A Survey of Announcement Effects on Foreign Exchange Returns

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Researchers have long studied the reaction of foreign exchange returns to macroeconomic announcements in order to infer changes in policy reaction functions and foreign exchange microstructure, including the speed of market reaction to news and how order flow helps impound public and private information into prices. These studies have often been disconnected, however; and this article critically reviews and evaluates the literature on announcement effects on foreign exchange returns. (JEL F31, F32, G14)

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Since the early 1980s researchers have sought to understand how foreign exchange markets react to various announcements. The motivation for studying this topic is a fundamental goal of economics: to understand the determination of prices. The study of announcement effects has lessons for both macroeconomics and microstructure. This paper surveys and summarizes the lengthy literature that has tenaciously built up a picture of how macroeconomic and policy announcements affect exchange rate returns.[1]

Announcement reactions reveal market perceptions of policy and how such policies change over time and between countries. They provide a unique window into how the economy operates because the efficient markets hypothesis (EMH) implies that asset prices should react directly and quickly to the surprise component of any announcement.[2] Thus, asset price reactions inform us about how markets form expectations of future fundamentals. Hardouvelis (1988) draws an analogy between research on the effect of macroeconomic announcements and controlled experiments.

The open-economy macro models of the 1970s, which focused on monetary determinants of exchange rates (e.g., Dornbusch, 1976), motivated the study of how money supply and interest rate announcements affected foreign exchange rates. For example, Cornell (1982) and Engel and Frankel (1984) used exchange rate responses to evaluate the evidence for how money supply shocks cause individuals to revise their expectations of inflation and future monetary policy.

[1] A related paper, Neely (2010b), surveys the literature on how foreign exchange volatility responds to macroeconomic announcements, including discontinuous reactions. Osler (2009) surveys the foreign exchange microstructure literature, including papers that focus on announcement effects. A chapter in Evans (2010) also reviews some of the issues in the literature on announcement effects on foreign exchange returns.

[2] Conveniently, survey expectations exist that allow us to decompose most announcements into their expected and unexpected components.

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Meese and Rogoff's (1983) failure to forecast exchange rates with a variety of macro variables further motivated researchers to study a broader array of macro announcements. By creating the widespread impression that exchange rates are "disconnected" from the broader economy, Meese and Rogoff (1983) strongly motivated researchers to link exchange rates to macroeconomic variables, as a first step toward comprehensive macroeconomic exchange rate modeling.

Analyzing foreign exchange reactions to announcements can inform us how market perceptions of policy rules or other factors change. Specifically, Hardouvelis (1984) and Hakkio and Pearce (1985) assess the Federal Reserve's changing inflation-fighting credibility by examining the reactions of exchange rates and interest rates to M1 innovations. International variation in reactions to announcements can similarly tell us about market expectations. For example, Love and Payne (2008) find that the USD/GBP exchange rate is more sensitive to the surprise component of U.S. inflation announcements than to that of the United Kingdom. The authors conjecture that market participants expect the Bank of England—which is an explicit inflation targeter—to bring inflation back down to the target. Alternatively, U.S. inflation shocks might simply have a larger effect on risk premia than do U.K. inflation shocks.

Cross-country institutional differences can also illuminate the importance of institutional details for outcomes. For example, U.S. macroeconomic announcements are regular and scheduled while Almeida, Goodhart, and Payne (1998) report that German announcements were not scheduled in the 1992-94 sample.[3] These authors found that the unscheduled German announcements had a smaller and more prolonged impact on exchange rates. Reactions to scheduled announcements might be quicker because agents have had time to form expectations and plan actions in response to the surprise component.

The reaction to scheduled versus unscheduled announcements is only one example of how the literature has illuminated the microstructure of the foreign exchange market. Ederington and Lee (1995), for example, determined that the systematic reaction to announcements took no more than 40 seconds. Doukas (1985) was the first to suggest that the order of related announcements was important. More recently, the literature has begun to seriously explore how public information (an announcement) creates trading (order flow) that reveals private information. Order flow has a greater price impact after announcements and contributes to a response that can last for days (Evans and Lyons, 2002 and 2005).

In short, the literature on exchange rate responses to macroeconomic announcements has learned a great deal about market perceptions of policy reaction functions and the microstructure of foreign exchange markets. Unfortunately, the papers tend to be disconnected from each other, making it difficult to see broad themes. This paper attempts to remedy that situation by reviewing the literature on announcement effects on exchange rate returns and linking those works to broader points.

The next section of the article briefly discusses the most commonly studied U.S. announcements, and the rest of the paper reviews the major areas of research on the effects of announcements on the conditional means of foreign exchange returns.

U.S. MACROECONOMIC ANNOUNCEMENTS

Several factors facilitate the study of U.S. announcement effects on foreign exchange rates. U.S. announcements are scheduled and expectations of those announcements and accompanying exchange rate data are widely available. Thus, the literature has devoted disproportionate attention to U.S. announcements. Table 1 displays a number of commonly used U.S. announcements, as well as their source and the delay in their release. Other papers, such as Andersen et al. (2003), Ehrmann and Fratzscher (2005), and Faust et al.

[3] Almeida, Goodhart, and Payne (1998) describe the time of German announcements as "not regular" and obtain specific times from Reuter's reports. They cite the transition from West German to unified German data as causing some irregularity in trade balance announcements. Andersen et al. (2003) report that markets had advance warning of the days but not the times of German macro announcements for their March 1993 to December 1998 sample.

(2007) also provide summary information on the releases they use.

Fama's (1970) semi-strong form EMH has guided researchers in connecting exchange rates to macroeconomic fundamentals. This hypothesis states that current prices reflect publicly available information to the extent that one cannot make a risk-adjusted profit by trading on the basis of that information (Jensen, 1978). Because at least some market participants continually gather information, develop expectations of macroeconomic conditions, and trade on those beliefs, asset prices should always approximately reflect the marginal investor's current expectations and prices should quickly react only to the surprise component of an announcement at the time of the release.[4] Any systematic delay in the market reaction or systematic response to the expected component of the release would provide a profit opportunity and therefore should not exist. To test this no-risk-arbitrage hypothesis, researchers require good estimates of market expectations of the announcement and high-frequency data to precisely estimate the systematic response and to judge its speed. Fortunately, such data were available very early for U.S. announcements, which helps explain the attention that they received.[5] Researchers generally use the median response from the Money Market Services (MMS) survey to estimate the expected announcement. Each Friday, MMS surveys 40 money managers on their expectations of economic indicators.[6] (Ideally, the surveys would be conducted as close as possible to the announcement time to more precisely estimate the market's expectation at the time of the announcement.) Cornell (1982) and Engel and Frankel (1984) first used these survey data in the literature on announcement effects in the foreign exchange market, though other researchers—for example, Grossman (1981)—had used them in other contexts. Grossman (1981), Engel and Frankel (1984), Pearce and Roley (1985), and McQueen and Roley (1993) showed that the MMS survey data provide approximately unbiased and informationally efficient estimates of news announcements that outperform time-series models.[7] These MMS survey measures of announcement expectations soon became standard.

Certain sets of U.S. announcements contain highly correlated information, such as the Conference Board and the University of Michigan consumer confidence indices. Doukas (1985) was probably the first researcher to note that timing among related releases matters. He speculated that U.S. monetary announcements were more important than Canadian monetary announcements because they were released 50 minutes earlier. Tandon and Urich (1987) made a similar observation about U.S. PPI and CPI news. Andersen et al. (2003) show that markets typically react most strongly to the surprise component of the earliest release within a set of related U.S. announcements.

Although the vast majority of announcements are backward looking—they pertain to previous economic activity—monetary policy announcements are forward looking: The Federal Open Market Committee (FOMC) considers all available information, including forecasts and the latest announcements, when making decisions about short-term interest rates.[8] The FOMC meets eight

[4] There are at least two caveats to this statement: (i) Pre-announcement prices might reflect not only the investor's expectation but also some adjustment for risk; (ii) an announcement whose content matches market expectations can affect prices and volatility by removing uncertainty. These effects are likely to be small in most circumstances, however.

[5] MMS expectations have been available for other countries for some time.

[6] The number of survey participants and the dates of the survey have changed over time. Hakkio and Pearce (1985) report that MMS surveyed about 60 money market participants during the early 1980s. MMS conducted the surveys on both Tuesdays and Thursdays before February 8, 1980, and on Tuesdays after that date.

[7] Although the MMS survey expectations exhibit fairly good properties compared with alternatives, they still surely measure market expectations with some error, both because they are at least a couple days old and because they reflect the views of a small group of money managers. More subtly, any macroeconomic release will surely contain some error about the true state of the economy because it is estimated with finite resources and limited information. Therefore researchers will estimate macroeconomic surprises with error and this error will generally attenuate the estimated market response toward zero in regressions where the surprise is the independent variable. Rigobon and Sack (2008) discuss two methods to compensate for this error. Bartolini, Goldberg, and Sacarny (2008) discuss the application of this methodology.

[8] Market analysts sometimes assume that a central bank, such as the Federal Reserve, has special knowledge of economic conditions that the public does not share. Faust, Swanson, and Wright (2004), however, show that the unexpected component of the Fed's policy actions does not generally improve private sector forecasts of economic variables, except for industrial production—which the Federal Reserve produces.

Table 1

U.S. Macroeconomic Announcements

Name of announcement	Units of announcement	Frequency	Release lag	Source	Release time
Average Hourly Earnings	$ per hour	Monthly	Almost none	BLS	8:30 AM
Beige Book		8 times per year		FRB	2:15 PM
Business Inventories	% m-m	Monthly	~6 weeks	CB	10:00 AM
Capacity Utilization Rate	Index (2002 = 100), % m-m	Monthly	~2 weeks	FRB	9:15 AM
Construction Spending	% m-m	Monthly	~5 weeks	CB	10:00 AM
Consumer Confidence Index	Index (1985 = 100)	Monthly	None	Conf. Board	10:00 AM
Consumer Credit Report	% m-m	Monthly	~5 weeks	FRB	3:00 PM
Consumer Installment Credit	% m-m, % q-q, $ Billions	Monthly	~5 weeks	FRB	3:00 PM
Consumer Price Index (CPI)	% m-m (1982 = 100)	Monthly	~2 weeks	BLS	8:30 AM
Current Account	$ Billions	Quarterly	~10 months	BEA	8:30 AM
Domestic Vehicle Sales	Millions of vehicles	Monthly	Almost none	BEA	3:00 PM
Durable Goods Orders	% m-m	Monthly	~3-4 weeks	CB	8:30 AM
Employment Cost Index	% q-q (2005 = 100)	Quarterly	~2-3 weeks	BLS	8:30 AM
Existing Home Sales	No. of sales	Monthly	~4 weeks	NAR	10:00 AM
Factory Inventories	Change in $ billions	Monthly	~4 weeks	CB	10:00 AM
Factory Orders	Change in $ billions	Monthly	~4 weeks	CB	10:00 AM
Federal Budget/Deficit	$ Trillions	Monthly		CBO	2:00 PM
FOMC Minutes		8 times per year	~2-3 weeks	FRB	2:00 PM
GDP-Advance	% q/q	Quarterly	1-month lag	BEA	8:30 AM
GDP-Deflator	% q/q	Quarterly		BEA	8:30 AM
GDP-Final	% q/q	Quarterly	3-month lag	BEA	8:30 AM
GDP-Preliminary	% q/q	Quarterly	2-month lag	BEA	8:30 AM
Housing Starts	No. of units, % m-m	Monthly	~3 weeks	CB	8:30 AM
Humphrey-Hawkins Testimony		Semiannual		FRB Chairman	10:00 AM
Index of Coincident Indicators	m-m	Monthly	~3 weeks	Conf. Board	10:00 AM
Industrial Production	Index (2002 = 100), % m-m	Monthly	~2 weeks	FRB	9:15 AM
Initial Unemployment Claims	No. of claims	Weekly	~5 days	ETA	8:30 AM

NOTE: CPI, consumer price index; GDP, gross domestic product; NAPM, National Association of Purchasing Managers; NFP, nonfarm payroll; PCE, personal consumption expenditures; PMI, Purchasing Managers' Index; PPI, producer price index. The following abbreviations are used for announcement sources: BEA, Bureau of Economic Analysis; BLS, Bureau of Labor Statistics; CB, U.S. Census Bureau; Conf. Board, Conference Board; CBO, Congressional Budget Office; Commerce, U.S. Department of Commerce; ETA, Department of Labor's Employment and Training Administration; FRB, Federal Reserve Board; ISM, Institute for Supply Management; NAR, National Association of Realtors; Treasury, U.S. Department of the Treasury. m-m, Level change from month to month; % m-m, percent change from month to month; % q/q, percent change quarter over quarter; % q-q, percent change from quarter to quarter. All times are eastern standard.

Description of announcement
Average hourly wage of production and nonsupervisory workers on private nonfarm payrolls by industry sector and selected industry detail.
Overviews of the economy by Federal Reserve district.
Value of unsold goods held by manufacturers, wholesalers, and retailers.
Percentage of available resources being utilized by factories, mines, and utilities.
Total amount spent by builders on public, residential, and non-residential construction projects.
Mood of consumers with respect to present and future economic conditions.
Consumer credit outstanding; categorized as auto, revolving, and other and disaggregated by major holders.
Total value of outstanding consumer installment debt, such as credit cards, education, and auto loans. Excludes debt secured by real estate.
The normalized price paid by urban consumers for a representative basket of goods and services using a fixed-weight index. The core CPI excludes prices of food and energy.
Balance of trade + net factor payments + net transfer payments.
Annualized number of domestically produced vehicles sold in the previous month.
Value of new purchase orders placed with domestic manufacturers for goods with a life expectancy of more than 3 years, such as automobiles, computers, appliances, and airplanes.
Total compensation for civilian workers.
Annualized number of existing residential buildings that were sold during the previous month.
Value of inventories of domestic manufacturers for durable and nondurable goods.
Value of new purchase orders placed with domestic manufacturers for durable and nondurable goods.
A review of the state of the economy and budget, and related forecasts on future outlook.
A detailed record of the Committee's interest rate meeting held about two weeks earlier. The minutes provide detailed insights regarding the FOMC's stance on monetary policy, so traders carefully comb them for clues regarding future interest rate shifts.
Initial estimate of GDP, total value of all goods and services produced by the economy.
Annualized quarterly implied rate of inflation for all economic activity. Used to calculated difference between nominal and real GDP.
Final estimate of GDP, total value of all goods and services produced by the economy, revising the preliminary.
Revision to estimate of advance-GDP, total value of all goods and services produced by the economy.
Annualized number of new residential buildings that began construction during the previous month.
Report on monetary policy and U.S. economic performance from the Federal Reserve.
Measure of aggregate economic activity from several series.
Output of industrial firms.
Number of first-time filings of jobless claims, seasonally adjusted.

Table 1, cont'd

U.S. Macroeconomic Announcements

Name of announcement	Units of announcement	Frequency	Release lag	Source	Release time
International Trade in Goods and Services	$ Billions	Monthly	~6 weeks	Commerce	8:30 AM
Inventories and Sales Ratio		Monthly	~6 weeks	CB	10:00 AM
ISM Index (formerly the NAPM Survey)	Index	Monthly	Almost none	ISM	10:00 AM
Lagging Indicators	m-m	Monthly	~3 weeks	Conf. Board	10:00 AM
Leading Indicators	m-m	Monthly	~3 weeks	Conf. Board	10:00 AM
M1	Change in $ billions	Weekly		FRB	4:30 PM
M2	Change in $ billions	Weekly		FRB	4:30 PM
Merchandise Trade Balance	$ Billions	Monthly	~6 weeks	CB	8:30 AM
New Home Sales	Thousands	Monthly	~3-4 weeks	CB	10:00 AM
Nonfarm Payrolls	Thousands	Monthly	A few days	BLS	8:30 AM
Personal Consumption Expenditure Index (PCE)	% m-m	Monthly	~4 weeks	BEA	8:30 AM
Personal Income	% m-m	Monthly	~4 weeks	BEA	8:30 AM
Personal Spending	% m-m	Monthly	~4 weeks	BEA	8:30 AM
Producer Price Index	% m-m, Index (1982 = 100)	Monthly	~2 weeks	BLS	8:30 AM
Productivity Costs	Index of output/ index of hours worked	Quarterly	Several months	BLS	8:30 AM
Retail Sales (Advance)	% m-m	Monthly	~2 weeks	CB	8:30 AM
Retail Trade	$ Millions	Monthly	~6 weeks	CB	8:45 (Sales) and 10:15 (Inventories)
Target Federal Funds Rate	%	8 times a year		FRB	2:15 PM
Trade Balance	$ Billions	Monthly	~6-7 weeks	BEA	8:30 AM
Treasury Auction Results		Weekly		Treasury	11:00 AM
Unemployment rate	% of labor force	Monthly	A few days	BLS	8:30 AM
U.S. Exports	% m-m (2000 = 100)	Monthly	~5-6 weeks	CB	8:30 AM
U.S. Imports	% m-m (2000 = 100)	Monthly	~5-6 weeks	CB	8:30 AM
Value of New Construction Put in Place	$ Millions, % m-m	Monthly	~5 weeks	CB	10:00 AM

NOTE: CPI, consumer price index; GDP, gross domestic product; NAPM, National Association of Purchasing Managers; NFP, nonfarm payroll; PCE, personal consumption expenditures; PMI, Purchasing Managers' Index; PPI, producer price index. The following abbreviations are used for announcement sources: BEA, Bureau of Economic Analysis; BLS, Bureau of Labor Statistics; CB, U.S. Census Bureau; Conf. Board, Conference Board; CBO, Congressional Budget Office; Commerce, U.S. Department of Commerce; ETA, Department of Labor's Employment and Training Administration; FRB, Federal Reserve Board; ISM, Institute for Supply Management; NAR, National Association of Realtors; Treasury, U.S. Department of the Treasury. m-m, Level change from month to month; % m-m, percent change from month to month; % q/q, percent change quarter over quarter; % q-q, percent change from quarter to quarter. All times are eastern standard.

Description of announcement
Total exports of goods and services minus total imports.
Inventories/sales ratio.
A national manufacturing index based on a survey of purchasing executives at roughly 300 industrial companies. Signals expansion when the PMI is above 50 and contraction when below.
Lagging measure of aggregate economic activity from several series.
Combining 10 series to measure likely change in economic activity.
A relatively narrow measure of the money supply (M1). The most-liquid forms of money, namely currency and checkable deposits.
A less-liquid measure of money than M1. The non-M1 components of M2 are primarily household holdings of savings deposits, small time deposits, and retail money market mutual funds.
The net difference between imports and exports in an economy.
Annualized number of new residential buildings that were sold during the previous month.
Nonfarm payrolls: change in number of employed people during the previous month, excluding the farming industry, as well as trends in hiring payments and sectors.
Price level of consumers when purchasing goods and services, a Fisher index. The core PCE excludes prices of food and energy.
Income received by individuals.
Amount spent by consumers on goods and services.
Price level of output from domestic producers.
Output, measured net of price change and interindustry transactions, is compared with labor input, measured as hours at work in the sector for the major U.S. economic sectors, including the business sector, the nonfarm business sector, nonfinancial corporations, and manufacturing, along with subsectors of durable and nondurable goods manufacturing.
An advance estimate of the value of sales at the retail level, based on a sample of both small and large firms.
Comprises establishments engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise.
FOMC sets the target interest rate at each of its meetings.
Value of exported less imported goods and services.
The type and value of Treasury securities to be auctioned.
Unemployed workers—those seeking work but never employed during the period—as a percentage of the labor force.
Exports disaggregated by country of final destination and type of good.
Imports disaggregated by country of origin and type of good.
This is part of the total construction spending report released by the Census Bureau.

times per year and since February 1994 has issued a statement about the state of the economy and its federal funds rate decision upon the conclusion of the meetings. Since 1995, these statements have been issued at about 2:15 PM, except for March 1996, when the statement was released at 11:39 AM to avoid a conflict with the Chairman's congressional testimony.[9] Before 1994, the FOMC did not explicitly announce its target rate but signaled it through open market transactions. FOMC decisions affect the value of the dollar; unexpectedly higher interest rates are thought to raise the value of the dollar by increasing the quantity demanded of U.S. debt instruments.

Several important news releases pertain to real economic activity in the labor, housing, consumption, and production markets. Because the Federal Reserve usually raises short-term interest rates in response to unexpectedly strong real activity, such a positive shock usually raises expected future U.S. interest rates relative to foreign interest rates and therefore strengthens the dollar immediately.[10]

Although it is not the first employment report released, market participants view the Bureau of Labor Statistics (BLS) Employment Situations report, which includes nonfarm payrolls, as the most influential employment release. The Department of Labor releases a timelier but less watched—per conventional wisdom in the financial press—weekly report on initial unemployment claims on Thursdays at 8:30 AM eastern time.

Market participants likewise closely watch housing news because of the cyclical sensitivity of the housing market. The Census Bureau releases monthly Housing Starts—the number of new houses started, expressed at an annual rate—about two or three weeks into the month that follows the announncement; New Home Sales (single-family) about 30 days after the end of the month; and Construction Spending on the final day of the second month that follows the activity to which the announcement pertains. Finally, the National Association of Realtors releases the monthly Existing Homes Sales report about five weeks after the end of the month. The Existing Home Sales report has limited predictive power, however, because its information is dated; sales of existing homes are counted only at the end of the home-buying process. In contrast, Housing Starts is timelier because it records the start of new home construction.

Gross domestic product (GDP) is the most comprehensive measure of real economic activity and, as such, is important to financial markets. The Bureau of Economic Analysis (BEA) releases quarterly advanced GDP reports in the final week of January, April, July, and October, with two revision rounds—preliminary and final—following one and two months later, respectively.

Several releases pertain to consumer behavior: monthly retail sales, monthly personal income, monthly personal spending, and monthly consumer confidence. Retail sales (of goods) is the first monthly announcement on consumer spending—the Census Bureau releases it about two weeks into the following month—and it often contains a large surprise component. Both the Conference Board and the University of Michigan release survey data on consumer confidence. Each month the Conference Board surveys 5,000 households about labor market conditions, typically receiving 3,500 responses. It summarizes the results in a Consumer Confidence survey on the last Tuesday of the month. The University of Michigan surveys 500 people about their financial situation and their views of the U.S. economy and then releases a study on Consumer Sentiment on the second Friday of each month, with final revisions released on the last Friday of the month. The Michigan study has a broader perspective than the Conference Board survey, which concentrates on labor market conditions.

At least three monthly announcements focus on production: the Institute for Supply Management (ISM) Manufacturing Survey, the Durable

[9] The federal funds rate is an overnight interbank interest rate. The Open Market Desk of the Federal Reserve Bank of New York buys and (rarely) sells Treasury bills to control the federal funds rate, which strongly influences other short-term interest rates. Mizrach and Neely (2009) detail Federal Reserve procedures and institutional details regarding trading in U.S. Treasuries. Fleming and Piazzesi (2005) nicely document the recent history of FOMC policy announcement times and market reactions.

[10] Faust et al. (2007) and Evans (2010) each detail their own preferred views of the relation of exchange rates to fundamentals and how macro announcements could affect exchange rates through interest rates and risk premia.

Goods Orders report, and the Business Inventories report. The ISM Manufacturing Survey—formerly the NAPM survey—is very timely, released on the first business day of the following month. Its new export orders series is most directly relevant to currency markets. The Federal Reserve Board simultaneously releases the monthly Industrial Production and Capacity Utilization reports about two weeks following the business month. The Census Bureau's Durable Goods Orders report is less timely, coming three or four weeks into the following month, but is still influential: It describes orders for cyclically sensitive items that last more than 3 years, such as capital goods, computers, and steel. The Factory Orders report, released weeks later by the Census Bureau, includes nondurable goods but lacks additional forecasting value. The Census Bureau also publishes the Business Inventories Report—formerly the Manufacturing and Trade Inventories and Sales Report—six weeks after the relevant month. Currency traders usually interpret a rising inventories-to-sales ratio as indicative of a weaker economy, lower interest rates, and a weaker dollar.

The BLS releases three monthly inflation announcements around the middle of the following month: Import and Export Prices, the Producer Price Index (PPI), and the Consumer Price Index (CPI). The PPI measures the price inflation of initial (crude), intermediate, and final goods, and presages the CPI release.[11] Although one might think that unexpectedly high inflation would reduce the value of the dollar through purchasing power parity (PPP), the effect depends on the expected Federal Reserve reaction to inflation pressures. If inflation pressures create expectations of higher interest rates, then the dollar could appreciate.

The Census Bureau releases the highly relevant but untimely monthly trade balance report 1½ months after the trading month. Similarly, the BEA releases the quarterly current account balance—with a Merchandise Trade Balance section, matching the Census Bureau release—2½ months after the end of the quarter. These announcements are formally called the International Trade in Goods and Services and the International Transactions Account (Current Account), respectively.[12] A positive (negative) trade balance surprise implies a smaller (larger) U.S. trade deficit and generally dollar appreciation (depreciation).

The Conference Board publishes indices for the Leading Economic Indicators, Coincident Indicators, and Lagging Indicators about three weeks after the reviewed month. These indicators do not generally influence the foreign exchange market because the components are essentially known by the time that they are released.

THE LITERATURE ON ANNOUNCEMENTS AND FOREIGN EXCHANGE

This section describes the literature that studies the effect of announcements on conditional mean exchange rate returns. The appendix shows summary information—an abbreviated abstract, the type of exchange rate, sample period, announcements, etc.—for these papers.

Methodology

To compare coefficients on announcement surprise series with different magnitudes, recent researchers have typically followed Balduzzi, Elton, and Green (2001) in standardizing surprises by subtracting the MMS expectation from the release and dividing those differences by the standard deviation of the series of differences. For example, the standardized surprise for announcement j is as follows:

[11] Initial goods include raw materials such as oil, coal, and wheat. Intermediate goods encompass papers, fabrics, cogs, and any other materials in the process of becoming a final good. Final goods are those goods used directly by consumers and businesses, rather than inputs to production.

[12] The current account also includes international factor payments—e.g., dividend or coupon payments—from past asset purchases. In addition, there are technical differences in how these statistics are constructed. The BEA uses quarterly chaining on annualized data, as well as underlying NIPA current dollar data. The Census uses monthly chaining with monthly data and Census current dollar data.

$$(1) \qquad S_t^j = \frac{R_t^j - E_t^j}{\hat{\sigma}_j}$$

where R_t^j is the realization of announcement j at day t, E_t^j is the MMS market expectation, and $\hat{\sigma}_j$ is the estimated standard deviation of the series of the differences. Thus, researchers use announcement surprises that are close to mean zero and have a unit standard deviation.

Because causality runs one way—exchange rates should react rapidly to the surprise component of announcements—the determination of the effect of announcement surprises on exchange rate returns is simple in a traditional "event study." Specifically, the most common method to study the effect of announcements on exchange rate returns is to simply regress exchange rate returns on J announcement surprises—perhaps with leads and lags of the surprises to characterize information leakage or delays in response—and other variables ($\boldsymbol{X_t}$), such as interest rates, that may affect exchange rate returns:

$$(2) \qquad R_t = \alpha + \sum_{j=1}^{J} \alpha_j S_t^j + \boldsymbol{\beta X_t} + \boldsymbol{\varepsilon_t}\,.$$

Researchers interpret the coefficient, α_j, as the change in the return as a result of a one-standard-deviation surprise in the jth type of news.[13]

Efficient Markets and the Earliest Announcement Studies

Researchers began assessing the role of macroeconomic news on foreign exchange rates in the early 1980s. Fama's (1970) EMH and the uncovered interest rate parity (UIP) hypothesis motivated the methods of these early papers. Specifically, efficient markets implied that "news" should explain any deviations of exchange rates from UIP. Several similar papers—Dornbusch (1980), Frenkel (1981), and Edwards (1982a,b)—explored this issue. Generally, they regressed monthly interest rate–adjusted foreign exchange returns—i.e., deviations from UIP—on "news" about various macro fundamentals related to monetary conditions, output, trade balances, and such. Edwards (1982a), for example, applied Zellner's (1962) seemingly unrelated regressions (SUR) to a system of UIP equations augmented with the difference between U.S. and foreign news about money supplies, income, interest rates, and monthly returns from July 1973 to September 1979. The author found mixed evidence that these news differentials predict deviations from UIP. Finding the "news" that moves exchange rates would require further investigation.

Unfortunately, the monthly data used in these early studies hindered precise estimates of announcement effects because noise from unrelated effects or other announcements would obscure true relations in the data (Hakkio and Pearce, 1985). In the 1980s the increasing availability of high-frequency data and more powerful computers allowed researchers to investigate foreign exchange reactions to macroeconomic announcements with much greater precision. High-frequency data produce inherently more precise estimates because they enable the econometrician to analyze price movements in a short interval around the announcement, which isolates the announcement's effect on the exchange rate.

Early Studies of the Effect of U.S. Monetary Policy on Foreign Exchange Returns

Early announcement studies focused on money supply releases because money was key to the exchange rate models of the 1970s and the Federal Reserve targeted nonborrowed reserves to achieve a desired path for M1 from October 1979 to October 1982. Several papers studied the impact of U.S. monetary news on foreign exchange markets, including the stability of such reactions in the presence of changes in Federal Reserve operating procedure.

A puzzling positive correlation between weekly money supply (M1) shocks and interest rate changes motivated some of this research. The correlation was puzzling because it seemed counter to the presumption that a liquidity effect should produce a negative correlation between money supply shocks and interest rates. Two possible explanations for the negative correlation

[13] We will see later that microstructure researchers would prefer a more complex system that includes order flow.

were (i) positive money supply shocks increased interest rates through a Fisher effect or (ii) positive money supply shocks raised interest rates by creating expectations that the Federal Reserve would reverse those positive shocks in the future by raising interest rates.[14] These explanations could alternatively be interpreted as a market expectation of a persistent money supply shock or a market expectation that the Fed would counter a money demand shock with higher rates.

Two very similar, approximately contemporaneous studies—Cornell (1982) and Engel and Frankel (1984)—attempted to resolve this puzzle with evidence from the foreign exchange market.[15] These studies regressed daily exchange rate changes on money supply announcement surprises, determining that positive M1 shocks increased the value of the USD. Cornell (1982) and Engel and Frankel (1984) argue that these results support the notion that a rising money supply produces expectations of future monetary tightening. The latter authors described this notion as "Keynesian," but it is not clear why it should be specifically associated with Keynesian thinking.[16] Cornell (1983) added evidence from stock and long-term interest rate markets, considered more explanations for the puzzle, and concluded that the data were not fully consistent with any one model.

Later papers considered two questions: How do reactions vary in response to policy changes? How do exchange rates react to a broader set of macroeconomic surprises?

Hardouvelis (1984) studied the October 1979 shift in Fed operating procedures from interest rate targeting to control of the money supply. Using Friday-to-Monday spot exchange rates from February 15, 1980, to June 25, 1982, and UIP to measure expected future exchange rates, Hardouvelis (1984) found that positive M1 surprises appreciate the spot value of the dollar but reduce its expected future value.[17] He concluded that the liquidity effect dominates in the short run—markets expect higher real rates in response to M1 growth—but that the inflation premium (the Fisher effect) reduces the expected future value of the dollar.[18] In contrast, positive M1 shocks tended to depreciate the dollar in 1977-79. Although the Fed did not have complete inflation-fighting credibility in either sample, results from the foreign exchange market indicate that its credibility was much higher in the second subsample, after October 1979.

Hardouvelis (1988) followed up on his earlier study by examining how the importance of monetary and macro announcements changed in response to the end of Federal Reserve monetary targeting in October 1982. Using daily data from October 11, 1979, through August 16, 1984, he showed that markets responded significantly to trade deficit, inflation, and business cycle news. But exchange rate reactions to news about reserves displayed some instability. Sheehan and Wohar (1995) found that U.S. money supply announcements stopped affecting USD rates in 1986 or 1987. This date is consistent with Meulendyke's (1998) estimate of when the FOMC switched to interest rate targeting but later than Thornton's (2006) assessment of 1982. Sheehan and Wohar (1995) also found some evidence of asymmetry: Only bad news affects exchange rates.

Hakkio and Pearce (1985) researched the effect of M1, CPI, PPI, unemployment, and industrial production shocks on seven exchange rates with three exchange rate observations per day over three subsamples that were defined by perceived changes in Federal Reserve operating procedures: (i) federal funds targeting, September 29, 1977, to October 5, 1979; (ii) reserves targeting, October 6,

[14] This line of research helped to illuminate the distinction between uncertainty about the long-run inflation rate and short-run liquidity. This distinction is featured in recent New Keynesian models such as Smets and Wouters (2007), Ireland (2007), and Cogley and Sbordone (2008).

[15] Engel and Frankel (1984) was written in 1982.

[16] Engel and Frankel (1984) associated the idea that tighter money market conditions would raise interest rates with Keynesian IS/LM modeling.

[17] With the benefit of hindsight, the persistent failure of the UIP relation to predict exchange rates makes it seem inappropriate to equate interest-adjusted exchange rates (i.e., forward or future rates) with "expected spot rates." In the early 1980s, such evidence was just beginning to emerge, however.

[18] Culbertson and Koray (1986) investigate the correlation between money growth and interest rates through regressions of the forward premium on money shocks, but this does not shed light directly on foreign exchange responses to money supply changes.

1979, to October 4, 1982; and (iii) federal funds targeting, October 6, 1982, to March 2, 1984. Only unexpected changes in M1 consistently affected exchange rates, the changes in exchange rates occurred rapidly, and those effects were significant only after October 1979, confirming the results of Hardouvelis (1984). After October 1979, the foreign exchange market began to behave as though it believed that the Federal Reserve would reverse positive M1 shocks by raising interest rates.

Tandon and Urich (1987) evaluate the effects of both U.S. money supply and PPI and CPI inflation announcements on interest rates and exchange rates for seven industrialized countries from 1977 to 1982. Regrettably, they did not allow for structural breaks during the sample to reflect the October 1979 changes in Federal Reserve operating procedures, as they did for some of their work on interest rates. Nevertheless, the authors found that the value of the USD significantly appreciated with respect to the GBP and CAD in response to a positive PPI shock, possibly because markets expected the Federal Reserve to reverse such a price level shock with higher interest rates in the future.[19] CPI announcements, which are released later than PPI, had no effect on exchange rates or interest rates. It is not clear why Tandon and Urich (1987) found significant effects for PPI shocks on the GBP and CAD when Hakkio and Pearce (1985) had not, but Hakkio and Pearce's (1985) relatively short subsamples might have contributed by reducing the power of their tests. On the other hand, Hakkio and Pearce's (1985) three observations per day should have provided better power to reject the null of no effect.

One should note that it is not necessary for the FOMC to respond directly to PPI shocks for such shocks to influence expectations of future policy. Shocks can move exchange rates if the market thinks that either the FOMC does pay attention to the shock or the FOMC (or another central bank) pays attention to something that PPI predicts, such as shocks to the CPI or shocks to PCE. It is also possible that the results were simply spurious.

Early Studies of Non-U.S. Monetary Policy and Foreign Exchange Returns

Several papers studied exchange rate reactions to non-U.S. money supply/monetary policy announcements. A common theme was that market reactions to money supply or macroeconomic announcements depended on market expectations of the central bank's response to the surprise.

Doukas (1985), for example, used daily data to compare the reactions of the CAD/USD exchange rate to U.S. and Canadian money supply announcements from 1974 to 1978. Using an ARIMA model to compute expectations, he found that U.S. money surprises were more influential on foreign exchange markets than were their Canadian counterparts, speculating that this was because the weekly U.S. figures were released 50 minutes before the analogous Canadian numbers.[20] Alternatively, Canadian monetary policy announcements might have been perceived as less important because markets believed that the Bank of Canada was following the Federal Reserve's policy actions to maintain stable exchange rates.

Ito and Roley (1987) investigated whether tight monetary policy or the underlying strength of the U.S. economy was responsible for the strong appreciation of the USD in the early 1980s. Using five observations per day over several subsamples of 1980-85, Ito and Roley (1987) examined responses to U.S. and Japanese money, industrial production, and price announcements. Positive shocks to the U.S. money supply had the largest positive effect on the value of the dollar, which probably reflected expectations that the positive shocks would be reversed in the future with higher interest rates. This effect confirms findings by Hardouvelis (1984) and Hakkio and Pearce (1985).

[19] Clarida and Waldman (2008) show that the domestic currency can appreciate in response to a higher-than-expected inflation shock if the domestic central bank follows a Taylor rule. They also provide some empirical evidence on the effect of inflation shocks on the exchange rates of 10 countries over the 2001-05 period.

[20] Gilbert et al. (2010) investigate the importance of three factors—ability to forecast FOMC decisions and current GDP, timeliness, and revision noise—in explaining the differential impact of news on interest rates, equities, and exchange rates. They find that timeliness is the single most important factor, followed by ability to forecast FOMC decisions and current GDP.

Very similarly, MacDonald and Torrance (1988) used exchange rate reactions to U.K. money supply announcements to determine that a higher-than-anticipated money supply induced expectations of future reversals of the money supply, higher interest rates, and exchange rate appreciation rather than the depreciation that would be induced by expectations of higher inflation.

Almeida, Goodhart, and Payne (1998) used two years of 5-minute DEM/USD data to determine the effects of U.S. and German macroeconomic news. Markets reacted less strongly and more slowly to German announcements than U.S. announcements, perhaps because—according to Almeida, Goodhart, and Payne (1998)—the former were unscheduled during 1992-94. Of course, another explanation for the weaker reaction is that the reaction occurred gradually as information leaked prior to the official announcement. While other papers have presented evidence of information leakage prior to German announcements, Almeida, Goodhart, and Payne (1998) argue that this explanation is unlikely: There was no evidence of systematic reaction to the announcement surprise in the minutes prior to the release.[21] As with many other papers in the literature on monetary policy news and exchange rates, the authors concluded that expectations of the respective central bank's reaction function determine market reaction to announcements.

Budget Deficits and Foreign Exchange Returns

Deravi et al. (1989) define three subsamples—similar to those defined by Hakkio and Pearce (1985) according to Federal Reserve operating procedures—in finding that neither anticipated nor unanticipated U.S. Treasury debt announcements (1975:Q3–1985:Q3) affect foreign exchange returns. The authors suggest that some combination of Federal Reserve interest rate–targeting policies, an incorrect expectations specification from ARIMA models, or a lack of power could explain their negative results. Indeed, the short length of their subsamples (3 to 4 years) with quarterly announcements suggests that the tests probably had very little power to reject the null hypothesis that debt announcement shocks did not influence foreign exchange markets.

Later work by Beck (1993) and Kitchen (1996) on debt announcements suggests the sample might have been part of the problem. Using data from January 1980 through July 1990, Beck (1993) considered whether M1 shocks, U.S. federal budget balance shocks, and spending projections influenced exchange rates. Beck's results emphasized the importance of international capital flows: Unexpectedly large budget deficit surprises raised real U.S. rates, which caused capital inflows and USD appreciation.[22] Government deficits did not crowd out real investment so much as they imported investment from abroad. As with the findings for money supplies, Beck (1993) found some evidence that market perceptions of policy changed the impact of deficit shocks. That is, foreign exchange markets seemed to stop reacting to deficit shocks after the passage of the Gramm-Rudman-Hollings bill in 1985, which was widely perceived to limit future deficits. In short, exchange rates react to budget deficit news when that news is viewed as indicating persistent, unsustainable deficits.

Early Work on the Trade Balance and Employment Effects

Just as monetary policy issues strongly influenced research in the late 1970s and early 1980s, the emergence of very high unemployment rates in the early 1980s and record U.S. trade deficits in the mid- to late 1980s prompted a surge in research on the effects of those announcements on foreign exchange markets. During the late 1980s, anecdotal reports indicated that the large U.S. trade deficit heavily influenced currency markets: Geiger (1989) notes that "the dollar finished stronger yesterday, lifted by the report of the smallest monthly U.S. trade deficit since December 1984."

[21] Andersson, Hansen, and Sebestyén (2009) find evidence that markets obtain information about German unemployment data prior to the official announcement.

[22] With a somewhat longer sample, 1981 to 1994, Kitchen (1996) confirmed Beck's (1993) results that the larger deficit projections tend to raise the value of the USD. Interestingly, Kitchen notes that the degree of international financial integration influences the strength of the response of foreign financial markets to U.S. news.

Traders presumably feared either (i) that U.S. policymakers would respond to high deficits with protectionist measures or contractionary monetary policy or (ii) that natural equilibrating mechanisms—associated with dollar depreciation—would tend to reduce deficits.

Even the earliest researchers noticed that market reactions to trade deficit news varied through time, as trade deficits became too large to be sustainable. Deravi et al. (1988) and Irwin (1989) found evidence that the trade balance had significant effects, but only after 1985 and June 1984, respectively. Larger U.S. trade surpluses (deficits) were associated with USD appreciation (depreciation). Hogan, Melvin, and Roberts (1991) examine reasons for the increasing sensitivity and conclude that unexpectedly large trade deficits create expectations of U.S. foreign exchange intervention and/or protectionist trade measures. Klein, Mizrach, and Murphy (1991) and Aggarwal and Schirm (1992) both argue that increased policy cooperation—the 1985 Plaza accords—increased the influence of balance of trade announcements on currency returns. Karfakis and Kim (1995) discover two significant breaks in the effect of U.S. trade deficit news on the AUD/USD exchange rate from 1985 to 1992. The breaks occurred in October 1987 and January 1990, which coincided with a major worldwide stock market crash and a shift in Australian monetary policy, respectively. It is not clear why these events would have prompted a change in currency markets' reactions to trade deficits.

Returns might react asymmetrically to trade deficit news, as they do to other announcements. For example, if the U.S. trade deficit is viewed as nearly unsustainable, an unexpected rise in that statistic could have large effects on the expected (and thus current) value of the dollar, whereas an equally sized unexpected decline in that statistic could lead to almost no change in the dollar's value. This possibility motivated study of the symmetry of response to trade balance releases. Sultan (1994) finds that positive/negative balance of trade announcements have asymmetric influences on exchange rates and that the impact of that news can differ across spot and futures markets. No subsequent research confirmed this latter pattern.[23] Aggarwal and Schirm (1998) find both asymmetry and nonlinearity in exchange rate reactions to U.S. trade balance announcements. Curiously, smaller surprises have a proportionately larger impact on exchange rates. Fatum, Hutchison, and Wu (2010) studied asymmetric effects for a wide variety of announcements with a fairly long sample but found no asymmetry for U.S. trade balance announcement effects on the JPY/USD.

In addition to the trade balance and monetary policy announcements, early researchers such as Harris and Zabka (1995) and Moorthy (1995) recognized the importance of the employment report. Unexpectedly strong employment in the United States increased the foreign exchange value of the dollar, perhaps because it increased expected short-term interest rates. Consistent with this interpretation, Moorthy (1995) documents that U.S. employment news that raised the value of the dollar also raised short-term U.S. interest rates. Ederington and Lee (1993, 1995) support the claim that employment news affects foreign exchange returns through expectations of future interest rates.

Curiously, Payne (1996) finds that U.S. trade balance and employment releases produce large effects that persist for over an hour. The reason for the delay is not clear and the finding could be spurious. The next section describes the event study results on the speed of market reactions to announcements.

How Fast Do Markets Adjust?

As discussed previously, the semi-strong form of the EMH predicts that any systematic reaction to public news should be very rapid, to preclude abnormal profit opportunities. Ederington and Lee (1993) investigate how the release of macroeconomic news affects absolute 5-minute USD/DEM returns. Serial correlation tests indicate that the mean exchange rate adjusts to scheduled news within one minute. Ederington and Lee (1994) confirm these results using USD/JPY data. Ederington and Lee (1995) use tick-by-tick data

[23] Puffer (1995) studies the dynamic behavior of successive balance of trade announcements and their relation to exchange rates.

to refine estimates of the speed of adjustment. The currency market begins to adjust its prices within 10 seconds of a news release and completes the change within 40 seconds. The authors also argue that prices overreact in the first 40 seconds and then retreat over the next couple of minutes.

With a sample similar to that of Ederington and Lee (1993), Tanner (1997) finds that although DEM/USD markets react rather quickly to trade balance announcements, the response to U.S. CPI announcements is insignificant from 9 to 10 AM but becomes significant for several periods later in the day. Tanner suggests that market participants require hours to digest the complexity of the CPI report. This explanation is difficult to reconcile with the fact that the delayed systematic response is to a simple object (i.e., the surprise component of the CPI). It is also inconsistent with other studies of the CPI, such as Hakkio and Pearce (1985), Tandon and Urich (1987), and Faust et al. (2007), who all found no significant effect of the CPI. These facts suggest that Tanner's finding is most likely spurious. The systematic reactions of markets to scheduled news are very rapid when measured with conventional event study methods.[24]

Joint Modeling of Mean Returns and Volatility

Andersen et al. (2003) use high-frequency (5-minute) data to comprehensively study the responses of both the conditional mean and the conditional volatility of DEM/USD, USD/GBP, JPY/USD, CHF/USD, and USD/EUR exchange rates to a large set of U.S. and German announcements. The authors reason that the conditional volatility cannot be modeled without correctly modeling the conditional mean, although they do not explore the practical significance of this methodological care. The authors estimate the model in two stages: (i) They estimate the model by ordinary least squares; (ii) then, with the residuals from the first stage, they reestimate the conditional mean by weighted least squares (WLS), permitting the variance weights to depend on the intraday calendar, news, and conditional volatility effects. WLS more efficiently estimates the announcement surprise coefficients than would unweighted estimates with heteroskedasticity-corrected standard errors.

Andersen et al. (2003) confirm and elaborate on some previous findings. Exchange rates react quickly—"jumping" to a new value and then showing no systematic movement. Also, the first release among a group of related announcements tends to be the most influential. U.S. payroll employment, orders of durable goods, the balance of trade, initial unemployment claims, the NAPM index, retail sales, consumer confidence, and advance GDP significantly affect all exchange rates studied. In addition to these universal effects, CPI, PPI, industrial production, leading indicators, housing starts, construction spending, the federal funds rate, new homes sales, and preliminary and final GDP influence the DEM/USD exchange rate. Among German announcements, only M3 and industrial production significantly influence exchange rates; the authors attribute the relative lack of significance to the unscheduled timing of German announcements. In addition, Andersen et al. (2003) note that markets react asymmetrically to positive/negative announcement surprises, where bad news moves exchange rates more than good news. Generally, positive (negative) U.S. announcement news induces dollar appreciation (depreciation).

Andersen et al. (2003) produced a comprehensive and careful event study of the effect of U.S. and German announcements on exchange rate returns and also documented asymmetry of responses and found that bad news produced more dispersion in analysts' expectations of events. In their conclusion, they discussed the importance of future investigations into how "order flow" actually translates news into price changes. The next section reviews how the microstructure literature considered this issue.

Order Flows and Announcement News

The microstructure literature studies the way that order flows—i.e., signed transaction flows—

[24] Evans and Lyons (2005), however, argue that persistent effects can be found by jointly analyzing order flow and returns data.

impound private information into asset prices.[25] For example, commercial firms make investments based partly on the basis of their privately known cost structures, and asset managers reallocate holdings based on their preferences and existing portfolio.[26] These trading decisions impound private information into prices. And private information can interact with public information in informing trading decisions. For example, investment decisions depend not only on private information but also on the information in macroeconomic releases, which might change judgments about the state of the economy or asset (co)variances.

Much of the literature on announcement effects on the foreign exchange market has implicitly assumed that markets react directly to surprises, without specifying the manner in which markets translate surprises to price changes. Starting around 2000, however, researchers began to consider how trading and news interact to influence exchange rates. Specifically, researchers asked two types of questions: (i) Does order flow itself react to news? (ii) Does order flow help impound news into prices? If so, does news influence the price impact of trading?

The issue of order flow reaction to news requires some explanation. In the context of the stock market, Hasbrouck (1991) reasoned that news surprises should not directly affect order flow under rational expectations. News should cause an immediate price adjustment to a new equilibrium price but should not cause systematic orders; otherwise, the price effects from those predictable orders would themselves be predictable, creating a profit opportunity. While the Hasbrouck reasoning has strongly influenced the microstructure literature, Evans (2010) lays out two microstructure models in which such reasoning fails because announcements can affect order flow through dealers' risk management practices. Dealers adjust their quotes to produce predictable patterns in order flow to better manage their inventory risk.

Four papers do study the effects of news on order flows (or trading flows). Evans and Lyons (2005) find that coefficients on standardized news surprises clearly explain order flow in reduced-form vector autoregressions (VARs). In fact, even lagged news significantly determines order flow, implying a prolonged impact of news on order flow. Rime, Sarno, and Sojli (2010) find a reduced-form effect on interdealer order flow for the USD/EUR, USD/GBP, and JPY/USD exchange rates. Similarly, Gradojevic and Neely (2009) find clear reduced-form effects on CAD trading flows from U.S. macroeconomic news. These reduced-form impacts are potentially consistent with Hasbrouck's (1991) claim that news should not systematically cause order flows if expectations are rational, however. For example, if order flows react systematically to exchange rate changes, then any announcement that changes the exchange rate will also predict order flow. The results of Love and Payne (2008) are not consistent with Hasbrouck's reasoning, but Evans' (2010) inventory management models could explain them. Love and Payne (2008) find both reduced-form and systematic structural effects of macro releases on order flow using identified bivariate VARs with macro surprises as regressors.

More papers have studied the second issue: How does order flow mediate the impact of news on exchange rates? Evans and Lyons (2002) pioneered the study of this question with actual order flows. Their paper does not directly study announcement effects on exchange rates but rather finds that macro announcements increase the price impact of order flow using four months of DEM/USD transactions from May 1 to August 31, 1996.

Evans and Lyons (2005) use all Citibank USD/EUR customer trades from April 11, 1993, to June 30, 1999, to reinvestigate the speed with which currency market returns and order flows

[25] Order flow is related to trading volume as the latter is the sum of absolute order flows. Some previous work, such as Fleming and Remolona's (1999) bond market studies, observed that announcement releases actually reduce trading volume in asset markets.

[26] Unfortunately, the nature of order flow data does not reveal the specific nature of the private information that prompts the order and researchers have not—to our knowledge—pursued this issue. It is unlikely that even the banks that collect the order flow data generally know the nature of the reason for the order. The closest that one can come to inferring the private information is to obtain order flow that is classified into various categories such as commercial or financial.

respond to news.[27] They define the *average news effect* as the direct effect of macroeconomic news releases on foreign exchange currency rates, while the sum of the direct effect and the indirect effect of order flows comprises the *total news effect*.[28] Evans and Lyons (2005) argue that the total news effect of a news release on foreign exchange rates should include not only the immediate price response but also the response to delayed trades. Using a reduced-form VAR model to examine the joint dynamics of returns and order flows, Evans and Lyons (2005) find substantial effects of macro surprises on both returns and order flows. In addition, they claim that announcements produce a delayed systematic reversal of the initial price impact, over the course of several days. This contrasts with Ederington and Lee (1995), who find that price movements are completed within 40 seconds of an announcement. Evans and Lyons (2005) explain the delay by arguing that end users do not constantly monitor currency markets and must take time to evaluate price changes and transact, presumably because they are rationally inattentive (Sims, 2005). While it is not immediately clear how to reconcile this systematic retrenchment from the initial price impact with an efficient market response, Evans and Lyons (2005) explain that the persistent effect is small and would be difficult to detect in returns alone; but analyzing the joint behavior of returns and order flows enables one to find the persistent effect. Evans (2010) discusses how dealer risk management might contribute to this persistent response. Evans and Lyons (2005) also argue that the inclusion of order flow makes the daily responses of returns to announcements relatively stable.

Evans and Lyons (2008) consider a broad measure of macro news—Reuters Money Market Headline News—rather than a small group of specific announcements and study how this news influences exchange rates through order flow using a four-month sample of daily and intraday interdealer order flow and DEM/USD exchange rates from 1996 (see Evans and Lyons, 2002).[29] The authors estimate a complex, nonlinear model of intraday exchange rate returns and interdealer order flow with the generalized method of moments. The arrival of news increases trading intensity and the price impact of order flow, which indicates that news disperses private information through trading activity. The authors go on to identify the contemporaneous relationship between daily exchange rates and order flow with the heteroskedasticity-dependent methods of Rigobon and Sack (2004) and estimate a simpler model on daily data with the generalized method of moments. Macro news generates about 36 percent of daily exchange rate variance: The direct impact creates about 14 percent and the order flow channel about 22 percent. Evans and Lyons (2008) note that 36 percent is an unusually large proportion of variance to attribute to public news, compared with previous studies, and they argue that the inclusion of order flow effects produces this more-credible level. Announcements fail to affect daily order flow's explanatory power.

With 10 months of 1-minute data on the USD/EUR, GBP/EUR, and USD/GBP exchange rates and Rigobon's (2003) "Identification Through Heteroskedasticity" procedure, Love and Payne (2008) use a structural VAR to show that Reuters' interdealer D2000-2 order flow partially impounds U.S., U.K., and euro-area aggregated macro news into prices.[30] Treating standardized and signed news surprises from different series as a single news variable, the authors find that order flow accounts for about one-third of the price adjustment produced by announcements. Despite the mediating role of order flow, prices adjust very quickly, within two minutes of the news release. Love and Payne (2008) also reconfirm the traditional finding that announcement effects depend on policy expectations. For example, a rise in U.S. inflation tends to cause the USD to depreci-

[27] Prior to 1999, the authors used the aggregated order flow of all the euro-area currencies as USD/EUR order flow.

[28] In the language of structural econometrics, the average effect is a pseudo-structural effect of news while the total news effect is a reduced-form effect.

[29] The authors also use alternative measures of macro news, including aggregated signed surprises for 28 U.S. and 12 German announcements.

[30] The identification scheme assumes that the exchange rate and order flow structural errors have zero covariance with each other and with news and follow GARCH(1,1) processes.

ate, consistent with PPP, but a rise in U.K. inflation tends to cause the GBP to appreciate. The authors conjecture that the latter result is consistent with expectations that the Bank of England—which is an explicit inflation targeter—will raise interest rates to bring inflation back down to the target. Alternatively, Beechey's (2007) work suggests that U.S. inflation expectations are well anchored and the Love and Payne findings could be explained if U.S. inflation shocks have a bigger effect on risk premia than do U.K. inflation shocks.

Order flow also responds to news—in the same direction as the exchange rate changes—with a slight delay. Love and Payne (2008) label this finding as "entirely novel." The authors speculate that news systematically influences order flow because heterogeneous agents disagree on the implications of announcements for rates and such disagreement induces order flow.

Carlson and Lo (2006) have an unusual announcement study in that they examine the reaction of the Reuters D2000-2 electronic order book on foreign exchange transactions to a single announcement—an October 9, 1997, surprise interest rate hike by the Bundesbank, aimed at heading off inflation pressures. Markets initially responded to this unscheduled and surprising news with high trading volume, volatility, and a fall in the DEM/USD rate.

Savaser (2006) uses proprietary order book data from the Royal Bank of Scotland over two subperiods during the September 1999 to September 2002 sample to show that investors substantially increase their use of limit orders—stop-loss and take-profit orders—prior to news releases and that accounting for this behavior increases the econometrician's ability to explain exchange rate changes, especially large ones.[31] Some of the exchange rate reaction to scheduled news might be independent of the release's information content.

Rime, Sarno, and Sojli (2010) use one year of high-frequency USD/EUR, USD/GBP, and JPY/USD data—February 13, 2004, to February 14, 2005—to investigate the ability of Reuters' interdealer D2000-2 order flows to predict daily exchange rates. In doing so, they find that macro announcements are important determinants of order flow. Consistent with Love and Payne (2008), good news for the U.S. (foreign) economy increases (decreases) order flow for the USD. In a novel contribution, Rime, Sarno, and Sojli (2010) find that order flow in the days just prior to the news announcement reflects recent revisions in MMS expectations after the day of the survey.

Gradojevic and Neely (2009) investigate the interaction of CAD/USD trading flows—net bank trades in the foreign exchange market—exchange rates, and macro news surprises with a vector error correction model. Although the authors focus on forecasting, the paper shows that GDP, housing starts, PCE, CPI, and the U.S. balance of trade all affect the CAD/USD exchange rate significantly. Curiously, exchange rates and trading flows exhibit a strong pattern in response to macro news surprises. Announcements that increase the value of the USD also tend to increase foreign financial demand for USDs and decrease commercial demand for USDs. Thus, the total impact of news on trading flows depends on the type of trading flow. One interpretation of the Gradojevic and Neely (2009) results is that non-Canadian financial traders react most strongly to news announcements, their trades drive the exchange rate, and price-sensitive commercial traders then tend to buy the currency that became cheaper as a result of the news release.

The announcement/order flow literature considers how announcements might affect exchange rates by releasing private information through order flows. Although private agents generally have incentives to keep their own information private, policymakers usually have an incentive to reveal their information to the public to ensure smooth functioning of markets. The following section reviews studies of the release of monetary policy information.

Recent Research on Monetary Policy, Announcements, and Exchange Rates

Several trends and events in the late 1990s renewed attention on monetary policy announce-

[31] A stop-loss (take-profit) order instructs dealers to liquidate an agent's position in the event that asset prices move to specified levels against (in favor of) the agent's position. For example, a stop-loss order on a long position would be triggered if the price fell below a specified level.

ments. First, the U.K. government gave the Bank of England operational independence in the conduct of monetary policy in 1998. Second, as of January 1, 1999, the European Central Bank (ECB) began to conduct a common monetary policy for the original members of the European Monetary Union: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Third, policymakers and researchers began to seriously consider the importance of communication and central banks responded by increasingly explaining their policy actions.[32] Naturally, researchers began to investigate the effects of policy expectations, policy actions, and communications more carefully.

Soon after the ECB began to conduct monetary policy in 1999, researchers began to study its effect on foreign exchange markets and its influence on how these markets react to announcements. Galati and Ho (2003), for example, compare the influence of U.S. and European macroeconomic announcements on daily USD/EUR exchange rates in the first two years of the European Monetary Union. Using rolling regressions, they find that the geographic origin of news and its "sign" (i.e., whether it is good or bad news) determine the response of the USD/EUR exchange rate.[33] The authors interpret their result to indicate that markets became pessimistic about the euro's prospects near the end of 1999 and reacted strongly to any bad news from the euro area.

Cagliesi and Tivegna (2005) study scheduled and unscheduled U.S. and euro-area announcements—policy statements, market events, market beliefs, terror-related events—using twice-daily data. Scheduled news affects U.S. trading more, whereas unscheduled news dominates in European trading. After dividing their 1999-2004 sample into three subperiods, the authors find lagged effects of news on exchange rates, which lead them to reject the semi-strong form EMH. Other research has not confirmed this curious finding.

Conrad and Lamla (forthcoming) study the separate effects of the ECB's interest rate decision, press conference, and question-and-answer session on the level and volatility of the EUR/USD exchange rate. The authors find that the press conference is most relevant for exchange rate returns. The EUR appreciates in response to communications about increasing risks to price stability, consistent with market beliefs that the ECB will respond strongly to inflation.[34] In contrast, communications about the real economy or monetary aggregates do not generate significant reactions.

Each month since 1997, the Bank of England's Monetary Policy Committee has met to decide interest rate policy.[35] Melvin et al. (2009) study the effect of these Bank of England announcements on currency markets from 1997 to 2007. Surprisingly, the noon interest rate announcement does not systematically affect returns but does raise exchange rate volatility for 60 to 90 minutes and such effects are particularly likely to be large when the announcement content is unexpected.

Hayo and Neuenkirch (2008 and 2009) use daily GARCH-in-mean models to analyze the effect of U.S. macro announcements and monetary policy communications on Argentinean and Canadian stock, bond, and foreign exchange market returns and volatility, respectively. Both sample periods are from 1998 to 2006. The particular sample period is useful because it contains important breaks in both Argentinean and Canadian policy. That is, Argentina operated a currency board until 2002, tightly linking domestic money markets to those in the United States. The Bank of Canada introduced "fixed announcement days"—scheduled interest rate announce-

[32] For example, the FOMC began to contemporaneously announce policy actions in 1994 and adopted this as formal policy in 1995. Starting in August 1997, each FOMC policy directive has included the quantitative value of the "intended federal funds rate." And since 1999, the FOMC has issued a press release after each meeting with the value of the "intended federal funds rate" and, in most cases, an assessment of the balance of risks (Poole, Rasche, and Thornton, 2002).

[33] Edison (1996) mentions asymmetry between responses to good and bad news.

[34] This result supports the arguments of Engel and West (2006) and Clarida and Waldman (2008).

[35] On May 6, 1997, Chancellor of the Exchequer Gordon Brown announced that the U.K. government would grant the Bank of England operational independence over monetary policy. The Bank of England Act 1998 formalized this arrangement.

ments—in September 2000. Hayo and Neuenkirch (2008) find that, although U.S. announcements had a significant impact on Argentine markets, their influence (unsurprisingly) diminished after the end of the currency board, which was never completely credible.[36] Hayo and Neuenkirch (2009) determine that while both U.S. and Canadian macroeconomic announcements influence foreign exchange returns, the Canadian interest rate announcements mattered most when U.S. and Canadian interest rate policies diverged in 2002-04. This is intuitively sensible: As Canadian announcements imparted more independent information about relative fundamentals, markets would pay more attention to them.

Hayo, Kutan, and Neuenkirch (2008) study FOMC effects on several financial markets, including the USD/EUR market, from 1998 to 2006. They find that formal communications have a greater influence than informal communications and that the importance of FOMC members' statements depends on their role on the Committee. The Chairman and Vice Chairman have the greatest effect on financial markets, governors' statements have greater importance than Reserve Bank presidents, and voting presidents have greater impact than non-voting presidents. Financial markets react more to newswire reports than to the actual speeches.

With the onset of the financial crisis in 2007, central banks began to consider alternative monetary policy tools, including asset purchases. Although work on the effects of these new policy tools has been limited, Neely (2010a) used event study methods to find that announcements of the Federal Reserve's large-scale asset purchases (LSAP) of agency debt, MBS, and long-term U.S. Treasuries substantially reduced long-term U.S. and foreign bond yields as well as the foreign exchange value of the dollar. The exchange rate effect was roughly consistent with that implied by a UIP-PPP–based model. The author argues that the LSAP's success in reducing long-term interest rates and the value of the dollar shows that central banks are not toothless when short rates hit the zero bound.

In summary, relatively recent research indicates that the effect of monetary policy communications on foreign exchange markets depends on the nature of the communication. That is, who is the communicator? What sort of news (i.e., type and geographic origin) do markets perceive as influencing the particular central banks? What are the stated and unstated goals of the central banks? In other words, news influences exchange rates to the extent that it changes market expectations of central bank actions.

Recent Research on Announcements and Larger Exchange Rate Issues

Researchers have continued to characterize the exchange rate reactions to macroeconomic surprises while often attempting to link those reactions to larger questions. Simpson, Ramchander, and Chaudhry (2005) consider what the effects of announcements imply for the speed of adjustment to several equilibrium foreign exchange conditions. Ehrmann and Fratzscher (2005) reconnect the announcement literature with forecasting, while Faust et al. (2007) study the implications of the joint movement of exchange rates and interest rates for expected depreciation and risk premia. Finally, Andersen et al. (2007), Pearce and Solakoglu (2007), and Fatum, Hutchison, and Wu (2010) investigate whether the state of the business cycle influences the impact of macro announcements on exchange rate returns.

Simpson, Ramchander, and Chaudhry (2005) investigate the implications of macro surprises for several "theories of exchange rate determination"—PPP, covered interest parity, the international Fisher effect, balance of payments, and portfolio balance effects—that might be better termed equilibrium conditions. The authors calculate the effect of 23 types of U.S. macroeconomic surprises on a 10-year sample (January 1, 1990, to September 7, 2000) of daily spot and forward returns for five exchange rates: CAD, DEM , JPY, CHF, and GBP per USD. The authors interpret

[36] A lack of complete credibility simply means that there is evidence that people believe that it is possible—even if very unlikely—that the currency board could break down. One can usually reject complete credibility for fixed exchange rate arrangements (Neely, 1994 and 1996).

announcements that reflect consumer demand, such as the trade balance, as affecting the dollar's value through balance of payments equilibrium. As in other studies, positive shocks to U.S. inflation do not reduce the dollar's value, which is inconsistent with continuous adjustment to PPP, but is consistent with stable long-run inflation expectations.

Ehrmann and Fratzscher (2005) attempt to combine the literatures on exchange rate forecasting and macro surprises. Using daily data from 1993 to 2003 and a WLS procedure similar to that of Andersen et al. (2003), Ehrmann and Fratzscher (2005) estimate the impact of macro surprises from the United States, Germany, and the euro area. Echoing the findings of Doukas (1985) on U.S. and Canadian monetary policy announcements, Ehrmann and Fratzscher (2005) find that U.S. surprises have a larger effect than euro-area surprises because the U.S. announcements are released earlier in the month; exchange rates respond more strongly to negative or large shocks or when market uncertainty—measured by volatility—is high. These authors then argue that the in-sample fit of the macro announcements effectively tracks the directional changes in the exchange rate.

Faust et al. (2007) formalize the point that the source of the shocks determines the effect of the macro announcements. The change in asset prices directly around a macro announcement should depend on how the release changes the public's perception of the economy's state. In particular, Faust et al. (2007) describe an example in which lower-than-expected inflation might result from either weak demand or high productivity growth. The former shock should decrease expected future interest rates, whereas the latter might increase them. Reminiscent of Cornell's (1983) methods, Faust et al. (2007) argue that one should jointly study the effects of announcements on multiple asset prices to distinguish which source of shocks is most likely. Using a 16-year span (January 1987 through December 2002) of 5-minute exchange rate and interest rate data, the authors find that 10 U.S. macroeconomic announcement surprises strongly affect exchange rate returns. Stronger U.S. real activity or overnight higher interest rates appreciate the USD and raise (reduce) U.S. (foreign) interest rates at all horizons.

Nyblom (1989) tests of parameter constancy generally fail to reject the null of constant parameters over the sample, but random coefficients estimation do detect a definite decline in the trade balance coefficients and some decline in the nonfarm payroll coefficients for the exchange rate equations.[37] This paper generally rejects parameter instability, concluding that time variation "does not seem to have been a first order issue." But its sample coincides fairly closely with the well-known "Great Moderation," a period of very low macroeconomic volatility (Blanchard and Simon, 2001). Therefore one might think that parameter instability is not a first-order issue when macroeconomic conditions and policies are stable.

Reasoning from a risk-augmented UIP relation, Faust et al. (2007) argue that if stronger-than-expected U.S. economic data immediately appreciate the USD, then they must also produce some combination of expected future USD depreciation or a lower risk premium (i.e., higher prices) for foreign assets. The authors conclude that because existing models of risk cannot explain the necessary declines in the risk premium, expected depreciation seems to be a more plausible consequence of the announcement-induced exchange rate changes.

Andersen et al. (2007) also emphasize the use of multiple assets in investigating larger issues, including the impact of announcements conditional on the state of the business cycle and comovements among asset prices. Using their previously developed two-step WLS procedure, Andersen et al. (2007) study the effect of 25 U.S. macro announcements on USD exchange rate futures, as well as U.S., British, and German stock and bond futures, using 5-minute data. They measure the effects for periods of U.S. expansions, contractions, and the full sample, from January 2, 1992, through December 31, 2002. As in previous work, positive real shocks to the U.S. economy

[37] Nyblom (1989) proposes a test that parameters are constant versus the alternative that they follow a random walk.

tend to cause USD appreciation. Although they focused on stock and bond returns, the authors also documented cross-country linkages in the U.S. Treasury bond, the S&P500, and the USD/EUR futures returns over both U.S. expansions and contractions, identifying the conditional correlation with Rigobon's (2003) heteroskedasticity-based methods. The U.S. announcements cannot explain all the cross-country linkages.

Two recent papers have considered whether announcement effects are symmetric and dependent on the business cycle. Pearce and Solakoglu (2007) find apparently linear, symmetric, and rapid effects of 11 types of U.S. shocks on 10 years of high-frequency DEM/USD and JPY/USD exchange rates but do argue that the effects depend on the state of the economy. Fatum, Hutchison, and Wu (2010) investigate the impact of 19 U.S. and 16 Japanese announcements on 5-minute JPY/USD returns during Japan's period of zero interest rates, breaking down the responses by the state of the business cycle in the two countries and permitting asymmetry. They conjecture that the exchange rate is more likely to respond asymmetrically to news when the zero bound restricts Japanese policy reactions. This preliminary work finds some evidence of asymmetries but would benefit from more formal tests for such behavior that account for the multiplicity of simultaneous tests on similar hypotheses.

DISCUSSION AND CONCLUSION

This article has surveyed the large literature examining how exchange rate returns react to economic announcements. Such announcements furnish a virtual "controlled experiment," in the words of Hardouvelis (1988), that permits researchers to investigate which announcements influence foreign exchange markets, how markets perceive policies, how quickly markets react to new information, and how this information is impounded into prices.

The fundamental finding of the literature is that a number of macro announcements—from several countries—influence exchange rate returns in consistent ways. Researchers have consistently found that interest rates, employment, output, and—though declining in importance—the trade balance are among the most important U.S. announcements to the foreign exchange markets. German monetary announcements and Japanese manufacturing, industrial, and spending announcements are also influential. Early researchers used the response of exchange rates to money supply shocks to illuminate the relation between money supplies and interest rates (see Cornell, 1982 and 1983; and Engel and Frankel, 1984). This line of research highlighted the distinction between uncertainty about short-term liquidity provisions and long-run inflation objectives.

UIP implies that announcements that raise (lower) current domestic or expected future domestic interest rates relative to foreign interest rates tend to immediately appreciate (depreciate) the domestic currency. Thus, market reactions to shocks vary over time, between countries, and with the state of the business cycle because the response depends on how the macro shock causes participants to revise their views of the current and future state of the economy. As a central bank gains inflation-fighting credibility, for example, markets will assume that it will reverse a positive inflation shock with higher interest rates and thus positive inflation shocks will appreciate the domestic currency.

Researchers have exploited this variation over time and between countries to discern market perceptions of policy reactions. Hardouvelis (1984) and Hakkio and Pearce (1985) used foreign exchange reactions to macro announcements to document the Federal Reserve's growing inflation-fighting credibility after October 1979. Other researchers investigated how markets reacted to similar announcements across countries. For example, Almeida, Goodhart, and Payne (1998) argue that differences in the likely responses of the respective monetary authorities drive differences in reactions to U.S. and German announcements. Kim (1998) finds that Australian macro releases produce qualitatively similar impacts on the AUD as U.S. macro releases do on the USD.

Foreign exchange responses to macro news can also depend on the shocks or the state of the business cycle. For example, Andersen et al.

(2003) and Fatum, Hutchison, and Wu (2010) both consider asymmetry based on the sign of shocks and the latter paper extends the analysis to the relative state of the business cycle between countries. Similarly, Faust et al. (2007) argue that the source of an inflation shock—demand or productivity—matters for how markets will interpret its effect.

Because announcement effects in foreign exchange markets are not structural—they depend on market expectations of policy and other factors—they can be unstable; but researchers disagree on how prevalent or important such variability is. Bartolini, Goldberg, and Sacarny (2008) emphasize that only a few types of announcements have consistently large and stable effects on asset prices over time. Bacchetta and van Wincoop (2009) and Sarno and Valente (2009) provide similar perspectives on the reasons for this instability. Bacchetta and van Wincoop (2009) argue that small but persistent changes in structural parameters of the economy can produce very unstable expectations that create unstable reduced-form relationships between macro surprises and exchange rates over time. Similarly, Sarno and Valente (2009) show that modeling selection strategies for exchange rate forecasting might perform poorly because shifting market expectations changes the relative importance of fundamentals over time. Faust et al. (2007) dispute the practical importance of instability, however. Ignoring measurement error in surprises, they find that nine announcements are statistically significant determinants of either the USD/DEM-EUR or USD/GBP in a 14-year sample. They argue that coefficient instability is not "a first order issue." The relative macroeconomic stability of their sample period might contribute to this conclusion, however.

Although the announcement literature originally studied macroeconomic relations, it has also taught us about microstructure, in particular the role of order flow, announcement order/timing, the speed of market reaction, and how information is transmitted. One important contribution of the microstructure literature is to reveal additional—indirect—channels through which announcements can affect exchange rate returns. Love and Payne (2008) and Evans and Lyons (2008) take different econometric approaches but both conclude that macro news substantially affects exchange rate returns both directly and indirectly, through order flow. Evans (2010) emphasizes that this finding of substantial indirect effects on returns helps to resolve (partially) the puzzle that announced news directly explains only a very small portion of exchange rate variation.

The importance of an announcement surprise depends on how it changes the market's view of the state of the economy. Because some groups of announcements provide correlated information, the order of announcements' release is important. Doukas (1985), Tandon and Urich (1987), Andersen et al. (2003), and Ehrmann and Fratzscher (2005) have all presented evidence that earlier announcements within a correlated group have a bigger impact on returns.

The initial research on the speed of price adjustment confirmed the prediction of the EMH that exchange rates should adjust very rapidly to scheduled releases (Ederington and Lee, 1995). Such a very rapid change will show up as a price discontinuity (or jump), as found by Andersen et al. (2003 and 2007) and Lahaye, Laurent, and Neely (2009). On the other hand, reactions to unscheduled announcements can be slower. Almeida, Goodhart, and Payne (1998) found that markets reacted more quickly and strongly to scheduled U.S. announcements than to unscheduled German announcements. Reactions to scheduled announcements might be quicker because agents have made contingent plans to respond to the news.

In contrast to Ederington and Lee's (1995) findings of very rapid adjustment to scheduled news, Evans and Lyons' (2005) study of order flows and exchange rates suggests that there are delayed systematic responses as announcements prompt sustained trading that gradually recovers part of the initial price impact. Evans and Lyons (2005) argue that such effects would be small and difficult to find with returns data alone; only joint analysis of returns and order flow reveals it. Evans (2010) discusses the possible role of risk management in producing persistent responses of exchange rates and order flow to macro surprises.

Very high-frequency data help to pin down the direct response of exchange rates to announcements because one can attribute almost all of an exchange rate's movement to the announcement in a sufficiently small window around the announcement.[38] There is, however, a little-discussed, practical tradeoff between data frequency and sample length. Both higher-frequency data and longer samples allow one to estimate announcement effects more precisely, so longer samples might substitute for high-frequency data.

Conversely, as the forecast horizon goes to infinity, the uncertainty about the exchange rate in the absence of an announcement becomes arbitrarily large and therefore uncertainty about the announcement effect likewise becomes arbitrarily large. Therefore one cannot know whether announcement surprises have long-run effects.

In summary, researchers have learned a great deal about how exchange rate returns react to various announcements and how these reactions vary with market policy expectations and institutional details such as scheduling. A number of unresolved issues remain, however. What is the extent of asymmetric reactions, by sign of shock and by state of the business cycle, and what economic behavior induces this asymmetry?

More recently, economists have begun to investigate how public announcements precipitate the release of private information that trading impounds into prices. This line of research is still in its early stages and many unresolved issues remain. One area of potential progress would be to use the data from announcement effects on asset prices to inform more realistic structural models of the macro determinants of asset prices.

[38] The conditional variance of a foreign exchange rate rises with the forecast horizon, starting arbitrarily low at the shortest horizons but eventually becoming arbitrarily high at long horizons. The rise is linear for a homoskedastic variable.

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