.99)
SPREAD	0.540***	0.721***	0.266
	(12.77)	(4.579)	(3.30)
LTV	-0.050***	-0.063***	-0.044***
	(65.80)	(23.19)	(58.26)
HSD	6.252***	2.357	3.983***
	(13.45)	(0.26)	(5.28)
AGE	-0.536***	-0.404	-0.273
	(6.64)	(0.65)	(1.77)
AGESQ	-0.040***	-0.073	-0.053***
	(4.652)	(1.97)	(7.76)
LE	4.981***	3.970***	4.798***
	(38.64)	(5.10)	(38.39)
DUM_IL	-0.703***	-0.846	-1.039***
	(4.24)	(0.86)	(7.04)
DUM_FL	0.579***	1.311***	0.496***
	(5.36)	(5.29)	(4.11)
DUM_CA	1.183***	2.626***	0.694***
	(14.35)	(11.94)	(5.67)
Number of refinancings	221	55	218
Number of nonrefinancings	788	249	802
Pseudo R-squared[a]	0.260	0.339	0.244
Chi-square of model	264.74	101.96	250.31
Concordant ratio (percent)	81.3	86.3	80.5

Source: Authors' calculations.

Note: Figures in parentheses are chi-square statistics.
[a]Pseudo R-squared is defined in Estrella (1997).
* Significant at the 1 percent level.
** Significant at the 5 percent level.
*** Significant at the 10 percent level.

SIMULATING THE EFFECTS OF CREDIT AND EQUITY ON THE PROBABILITY OF REFINANCING

Using the separately estimated equations for the WRSTNOW=1 and WRSTNOW= 400 subsamples, we simulate values for the probability of refinancing for hypothetical individuals with different credit histories and different values of the post-origination LTV ratio (Table 6). The four columns of this table represent alternative combinations of the variables WRSTNOW and the LTV ratio. Moving down each column, we see that the variable SPREAD rises from 0 to 300 basis points, an increase that should normally motivate refinancing. The first column, with WRSTNOW=1 and the post-origination LTV ratio=60 percent, shows how an individual who is neither equity- nor credit-constrained would react to an increase in SPREAD. Note that with SPREAD=0, the probability of refinancing is 0.29, suggesting that refinancings motivated by the desire to extract equity from the property are fairly high among this group. As SPREAD rises to 300 basis points, the probability of refinancing essentially doubles, reaching nearly 60 percent. In the second column, where the LTV ratio=100 percent, the probabilities drop sharply; at SPREAD=0, the probability is just 0.1, while at SPREAD=300, the probability is 0.32, about half of that when the LTV ratio=60 percent.

In contrast, the third and fourth columns depict an individual who is severely credit-constrained (WRSTNOW=400). As suggested above, having substantial equity can overcome many of the problems associated with

Table 6
PROBABILITY OF REFINANCING UNDER ALTERNATIVE COMBINATIONS OF SPREAD, CREDIT HISTORY, AND LOAN-TO-VALUE RATIO

	WRSTNOW=1		WRSTNOW=400	
SPREAD	LTV Ratio=60	LTV Ratio=100	LTV Ratio=60	LTV Ratio=100
0	0.29	0.11	0.34	0.11
100	0.38	0.16	0.36	0.12
200	0.48	0.23	0.37	0.13
300	0.58	0.32	0.39	0.14

Source: Authors' calculations.

Note: The simulated probabilities were obtained using models summarized in Table 4.

a poor credit history, particularly because more lenders have moved into subprime lending programs. With the LTV ratio=60 percent, probabilities of refinancing are essentially the same at SPREAD=0 and SPREAD=100 as in the WRSTNOW=1 case. However, without substantial equity (an LTV ratio=100 percent), the probability of refinancing is not only low but also unresponsive to increases in SPREAD.

Additional simulations test the marginal effect on the probability of refinancing of relevant changes in the model's other explanatory variables (Table 7). We saw in Table 1 that the mean value for LE for refinancers is 24 basis points. The results reported in Table 7 indicate that, all else being equal, this mean value of LE results in a 0.2 increase in the probability of refinancing. Comparing Table 7 with Table 6, we conclude that the change in the lending environment over the past decade has had an effect on the probability of refinancing equivalent to moving from an LTV ratio of 100 percent to an LTV ratio of 60 percent—a very powerful effect. Similarly, each year in which a loan ages reduces the probability of refinancing by 0.1, all else being equal.

Table 7
MARGINAL EFFECT OF OTHER EXPLANATORY VARIABLES ON THE PROBABILITY OF REFINANCING

Variable	Change in Variable	Change in Probability
LE	+25 basis points	+0.20
HSD	+5 basis points	+0.04
AGE	+1 year	-0.10

Source: Authors' calculations.

Note: Changes for LE and HSD are roughly equal to a change of one standard deviation.

CONCLUSION

Our analysis provides compelling evidence that a poor credit history significantly reduces the probability that a homeowner will refinance a mortgage, even when the financial incentive for doing so appears strong. Moreover, consistent with previous studies, we find that refinancing probabilities are quite sensitive to the amount of equity a homeowner has in his or her property. Homeowners with poor credit histories and low equity positions cannot easily meet lenders' underwriting criteria, so they are often blocked from obtaining the replacement financing necessary to prepay their existing mortgage.

On another level, this research contributes to the evidence that households' financial conditions can have significant effects on the channels through which declines in interest rates influence the overall economy. From the broadest viewpoint, mortgage refinancings can be viewed as redistributions of cash flows among households or investment intermediaries. For those households able to reduce costs by locking in a lower interest rate on their mortgage, refinancing is likely to have a wealth or permanent income effect that might boost overall consumption spending. Conversely, to the extent that households are unable to obtain replacement financing at lower interest rates because of deteriorated credit histories or erosion of equity, the stimulative effect on consumption would likely be less.

Of course, refinancing decisions also affect the investors in the various cash flows generated by pools of mortgages. When homeowners refinance, those investors lose above-market-rate income streams and so are keenly interested in any factors that may have a significant bearing on the probability of refinancing. This analysis demonstrates that, in addition to monitoring changes in interest rates and home prices, those investors should be concerned with the credit histories of the homeowners represented in a particular pool of mortgages as well as trends in those credit histories over time. Despite guarantees against credit risk, the relative proportions of credit-constrained households represented in pools of mortgages will have a significant impact on the prepayment behavior of those pools under various interest rate and home price scenarios.

A homeowner decides to refinance by comparing the costs of continuing to hold the current mortgage with the costs of obtaining a new mortgage, both evaluated over some expected holding period. For simplicity, let B* represent the difference between the cost of continuing to hold the mortgage at the original rate and the cost of refinancing at the current rate, discounted over the expected duration of the loan. The variable B* represents the net benefit from refinancing; if B* is positive, the homeowner would want to refinance.

Although this notional desire to refinance, measured by B*, is not observable, we can observe some of the key factors that determine it. Such factors include the difference between the homeowner's current mortgage interest rate and the prevailing market interest rate at the time this decision is being evaluated (SPREAD), the homeowner's credit history (WRSTNOW), the amount of equity in the property (LTV), the number of months since the origination of the existing mortgage (AGE), the volatility of mortgage interest rates since origination (HSD), and any changes in the lending environment since origination that may have reduced the financial, psychic, or opportunity costs of obtaining a loan (LE). Thus, we can express B* as a function of these explanatory variables:

(A1) $$B_i^* = \alpha_0 + \alpha_1 SPREAD_i + \alpha_2 WRSTNOW_i + \alpha_3 LTV_i + \alpha_4 AGE_i + \alpha_5 HSD_i + \alpha_6 LE_i + u_i \ ,$$

where the subscript (i) represents the i-th mortgage holder and u_i represents the error term. We assume for simplicity that the relationship between B* and the factors that determine it is linear.

The decision to refinance can be expressed as a simple binary choice that assumes:

(A2) $$r_i = 1 \quad \text{if} \quad B_i^* > 0 \quad \textit{(refinancing)}$$
$$r_i = 0 \quad \text{if} \quad B_i^* \leq 0 \quad \textit{(no refinancing).}$$

Equations A1 and A2 jointly represent an econometric model of binary choice. If the net benefit from refinancing is positive, we would expect on average that the i-th homeowner would refinance (represented by binary outcome $r_i = 1$); otherwise the individual would not (outcome $r_i = 0$). We estimate the parameters of the binary choice model (that is, $[\alpha_0, \alpha_1, \ldots, \alpha_6]$) using maximum likelihood logit analysis (for more details, see Maddala [1983] and Green [1993]).

Noting the significant interaction effects between the creditworthiness measure and the other explanatory variables, and the uncertainty over whether WRSTNOW is a continuous or categorical variable, we develop an alternative to an estimation of equation A1 by dividing the sample into subsamples based on the various values of WRSTNOW, dropping WRSTNOW as an explanatory variable, and estimating the resulting equation, A3, over those subsamples:

(A3) $$B_i^* = \alpha_0 + \alpha_1 SPREAD_i + \alpha_2 LTV_i + \alpha_3 AGE_i + \alpha_4 HSD_i + \alpha_5 LE_i + u_i \ .$$

ENDNOTES

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1. Another factor that may have impeded a borrower's ability to refinance is a decline in household income. Unfortunately, the data set used in this study does not include information on an individual borrower's income at the time of the initial purchase of the home or afterward.

2. In the literature on this topic, a distinction is made between the values of LTV ratios, income, and credit history at the time the mortgage loan is originated (the origination values) and the values of those variables at some point in time after the origination (the post-origination values). The post-origination values are the most relevant for the decision to prepay a mortgage, but they also tend to be the most difficult on which to obtain data.

3. Homeowners' assessments of the current market values of their properties may be biased, particularly during periods when there are significant changes in those values. See, for example, DiPasquale and Sommerville (1995) and Goodman and Ittner (1992).

4. Case Shiller Weiss, Inc., of Cambridge, Massachusetts, provided these home price indexes.

5. See Follain, Scott, and Yang (1992) and Follain and Tzang (1988).

6. The interest rate on existing loans C is not directly observed in the data base. An estimate of that interest rate can be derived from information on the original loan balance, original maturity, and periodic readings of the amortized balance, which is reported in the TRW credit reports discussed below.

Strictly speaking, an interval of thirty to sixty days usually separates the date of application for a mortgage from the date of closing, although borrowers typically have the option of locking in the interest rate at the time of application or letting the rate float, in some cases up to the date of closing. We experimented with lagging the national average mortgage interest rate by one and then two months and found that in neither case were the results significantly different from those we obtained using the average rate for the month in which the loan closed.

7. In a more technical version of this study, we tested four alternative, increasingly complex measures of the incentive to refinance. Details on the definitions and specifications of these measures, as well as the estimation results, are presented in Peristiani et al. (1996).

8. For example, Archer, Ling, and McGill (1995) assign to those observations that did not refinance the lowest monthly average Freddie Mac commitment rate on thirty-year fixed-rate mortgages over the two-year time interval of their study.

9. In the technical version of this study (Peristiani et al. 1996), we use total derogatories as an explanatory variable in determining the probability of refinancing and find it to be highly significant with the predicted sign, although somewhat less significant than WRSTNOW or WRSTEVER.

10. In fact, each variable can take on more values than those listed. For example, a value of 34 indicates that an individual is persistently thirty days late. For the purposes of this study, we have constrained WRSTNOW and WRSTEVER to take on only those values cited in the text.

11. To an increasing extent, mortgage lenders are relying on a single credit score summarizing the vast amount of information on an individual's credit report. For an overview of this issue, see Avery, Bostic, Calem, and Canner (1996). As an extension of the research on the effect of credit histories on mortgage refinancings, credit scores could also be tested as an alternative measure of creditworthiness.

12. For additional information on these alternative specifications, see Peristiani et al. (1996).

13. The presence of second mortgages and home equity loans introduces additional considerations into the issue of refinancing. On the one hand, second mortgages and home equity loans would tend to reduce a homeowner's equity. On the other hand, since second mortgages and home equity loans typically have interest rates well above the rates on first mortgage loans, the spread based on the homeowner's weighted-average cost of credit would likely be higher. Although the MRG data base indicates the presence and amount of second mortgages and home equity loans taken out since the original purchase, we do not investigate their effect on refinancing probabilities. This is an area for future research.

14. As noted earlier, the sample excludes observations with AGE of less than twelve months.

15. Dividing the sample into three subsamples based on credit rating is equivalent to estimating the model over the entire sample with dummy variables for the three credit classifications and fully interacting those dummy variables with the other explanatory variables of the model.

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