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What defines 'news' in foreign exchange markets?

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Abstract

This paper examines whether the traditional sets of macro surprises, that most of the literature considers, are the only sorts of news that can explain exchange-rate movements. We examine the intra-daily influence of a broad set of news reports, including variables which are not typically considered "fundamentals" in the context of standard models of exchange-rate determination, and ask whether they too help predict exchange-rate behavior. We also examine whether "news" not only impacts exchange rates directly, but also influences exchange rates via order flow (signed trade volume). Our results indicate that along with the standard fundamentals, both non-fundamental news and order-flow matter, suggesting that future models of exchange-rate determination ought to include all three types of explanatory variables.

JEL classification: F31; F37; G15

Keywords: Intra-day foreign exchange-rate determination; Order flow; Fundamental news; Non-fundamental news

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1. Introduction

This paper examines intra-day foreign exchange market reactions to a wide array of ''news'' reported in the financial press. A number of previous studies have shown that in order to find significant reactions in the foreign exchange market to the macroeconomic variables that theory suggests should matter, one needs to measure the precise impact of macro surprises at the intra-day level. While these studies provide evidence that macro news influences both returns and volatility, because these announcements occur very infrequently (typically once a month or quarter) they cannot go far in explaining the bulk of foreign exchange-rate movements. In this paper, we ask whether a much broader definition of ''news'' influences currency values and ought to be included in our models of exchange-rate determination. Using Reuters' time-stamped newswire reports, we include all news stories that provide information relevant to foreign exchange markets. The stories are then classified by information source (policymaker or market participant), geographic region (Euro-zone, Japan, US or UK) and substance (both actual events and rumors involving fundamentals and non-fundamentals). Our ''news'' data include the scheduled macro announcements that have been used in previous studies to allow us to compare the effects of our broader definition of news against these more ''traditional'' variables.

The intra-day foreign exchange data used in this study are transaction prices and quote spreads in the USD–EUR and USD–GBP market from the Reuters D2000-2 electronic trading system. The data do not include information on traded quantities, but they do indicate whether trades were initiated by a buyer or seller, allowing us to measure order flow as well as returns and volatility. We use a 20-min sampling frequency for each exchange rate and we measure order flow as the cumulative number of buyer-initiated trades minus the cumulative number of seller-initiated trades over the same 20 min.

These data allow us to test a number of interesting hypotheses. First, we test whether non-scheduled ''news'' of different sorts has similar impact effects on returns and volatility as compared to (the already heavily studied) scheduled macro announcements. Theory suggests that ambiguous information may lead to stronger differences of opinion about the implications of the information (and, in turn, larger increases in volatility). In our application, we can distinguish between scheduled (and presumably better-understood) macro announcements and more ambiguous news (for example, market rumors of impending interest rate changes). Second, we test whether news that is typically not considered ''fundamental'' in the context of standard models of exchange-rate determination (for example, news related to technical analysis), helps to explain exchange-rate movements. Third, we examine whether any of the price discovery process in reaction to news occurs via order flow. Previous studies have found evidence that a substantial proportion of the market reaction to macro announcements occurs via order flow. By examining how a broader set of news events influences order flow – we can begin to better understand how this measure relates to price and volatility movements in the foreign exchange markets.

The paper is organized as follows. Section 2 reviews the links between macroeconomic fundamentals and exchange rates in standard models, the lack of empirical support for these links, and alternative modeling strategies that may improve our understanding of what drives exchange-rate movements. Section 3 describes the exchange-rate and order-flow data from Reuters D2000-2 used in our empirical analysis. Section 4 provides results of our event study analysis of the influence of our broader definition of news on exchange-rate returns and volatility. Section 5 introduces our order-flow information and examines its role in explaining exchange-rate movements. Section 6 examines the influence of news on returns and order flow simultaneously in the context of a VAR analysis. Section 7 concludes.

2. News and exchange rates

The asset approach to exchange-rate determination suggests that exchange rates are forward looking asset prices that react to changes in the market's expectation of future fundamentals. Empirical tests of the asset approach examine in various ways whether changes in the macroeconomic variables that are considered fundamentals explain exchange-rate movements.[1] These tests generally find that macroeconomic variables, which tend to have fairly stable time series properties, can explain little of the (sometimes dramatic) variation in exchange-rate movements. This line of research is best summarized by a series of papers by Meese and Rogoff (1983a,b) which find that forecasts of exchange rates based on a random-walk model of exchange-rate determination do better than forecasts that are based on macroeconomic models.[2]

In the wake of the Meese and Rogoff papers,[3] one branch of empirical research has focused on the possibility that their result was more a function of estimation imprecision than an indictment of the asset approach.[4] If the window of time around the shock to fundamentals is too wide, other news hitting the market will confound the econometrician's ability to precisely estimate the effects of the change in fundamentals on exchange rates. One solution is to use intra-daily exchange-rate data that will allow a narrow enough window around the time of macro announcements to be able to set up a natural experiment. A number of papers, including Andersen et al. (2003), find that when a narrow window is used, they are able to find a strong relationship between certain macro surprises and exchange-rate returns.[5] An alternative approach is taken by Fair (2003) who identifies large intra-day changes in exchange rates (and stock and bond prices) over the period 1982 through 1999 and then looks for "news" that hit markets around the large changes to connect exchange-rate movements to changes in macro fundamentals.

This paper takes the results from Andersen et al. (2003) as a benchmark, and asks three important follow-on questions. First, are the traditional sets of macro surprises that most of the literature considers the only sorts of news that can explain exchange-rate movements? We examine the intra-daily influence of a broad set of news reports, including variables which are not typically considered "fundamentals" in the context of standard models of exchange-rate

[1] Examples of "fundamentals" include: income (or output) differentials, money differentials, interest rate differentials, inflation differentials and the trade balance.

[2] Engel and West (2005) provide an explanation for the Meese–Rogoff result based on the present value relationship that follows from the asset approach. They show that if the discount factor is near one, exchange rates will be largely driven by expected fundamentals far out into the future, which will be dominated by their random-walk component. Other studies that re-examine the Meese–Rogoff result for long-horizon forecasts include Mark (1995), Kilian (1999), and Kilian and Taylor (2003).

[3] A number of researchers have re-investigated the original Meese and Rogoff (1983a,b) result and have generally found it to be robust. See, for example, Flood and Rose (1995) and Cheung et al. (2005).

[4] An alternative approach assumes that the underlying reason for the Meese–Rogoff result is that the foreign exchange market is either not efficient, or that market participants are not rational. The fact that many foreign exchange traders follow technical trading rules that are unrelated to the types of variables found in standard exchange-rate determination models provides suggestive evidence that this approach may have some merit. See Osler (2003) for an example of this approach.

[5] The enormous literature measuring the effects of macro news on intra-daily exchange rates includes Hakkio and Pearce (1985), Ito and Roley (1987), Ederington and Lee (1995), DeGennaro and Shrieves (1997), Almeida et al. (1998), Andersen and Bollerslev (1998), Melvin and Yin (2000), Faust et al. (2003), Love and Payne (2003), Love (2004), Chaboud et al. (2004) and Ben Omrane et al. (2005).

determination, and ask whether they too help explain exchange-rate movements.[6] If we find that non-fundamental variables matter, the "positive" results that many researchers have found for the influence of macro announcements on exchange rates at intra-daily frequencies may need to be re-interpreted. If all sorts of news influence exchange rates, the "narrow window" explanation for why low-frequency empirical tests of standard models are inappropriate, is no longer sufficient. Or, put another way, we are back again to the Meese–Rogoff result that it is not macro fundamentals that best predict exchange-rate behavior. Second, we ask whether using a broader definition of news, we are able to explain a significant portion of the overall variation of exchange-rate movements. Macro announcements occur relatively infrequently, so that even if they explain 100% of the short-term movements in exchange rates, this translates into explaining less than 1% of overall exchange-rate movements. The third question we consider is whether "news" not only impinges on exchange rates directly, but also influences exchange rates via order flow (signed trade volume). Like non-fundamental news, order flow plays no role in standard models of exchange-rate determination, so a finding that order-flow matters will provide evidence in favor of a different modeling strategy for exchange-rate determination (at least for very short-term movements).[7]

There are a number of reasons for questioning whether macro announcements are the best real-time source of information on fundamentals. First, macro announcements are retrospective, in the sense that they provide information about past changes in variables. Second, announcements are often revised substantially so that the first (or preliminary) report is not necessarily a good indication of the true (or final) report. When macro announcements are used in empirical studies they are generally measured relative to market expectations. Money Market Services International's median survey responses are used to calculate the "surprise" component, based on the assumption that market participants (and survey participants) are rational and the foreign exchange market is efficient, so that only unexpected news matters. There are a number of reasons to be skeptical that the median survey response accurately reflects market expectations.[8] So that both the announcements and the proxy used to measure the expectation of the announcements may be noisy indicators of actual macro surprises.[9]

In practice, dealers in the foreign exchange market receive information from numerous different sources, including their own customers, electronic brokerage systems, squawk boxes, and newswire services. Newswire services report the macro announcements described previously along with various other sorts of news which sometimes are also directly related to macro fundamentals. One of the major distinctions that can be made between macro announcements and other news is that the announcements are typically made on a schedule, so that market participants can plan their reactions in advance (depending on realizations). Non-scheduled news is

[6] A number of papers have considered the influence of central bank interventions and official policy statements on exchange rates. These papers include: Dominguez (1998, 2003, in press), Cai et al. (2001), Evans and Lyons (2003), Fatum and Hutchison (2003), Fratzscher (2004), Panthaki (2004), Sager and Taylor (2004), Ehrmann and Fratzscher (2005) and Jansen and De Haan (2005).

[7] Evans and Lyons (2002) is one of the first studies that found a link between order flow and exchange-rate movements. We will be examining these same links though with a very different data set and time period.

[8] For example, the median survey participant may not be representative of "market" opinion, or survey participants may have strategic reasons not to reveal their true expectation.

[9] Chaboud et al. (2004) and Laakkonen (2004) find that even if there is no macro surprise (so that the expectation exactly matches the announcement) volatility (and trading volume) tends to rise after the release of the (unsurprising) announcement. These results could either be interpreted as suggesting our measure of macro surprise is flawed, or that market reactions to news do not conform to our standard models.

by its nature less likely to be anticipated by the market. It may also be the case that market participants are less able to quickly interpret the implications of non-scheduled news for exchange rates, potentially leading to more heterogeneity in their responses to the news.[10]

Whether news is scheduled or non-scheduled its influence on exchange rates may be related to the state of the market at the time of the news arrival.[11] News that arrives during periods of high uncertainty may have different effects on the exchange rate, than news that arrives in calmer periods.[12] It may also be the case that the frequency of news arrival itself will influence the relative importance of individual news releases.[13]

In this paper we allow for the possibility that exchange rates react to a wide spectrum of ''news'', including, but not exclusively, macro announcements. We also allow for the possibility that information on the ''state of the market'' will influence the way that news influences exchange rates. Finally, we allow for the possibility that the trading process itself serves to convey information to the market via order flow.

One way to think about why order flow might matter is suggested in the Kyle (1985) model which focuses on the strategic aspects of informed trading in a market microstructure model. Informed traders in Kyle's model can be thought of as information monopolists who act to exploit this advantage by maximizing the value of private information. In the model, Kyle introduces the concept of a price impact coefficient which reflects how much the market adjusts prices to reflect the information content of trades. The model suggests that since the more liquid a market, the less individual trades will impact price, informed traders will prefer to ''hide'' their private information by trading during periods of high liquidity. In this context private information will eventually become known (and be reflected in price) but the process of information revelation takes place gradually via order flow. Standard exchange-rate models give no role to private information (or order flow) because the assumption is that the sorts of information that matter, macro fundamentals, are common knowledge and are incorporated into price instantaneously.

An alternative view is that individual traders are not ''informed'' in the sense that they have a better understanding of future market movements than other traders, but that their own trading motives (based on real trade, profit repatriation, speculation, portfolio rebalancing) may be correlated with other traders, eventually leading to aggregate changes in fundamentals. In this context, dealers who have information about order flow may learn about fundamentals before they

[10] Of course, an increase in market heterogeneity may also occur in reaction to scheduled announcements. Kondor (2004) shows that if traders display confirmatory bias, the release of public information may increase divergence in opinion. The main insight is that sometimes (public) information implies something different when it is coupled with different (private) pieces of existing information. Bacchetta and van Wincoop (2003) also model the influence of higher-order expectations in reaction to news.

[11] For example, Dominguez (2003) shows that the influence of central bank interventions on exchange-rate returns depends on the intra-day timing of intervention operations (whether they occur during heavy trading volume, or are closely timed to scheduled macro announcements) as well as whether the operations are coordinated with another central bank.

[12] Andersen et al. (2003) find evidence that ''bad'' news in good times (economic expansions) have greater impacts than good news in good times, suggesting that good news in good times confirms beliefs but bad news in good times comes as more of a surprise. Our short sample period will not allow us to test this hypothesis directly, though in future work we intend to test whether ''confirming'' versus ''surprising'' news have different effects.

[13] A dramatic example of this occurred during the period in late 1995 when the US government was shut down and macro announcements went unreported. During this period traders apparently reacted to ''news'' (such as the shoe manufacturer's monthly sales survey) which in normal periods have little influence.

are officially announced. Evans and Lyons (2004) test this proposition using a data set that allows them to disaggregate order flow among various end-user segments (non-financial corporations, investors, leveraged traders); they find evidence that order-flow information forecasts macro fundamentals.

We are not able to directly measure the ''private'' information available to individual dealers, but we have collected a relatively rich measure of public (time-stamped) news from Reuters's newswire reports[14] as well as the order-flow information available from Reuters D2000-2. We use these two sources of ''common knowledge'' news, as well as the macro announcements typically used in the literature, to test some intra-daily implications of standard exchange-rate models.

Tables 1–3 provide information about: (1) the scheduled macro news announcements from the UK, the US, and the Euro-zone; (2) the broad categories of non-scheduled fundamental news; and (3) the broad categories of non-scheduled non-fundamental news that we include in our empirical analysis. Our news variables were created using a search criteria which retrieved newswire articles under the broad subject areas of ''money'', ''foreign exchange'' and ''economics'' over the period 15 November 1999 through 18 January 2000. We excluded all re-published news, recurring price and market data, articles covering obituaries, sports, calendars of events, letters, diaries, weather, cooking and personal announcements. We then coded and grouped[15] news articles according to source (policymaker or market participant), geographic region (Euro-zone, US or Japan) and substance (related to fundamentals or non-fundamentals). On average there were four news items per day so that approximately 5% of our 72 20-min return intervals per day include a news report. Approximately 65% of these news reports were categorized as related to 'fundamentals', while 35% were coded as non-fundamental news.

News that we code as ''non-scheduled non-fundamental'' largely falls into six main subcategories. The first four categories: the options market, technical analysis, market characteristics and market sentiment, are all related specifically to the foreign exchange market, and are often based on interviews with or quotes from market participants who trade based on ''technical'' rather than ''fundamental'' information.[16] Our non-fundamental news also includes news related to the private sector (often focused on restructuring, and mergers and acquisitions), and politics. While it is possible that some of this news is indirectly related to fundamentals (when firms restructure they may improve profitability, and, in turn this may lead to higher country-level growth) our sense is that these sorts of news reports do not fit the traditional definition of ''fundamentals''. It is also likely that there is more heterogeneity in market participant's interpretations of the importance of this sort of news relative to, for example, scheduled macro announcements. In any case, given that a significant portion of newswire reports fall into

[14] These data are from the Factiva database and, unfortunately, do not include the headline news that run over the Reuters and Bloomberg ticker second by second, but they include the major economic news events that occur over a given day.

[15] In theory each ''news'' report may have a different one-time influence on exchange rates. We group similar news items together in order to examine whether certain ''types'' of news have a systematic influence on exchange-rate behavior.

[16] For example here are some quotes from market participants: ''Price action today was dictated by technical factors, options related factors''; ''Dealers said the euro would likely struggle to break key technical levels near $1.0350''; ''Analysts said only a breach of key chart resistance located around $1.03 could give an incentive to market bulls for betting on the euro''; ''Liquidity is still pretty poor… but it is a market that is moving as more people get sucked in, so inevitably momentum can build up and we can get a reasonably sharp move''.

this category of non-scheduled non-fundamental news, it seems worth examining whether their influence on exchange rates differs from fundamentals-related news.

3. Exchange market data

Our intra-day exchange-rate and order-flow data cover a 10-month period, from 06 Oct 1999 to 24 July 2000 for the USD–EUR and USD–GBP.[17] The data are from the brokered segment of the inter-dealer exchange-rate market as captured by the Reuters D2000-2 electronic trading system.[18] Electronic brokers were first introduced in 1992 and since that time their market share has increased rapidly. In the early 1990s the inter-dealer market was split evenly between direct and voice-broker trading but by the late 1990s the two top electronic brokerage systems, Reuters and EBS, made up over 50% of the market.

Inter-dealer brokering systems provide prices that are advertised to all member dealers (though the identity of the quoting dealer is only available once the quote is hit). Dealers can submit a buy or sell quote or "hit" a quote of another dealer. Only the highest bid and lowest ask (the touch) are shown on the Reuters screen.[19] The quantity available at each (best) bid and ask is also shown (which may involve more than one bank), and when a bid or ask is hit the quantities available at that price are adjusted if they dip below $10 million. When multiple banks have entered the same bid or ask price, and the price is hit, offers are met on a first come basis (meaning that the dealer who first input the price gets the deal first and if more quantity is needed, the dealer that next submitted the same price fills the order, and so on). All transactions are made at either the posted bid or ask.[20] Table 4 provides a snap-shot (from Rime, 2003) of what the Reuters D2000-2 screen might look like to a dealer at a point in time. Fig. 1 shows bid and ask quotes for the USD–EUR and USD–GBP rates over our sample period along with the quote mid-point. It is worth noting that the USD–GBP rate was relatively stable over this sample period, with a fluctuation range of between 1.47 and 1.68. The USD–EUR rate was roughly twice as variable, with trades ranging from 0.82 to 1.26.

While dealers in individual banks will know their own customer order flow – they do not have access to information on customer orders of other banks. One of the reasons that inter-dealer brokerage systems have become so popular is that they provide an important source of real-time information on both market quotes and overall market order flow. The Reuters D2000-2 system classifies transactions as buyer-initiated or seller-initiated,

[17] EBS, the other major electronic brokerage system, has a much larger share of total trading in the USD–EUR market potentially leading the Reuters data for the USD–EUR to be less representative. Reuters USD–EUR order-flow data, in particular, may not well capture average trading behavior in that market outside of European hours. Reuters dominates EBS in the USD–GBP market.

[18] See Rime (2003) for a detailed description of electronic trading systems and Lyons (2001, chapter 3) for a full description of the three basic types of trades in the foreign exchange market. Direct inter-dealer trading was traditionally the most liquid part of the foreign exchange market – it is typically used for large size trades (above $10 million) and spreads are typically only 1–2 basis points. Brokered inter-dealer trades are a growing segment of the market, and typically involve slightly higher spreads of 2–3 basis points (especially for trades below $10 million). Customer–dealer trades involve 3–7 basis point spreads for "good" customers.

[19] Limit orders with prices below the best bid or above the best offer are not observable on Reuters D2000-2 but are shown on Minex.

[20] One advantage of the (shrinking) voice-brokered market is that it allows for some communication between dealers and brokers which allows for negotiation over price.

Table 1
Summary statistics of macro news announcements

Announcement	Reported as	Local time
UK announcements (total = 80)		
RPIX	Y/Y% change	08:30 GMT
Retail sales	M/M% change	08:30 GMT
Global trade	GBP (billion)	08:30 GMT
Provisional M4	M/M% change	08:30 GMT
PPI	M/M% change NSA	08:30 GMT
Industrial production	M/M% change	08:30 GMT
Unemployment	Thousands	08:30 GMT
Current account	GBP (billion)	08:30 GMT
US announcements (total = 80)		
PPI	M/M% change	08:30 ET
CPI	M/M% change	08:30 ET
Industrial production	M/M% change	09:15 ET
Monthly M3	Change $ (billion)	16:30 ET
Goods and services trade balance	USD (billion)	08:30 ET
Civilian unemployment rate	Percent	08:30 ET
Nonfarm payrolls	Thousands	08:30 ET
Retail sales	M/M% change	08:30 ET
Euro area announcements (total = 58)		
PPI	M/M% change	11:00 GMT
Harmonised CPI	M/M% change	11:00 GMT
Industrial production	3M/3M% change	11:00 GMT
M3	Y/Y% change	09:00 GMT
Trade ex-EMU prel. EUR	EUR (billion)	11:00 GMT
Unemployment rate	Percent	11:00 GMT

Notes: The data cover the 10-month period from 06 Oct 1999 to 24 July 2000. M/M% change refers to month-on-month percentage change. 3M/3M% change is 3 month-on-3 month percentage change. Y/Y% change is year-on-year percentage change. NSA refers to non-seasonally adjusted.

providing dealers with a real-time proxy of signed trading volume.[21] We measure order flow in this study as the difference between the number of buyer-initiated trades and seller-initiated trades in each 20-min interval. Fig. 2 shows the number of buy and sell orders separately as well as our measure of order flow for the USD–EUR and USD–GBP rates.

The intra-day price series used in this study incorporates information from both transaction prices (actual trades) and (tradeable) bid and ask quotes submitted by dealers (but not hit).[22] We use tradeable quotes in addition to actual transaction prices to create a 20-min price series for each of our two exchange rates that spans the period over which we have ''news'' data.[23] We measure exchange-rate returns, Δs_{t_i}, as the log difference in

[21] The dealer posting the quote is considered the non-initiating side. Reuters does not provide information on the size of each trade.

[22] Tradeable quotes differ from indicative quotes, which have been used in a number of previous studies, in that they provide ''firm'' prices. Indicative quotes provide market information for non-dealers.

[23] There are periods of low liquidity on Reuters D2000-2 due to technical problems (the feed failing), holidays, and during Asian trading hours. Some studies simply drop these time periods from the sample. Our approach is to interpolate a 20-min time series (using a piecewise cubic Hermite interpolating function which preserves the monotonicity and shape of the data) from all available quotes in order to fully span our ''news'' data set. Reuters does not include weekend data so any news that arrives over a weekend is moved to the first 20-min interval on the nearest Monday.

Table 2
Broad categories of non-scheduled fundamental-related news

Monetary fundamentals	Fiscal fundamentals	Growth and unemployment	Exchange rate policy fundamentals
Inflation (rise/fall)	Trade (surplus/deficit)	Growth (positive/negative)	Exchange rate target
Interest rates (rise/fall)	Fiscal position (good/bad)	Unemployment (good/bad)	Intervention
Bias (loosening/tightening)		Real effective exchange rate	Intervention (potential weapon)
		Housing (weak/strong)	Joint intervention
			No intervention
			Strong dollar policy
		Differences b/w Economies	
		Growth gap increase/decrease	
		B/w Europe-US	
		B/w Europe-Japan	

20-min (mid-point) prices and exchange-rate volatility, V_{t_i}, as the absolute value of the 20-min returns. Fig. 3 shows USD–EUR and USD–GBP returns and volatility over our sample period. The volatility series displays the strong seasonal pattern that is typically found in intra-day exchange-rate volatility data which, in turn, largely reflects the opening and closing of the three main trading markets in Tokyo, Europe and New York. We deseasonalize the volatility series using the Andersen and Bollerslev (1997a,b, 1998) flexible Fourier form (FFF) regression method which involves decomposing the demeaned *i*-min exchange-rate returns, into a daily volatility factor, a periodic component for the *i*th intra-day interval and an i.i.d. mean zero unit variance innovation term all divided by the square root of the number of uncorrelated intra-day return components.[24] Fig. 4 shows the average absolute USD–EUR and USD–GBP returns in each 20-min interval over the 24-h GMT time scale along side the estimated FFF seasonal. Fig. 5 shows average daily USD–EUR and USD–GBP returns, order flow and news arrival also over the 24-h GMT time scale. It is worth noting that news arrival is fairly evenly spread over the day, while order flow for the USD–EUR market is relatively light outside of European trading hours, presumably reflecting that EBS holds a dominant share of trading volume in that market. There is little evidence of a within-day trend in average returns for either exchange rate.

Table 5 provides descriptive statistics for our 20-min USD–EUR and USD–GBP exchange rates, returns[25] and volatility, order flow and order-flow volatility, and transaction frequency (measured as the number of transactions in a given 20-min interval). The USD–EUR exchange-rate returns series only display first-order autocorrelation, suggesting that future exchange rate changes cannot be predicted from past changes beyond a 20-min horizon. There is no evidence of autocorrelation for the USD–GBP returns. Intra-day return volatility and transaction frequency for both currencies show evidence of strong and persistent autocorrelation. While buy and sell orders are highly autocorrelated, order flow (buy orders minus sell orders) does not display significant autocorrelation for either currency.

Table 6 presents contemporaneous correlations among our key variables: exchange-rate returns and volatility, order flow and order-flow volatility as well as a measure of news

[24] See Dominguez (in press) for a detailed description of how this was implemented.
[25] We compute returns (approximately) as the percentage change in the exchange rate multiplied by 100, so the units can be thought of as basis points.

Table 3
Broad categories of non-scheduled non-fundamental-related news

Options market	Technical analysis	Market characteristics	Market sentiment	Private sector	Politics
Options market (support/no support)	Technical factors (good/bad)	Year end	Europe (positive/negative)	Restructuring good/bad news	Political uncertainty
Demand for barrier options (up/down)	Technical magnetism of parity	Month end	US (positive/negative)	Government intvn in corporate sector	Political news (good/bad)
Market for current contracts (thin/liquid)	Window dressing	Y2K		Holzman	
Trading (at/below) par	Exposure driven trading	Thin/concentrated markets		M&A	
	Lack of momentum	Risks from large orders		Mannesman-Orange	
	Institutional selling	Aggressive selling (curbed)		Vodafone-Mannesman	
		Stop-loss selling/orders executed		Coca-Cola-Orangina	
		Investors/traders cut losses		Novartis-AstraZeneca	
		Long positions (opened/closed)		Banking M&A	
		Trading (choppy, lively, jittery)		Attempts to block M&A	
		Exchange rate volatility (up/down)		Speculation about flows due to M&A	
		Spreads (wider/narrower)		Deals (more/large)	

arrival (measured as the number of news articles in a given 20-min interval) and trading frequency.[26] The correlations indicate that there exists a strong contemporaneous association between exchange-rate returns and order flow and order-flow volatility and transaction frequency for both currencies. For the USD–GBP rate the correlations between exchange-rate volatility, order-flow volatility, and transaction frequency are also high. Beyond these contemporaneous correlations, we might expect longer-lived correlation between news and the other variables if traders have different views of the implications (and information content) of the news.

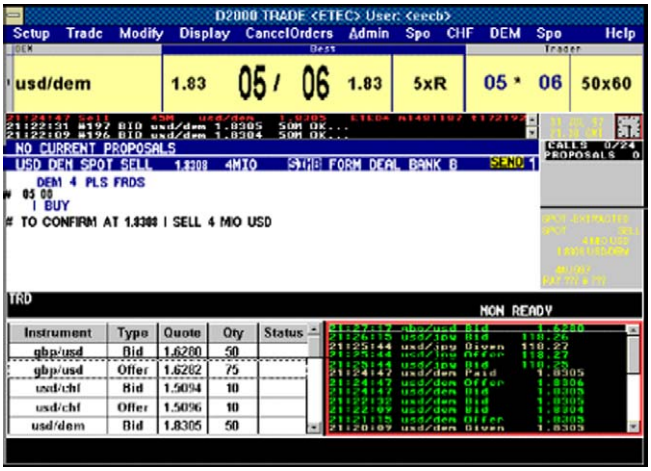
4. Effects of different categories of news on returns and volatility

The standard approach in the empirical exchange-rate literature is to run the following sort of ''event study'' style regression[27] of the conditional mean of i-min exchange-rate returns, Δs_{t_i},

[26] Evans and Lyons (2003) document strong contemporaneous correlation between news arrival, transaction frequency and order-flow volatility. Melvin and Yin (2000) find a positive correlation between trading frequency (using indicative quotes) and the rate of flow of public information.

[27] An alternative approach based on state dependent heteroskedasticity is used by Rigobon and Sack (2002) and Evans and Lyons (2003).

Table 4
Sample Reuters D2000 screen



Source: Rime (2003, p. 485). This screen shows the Reuters Dealing 2000 system. The middle section contains the D2000-1 system for direct bilateral trading, and the top section is the D2000-2 electronic broker. The dealer chooses which exchange rates to display and whether to display the best prices in the market (column marked best) and/or the best available to him (from credit-approved banks only). In the D2000-1 section the dealer has been contacted for a quote for USD 4 million against DEM. The dealer replies with the quote "05 08", which is understood to be bid 1.8305 and ask 1.8308. The contacting dealer responds with "I BUY," and the system automatically fills in the line "TO CONFIRM AT 1.8308…". In the lower right corner of the screen, the dealer can see the price and direction of the last trades through the D2000-2 system.

on j leads[28] and lags of each of the k "news" announcements and g lags of past returns (to account for the autocorrelation we found in Table 5), that is:

$$\Delta s_{t_i} = \alpha_0 + \sum_k \sum_j \alpha_{1,j}^k N_{t_{i-j}}^k + \sum_g \alpha_{2,g} \Delta s_{t_{i-g}} + \varepsilon_{t_i}, \tag{1}$$

where Δs_{t_i} denotes the change in the natural log of the i-min (spot market) exchange rate on day t and N denotes the (time-stamped to the nearest i-min) "news".[29] We use the Schwarz (1978) criteria to fix the lag length on returns and the lead/lag length on "news", and we correct for heteroskedasticity and serial correlation in the error term using the Newey and West (1987) approach. Using this general regression specification it is possible to test for the impact and intra-day effects of news on exchange-rate returns by examining whether the N^ks are individually and jointly statistically significant. The $\alpha_{1,j}^k$ s in this context measure the typical effect of the kth news announcement at time j (on day t) on exchange-rate returns in the same (narrow) 20-min window. It is worth noting that in order to be able to interpret the $\alpha_{1,j}^k$ s in this way we

[28] We include leads in order to take into account the possibility that the time-stamp on our "news" lags the actual timing of when market participants first learn about the news. We find evidence of significant lead effects for many of our variables for up to 2 h prior to the Reuters' time-stamp.

[29] The Reuters news variables are (0,1) dummy variables. The macro surprises are measured as the difference between the specific announcement and the ex-ante expectation of the announcement (based on the median response to a survey conducted by Money Market Services International) divided by the sample standard deviation of each announcement (this serves to normalize the surprises so that comparisons of the relative size of coefficients are feasible).

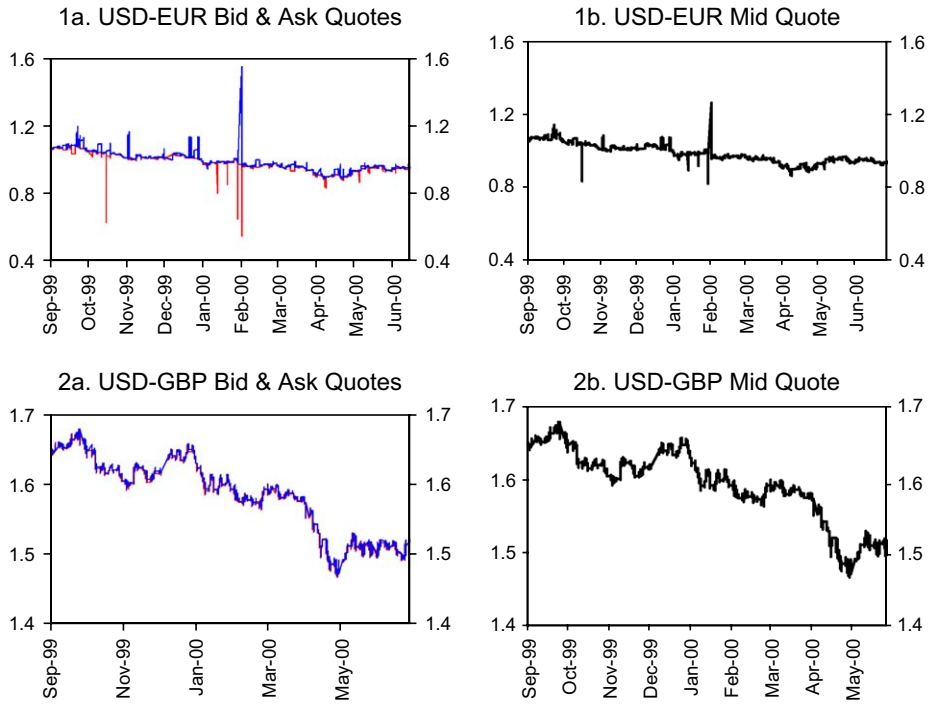


Fig. 1. Reuters D2000-2 USD–EUR and USD–GBP bid, ask and mid quotes. The data cover the 10-month period from 06 Oct 1999 to 24 July 2000. Both currencies are defined as the number of dollars per foreign currency (euro and sterling, respectively). The mid quote is calculated as the average of the bid and ask quotes.

need to assume that the variables in the regression can be viewed as fixed over the 20-min period (which is less likely to be realistic for low-frequency data windows). It is also the case that the $\alpha^k_{1,j}$ s will measure the linear combination of exchange-rate return effects associated with the market's assessment of both the "news" *and* how the news will influence the economy.[30]

Our "news" variable includes three distinct categories of news: (1) scheduled macro surprises, (2) non-scheduled but fundamentals-driven news, and (3) non-scheduled non-fundamental based news. Within categories (2) and (3) news was further broken down by source (policymaker or market participant), geographic region (Euro-zone, Japan, US or UK), substance (sub-categories of fundamentals and non-fundamentals) and expected direction of influence (whether the news is expected to appreciate or depreciate the exchange rate).[31] Categories

[30] For a nice discussion of the underlying assumptions in this sort of event study analysis see Faust et al. (2003) pp. 6–9.

[31] We attempted to group news into variables in such a way as to insure that we would not be combining news that would be expected to lead to opposite effects on exchange rates. The coefficients on these disaggregated news variables are then aggregated into broader groupings of variables (monetary fundamentals, fiscal fundamentals, growth and unemployment, options market, technical analysis, private sector) in order to keep our tables readable. Regression results with the disaggregated news categories are available upon request.

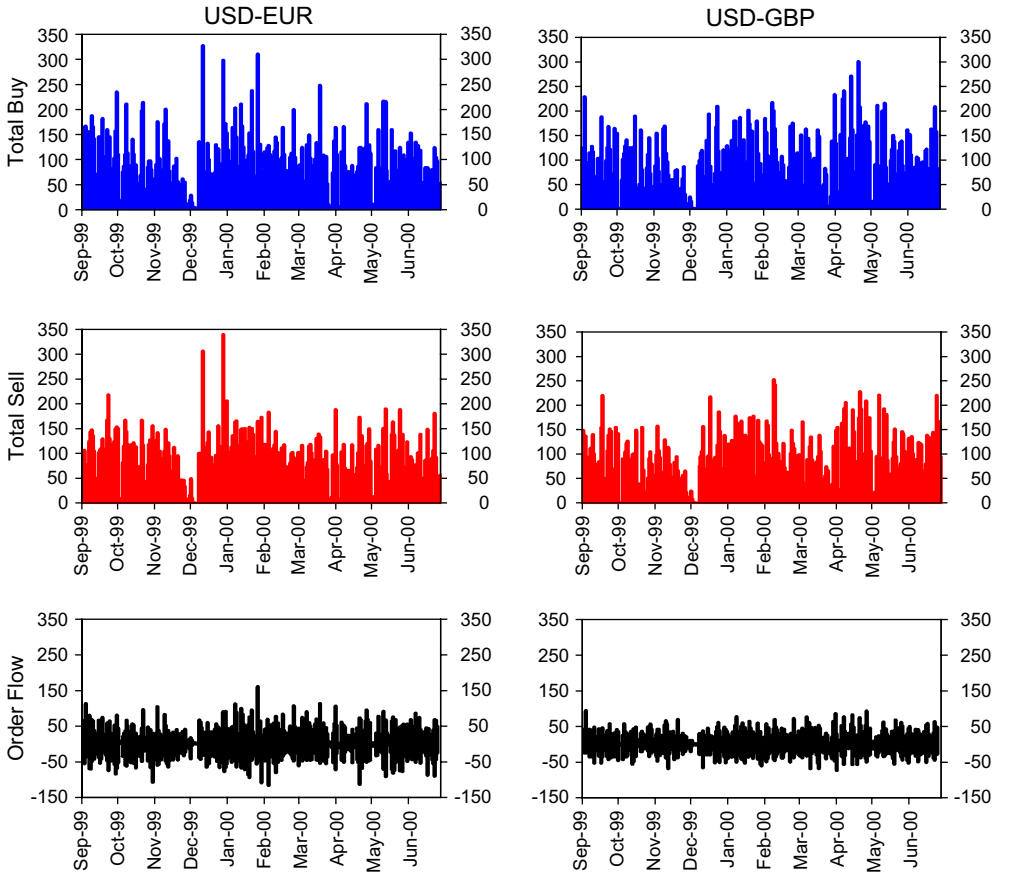


Fig. 2. Total buys, total sells and order flow. The data cover the 10-month period from 06 Oct 1999 to 24 July 2000. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD–EUR and sterling for USD–GBP).

(2) and (3) news are in binary dummy variable form which is likely to downward bias our results if these sorts of news are sometimes anticipated by the market.

Table 7 presents results of our regression of USD–EUR and USD–GBP returns on various categories of ''news''. The first and third columns in Table 7 present the results of our benchmark regression which include only the macro surprises as ''news'' for the USD–EUR (first column) and USD–GBP (third column). As has been found in previous studies, the macro surprises significantly influence both USD–EUR and USD–GBP returns, though the relatively low regression goodness-of-fit (especially for the USD–GBP) suggests that macro surprises account for a small fraction of the overall variability of returns.[32] The second and fourth columns

[32] The macro surprises are disaggregated by region (so that all US surprises are included as one variable). As robustness checks we also included disaggregated macro surprises (by type and region, e.g. US PPI, etc.) as well as aggregating the surprises (all US, UK and European surprises included as one variable). Results were qualitatively similar across the three levels of aggregation. The non-reported results (disaggregated by type and region, and fully aggregated) are available upon request.

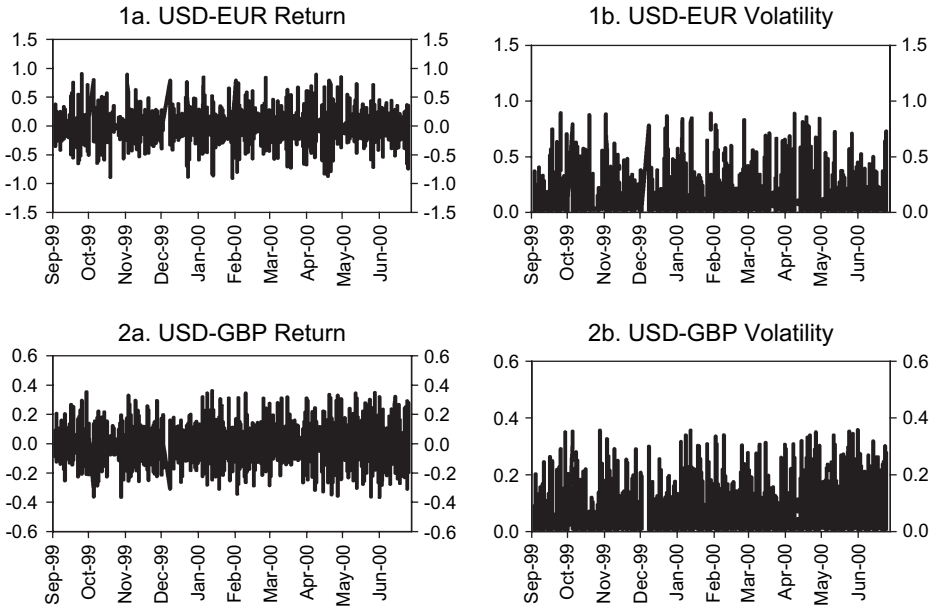


Fig. 3. Exchange-rate returns and volatility (in basis points). The data cover the 10-month period from 06 Oct 1999 to 24 July 2000 and are sampled at 20-min frequency. Both currencies are defined as the number of dollars per foreign currency (euro and sterling, respectively). Returns are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. Volatility is defined as the absolute return.

in Table 7 present results of regressions that include our broader definition of news. These columns include, along with the macro surprises, non-scheduled news reports that are related to fundamentals and news that is not related to fundamentals. In the USD−EUR regressions Euro-zone macro surprises are only statistically significant when other "news" is not included (first column). For the USD−GBP regressions both UK and Euro-zone macro surprises matter, even when other "news" is included (third and fourth column). US macro surprises did not enter significantly in any of the regressions.

Looking first at the influence of non-scheduled fundamentals, we find that a number of these "news" reports matter in terms of statistical significance. The first variable that shows up significant in the USD−EUR regression is contemporaneous "Euro-zone monetary fundamentals" with a coefficient of −0.02, which can be interpreted as indicating that these news reports (which tended to mention Euro-zone interest rates or inflation) led to a 2 basis point appreciation of the dollar relative to the euro. It is interesting to note that reports of Japanese interventions (which were aimed at weakening the yen over this time period)[33] led to a contemporaneous 3.8 basis point appreciation of the dollar relative to the euro and a similar size influence on the dollar relative to the pound (though in the 20 min prior to the Reuters time-stamp). Focusing next on the influence of non-fundamentals-related news, we find

[33] The Japanese government intervened on four occasions during our sample period, all of these were dollar strengthening operations. A number of unrequited interventions (interventions that the market expected but did not occur) also influenced returns over this period. See Dominguez and Panthaki (2005) for a more detailed examination of the influence of actual and unrequited interventions.

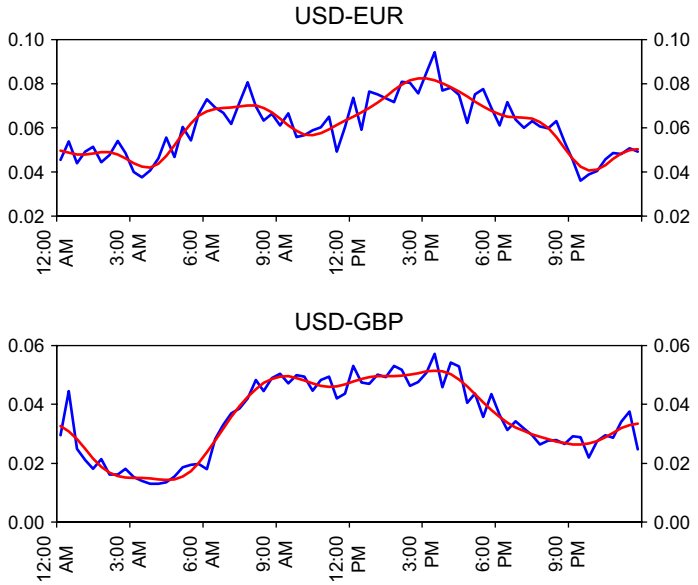


Fig. 4. Average daily volatility and FFF seasonal (in basis points). The data cover the 10-month period from 06 Oct 1999 to 24 July 2000 and are sampled at 20-min frequency (euro and sterling, respectively). The figures plot the average intra-daily pattern of volatility (jagged line) and the Flexible Fourier Form seasonal (smooth line) over a 24-h period. Volatility is defined as the absolute return, where returns are calculated as 100 times the log difference of the mid quote. The mid quote is calculated as the average of the bid and ask quotes.

evidence that reports connected to all our included categories (option market, technical analysis, sentiment, private sector and politics) enter significantly. Moreover, the coefficient estimates on non-fundamental news are similar in size to those found for fundamentals-related news. We also find strong evidence of both lead (especially for the USD−GBP)[34] and lag effects on the non-scheduled news variables, suggesting both that some traders learn of the news before our Reuters' time-stamp and that market reaction to "news" is often not instantaneous.

The results in Table 7 indicate that both scheduled macro surprises and non-scheduled fundamental and non-fundamental news influence returns. In order to further examine how information is processed by the market under different market conditions, we test for two types of interaction effects. First, we ask whether news is more (or less) likely to influence returns during periods when lots of other news is hitting the market. We create an indicator variable that takes on the value 1 during 20-min intervals when the number of news reports exceeds the sample average by two standard deviations. The first two columns of Table 8 suggest that for both USD−EUR and USD−GBP returns "news" often had a larger impact on returns when it arrived during heavy news periods. Our results are even more dramatic when we test whether news has a stronger impact during periods of high market uncertainty (proxied by high volatility). We create an indicator variable that takes on the value 1 during 20-min intervals when volatility (measured as the absolute value of returns) exceeds the sample average by two standard deviations. The second two columns in Table 8 present

[34] One explanation for why lead effects are more important for the USD−GBP market is that the source of our data, Reuters, is the dominant player (in terms of market share) in this currency market.

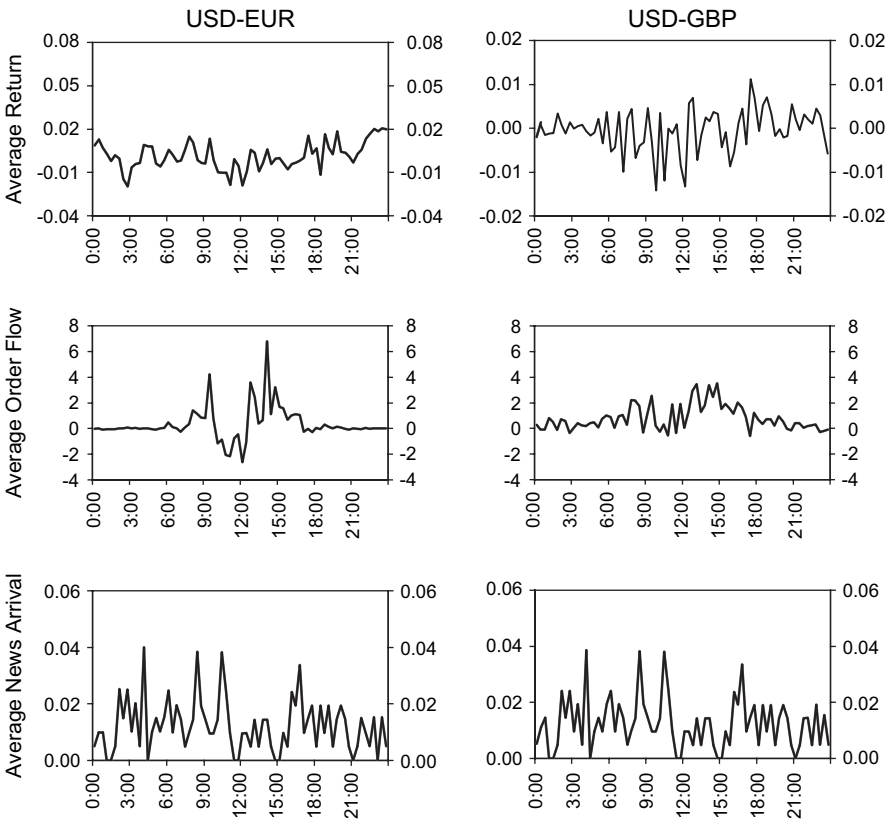


Fig. 5. Average daily USD–EUR and USD–GBP returns, order flow and news arrival. The data cover the 10-month period from 06 Oct 1999 to 24 July 2000 and are sampled at 20-min frequency. Both currencies are defined as the number of dollars per foreign currency (euro and sterling, respectively). The figures plot the average intra-daily pattern of returns, order flow and news arrival over a 24-h period. Returns are calculated as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD–EUR and sterling for USD–GBP). News arrival is the number of Reuters news articles in each 20-min period.

regression results which show that during periods when the market is most uncertain ''news'' (of all types) had a significantly larger influence on returns than was the case when news arrived during normal periods.

The regression results presented in Tables 7 and 8 indicate that ''news'' both narrowly defined as macro surprises, and more broadly defined, has an influence on intra-daily exchange-rate returns. However, the relatively low regression goodness-of-fit suggests that even our broader measure of news does not go very far in explaining overall exchange-rate movements. It is possible that our binary coding of news is partly to blame for our inability to explain a larger fraction of exchange-rate variation. It may be that while we are not able to ''sign'' exchange-rate movements using such a crude indicator of information flow, our ''news'' variables will be more successful at explaining exchange-rate volatility. It may also be that news (however measured) does not have an impact on price directly, but that its influence is mediated through order flow. We investigate both these possibilities in the next two sets of regressions.

Table 5
Summary statistics for USD–EUR and USD–GBP quotes, returns, volatility, order flow and transaction frequency

	Mid quote	Return	Volatility	Net order flow	Order flow volatility	Transaction frequency
a. USD–EUR						
Mean	0.98	0.14	6.08	0.33	1.22	32.90
Variance	0.05	11.27	9.49	13.55	1.76	54.09
Skewness	0.25	0.23	3.53	0.50	1.84	2.13
Kurtosis	2.40	16.24	20.64	15.85	9.72	9.76
Autocorrelation lags						
1	0.99	0.26	0.51	0.04	0.86	0.85
5	0.99	0.04	0.24	0.02	0.60	0.54
10	0.98	−0.01	0.14	−0.01	0.35	0.29
20	0.98	−0.01	0.07	0.00	−0.06	−0.06
b. USD–GBP						
Mean	1.58	−0.04	3.51	0.81	1.33	38.52
Variance	0.05	5.71	4.50	10.39	1.34	53.96
Skewness	−0.42	0.09	2.57	0.66	1.27	2.30
Kurtosis	1.99	9.25	11.91	10.78	4.65	10.23
Autocorrelation lags						
1	1.00	−0.02	0.33	0.02	0.80	0.80
5	1.00	−0.01	0.20	0.02	0.57	0.52
10	1.00	0.01	0.12	0.00	0.37	0.30
20	1.00	−0.03	0.08	−0.01	0.08	0.02

Notes: The data cover the 10-month period from 06 Oct 1999 to 24 July 2000 and are sampled at 20-min frequency. Both currencies are defined as the number of dollars per foreign currency (euro and sterling, respectively). The mid quote is calculated as the average of the bid and ask quotes. Returns are defined as 100 times the log difference of the mid quote. Volatility is defined as the absolute return. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD–EUR and sterling for USD–GBP). Order flow volatility is the standard deviation of order flow. Transaction frequency is the number of transactions in the 20-min period.

In order to examine whether our broader definition of news helps to explain the absolute value of exchange-rate returns, we regress de-seasonalized intra-day volatility, $V^s_{t_i}$, on the same set of explanatory "news" variables:

$$V^s_{t_i} = \lambda_0 + \sum_k \sum_j \lambda^k_{1,j} N^k_{t_{i-j}} + \sum_g \lambda_{2,g} V^s_{t_{i-g}} + \eta_{t_i}. \tag{2}$$

Andersen and Bollerslev (1998) find that three factors influence intra-daily exchange-rate volatility: calendar effects and volatility dependencies (both of which are captured in the FFF seasonal) and macro surprises, with macro surprises providing the least explanatory power. We examine the influence of our broader definition of news on de-seasonalized[35] volatility and allow for a longer lag structure to test whether the effects of non-scheduled news reports are longer-lived. We use the Schwarz (1978) criteria to fix the leads and lags in the regression

[35] It could be that the intra-day seasonal is explained by news arrival. We test for this possibility by including our news variables directly in the FFF regression and find no evidence of correlation between the daily seasonal and our news variables.

Table 6
Contemporaneous correlations between returns, volatility, order flow, transactions and news Arrival

	Return	Volatility	Order flow	Order flow volatility	Transaction frequency	Reuters news arrival
a. USD–EUR						
Return	1	–	–	–	–	–
Volatility	0.055	1	–	–	–	–
Order flow	0.451	0.007	1	–	–	–
Order flow volatility	−0.027	0.233	0.034	1	–	–
Transaction frequency	−0.019	0.248	0.063	0.956	1	–
Reuters news arrival	0.008	−0.007	0.001	−0.005	−0.004	1
b. USD–GBP						
Return	1	–	–	–	–	–
Volatility	0.005	1	–	–	–	–
Order flow	0.471	0.073	1	–	–	–
Order flow volatility	−0.030	0.506	0.084	1	–	–
Transaction frequency	−0.025	0.534	0.112	0.923	1	–
Reuters news arrival	−0.004	−0.018	−0.011	−0.017	−0.017	1

Notes: The data cover the 10-month period from 06 Oct 1999 to 24 July 2000 and are sampled at 20-min frequency. Both currencies are defined as the number of dollars per foreign currency (euro and sterling, respectively). Returns are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. Volatility is defined as the absolute return. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD–EUR and sterling for USD–GBP). Order flow volatility is the standard deviation of order flow. Transaction frequency is the number of transactions in each 20-min period and Reuters news arrival is the number of news articles in each 20-min period.

specification and correct for potential heteroskedasticity and serial correlation in the error term using the Newey and West (1987) approach.

Table 9 presents our volatility regression results using the same column format as we did in Table 7. The first thing to note about these results, is that many more of our fundamental-related news reports, and especially our non-fundamentals-related news reports, have a statistically significant effect on de-seasonalized volatility.[36] This provides suggestive evidence that non-scheduled news, perhaps because it is more ambiguous, leads to stronger differences in opinions about the implications of the information. None of the macro surprises are significant in the USD–EUR regressions, while US macro surprises enter with a high degree of statistical significance in the USD–GBP regressions both when entered alone and when included with the other ‘‘news’’ variables.

5. What does order flow reveal?

In standard models of exchange-rate behavior when ‘‘positive’’ news arrives for a currency, demand for that currency rises, causing the relative value (the price) of the currency to rise. In these models there is no reason for order flow to rise in reaction to news because price is assumed to instantaneously reflect the news. Trading volume may rise in reaction to news, but as long as the new price is efficient, there is no reason for these trades to be biased in favor of

[36] It is also worth noting that the regression goodness-of-fit is dramatically higher, due in part to the strong AR component of volatility.

Table 7
The Influence of "news" on USD–EUR and USD–GBP returns

Independent variables	USD–EUR		USD–GBP	
	Benchmark	Benchmark + Reuters news	Benchmark	Benchmark + Reuters news
Non-news				
Constant	–	–	–	–
Lagged dependent variable				
Lag 1	0.2693***	0.2562***	−0.1159***	−0.1365***
Lag 2	0.1813***	0.1673**	–	–
Macro surprises				
UK	–	–	0.0292*	0.0331**
US	–	–	–	–
Euro-zone	−0.0329***	–	−0.0441***	−0.0222**
Monetary fundamentals				
Euro-zone contemporaneous		−0.0221*		–
US leads 2–6		−0.0111*		–
US contemporaneous		–		0.0125*
Other asset markets				
Euro-zone lead 1		–		0.0203**
US contemporaneous		–		−0.0116*
Fiscal fundamentals				
US lead 1		–		0.0241*
US contemporaneous		−0.0403*		–
US lags 2–6		–		−0.0240**
Exchange rate policy fundamentals				
US leads 2–6		–		0.0234**
Japan contemporaneous		0.0385**		–
Japan lag 1		−0.0253*		−0.0130*
Actual intervention				
Japan leads 2–6		–		−0.0125**
Japan lead 1		–		0.0384**
Japan contemporaneous		−0.0479**		–
Other macro fundamentals[a]				
Euro-zone lag 1		–		0.0134*
US lag 1		−0.0246**		–
Japan lag 1		−0.0713**		−0.0287*
Non-fundamentals				
Options market				
Leads 2–6		–		−0.0058*
Lag 1		−0.0240**		–
Lags 2–6		–		0.0112**
Technical analysis				
Contemporaneous		–		−0.0155*
Market sentiment				
Euro-zone lags 2–6		–		0.0233***
US leads 2–6		–		0.0455***
US lead 1		–		0.0555***
US lag 1		−0.0330***		–
Private Sector				
Lags 2–6		–		−0.0058***

Table 7 (*continued*)

Independent variables	USD–EUR		USD–GBP	
	Benchmark	Benchmark + Reuters news	Benchmark	Benchmark + Reuters news
Politics				
Lead 1		–		0.0266*
Contemporaneous		−0.0439*		–
R^2	0.1374	0.1478	0.0156	0.061
$\bar{R}^2$	0.1360	0.1168	0.0140	0.027

Notes: Returns are calculated at 20-min frequency and are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. *, ** and *** represent significance at 10, 5 and 1% levels, respectively, and "–" indicates that the coefficient is insignificant. For each regressor the sum of leads 2–6, lead 1, contemporaneous, lag 1 and the sum of lags 2–6 are included in the regression but for reasons of space only the significant coefficients are reported.

[a] This category of news including growth, unemployment, and the real effective exchange rate.

purchases or sales. So that in standard models the arrival of "news" should increase volume, but be orthogonal to changes in order flow.[37]

We use transaction frequency, TF, as a proxy for volume, and first test whether the arrival of "news" in our sample is positively related to transaction frequency.

$$\mathrm{TF}_{t_i} = \gamma_0 + \sum_k \sum_j \gamma^k_{1,j} N^k_{t_i - j} + \sum_g \gamma_{2,g} \mathrm{TF}_{t_i - g} + \nu_{t_i}. \tag{3}$$

We find strong evidence of a positive association between "news" and transaction frequency. Interestingly, macro surprises were sometimes associated with a decrease in transactions, while all other "news" (and especially non-fundamental news) generally were positively associated with transaction frequency. In the USD–EUR regression macro surprises had no influence on transaction frequency, but other news, and again especially non-fundamentals-related news, led to increases in transaction frequency.

Under what circumstance might "news" cause a change not just in volume, but in order flow? One reason that price might not immediately (or fully) react is if the "news" either is not common knowledge, or if different market participants interpret the news differently. In this case, order flow might convey this information to the market (rather than price). Further, if underlying demand for currencies is driven not by news per se, but by changes in risk aversion or hedging technologies, again it might be order flow that will convey this information to the market.[38]

[37] One view of the relationship between order flow and prices is that it is only a temporary phenomenon. Order flow in this context reflects trader "digestion effects" in reaction to news, so that once the news is fully "digested", any order flow induced price effects will revert back. Work by Evans and Lyons (2002) and Danielsson et al. (2002), however, shows that order flow continues to explain changes in foreign exchange returns well after 24 h, suggesting either that digestion is very slow, or more likely, that the influence of order flow on prices is not temporary.

[38] Recent papers that have studied the link between "news" and order flow are Love (2004), Love and Payne (2003), Melvin and Yin (2000), and Evans and Lyons (2003, 2004, 2005a). Breedon and Vitale (2005) examine the connection between order flow and liquidity risk.

Table 8
The Influence of "news" on USD–EUR and USD–GBP returns in "high news arrival" and "high volatility" periods

Independent variables	"High news arrival"		"High volatility"	
	USD–EUR	USD–GBP	USD–EUR	USD–GBP
Non-news				
Lagged dependent variable				
Lag 1	0.2557***	−0.1359***	0.1592**	−0.1196***
Lag 2	0.1716**	–	0.1055*	–
Macro surprises				
UK	–	0.0331**	–	0.0336**
US	–	–	–	–
Euro-zone	–	–	–	−0.0226**
Monetary fundamentals				
Euro-zone contemporaneous	−0.0263*	–	−0.0183*	–
Euro-zone lags 2–6	–	–	–	0.0053*
US leads 2–6	–	–	−0.0087**	–
US lag 1	–	–	–	0.0103**
US lags 2–6	–	–	0.0050*	–
Other asset markets				
Euro-zone lead 1	–	0.0211**	0.0240*	0.0216***
Japan leads 2–6	–	0.0115**	–	–
Japan lag 1	0.0697*	–	–	–
Fiscal fundamentals				
Euro-zone lead 1	–	–	–	−0.0152**
US leads 2–6	–	–	−0.0184*	–
US lag 1	–	–	0.0435**	–
US lags 2–6	–	−0.0222**	−0.0224*	−0.0267***
Exchange rate policy fundamentals				
US leads 2–6	–	0.0196**	–	0.0141*
US lag 1	–	–	−0.0503**	−0.0433***
Japan contemporaneous	0.0350**	–	–	–
Japan lag 1	−0.0253*	−0.0128*	–	−0.0124*
Actual Intervention				
Japan leads 2–6	–	−0.0121**	–	−0.0069**
Japan lead 1	–	0.0385*	0.0303**	0.0160**
Japan contemporaneous	−0.0642*	–	−0.0347*	–
Japan lags 2–6	–	–	–	−0.0064**
Other macro fundamentals[a]				
Euro-zone leads 2–6	–	–	−0.0071*	–
Euro-zone contemporaneous	–	0.0144**	–	–
Euro-zone lag 1	–	–	–	0.0133**
US lag 1	−0.0311**	–	–	–
US lags 2–6	–	–	–	−0.0036*
Japan contemporaneous	–	−0.0879***	–	–
Japan lag 1	–	−0.0303**	–	–
Non-fundamentals				
Options market				
Leads 2–6	–	−0.0052*	–	−0.0052*
Lag 1	−0.0421***	–	−0.0192*	–
Lags 2–6	–	0.0142***	0.0069*	–

Table 8 (*continued*)

Independent variables	"High news arrival"		"High volatility"	
	USD–EUR	USD–GBP	USD–EUR	USD–GBP
Market sentiment				
Euro-zone lags 2–6	–	0.0258***	–	–
US leads 2–6	–	0.0500***	0.0340**	0.0267***
US lead 1	–	−0.1420*	–	0.0428***
US contemporaneous	−0.8874*	−1.0732***	−0.0419*	–
US lag 1	−0.0337***	–	−0.0474***	–
Private Sector				
Lead 1	–	–	–	−0.0157***
Contemporaneous	–	−0.0077*	–	−0.0083**
Lags 2–6	–	−0.0053**	–	−0.0056***
Politics				
Leads 2–6	–	–	0.0223*	–
Lead 1	–	0.0281*	–	0.0402***
Contemporaneous	−0.0676**	–	−0.0538**	–
Interaction terms				
Monetary fundamentals				
US leads 2–6	–	–	0.9797***	–
US lags 2–6	–	–	−0.1100***	–
Other Asset Markets				
Japan leads 2–6	–	−0.1767***	0.2342***	–
Japan lag 1	−0.8273***	−0.7267***	0.3322***	
Fiscal fundamentals				
US lags 2–6	–	–	−0.5274*	0.3910***
Exchange rate policy fundamentals				
Actual Intervention				
Japan lead 1		0.0458**	0.5289***	0.3010***
Other macro fundamentals[a]				
Euro-zone leads 2–6	–	–	0.4087***	–
Non-fundamentals				
Options market				
Lags 2–6	–	−0.0591**	–	0.0779*
R^2	0.1627	0.0814	0.3156	0.2117
$\bar{R}^2$	0.1150	0.0293	0.2833	0.1716

Notes: Returns are calculated at 20-min frequency and are defined as 100 times the log difference of the mid quote where the mid quote is calculated as the average of the bid and ask quotes. *, ** and *** represent significance at 10, 5 and 1% levels, respectively, and "–" indicates that the coefficient is insignificant. For each regressor the sum of leads 2–6, lead 1, contemporaneous, lag 1 and the sum of lags 2–6 are included in the regression but for reasons of space only the significant coefficients are reported. "High news arrival" is an indicator variable which takes the value 1 during 20-min intervals when the number of news reports exceeds the sample average by two standard deviations. "High volatility" is an indicator variable which takes the value 1 during 20-min intervals when volatility exceeds the sample average by two standard deviations.

[a] This category of news includes growth, unemployment, and the real effective exchange rate.

Table 9
The influence of "news" on USD–EUR and USD–GBP volatility

Independent variables	USD–EUR		USD–GBP	
	Benchmark	Benchmark + Reuters news	Benchmark	Benchmark + Reuters news
Non-news				
Constant	−0.0035*	−0.0042**	−0.0033***	−0.0042***
Lagged dependent variable				
Lag 1	0.4674***	0.4604***	0.2181***	0.2023***
Lag 2	0.0903*	0.0877*	0.1308***	0.1219***
Lag 3	0.0971***	0.0958***	0.0486**	0.0421*
Lag 4	0.0586**	0.0552**	0.0943***	0.0943***
Lag 5	–	–	0.0518*	0.0477*
Lag 6	–	–	0.0528*	0.0525*
Macro surprises				
UK	–	–	–	–
US	–	–	−0.0376***	−0.0379***
Euro-zone	–	–	–	–
Monetary Fundamentals				
US lags 2–6		–		0.0039*
Other asset markets				
Euro-zone leads 2–6		–		0.0067*
US lag 1		–		0.0108**
Japan leads 2–6		–		−0.0115***
Japan lag 1		–		−0.0130*
Fiscal Fundamentals				
Euro-zone leads 2–6		–		−0.0105**
Euro-zone lag 1		−0.0365***		–
Euro-zone lags 2–6		–		−0.0110**
US lead 1		−0.0442**		−0.0196**
US contemporaneous		–		0.0254*
Exchange rate policy fundamentals				
Euro-zone lags 2–6		–		0.0056***
US leads 2–6		–		−0.0133*
Japan lag 1		–		−0.0081**
Japan lags 2–6		–		−0.0044**
Other macro fundamentals[a]				
Euro-zone contemporaneous		−0.0118**		–
US lag 1		−0.0159**		–
US lags 2–6		–		−0.0045**
Non-fundamentals				
Options market				
Leads 2–6		–		−0.0058*
Contemporaneous		0.0106**		–
Lag 1		0.0106*		−0.0061**
Technical analysis				
Contemporaneous		−0.0147*		–
Market sentiment				
Euro-zone lead 1		–		−0.0240**
US leads 2–6		0.0336*		0.0102*
US lead 1		−0.0674***		–

Table 9 (*continued*)

Independent variables	USD–EUR		USD–GBP	
	Benchmark	Benchmark + Reuters news	Benchmark	Benchmark + Reuters news
US contemporaneous		−0.0451**		−0.0487***
US lag 1		0.0221**		−0.0138**
US lags 2–6		–		0.0132*
Private sector				
Leads 2–6		–		−0.0029**
Lead 1		–		0.0057**
Contemporaneous		–		0.0053*
Politics				
Contemporaneous		–		−0.0199**
R^2	0.3871	0.3860	0.1528	0.185
$\overline{R}^2$	0.3853	0.3628	0.1503	0.154

Notes: Volatility is calculated at 20-min frequency and is defined as the absolute return where returns are calculated as 100 times the log difference of the mid quote .The mid quote is calculated as the average of the bid and ask quotes. *, ** and *** represent significance at 10, 5 and 1% levels, respectively, and "–" indicates that the coefficient is insignificant. For each regressor the sum of leads 2–6, lead 1, contemporaneous, lag 1 and the sum of lags 2–6 are included in the regression but for reasons of space only the significant coefficients are reported.

[a] This category of news includes growth, unemployment, and real effective exchange rate.

A simple linear regression specification that relates foreign exchange returns to order flow is:

$$\Delta s_{t_i} = \beta_0 + \sum_j \beta_{1,j} \mathrm{OF}_{t_{i-j}} + \sum_g \beta_{2,g} \Delta s_{t_{i-g}} + \mu_{t_i}. \tag{4}$$

Table 10 presents results for a regression of USD–EUR and USD–GBP returns on contemporaneous and lagged order flow. The first thing to note in the table is that our measure of regression goodness-of-fit is now markedly higher. Our estimates suggest that order flow explains over 25% of the variation in 20-min USD–GBP returns and almost 40% in the USD–EUR market.[39] These results are strongly suggestive that order flow belongs in our empirical models of exchange-rate determination. Indeed, Danielsson et al. (2002) and Evans and Lyons (2005b) perform Meese–Rogoff style RMSE comparisons to examine whether forecasting out-of-sample exchange-rate returns with order flow outperforms the random-walk model (using future realized values of order flow) and find strong evidence in favor of the order-flow model.[40]

Our results so far suggest that news, broadly defined, influences exchange-rate returns and volatility, and that order flow influences returns. The next question to ask is what drives order

[39] Danielsson et al. (2002) compare the R^2 for this sort of regression over multiple sampling frequencies (from 5 min to one week) and find that for the USD–EUR rate the percent variation is fairly stable (around 40%) over all frequencies.

[40] However, when Danielsson et al. (2002) only use order-flow information available at the forecast date, the RMSE of the order-flow forecast model falls below the RMSE for the random-walk model. Using disaggregated order-flow information over a longer horizon (10 days or longer) Evans and Lyons (2005b) find that the forecasting ability of their order-flow model is significantly better than the random-walk model.

Table 10
The influence of order flow on USD–EUR and USD–GBP returns

Independent variables	USD–EUR	USD–GBP
	Return on order flow	Return on order flow
Non-news		
Constant	–	−0.0022***
Lagged dependent variable		
Lag 1	0.3765***	–
Lag 2	0.1422***	–
Order flow		
Contemporaneous	0.0041***	0.0028***
Lag 1	−0.0019***	−0.0003*
Lags 2–6	–	–
R^2	0.3906	0.2614
$\overline{R}^2$	0.3895	0.2601

Notes: Returns and order flow are calculated at 20-min frequency. Returns are defined as 100 times the log difference of the mid quote. The mid quote is calculated as the average of the bid and ask quotes. Order flow is the net of the total buys and total sells, where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD–EUR and sterling for USD–GBP). *, ** and *** represent significance at 10, 5 and 1%, respectively, and "–" indicates that the coefficient is insignificant. For each regressor the sum of leads 2–6, lead 1, contemporaneous, lag 1 and the sum of lags 2–6 are included in the regression but for reasons of space only the significant coefficients are reported.

flow? Previous studies have found a link between macro surprises and order flow, which runs counter to standard models that would suggest that common knowledge news, such as macro surprises, should be instantly incorporated in price. We test whether this result also holds for our data sample, and whether our broader definition of news is also linked to order flow, OF.

$$\mathrm{OF}_{t_i} = \gamma_0 + \sum_k \sum_j \gamma^k_{1,j} N^k_{t_{i-j}} + \sum_g \gamma_{2,g} \mathrm{OF}_{t_{i-g}} + \nu_{t_i}. \tag{5}$$

Table 11 presents results for the regression of USD–EUR and USD–GBP order flow on various categories of news. The first and third columns provide results for our benchmark specification which only includes the macro surprises. European macro surprises are highly statistically significant for USD–EUR order flow but none of the macro surprises are significant in the USD–GBP order-flow regression. The results in the second and fourth columns indicate that many of the non-scheduled fundamental news and non-fundamental-related news enter significantly for both currencies. However, "news" explains a relatively small fraction of the overall variation in order flow. Our regression goodness-of-fit measure never rises above 0.05 for either currency, indicating that our measure of order flow is largely not being driven by our measures of "news".[41] However, if we allow for interaction effects as we did previously in

[41] This result is at odds with results in Evans and Lyons (2004) which find a strong connection between disaggregated order flow and news. It is possible that the difference in results is due to the fact that our order-flow information is only reflecting inter-dealer trades.

Table 11
The influence of "news" on USD–EUR and USD–GBP order flow

Independent variables	USD–EUR		USD–GBP	
	Benchmark	Benchmark + Reuters news	Benchmark	Benchmark + Reuters news
Non-news				
Constant	–	–	0.7134***	0.6438***
Lagged dependent variable				
Lag 2	–	–	0.0612**	–
Macro surprises				
UK	–	–	–	–
US	–	–	–	–
Euro-zone	−14.3592***	−8.1623***	–	–
Monetary fundamentals				
Euro-zone lead 1		−4.6384**		−3.0961***
Euro-zone lag 1		–		−3.8553***
Euro-zone lags 2–6		−2.0149*		−1.4698*
US lags 2–6		1.1211**		–
Other asset markets				
Euro-zone leads 2–6		–		−1.4982**
Euro-zone lead 1		8.5026***		–
Euro-zone lags 2–6		−2.6458*		–
US lead 1		–		2.0473**
Japan lead 1		−8.4890***		–
Fiscal fundamentals				
Euro-zone lead 1		−6.1345*		–
US leads 2–6		−3.6302*		–
US lag 1		–		6.5694**
Exchange Rate Policy Fundamentals				
Euro-zone lead 1		2.2783*		1.3134*
Euro-zone contemporaneous		–		−2.1597**
Euro-zone lags 2–6		–		1.0142**
US leads 2–6		–		5.1489***
US lags 2–6		−6.6751*		−4.1263**
Japan lags 2–6		–		−0.8216*
Other macro fundamentals[a]				
Euro-zone lag 1		–		2.3196*
Non-fundamentals				
Options market				
Leads 2–6		–		−0.0058*
Lags 2–6		1.8932*		–
Technical analysis				
Lags 2–6		−1.1253*		–
Market sentiment				
Euro-zone lags 2–6		4.4319**		–
US leads 2–6		8.2922***		–
US lead 1		18.1050***		–
US lag 1		13.0734***		–
US lags 2–6		–		3.0685*
Private sector				
Lags 2–6		–		−0.7336*

(continued on next page)

Table 11 (*continued*)

Independent variables	USD–EUR		USD–GBP	
	Benchmark	Benchmark + Reuters news	Benchmark	Benchmark + Reuters news
Politics				
Leads 2–6		3.3832*		–
Lag 1		−5.8603**		−4.2438*
R^2	0.0037	0.0547	0.0065	0.047
$\overline{R}^2$	0.0020	0.0203	0.0048	0.012

Notes: Order flows are the net of the total buys and total sells at 20-min frequency where a buy (sell) refers to a trade in which the initiator is a purchaser (seller) of the denominator currency (euro for USD–EUR and sterling for USD–GBP). *, ** and *** represent significance at 10, 5 and 1% levels, respectively, and "–" indicates that the coefficient is insignificant. For each regressor the sum of leads 2–6, lead 1, contemporaneous, lag 1 and the sum of lags 2–6 were included in the regression but for reasons of space only the significant coefficients are reported.

[a] This category of news includes growth, unemployment, and the real effective exchange rate.

our returns regression, we find stronger evidence of a relationship between "news" and order flow. This is particularly true when we interact "news" with "high volatility" periods, where the regression goodness-of-fit rises to 0.14 for USD–EUR order flow and 0.13 for USD–GBP order flow.

6. VAR analysis

In the previous section we analyzed the relationships between returns (or volatility), order flow and various categories of news using single equation methods. It is probably more appropriate, however, to think of these variables as part of an interrelated economic system. News hits the market and influences trader expectations, which in turn has an impact on prices (and returns), volume, and order flow.[42] It is also clear that order flow (imbalances in buy and sell orders) influences returns. This suggests the following two-equation system:

$$\Delta s_{t_i} = \alpha_0 + \sum_k \sum_j \alpha^k_{1,j} N^k_{t_{i-j}} + \sum_g \alpha_{2,g} \Delta s_{t_{i-g}} + \sum_g \alpha_{3,k} \mathrm{OF}_{t_{i-k}} + \varepsilon_{t_i}, \tag{6}$$

$$\mathrm{OF}_{t_i} = \beta_0 + \sum_k \sum_j \beta^k_{1,j} N^k_{t_{i-j}} + \sum_g \beta_{2,g} \Delta s_{t_{i-g}} + \sum_g \beta_{3,k} \mathrm{OF}_{t_{i-k}} + \nu_{t_i}.$$

Our identifying assumption is that order flow does not depend on contemporaneous returns, so that $\beta_{2,0} = 0$. This assumption is not innocuous. If returns are mean-reverting,

[42] In standard macro models "news" should only influence prices and volume, not order flow. However, our single equation results strongly suggest that the influence of news is, at least in part, mediated through order flow, as well as directly affecting prices. Previous work by Evans and Lyons (2003) has attempted to disentangle the effects of news on prices and order flow by assuming that (common knowledge) news is orthogonal to (dispersed information) order flow. Our approach is to assume that news influences both prices and order flow and focus more on the total influence of news – rather than attempting to disentangle its separate effects.

feedback trading would be profitable and would in turn lead returns to influence order flow.

VAR regression results indicate that order flow enters with a very high degree of statistical significance in the returns regression, as was true in our single equation estimates. An increase in USD–EUR order flow (an increase in net purchases of euros) leads on average to an increase in the USD–EUR rate (a euro appreciation relative to the dollar) of 0.4 basis points. Similarly, in the USD–GBP market an increase in net purchases of pounds leads, on average, to a 0.3 basis point appreciation of the pound relative to the dollar. While it is clear that most of the explanatory power in the returns regression is coming from order flow, ''news'' and especially non-scheduled ''news'', continues to also matter. Or, put another way, the inclusion of order flow does not wipe out the influence of ''news''. Likewise, all three types of ''news'' enter significantly in the order-flow equations. Figs. 6 and 7 present examples of the intra-day impulse responses of returns and order flow to ''news''.

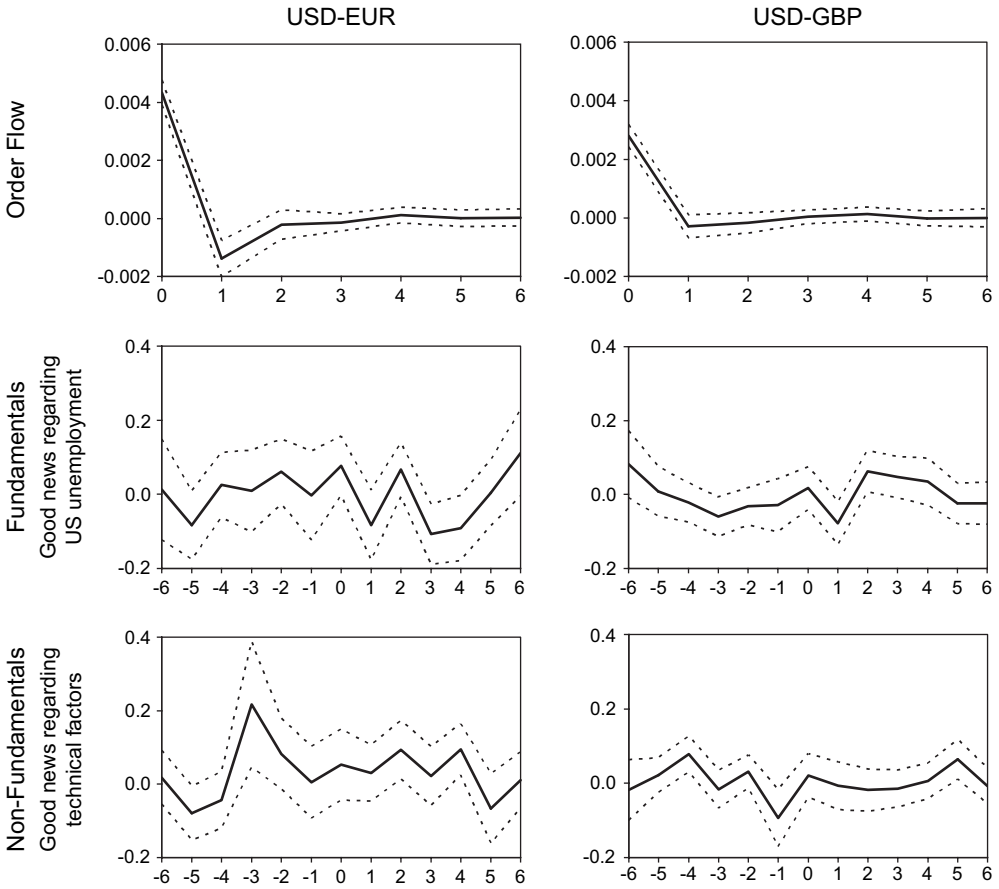


Fig. 6. Intra-day effects of order flow and news on USD–EUR and USD–GDP returns. These figures show the cumulative effects of order flow (up to 2 h after) and examples of fundamental and non-fundamental ''news'' (2 h before and 2 h after) on returns (where the Reuters news report occurs at time 0). The dashed lines show the 95% confidence interval.

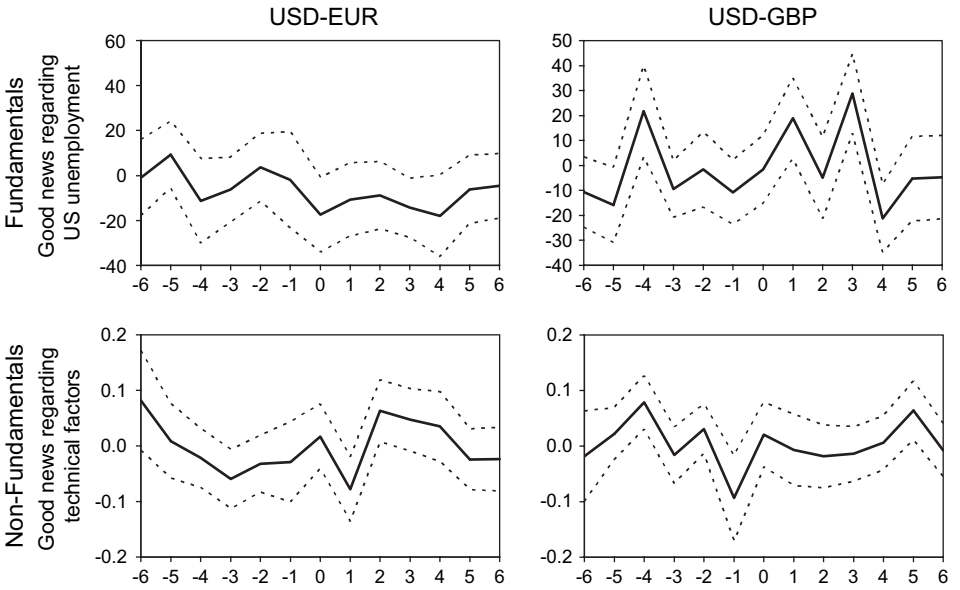


Fig. 7. Intra-day effects of news on USD–EUR and USD–GBP order flow. These figures show the cumulative effects of two examples of fundamental and non-fundamental "news" (2 h before and 2 h after) on order flow (where Reuters news report occurs at time 0). The dashed lines show the 95% confidence interval.

7. Conclusions

In this paper we examine the role of news in exchange-rate determination. Previous studies have found that scheduled macro announcements, when measured in surprise form, help to explain intra-daily exchange-rate behavior. These results, in turn, have breathed new life into the post Meese–Rogoff empirical exchange-rate literature. We measure news much more broadly, and include both fundamentals-related and non-fundamentals-related news reports to examine whether it is macro announcements, or simply intra-daily data (and a more "narrow window"), that accounts for these positive results. Overall, our results do not suggest that our broader definition of news provides a vast improvement over the macro surprises in explaining exchange-rate behavior, giving yet more credence to the importance of macro variables in standard models. We do, however, find that non-scheduled news, and intriguingly, non-scheduled non-fundamentals-related news have a statistically significant influence on both intra-day exchange-rate returns and volatility. Further, we find that news has its largest impact during periods of higher than normal news arrival and higher market uncertainty.

We also examine the role of order flow in exchange-rate determination. In standard models there is no reason for order flow to rise in reaction to news because price is assumed to instantaneously adjust. Trading volume may rise in reaction to news, but as long as the new price is efficient, there is no reason for trades to be biased in favor of purchases or sales. We find that order flow explains a large fraction of the variation in both USD–EUR and USD–GBP exchange-rate returns, suggesting that prices are, at the very least, slow to adjust. At the same time, we find that our measure of "news" explains a relatively small fraction of

the total variation in order flow. Overall, our results indicate that along with the standard fundamentals, both non-fundamentals-related news and order-flow matter, suggesting that future models of exchange-rate determination ought to include all three types of explanatory variables.

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