RESERVE BANK
OF NEW ZEALAND

DP2009/03

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April 2009

JEL classification: F31, G14

www.rbnz.govt.nz/research/discusspapers

Discussion Paper Series

ISSN 1177-7567

DP2009/03

Order flow and exchange rate changes: A look at the NZD/USD and AUD/USD*

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Abstract

In this paper, we apply a series of empirical microstructure tests to the NZD/USD and AUD/USD. In contrast to a more traditional macro approach to explaining exchange rate changes, microstructure studies focus on the role that transactions play in helping the market aggregate information on individual market participants' expectations of economic fundamentals and risk preferences. Our data comes from the Reuters Spot Matching service, the main interbank trading platform in both currency pairs, and covers almost five and a half years of transactions from January 2001 to March 2006, a much longer and more representative time series than many empirical microstructure applications to date. We find that there is a strong contemporaneous relationship between net order flow (the net of buyer-initiated and seller-initiated transactions) and changes in the NZD/USD and AUD/USD at frequencies from one minute to one week, similar to studies on other currencies. We also find that cross-currency order flow has a positive association with changes in the other exchange rate (ie AUD/USD order flow has a positive contemporaneous relationship with changes in the NZD/USD). Finally, we examine a wide range of New Zealand, Australian and US data releases and central bank interest rate decisions and find that order flow plays an important role in communicating different interpretations of macroeconomic news.

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* The views expressed in this paper are those of the author and do not necessarily reflect the views of the Reserve Bank of New Zealand or Statistics New Zealand. Special thanks to Leo Krippner and Hamish Pepper for help and comments on the paper. All errors and omissions are my own. We would like to thank Thomson Reuters for access to the data and permission to publish it, and for other assistance.

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ISSN 1177-7567

1 Introduction

Explaining daily and high frequency exchange rate changes has long been a difficult task for macroeconomists. Exchange rates have highly unstable relationships with macroeconomic variables at short-to-medium term frequencies. And exchange rates often fluctuate significantly from day to day, even in the absence of macroeconomic news or changes in observed 'fundamentals'. Perhaps the ultimate reflection of just how difficult it is to model exchange rates using a macro approach was illustrated by Meese and Rogoff (1983), who showed that a random walk outperformed a series of macro models in a test of forecasting ability.[3] Meese and Rogoff's results imply that macroeconomists would do better to use yesterday's level of the exchange rate as their forecast for today than a model with macroeconomic variables.

Market microstructure models represent a relatively new approach to explaining exchange rate changes. In contrast to the macro approach, microstructure models include a role for trading flows in determining the exchange rate. Order flow – 'signed' trading volumes – is the transmission mechanism in microstructure models that communicates information relevant to the exchange rate to the market (Evans and Lyons, 2002a). This information includes individual market participants' interpretation of current macroeconomic variables and their expectations for the future, and individuals' risk preferences. Order flow helps the market aggregate these different views of the underlying determinants of the exchange rate.

Microstructure models therefore do not imply that macroeconomic variables are unimportant or redundant, but that macro models do not accurately capture expectations of future fundamentals or different interpretations of publicly available information. Order flow to some extent is a proxy for these variables, and is observed by the market in the course of trading activity. In instances where macroeconomic news is released, order flow helps market participants understand what the economic data or central bank announcement means for the exchange rate. Surveys of dealers and anecdotes from market participants suggest strongly that order flow is a key driver of movements in the exchange rate (Cheung et al, 2004 and Gehrig and Menkhoff, 2004).

[3] Meese and Rogoff's test have been reproduced more recently by Neely and Sarno (2002) and Cheung et al (2005) with the same conclusions.

The results from market microstructure studies have been startling compared to previous macro studies. Evans and Lyons (2002a), for instance, were able to explain almost two-thirds of the daily variation world's two largest currency pairs, the USD/JPY and the EUR/USD, a significant advance on previously published work in the macro literature. Evans and Lyons found that interest rate differentials alone had almost no explanatory power on exchange rate movements, but order flow exhibited a strong contemporaneous relationship with both currency pairs. Subsequent research has extended Evans and Lyon's results to numerous other currencies, over different sample frequencies, and using a variety of alternative data sources (see Osler, 2006, and Gereben *et al*, 2005, for recent surveys of the literature).

Recently, Berger *et al* (2005) showed that order flow explained around 50% of daily exchange rate movements in the USD/JPY and EUR/USD, using five years of data from the EBS interbank electronic broker system – the main trading platform for both currencies. To date, however, there have been very few studies on either the AUD/USD or NZD/USD. Froot and Ramadorai (2002), as part of a wider study of 19 currencies using StateStreet data, find a positive relationship between monthly order flow and changes in the AUD/USD and NZD/USD, although they argue this effect is only temporary. Carpenter and Wang (2003) study the AUD/USD using data from a large Australian commercial bank, and find that order flow from financial customers and the Reserve Bank of Australia (RBA) has a positive association with changes in the AUD/USD, although order flow from non-financial customers – such as exporters and importers – does not have a significant effect.

The Reserve Bank of New Zealand (the Bank) has an ongoing research interest in understanding what drives the exchange rate. New Zealand is a small, open economy and therefore is exposed to movements in the New Zealand dollar. Monetary policy must consider both the expected path of the New Zealand dollar in the future, and the impact that interest rate decisions might have. The Bank also has a foreign exchange intervention mandate, whereby it can choose to buy or sell New Zealand dollars at extremes in the exchange rate cycle, if the New Zealand dollar is exceptionally low or high, deemed to be unjustified by fundamentals, market conditions are opportune for intervention to have a meaningful impact, and if the action is consistent with the Bank's Policy Targets Agreement (Eckhold and Hunt, 2005). The Bank also has the power to intervene in the foreign exchange market in times of extreme market disorder (Gordon, 2005). During an intervention period the Bank will generate order flow by transacting with the market. Examining the influence of order flow on the New Zealand dollar, and how this compares to the Australian dollar, is important in gaining a greater understanding of how large an impact and how persistent the effects of intervention might be on the exchange rate.

In this paper we examine the relationship between order flow and changes in the NZD/USD and AUD/USD using almost five and half years of transaction-level data from the Reuters Spot Matching service – an electronic broker system. The Reuters system is now the dominant electronic broker and the main interbank trading platform in both these currencies, accounting for upwards of 80% of interbank turnover by dealer estimates.[4] So our dataset covers a large portion of total trading in, and should be fairly representative of, the NZD/USD and AUD/USD markets.[5] Our dataset is much longer than those used for most microstructure studies, which have been limited to just days in some cases (Evans, 1995 and Payne, 2003).

We find that order flow has a positive contemporaneous relationship with changes in the NZD/USD and AUD/USD at frequencies ranging from one minute to one week. At a daily frequency, we find an R^2 of around 30% for the NZD/USD and around 50% for the AUD/USD, similar to studies on other currency pairs that have used data from electronic broker systems (Danielson *et al*, 2002, Berger *et al*, 2005, and Rime *et al*, 2007). We also find cross-currency order flow has a significant effect on exchange rate returns in both currencies – for instance, AUD/USD order flow is positively associated with movements in the NZD/USD. The inclusion of cross-currency order flow improves the explanatory power of our specifications by around 15% for the NZD/USD and by around 3% for the AUD/USD.

We also study the reaction of the exchange rate around data releases and central bank announcements in New Zealand, Australia and the US. We find

[4] A recent paper by the BIS suggests that 68% of spot interbank trading takes place via electronic broker systems (BIS, 2009). However, dealers suggest this number is probably higher for the NZD and AUD than other less developed currencies, which contribute to total spot turnover.
[5] Since interbank turnover accounts for close to half of all spot FX trading (BIS, 2007), our dataset probably represents around 40% of total market-wide trading, a much larger proportion than those studies that have relied on data from individual banks.

that the exchange rate reacts to both the initial headline 'surprise' and order flow in the first minute after release. In the following minutes, there is almost no relationship between the headline surprise and movements in the exchange rate, implying the information contained in the headline release is incorporated in the exchange rate very quickly. Order flow continues to be positively associated with exchange rate movements in the minutes and hour that follows the announcements, suggesting that the market learns the information that is contained in the detail of the data release gradually.

Our paper is divided into seven sections. In Section 2 we provide a short history of the theory and motivation for the microstructure approach to exchange rate determination. In Section 3 we describe the structure of the global FX market. In section 4 we describe our dataset and outline some general features of a limit order market. In Section 5 we report our empirical results on the relationship between order flow and the NZD/USD and AUD/USD over our five and a half years of data. In Section 6 we study the reaction of the NZD/USD and AUD/USD around data releases and central bank announcements between January 2004 and March 2006, and in Section 7 we conclude.

2 Market microstructure – a selective history

Market microstructure models have been applied to the equity market since the 1980s. Only more recently however have they been extended to foreign exchange (FX) market, primarily because transaction level data in the FX market was difficult for researchers to access prior to this. Kyle's (1985) model was one of the first microstructure models, and is still applied widely to a range of markets today, including the FX market.

In Kyle's model, dealers make prices for two types of customers – informed customers with private information about the underlying value of the asset, and uninformed customers who trade randomly (for example, because of shocks to their liquidity requirements). Dealers cannot differentiate between the two types of customers, so they revise their price quotes after customers trade with them to reflect the possibility they have traded with a more informed party. Therefore, there is a positive and causal relationship from customer order flow (x_t) to changes in the asset price, known as the information effect. Equation 1 shows the reduced form equation from

Kyle's model, where $\beta > 0$ and measures the sensitivity of the price maker's quotes to incoming customer orders.

$$\Delta P_t = \alpha + \beta x_t + \varepsilon_t \tag{1}$$

Kyle's model has a natural application to the equity market, where individuals sometimes have private information and trade in advance of upcoming earnings results and corporate announcements. In the FX market, it is rare for market participants to have private information on upcoming macroeconomic data releases or other information that is relevant for the exchange rate. Instead, a better interpretation of informed investors in the FX market are those market participants who have better quality analysis of public macroeconomic and market information which provides more accurate forecasts of the exchange rate in the future (Evans and Lyons, 2005b).[6] Although the coefficient β can only be interpreted as the price-impact of order flow under certain restrictive assumptions (such as the dealer and informed investors are risk neutral), Kyle's model has been heavily used in empirical applications to the FX market (for instance, Berger *et al*, 2005 and Rime *et al*, 2007 among others).

In contrast to the Kyle model, the Evans and Lyon's (2002a) model is based specifically on the structure of the FX market, and provides a stronger theoretical basis for the relationship between order flow and exchange rate changes. Evans and Lyons model the exchange rate (ER_t) as an asset price, which is equal to the sum of discounted future interest rate differentials, such as that shown in Equation 2 below.[7] In this framework, the exchange rate will change if expectations of future interest rate differentials

[6] There are variations on traditional macro models that incorporate some heterogeneity among market participants. Some models assume that market participants are symmetrically heterogeneous – that is, they differ, but in the same way. Some asset price models have incorporated 'noise' or 'liquidity' traders who trade in a different way to rational speculators (Kyle, 1985, Black, 1990). Finally, some models incorporate a central bank that has private information about future monetary policy settings. However, none of these methods fully incorporate the diverse nature of market participants in the FX market.

[7] In reality, market participants invest in a range of instruments besides just interest rate products, such as equities and property, whose value also depends on movements in the exchange rate. Therefore, in a broader sense, the exchange rate is the discounted sum of future payoffs which depends on a broad set of fundamentals.

$\sum_{k=0}^{\infty} E_t\left(r_t - r_t^*\right)_{t+k}$ change, or if the market-wide discount rate (which represents the collection of individuals' risk preferences), *d*, changes.

$$ER_t = \sum_{k=0}^{\infty} \frac{E_t\left(r_t - r_t^*\right)_{t+k}}{(1+d)^{t+k}} \qquad (2)$$

In the Evans and Lyons model, there are three stages to trading over the course of a day. At the start of the day, public information on the fundamental value of the currency, $\left(r - r^*\right)$, is revealed, after which dealers quote prices and then customers trade with the dealers. Customers' trades are driven by exogenous factors which influence their demand for the currency, like hedging requirements, and are not related to interest rate differentials. In the second stage, dealers trade with each other in the interbank market, and in the process learn about the market-wide customer demand for the currency. Finally, at the end of the day, dealers clear their positions by trading with the customers again. The exchange rate adjusts in the last round to trading via the discount rate to entice customers to take the dealers ' positions from them.

Evans and Lyons estimate the change in the exchange rate as a linear function of cumulative order flow and changes in the interest rate differential (see Equation 3). Similar to the Kyle model, $\beta > 0$ and measures the sensitivity of the exchange rate to interbank order flow. In Evans and Lyon 's model however, order flow in the interbank market communicates information about the market-wide discount rate associated with holding a currency. The impact of order flow on the exchange rate due to changes in risk preferences is referred to as the portfolio balance effect or the liquidity effect.[8] γ measures the sensitivity of the exchange rate to changes in the interest rate differential.

$$\Delta ER_t = \beta x_t + \gamma \Delta(r_t - r_t^*) + \varepsilon_t \qquad (3)$$

[8] Evans and Lyon's model requires that assets in different currencies are imperfect substitutes and market participants are risk averse, which implies the market demand curves for different currencies are downward sloping. Osler (2006) suggests that there is good reason to believe both these conditions are met, and shows a chart of RBS take-profit orders in USD/JPY as illustration that demand is indeed downward sloping.

A broader interpretation of the Evans and Lyons model is that order flow communicates information on both market participants' risk preferences *and* macroeconomic fundamentals not captured by changes in interest rate differentials. This can include information on (1) informed investors' expectations of future interest rates and other economic variables, and (2) timely information on the state of the economy that is generated by the FX activity produced by businesses and consumers (Evans and Lyons, 2006). While dealers might know nothing of the individual circumstances of businesses and consumers, they can gradually learn how the economy as a whole is doing by observing the aggregate trading activity in the market (and before government agencies publish economic statistics for past months and quarters).

3 The global foreign exchange market

The FX market is larger and more liquid than any other financial market in the world. Average daily trading volumes in the spot FX market – which is the market of most relevance for the determination of the exchange rate – across all currencies was just over USD 1 trillion in 2007 (BIS), compared to around USD 565 billion in the US Treasury market and USD 120 billion on the New York Stock Exchange (see figure 1).[9] The FX market is a 24 hour global market, starting at 8am Sydney time on Monday morning and running uninterrupted until 5pm New York time on Friday afternoon (with the exception of public holidays).

The FX market has a very diverse range of participants.[10] These participants include financial customers such as hedge funds and pension funds, non-financial customers, such as exporters/importers and central banks, and dealers, whose main role is to intermediate between buyers and sellers. These players have different objectives (from making speculative profit to purchasing foreign currency to pay for goods and services), time horizons for their positions, risk tolerances, and different opinions on the economic outlook and exchange rates.

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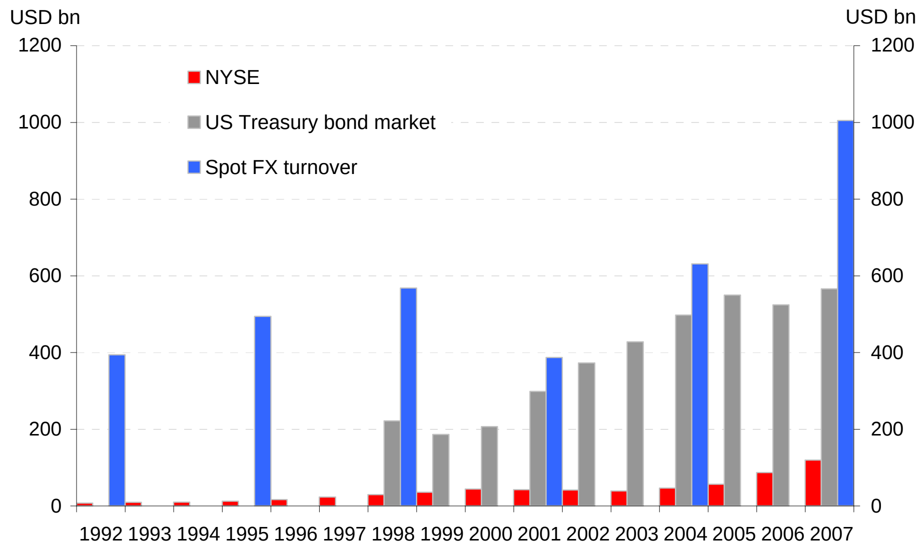
[9] Trading in the FX swap market, which is the largest component of the FX market, has no effect on the exchange rate. When most people refer to trading in the FX market, they are usually referring to the spot market, in which parties agree to settle the transaction two business days later (for most currencies)

[10] See Sager and Taylor (2006) for a detailed explanation on the structure of the global FX market and Smyth (2007) for a profile of the NZD FX market using the same dataset from Thomson Reuters.

Figure 1
Average daily trading volumes on the NYSE, US Treasury bond market, and the spot FX market

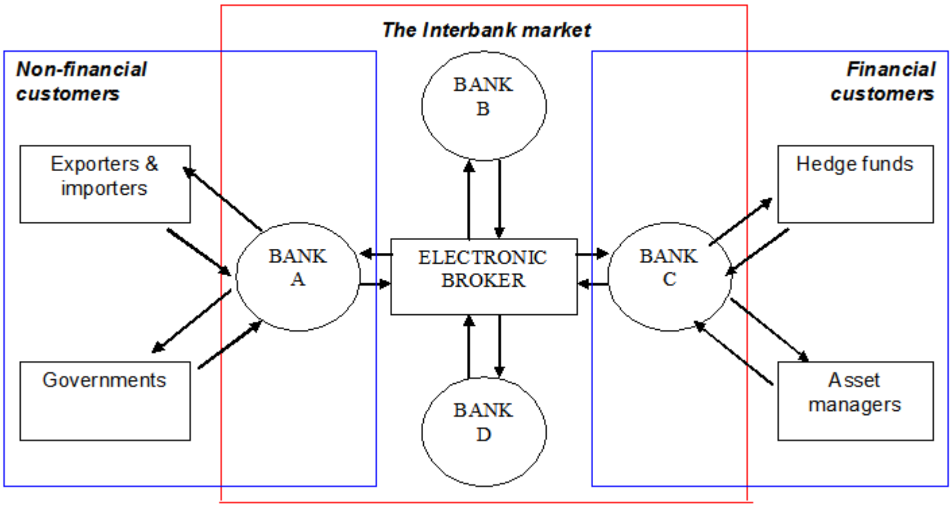


Source: NYSE volume data comes from http://www.world-exchanges.org/statistics/time-series/value-share-trading, spot FX trading volume data comes from the BIS - http://www.bis.org/press/p071219.htm and Treasury bond data from http://www.newyorkfed.org/markets/gsds/search.cfm . The data from the Federal Reserve Bank of New York does not include all trading activity because it does not include trading between non-primary dealers and it includes some double counting from trading activity between primary dealers.

Customers buy and sell currencies from dealers at investment and commercial banks (the customer-dealer market is represented by the blue areas in schematic below). Most customers tend to deal directly with dealers – either electronically or by phone – however, an increasing number of financial customers now use electronic trading portals run by investment banks to trade currencies.[11] Some financial customers, like hedge funds, prefer 'portals' because they offer anonymity, so other market participants can't discover their trading positions and styles. Trading between financial customers and dealers represents around 40% of total turnover in the FX market, while trading between non-financial customers and dealers represents around 17% (BIS, 2007). Interbank trading represents the remaining 43% of total turnover in the FX market.

[11] Barclays, Deutsche Bank and UBS operate the three main portals.

Stylised view of the modern FX market



Dealers at investment banks also trade actively amongst themselves in the interbank market. Dealers clear customer flows in the interbank market, as well as take speculative positions themselves if they have a view on the likely direction of the exchange rate. In the past, banks would trade with each other directly, either over the phone, or over an electronic trading system that allows for bilateral conversations between dealers, like the Thomson Reuters Dealing. Dealers were expected to show liquidity– that is show a two way, buy and sell price on an agreed parcel size – when requested by another bank. Hence, most early microstructure studies used data either from investment banks' individual trading records (for instance, Carpenter and Wang, 2003, and Evans and Lyons, 2006) or from the Thomson Reuters Dealing (for instance, Evans and Lyons, 2002a). The vast majority of interbank trading now takes place through electronic brokers, in particular the Reuters Spot Matching service and the EBS system.

The interbank market has traditionally been where the price discovery occurs in the FX market because bank dealers have traditionally been the main active players in the market, trading frequently during the day to manage their positions. While most of the price discovery still goes on in the interbank market, price discovery also now takes place over the portals, where hedge funds and other financial customers trade actively.

4 Data

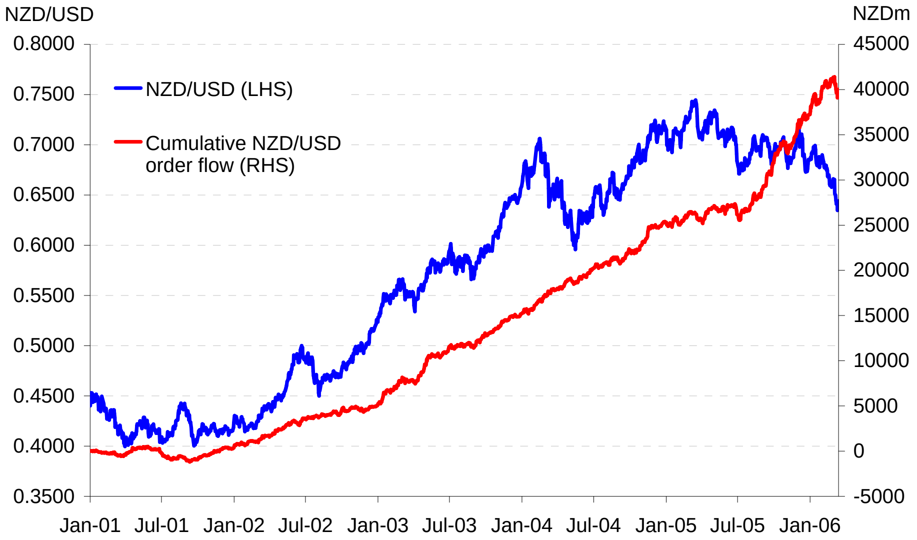
Our data comes from the Reuters Spot Matching service. The Reuters Spot Matching service is essentially an electronic limit order book, where dealers at banks can leave limit orders (orders to buy or sell a specific quantity of a currency at a specific price) or use market orders (orders to buy or sell a specific quantity at the best available limit order price(s)). The market can always see the best available limit orders – that is, the highest bid and the lowest offer – and the quantities attached to these, but dealers cannot see any orders behind the best prices.[12] When a trade takes place over the electronic broker, the market sees the price of the trade and the direction of the trade (that is, whether the incoming order that completes the trade is a buy or a sell order). However, the market does not find out who the counterparties to the trade were or the volume that was traded.

Our dataset covers the period from 1 January 2001 to 16 March 2006 and includes details on every single order that was entered into the system over this time – around 14 million AUD/USD data entries and 4 million NZD/USD data entries – time stamped to the millisecond. From the original dataset of orders, we constructed a derived dataset of transactions using an algorithm to match up the two (and sometimes more) sides of each trade. Our transactions dataset has details on the volume traded, the direction of the trades, the price, and the type of order (ie limit order or market order). Our dataset includes around 4.9 million AUD/USD transactions and 1.2 million NZD/USD transactions.

To measure order flow, we multiply the traded volume by the direction of the trade (where a buy order that results in an immediate trade takes a value of +1 and a sell order that results in an immediate trade takes a value of −1). Figure 2 and figure 3 below show the relationship between the NZD/USD and AUD/USD and cumulative order flow between January 2001 and March 2006.

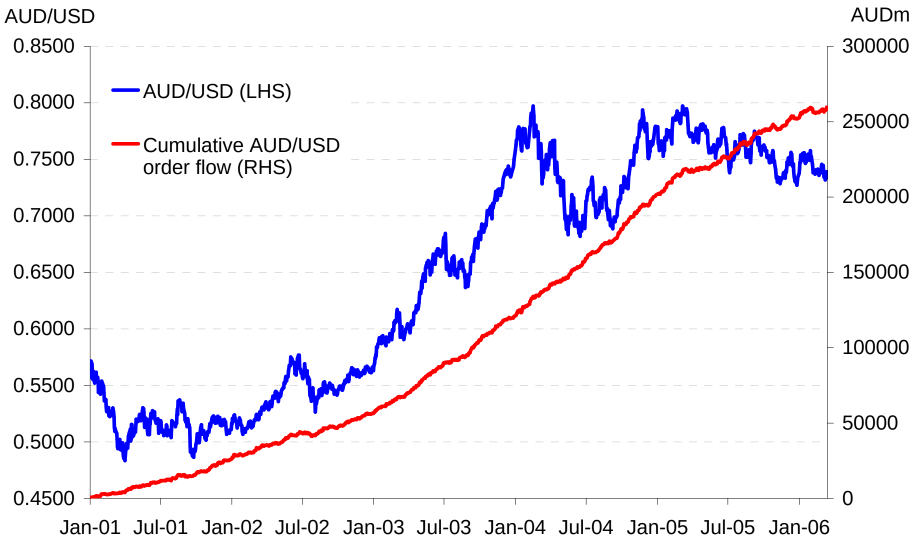
[12] Dealers actually see the best prices available to the market *and* the best prices available to them posted by counterparties they can deal with. Sometimes, a bank will not have counterparty limits with the bank that has a best limit order price that is shown to the market. It is also possible to leave "iceberg" limit orders – these are orders that do not reveal the total quantity, and appear as a smaller order than they actually are.

Figure 2
NZD/USD and cumulative order flow



Source: Thomson Reuters, RBNZ calculations

Figure 3
AUD/USD and cumulative order flow



Source: Thomson Reuters, RBNZ calculations

We have six daily observations each week. We measure daily order flow for Mondays from the first trade on Monday morning until 17:10 NZ time

Monday evening, then for Tuesdays from 17:10 NZ time Monday to 17:10 NZ time Tuesday etc. We measure daily order flow on Friday from 17:10 NZ time Friday until the last trade on the Saturday – usually around 10:00-11:00 NZ time – just before the New York market closes for the week. Our approach differs slightly from most order flow studies on major currencies, which usually exclude observations on Monday morning NZ time because trading volumes are relatively light (Berger *et al*, 2005). However, we did not consider this appropriate for the NZD/USD or AUD/USD because local data is sometimes released on Monday mornings, and the exchange rates can react significantly around these times.

Table 1 provides some descriptive statistics for our dataset. Over the five and a quarter year period, both NZD/USD and AUD/USD order flow has been positive on average. Our dataset captures a period of extended appreciation for both currencies, so it is unsurprising that we find order flow has been positive on average, although it is interesting to note that order flow does not fall by much during times when the two currencies have depreciated (such as took place in 2005).

Table 1
Descriptive order flow statistics – January 2001 - March 2006

NZD/USD	Average	Absolute Average	Standard Deviation	Maximum	Minimum
Minute	0.07m	3m	4m	112m	-230m
Hour	1m	14m	25m	284m	-551m
Day	25m	91m	133m	759m	-882m
Week	151m	288m	389m	1787m	-1618m
Month	651m	775m	795m	3480m	-822m

AUD/USD	Average	Absolute Average	Standard Deviation	Maximum	Minimum
Minute	0.21m	6m	7m	177m	-204m
Hour	8m	41m	64m	773m	-680m
Day	255m	302m	383m	1688m	-1232m
Week	1528m	1544m	942m	4383m	-751m
Month	4148m	4258m	2562m	9358m	-1869m

Source: Thomson Reuters, RBNZ calculations

5 Econometric Results

5.1 Price impact analysis

We start by examining the contemporaneous relationship between order flow and changes in the exchange rate shown in Equation 4 in the spirit of Kyle's (1985) asymmetric information model. We estimate Equation 4 using Newey-West standard errors to correct for heteroscedasticity and serial correlation in the residuals.

$$\Delta ER_t = \alpha + \beta x_t + \varepsilon_t \tag{4}$$

We find that the β coefficient is positive at frequencies ranging from one minute to one month for both the AUD/USD and NZD/USD, consistent with microstructure *ex ante* expectations. Moreover, the coefficient gets larger for higher sampling frequencies – table 2 shows that at a minutely frequency the β coefficient is 0.0024 for the NZD/USD and 0.0012 for the AUD/USD over the full five and a quarter year period. The coefficient estimates suggest that NZD 100 million positive order flow over a one minute period is associated with a 0.0024 (or 24 'pip) appreciation in the NZD/USD on average, while AUD 100 million positive order flow is associated with a 0.0012 (12 pip) appreciation in the AUD/USD. Although the β coefficients will be biased if there is feedback trading – that is, if changes in the exchange rate also have a contemporaneous impact on order flow – our informal discussions with traders provide us with some confidence our coefficient estimates are of a realistic magnitude.

The coefficient estimates for β are much higher for the NZD/USD than the AUD/USD.[13] This result could be due to two factors. First, given the AUD/USD market is larger and more liquid, it may be more informationally efficient, in which case the market might assign a lower probability to order flow carrying private information – that is, order flow might have a smaller information effect on the AUD/USD.[14] Second, because the AUD/USD

[13] We note that our findings here are the opposite of Froot and Ramadorai (2002).

[14] Here we refer to private information very broadly (Lyons, 2001). For instance, private information could refer to individual analysis of the economy and the exchange rate. If the NZD/USD market is not covered to the same extent as the AUD/USD market by analysts and institutional investors, then there may be greater asymmetric information in the NZD/USD market.

market is more liquid that the NZD/USD market, similar size flows might have a smaller impact on the AUD/USD if there are more potential counterparties to take the other side of the transaction – that is, order flow might have a smaller liquidity effect on the AUD/USD.[15] Our discussions with market participants suggests that the latter is likely to be a far more important driver of this result, as both currency markets tend to be widely followed and are both very informationally efficient.

Table 2
Coefficients from price-impact regressions for NZD/USD and AUD/USD

$\Delta ER_t = \alpha + \beta x_t + \varepsilon_t$

Frequency	Stats	NZD/USD	AUD/USD
Minute	β	0.0024	0.0012
	t-stat	(90.8)	(206.8)
	R^2	0.14	0.21
Hour	β	0.0019	0.0009
	t-stat	(46.6)	(78.8)
	R^2	0.20	0.40
Day	β	0.0015	0.0007
	t-stat	(17.2)	(31.3)
	R^2	0.28	0.49
Week	β	0.0012	0.0006
	t-stat	(7.34)	(19.4)
	R^2	0.32	0.51
Month	β	0.0006	0.0004
	t-stat	(2.21)	(5.55)
	R^2	0.08	0.29

Note: The estimated constants are not shown as they are not significantly different to zero for most of the specifications. The R^2 for this specification differs from the results in specification 1 in table 3 for the AUD/USD because the sample period is larger. In table 3 we include only days where we have data on New Zealand interest rates and NZ order flow because we need to include a cross currency order flow effect on the AUD/USD.
Source: Thomson Reuters, RBNZ calculations.

[15] Figure 12 in the Appendix shows that spot FX turnover in the AUD is substantially higher than the NZD. Other measures such as the depth of the order book and bid offer spreads also suggest the AUD is much more liquid than the NZD – these statistics are obtained from the Thomson Reuters dataset but not shown.

The simple price-impact regression explains around 30% of daily changes in the NZD/USD between 2001 and 2006 and almost 50% of changes in the AUD/USD, results similar to studies on other currencies (for instance, Berger *et al*, 2005 and Rime *et al*, 2007). Importantly, to the extent that the exchange rate follows a random walk at a daily frequency, our findings provide some evidence that the effect from order flow to the exchange rate is persistent (Evans and Lyons, 2002a).

The R^2 is also significantly higher for the AUD/USD than the NZD/USD. This probably reflects the more developed nature of the AUD/USD electronic broker market during the early part of our sample period, which means that the trading activity captured by our dataset was more representative of market-wide trading activity than for the NZD/USD. In 2005 and 2006, a time in which the Reuters Spot Matching service had established itself as the dominant interbank trading platform in the NZD/USD, the R^2 for the two currencies is more similar.

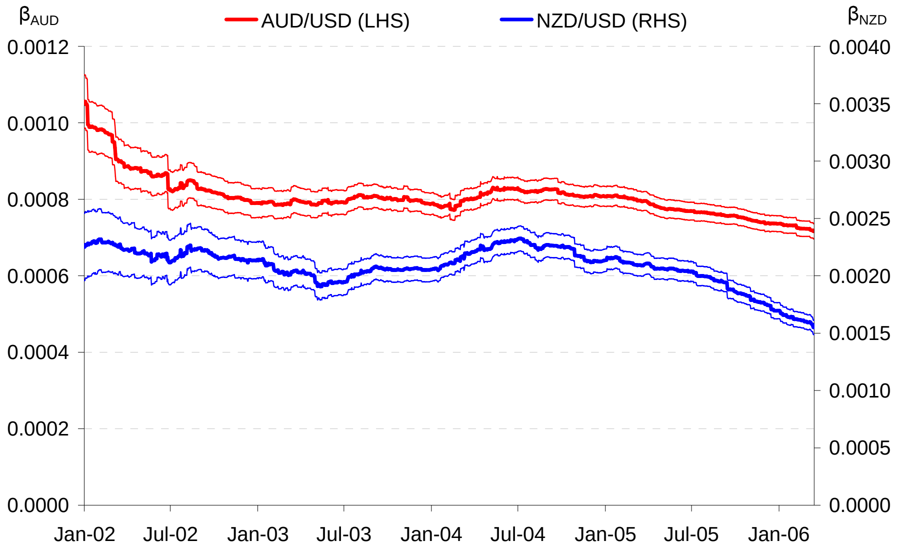
5.2 Trends over time

To test whether the relationship between order flow and the exchange rate has changed over our sample period we run a rolling cumulative regression on Equation 4 from the start of 2002, one year into our dataset. Figure 4 shows that the coefficient β has trended lower for both the AUD/USD and NZD/USD over the past four and a half years.

We also run Equation 4 separately on each of the six years of our dataset. Figures 5 and 6 show that the coefficient estimates of β have decreased over the past five years, implying that order flow has had a smaller effect on the exchange rate in the latter years of our sample. It is very likely that this is due to the increase in the liquidity in both currencies and the increasing use of the Reuters Spot Matching service as the main interbank trading platform.[16] The R^2 has also increased in more recent years, above 40% in 2005 and above 50% in 2006 for both currencies at a daily frequency, implying that order flow now explains a greater proportion of movements in these exchange rates (results not shown).

[16] Figures 11 and 12 in the Appendix show AUD/USD and NZD/USD turnover has increased in recent years. Figure 11 shows turnover from the RBNZ and RBA FX turnover surveys – that is turnover from NZ and Australian based financial institutions respectively. Figure 12 shows turnover from the BIS triennial FX turnover survey, which covers global trading in both currencies.

Figure 4
Recursive estimates of β for the NZD/USD and AUD/USD from equation 4



Note: The thin lines represent a one standard deviation confidence interval around the coefficient estimate.
Source: Thomson Reuters, RBNZ calculations

Figure 5
Estimates of β by year – NZD/USD

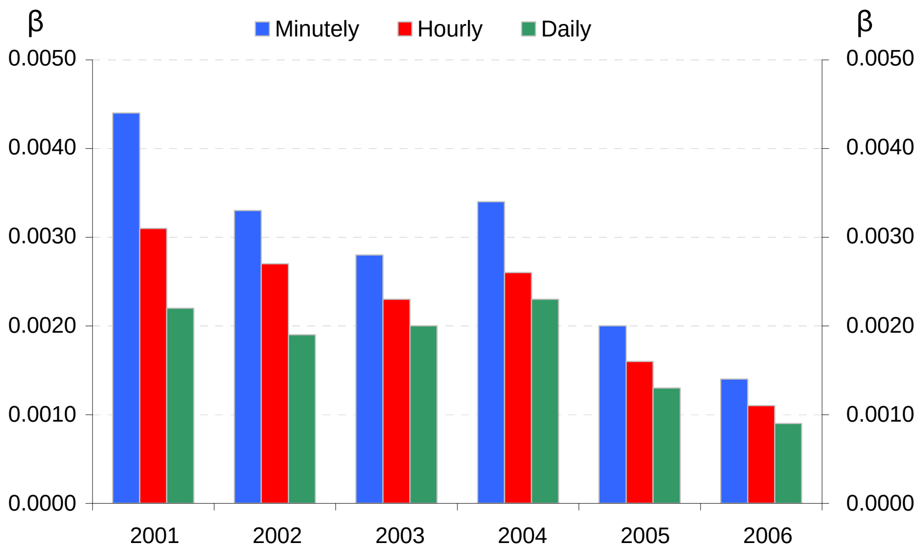
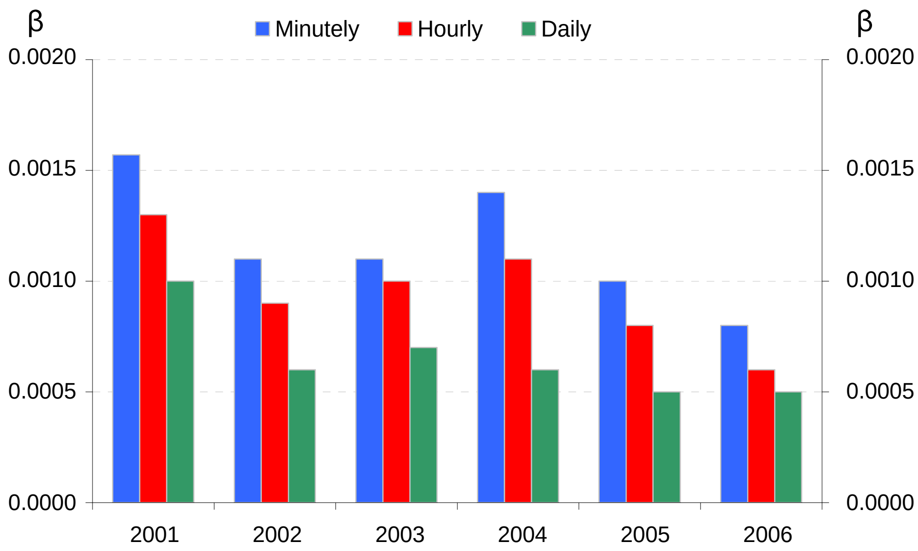


Figure 6
Estimates of β by year – AUD/USD



Source: Thomson Reuters, RBNZ calculations

5.3 Order flow and interest rate differentials

In the Evans and Lyons (2002a) model, daily exchange rate changes are a function of both order flow and changes in interest rate differentials. Like Evans and Lyons, we find that the inclusion of interest rate differentials adds little to the explanatory power of the model, suggesting that order flow is a much more important determinant of daily exchange rate returns in the NZD/USD and AUD/USD (see table 3). On their own, interest rate differentials explain almost no movement in either the NZD/USD or AUD/USD. In fact, the relationship between the two has shifted from positive to negative at times over our sample period (see figures 7 and 8). Order flow on the other hand, explains around 30% to 50% of movements in the two currencies.

Figure 7
Daily changes in the NZD/USD & the 2 year swap differential: 2001 - 2006

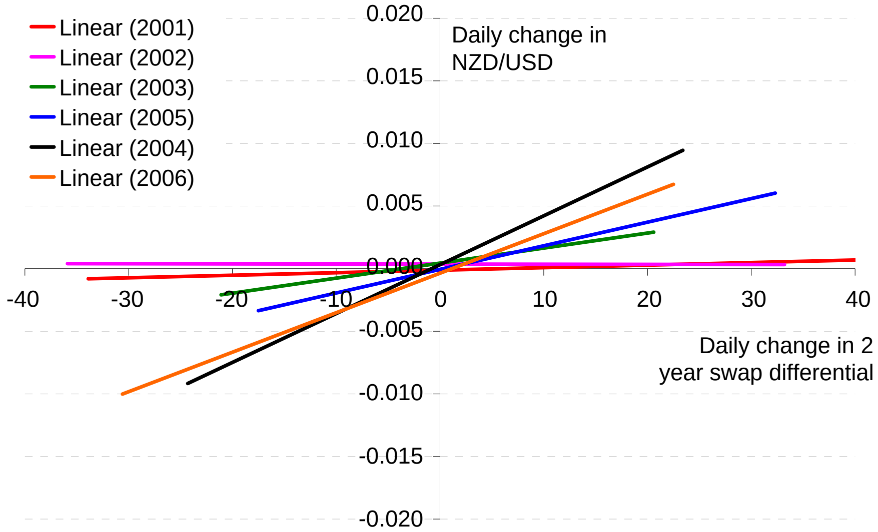
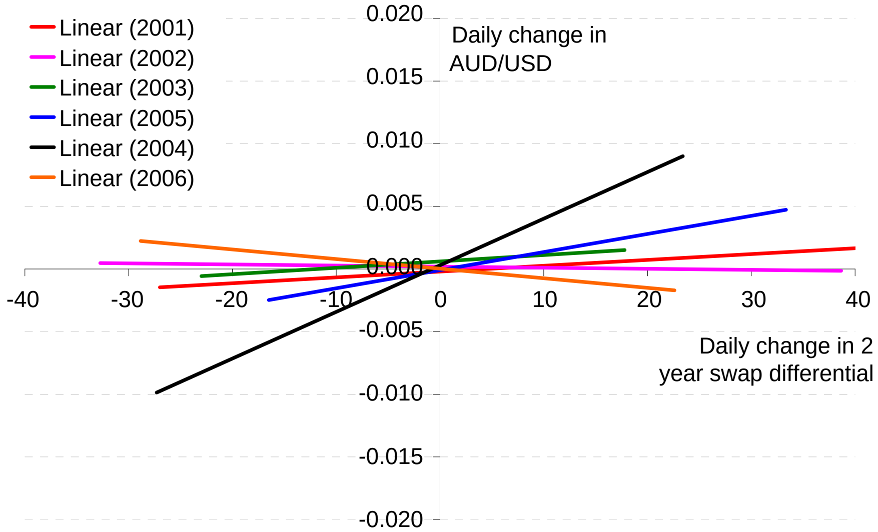


Figure 8
Daily changes in the AUD/USD & the 2 year swap differential: 2001 - 2006



Source: Thomson Reuters, RBNZ calculations

We also augment the Evans and Lyons (2002a) equation to allow for cross-currency order flow effects and a lagged effect in order flow (see Equation 5). δ measures the impact of 100 million of currency *j* cumulative order flow on exchange rate *i* while θ measures the impact of 100 million cumulative order flow in the last period on today's exchange rate changes.

$$\Delta ER_{i,t} = \alpha + \beta x_{i,t} + \gamma \Delta (r_t - r_t^*) + \delta x_{j,t} + \theta x_{i,t-1} + \varepsilon_t \qquad (5)$$

We find that the cross-currency order flow term is statistically significant for both the NZD/USD and AUD/USD specifications and increases the R^2 in both cases, particularly so for the NZD/USD. Our estimates suggest that AUD 100 million daily order flow is associated with around a 0.0004 (4 pip) change in the NZD/USD, whereas the same quantity of NZD order flow is associated with around a 0.0009 (9 pip) change in the NZD/USD.

The significance of the cross-currency order flow variable captures the close and integrated nature of the NZD/USD and AUD/USD markets. Investors often 'lump' – and trade – the two currencies together, either as part of the 'dollar bloc', as commodity currencies, as 'high yielding' currencies, or in a regional basket.[17] Traders also use the AUD/USD market sometimes to hedge positions in the NZD/USD, because it has historically had a close correlation with the NZD/USD but is more liquid and easier to transact large amounts quickly. Our empirical results suggest that when traders observe aggressive buying or selling in the AUD/USD, the NZD/USD tends to move in the same direction.

[17] Both the AUD/USD and NZD/USD were recipients of 'carry trade' flows between 2001 and 2006, particularly towards the latter part of our sample. A 'carry trade' is an investment strategy which involves borrowing in a low yielding currency and investing in a high yielding currency. The investor earns the interest rate differential as well as any currency appreciation. A paper by the BIS (2007) documents evidence of the carry trade and its effect on currency markets.

Table 3
Estimation results for the NZD/USD and AUD/USD over a daily frequency – various specifications

	NZD/USD			AUD/USD		
	Spec 1	Spec 2	Spec 3	Spec 1	Spec 2	Spec 3
Own currency order flow (β)	0.0015	0.0015	0.0009	0.00072	0.0007	0.00062
	(17.2)	(17.0)	(12.3)	(36.0)	(29.8)	(26.4)
Change in interest rate differential (γ)		0.0010	0.0008		0.0006	0.00058
		(4.2)	(4.5)		(3.9)	(3.8)
Cross currency order flow (δ)			0.0004			0.00057
			(16.8)			(7.1)
Lagged own currency order flow (θ)			-0.0002			- 0.00007
			(-2.6)			(-4.2)
R^2	0.28	0.30	0.44	0.45	0.46	0.49
Durbin Watson	2.08	2.10	2.04	1.95	1.95	2.11

Note: All equations estimated with Newey-West consistent standard errors. The R^2 for this specification differs from the results in table 2 for the AUD/USD because the sample period is smaller. We include only days where we have data on New Zealand interest rates and New Zealand order flow because we need to include a cross currency order flow effect on the AUD/USD. All specifications are estimated with a constant, although our estimates of the constants are not shown, as they are very close to zero for all specifications. *t*-statistics for the coefficient estimates are shown in brackets. All coefficients are significant at a 1% level, except for lagged own currency order flow for the AUD, which is significant at a 5% level. The estimated constant is not shown, and is not significantly different to zero for most of the specifications.
Source: Thomson Reuters, RBNZ calculations

We find that the coefficient for the cross-currency order flow variable is almost as large as the own-currency order flow variable in the AUD/USD specification. We are cautious about interpreting the relative magnitude of this coefficient given that the AUD/USD market is much larger than the NZD/USD market, and the AUD – rather than the NZD – tends to drive currency movements in the region. Our estimate of the cross currency order flow coefficient likely picks up the correlation between NZD and AUD order flow. Indeed, the inclusion of the cross-currency order flow variable does not increase the explanatory power of the AUD/USD equation nearly as much as it does for the NZD/USD equation.

The lagged order flow variable is also statistically significant and has a negative sign for both the AUD/USD and NZD/USD, implying that the exchange rate overreacts slightly to current-period order flow. However, the magnitude of the lagged order flow coefficient is much smaller than the contemporaneous coefficient – our results imply that NZD 100 million positive order flow on day *t* is associated with around a 0.0007 (7 pip) appreciation by the end of day *t+1* while AUD 100 million positive order flow is associated with around a 0.0005 (5pip) appreciation in the AUD/USD.

6 The reaction of the NZD/USD and AUD/USD to data releases and central bank announcements

Financial markets receive new information on a regular basis. Treasury and government officials make speeches, chief executives of major companies comment on their future prospects, analysts and strategists release investment advice, government agencies release official statistics on the economy, and central banks make interest rate decisions. As information comes to hand, market participants revise their views on the economic outlook and exchange rates move to reflect the new information.

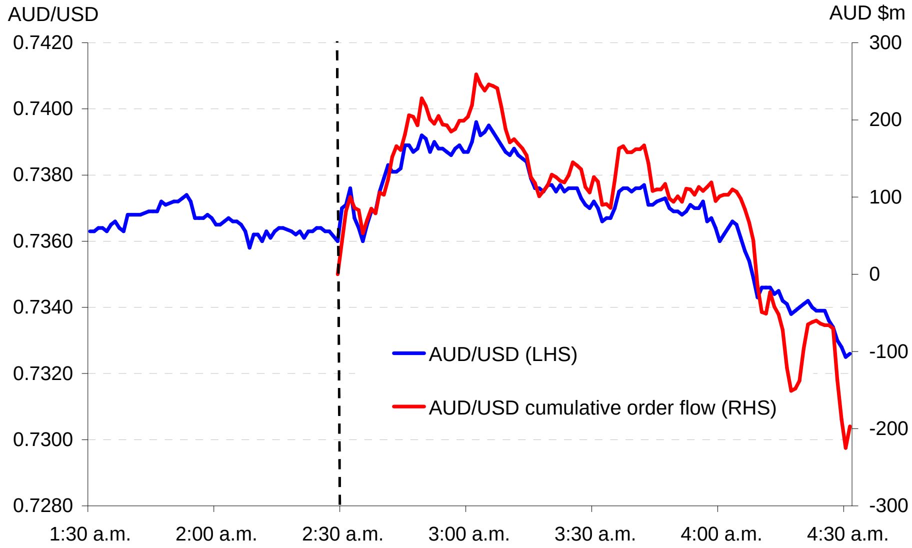
The high frequency nature of our dataset means we can analyse how the market responds around scheduled data releases and central bank decisions, and in particular the role that order flow plays in the price discovery process. Around news announcements, the macro approach and the microstructure approach predict very different outcomes.

The macro approach typically assumes that investors are homogeneous and have rational expectations, so it follows that the exchange rate reacts instantly after the release of new information to a new market clearing level. Investors understand the implications of the new information perfectly and identically, and therefore there is no trading at prices other than the new market clearing exchange rate. In fact, the macro approach implicitly assumes that the exchange rate only changes at times when new fundamental information is released.

These conclusions however are at odds with what we observe in the market: trading volumes are usually high around the release of important new information; exchange rates are often very volatile (in some instances for some time after the information is released); and since data is often ambiguous, market participants draw different conclusions about what it means for the exchange rate. Figures 9 and 10 show the reaction of the

NZD/USD and AUD/USD to the release of US non-farm payrolls in early November 2005. The USD initially weakened against both the NZD and AUD as markets reacted to the lower than expected increase in jobs created (56,000 vs. 120,000 expected), but later strengthened (the NZD/USD and AUD/USD decreased) as markets instead focused on the lower than expected unemployment figure (5.0% vs. 5.1% expected). Order flow is highly correlated with the moves in the exchange rate over the two hours following the payrolls release.

Figure 9
AUD/USD and cumulative AUD/USD order flow around the release of US non-farm payrolls, November 5th 2005, 2:30am NZT



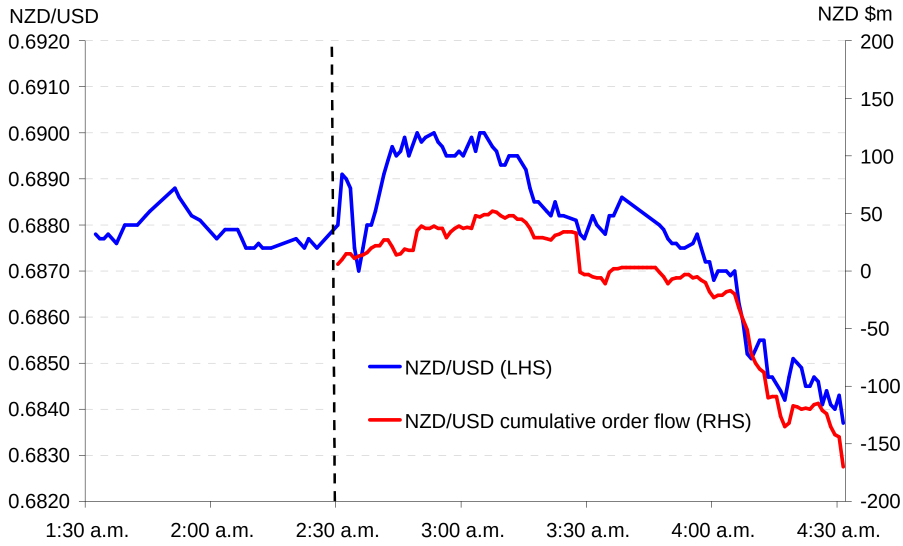
Source: Thomson Reuters, RBNZ calculations

Evans and Lyons (2003) refer to *common knowledge* as information provided by data releases and other announcements that is unambiguous, and which the exchange rate reacts to immediately – this is the only impact that the macro approach considers. In our example above, it's difficult to say there was any common knowledge because the two components of the US non-farm payrolls report were giving conflicting signals.[18] *Non-common*

[18] For the purposes of our study, we consider common knowledge to be the headline data surprise, as shown in Equation 6. In this example, the common knowledge would be the -64,000 surprise in non farm payrolls, which as shown in figures 9 and 10 resulted in an initial rise higher in the NZD/USD and AUD/USD.

knowledge is information that can be interpreted in different ways, and which the exchange rate reflects gradually as a result of the subsequent trading activity. If a US data release has a positive headline surprise, we would expect the US dollar to appreciate immediately as market reacts to the "good news". Afterwards, market participants buy or sell based not so much on whether the data is good, but on "just how good" they think the news is.

Figure 10
NZD/USD and cumulative NZD/USD order flow around the release of US non-farm payrolls, November 5th 2005, 2:30am NZT



Source: Thomson Reuters, RBNZ calculations

Microstructure studies have examined the role that order flow plays in communicating non-common knowledge around data releases (Evans and Lyons, 2003, Love and Payne, 2003, Berger et al, 2005, Rime et al, 2007). In one of the seminal microstructure studies on how the FX market absorbs macroeconomic news, Evans and Lyons (2003) found that only 10% of exchange rate moves are due to the direct effect of news on the exchange rate – what could be considered common knowledge. Evans and Lyons found 20% of moves were due to the indirect effect of news upon order flow – non-common knowledge – while 40% was due to order flow unrelated to the release of news. Using daily data, Rime et al (2007) found that the exchange rate reacts to macroeconomic news both directly, and via order flow. Berger et al (2005) found that news affects order flow only for a very short time after its release, implying that the foreign exchange market processes common knowledge information very quickly.

We look at a series of scheduled New Zealand, Australian and US data releases and central bank interest rate decisions between January 1 2004 and March 16 2006.[19] We choose to start our sample at the beginning of 2004 because trading activity – particularly in the NZD/USD – prior to this was sometimes sporadic around data releases.[20] Since exchange rates are forward looking and market participants anticipate future data releases and central bank announcements, we look at the 'surprise' between the actual data outturn and the median economist estimate taken from Bloomberg.[21] For central bank decisions, we use OIS prices to determine the market's expectations of the following day's interest rate decision (see Choy, 2003, for a discussion of how central bank policy rate expectations can be extracted from OIS prices). We standardise the surprises by the dividing by the standard deviation of surprises over our two year and three month period as in Equation 6 below.

$$z_{i,t} = \frac{x_{i,t} - E(x_{i,t})}{\sigma_x} \qquad (6)$$

where:

$z_{i,t}$ = The standardised surprise for data release *i* at time *t*

$x_{i,t}$ = The actual outturn for data release *i* at time *t*

$E[x_{i,t}]$ = The median economist estimate of data release *i* at time *t*

σ_x = The standard deviation of announcement surprises for data release *i* between 1 January 2004 and 16 March 2006

[19] Where there are two US data releases occurring at the same time, we leave both data releases out of our sample because on occasions they can give conflicting signals – so there is not necessarily common knowledge. For Australian data releases, there were three occasions when retail sales was released at the same time as current account data – we use current account data for our study.

[20] On some occasions, in particular in 2001 and 2003, there was no trading in the ten minutes that followed a large data surprise over the Reuters Spot Matching Service. We therefore did not think that the earlier data would be representative of the overall trading activity in the market around data releases (transactions could have taken place over the phone or via bilateral electronic conversations between banks instead).

[21] Although economist estimates area usually finalised and published a week or more in advance of scheduled data releases, they are usually used as a benchmark by investors for market expectations.

In table 4 we show the results of an OLS regression between data surprises and order flow in each of the three minutes following their release. Specifically, we estimate the following equation:

$$x_{t+k} = \alpha + \xi z_{i,t} + \varepsilon_{t+k} \quad \text{for } k = 0,1,2 \text{ minutes after release } i \tag{7}$$

We find that New Zealand data surprises explain around 25% of NZD/USD order flow in the minute after release, while Australian data surprises explain around 37% of AUD/USD order flow. US data releases explain around 20% of NZD/USD and AUD/USD order flow in the first minute after release (see table 10 in the Appendix). In the following two minutes after the release, the explanatory power of data surprises drops to close to 0% for US data releases, and only 2% to 9% for New Zealand and Australian data releases.

Our results suggest that the FX market reacts very quickly, with dealers trading in the direction of the data surprise in the first minute after release. However, there is little explanatory power after the first minute, implying that information that is unambiguous – the "surprise" – is traded on (and by extension, incorporated in the exchange rate) within the first minute. In fact, for the RBA and RBNZ cash rate decisions, there is a negative relationship between the announcement surprise and order flow in the subsequent minutes, implying that dealers tend to overreact initially, and trade in the opposite direction afterwards, albeit in smaller quantities of net order flow.

The announcements that tend to cause the greatest net order flow for a given headline surprise include Australian employment and GDP and New Zealand GDP – all economic indicators that tend to have an important bearing on monetary policy expectations if there is a significant surprise.[22] Our results imply for instance that a one standard deviation positive surprise in Australian employment (in our sample, equivalent to around a 28,000 surprise increase in employees hired) is associated with AUD 46 million net order flow in the first minute after release. New Zealand and Australian data surprises also tend to be associated with greater order flow after their release than US data surprises, possibly because we have included a number of second-tier US data releases that tend to have less

[22] The coefficient estimates for the RBA cash rate decisions are relatively small, mainly because there were few monetary policy surprises over our two and a half year period.

bearing on market participants' views of the economic outlook and monetary policy expectations.

Table 4. Order flow and data surprises in the 3 minutes following New Zealand and Australian data releases

$x_{t+k} = \alpha + \xi z_{i,t} + \varepsilon_{t+k}$ for *k =0,1,2* minutes after release *i*

		NZD/USD Minute			AUD/USD Minute		
Release		1st	2nd	3rd	1st	2nd	3rd
Trade Balance	ζ	8.7	7.6	2.3	15.2***	6.9**	3.6*
	R^2	*0.25*	*0.30*	*0.14*	*0.33*	*0.31*	*0.08*
RBNZ/RBA cash rate	ζ	8.6***	2.1	-1.9	3.6	-0.1	-3.8*
	R^2	*0.22*	*0.01*	*0.01*	*0.14*	*0.00*	*0.13*
Retail sales	ζ	8.6*	4.6**	3.5**	14.3**	4.3	3.6
	R^2	*0.18*	*0.26*	*0.20*	*0.28*	*0.08*	*0.05*
GDP	ζ	22.8	6.4	3.1	23.3***	-0.9	6.9
	R^2	*0.36*	*0.07*	*0.06*	*0.67*	*0.00*	*0.23*
CPI	ζ	10.4	-4.3	-1.2	19.8***	7.2**	5.0**
	R^2	*0.47*	*0.29*	*0.04*	*0.80*	*0.39*	*0.43*
Current account	ζ	7.1**	3.9	0.2	7.0*	2.4	1.9
	R^2	*0.43*	*0.21*	*0.00*	*0.25*	*0.07*	*0.03*
Employment	Z	-10.7**	-1.1	-1.5	45.4***	4.4	9.2**
	R^2	*0.46*	*0.11*	*0.04*	*0.60*	*0.03*	*0.20*
All NZ & Australian releases	ζ	**9.7*** **	**4.1*** **	**1.5***	**20.2*** **	**3.5** **	**3.1** **
	R^2	***0.25***	***0.09***	***0.02***	***0.37***	***0.05***	***0.05***
All US releases	ζ	**-3.4*** **	**-0.8*** **	**-0.6** **	**-10.6*** **	**-2.5*** **	**-0.4**
	R^2	***0.20***	***0.02***	***0.01***	***0.21***	***0.03***	***0.00***

Note: the coefficient on surprises for US data releases is negative, as expected, because better than expected US data surprises cause net NZD/USD and AUD/USD selling pressure. In addition, the coefficient on New Zealand employment is negative because we use the *unemployment* rate, rather than the increase in the number of people employed, as in Australia and the US. The estimated constant is not shown, and is not significantly different to zero for most of the specifications.
Source: Thomson Reuters, RBNZ calculations

Next, we look at the relationship between order flow and the exchange rate around news announcements. Microstructure theory predicts that order flow should have a greater impact on the exchange rate around data releases and central bank announcements since market participants, and in particular dealers, are very sensitive to how others interpret new information. The potential for asymmetric information is high around these times, and market participants with better quality analysis and faster reactions can potentially profit at the expense of those less well informed. To test this, we estimate an equation with dummy variables for each of the first three minutes after release, as shown below.

$$\Delta ER_t = \alpha + \beta_n d_n x_{t,n} + \beta_1 d_1 x_{t,1} + \beta_2 d_2 x_{t,2} + \beta_3 d_3 x_{t,3} + \varepsilon_t \tag{8}$$

where:
d_1 = a dummy variable that takes a value of 1 if data or a central bank interest rate decision has been announced in the previous minute, and 0 otherwise
d_2 = a dummy variable that takes a value of 1 if data or a central bank interest rate decision has been announced between one to two minutes ago, and 0 otherwise
d_3 = a dummy variable that takes a value of 1 if data or a central bank interest rate decision has been announced between two to three minutes ago, and 0 otherwise
d_n is a dummy variable that takes a value of 1 if data has not been released in the previous three minutes, and 0 otherwise.

Table 5 shows that the coefficient on order flow in the first minute after data is released (β_1) is more than twice as high as the coefficient on non-announcement periods (β_n) between January 2004 and March 2006. A Wald Test of coefficient restrictions confirms that we can reject the null hypothesis that $\beta_1 = \beta_n$ at the 1% level. The coefficient on order flow in the second and third minutes is similar to the average over the 2004 to 2006 period, implying that the information effect in order flow is only stronger immediately after data releases, consistent with the findings of Berger et al (2006).

Another reason for the large coefficient estimates in the first minute may be due to dealers 'paying' or 'giving' existing limit orders left in the Reuters system once the result has been announced.[23] For instance, if there were 10 million of NZD/USD bids in the system pre-release, and New Zealand CPI was much lower than expected, we would expect NZD/USD to fall sharply lower while order flow might not be much more than 10 million unless dealers submit additional bids around market levels (Berger *et al*, 2005).

[23] A dealer 'pays' the market if they use a market order to buy immediately. A dealer 'gives' the market if they use a market order to sell immediately.

Table 5
Exchange rate changes and order flow in the first three minutes after data releases and central bank announcements and all other times

$$\Delta ER_t = \alpha + \beta_n d_n x_{t,n} + \beta_1 d_1 x_{t,1} + \beta_2 d_2 x_{t,2} + \beta_3 d_3 x_{t,3} + \varepsilon_t$$

	NZD/USD	AUD/USD
β_n	0.0021 (71.8)	0.0011 (160.4)
β_1	0.0052 (11.2)	0.0024 (11.3)
β_2	0.0025 (6.4)	0.0014 (7.5)
β_3	0.0024 (8.5)	0.0014 (11.6)
R^2	0.16	0.24
Durbin Watson stat	2.18	2.16
Wald Tests of coefficient restrictions		
$\beta_n = \beta_1$	44.57***	35.69***
$\beta_n = \beta_2$	0.87	2.41
$\beta_n = \beta_3$	1.30	3.84**

Note: All equations estimated with Newey-West consistent standard errors. All specifications are estimated with a constant. These coefficient estimates are not shown as they do not affect the estimates of β. The estimated constants are not shown as they are not significantly different to zero for most of the specifications. *t*-statistics for the coefficient estimates are shown in brackets. All coefficients are significant at a 1% level.
Source: Thomson Reuters, RBNZ calculations

There are some quite large differences between the coefficient estimates for individual data releases. Table 6 shows the results from a series of price-impact regressions on the individual data releases (Equation 4 re-estimated in the minutes following each data release). Order flow after New Zealand CPI and RBNZ interest rate decisions tends to have the greatest impact on the NZD/USD while order flow after Australian CPI and GDP tends to have the greatest impact on the AUD/USD. In the US, the monthly non-farm payrolls release – which is often considered the release to have the greatest market impact – has the greatest coefficient on order flow. In the first minute after non-farm payrolls releases in our sample period, NZD 100 million order flow is associated with a 0.0132 (1.32 cent) move higher in the NZD/USD and AUD 100 million order flow a 0.0044 (0.44 cent) move higher in the AUD/USD (see table 9 in the Appendix). For other less important data releases, such as US housing starts and factory orders, the coefficient on order flow is not statistically different from zero.

Table 6
Exchange rate changes and order flow in the 3 minutes following New Zealand and Australian data releases

$\Delta ER_t = \alpha + \beta x_{i,t} + \varepsilon_t$ for t =*0,1,2* minutes after release *i*

Release		**NZD/USD** Minute 1st	2nd	3rd	**AUD/USD** Minute 1st	2nd	3rd
Trade Balance	β	0.0031***	0.0009***	0.0007	0.0018***	0.0013***	0.0007*
	R^2	*0.58*	*0.08*	*0.04*	*0.68*	*0.36*	*0.19*
RBNZ/RBA cash rate	β	0.0082***	0.0024*	0.0022***	0.0019	0.0029**	-0.0001
	R^2	*0.50*	*0.25*	*0.47*	*0.07*	*0.14*	*0.00*
Retail sales	β	0.0041***	0.0019*	0.0016**	0.0022***	0.0010***	0.0012***
	R^2	*0.50*	*0.18*	*0.20*	*0.53*	*0.21*	*0.53*
GDP	β	0.0038***	0.0017***	0.0024***	0.0029***	0.0029***	0.0019***
	R^2	*0.64*	*0.76*	*0.57*	*0.66*	*0.65*	*0.70*
CPI	β	0.0094***	0.0026***	0.0028*	0.0032***	0.0007	0.0014**
	R^2	*0.97*	*0.15*	*0.46*	*0.78*	*0.08*	*0.32*
Current account	β	0.0077**	0.0026	0.0031***	0.0012***	0.0034***	0.0012**
	R^2	*0.48*	*0.26*	*0.47*	*0.31*	*0.71*	*0.56*
Employment	β	0.0048***	0.0034	0.0009	0.0018***	0.0010**	0.0011***
	R^2	*0.80*	*0.16*	*0.08*	*0.51*	*0.30*	*0.41*
All NZ & Australian releases	β	**0.0049*** **	**0.0021*** **	**0.0022*** **	**0.0021*** **	**0.0012*** **	**0.0010*** **
	R^2	***0.53***	***0.25***	***0.40***	***0.51***	***0.26***	***0.35***
All US Releases	β	**0.0057*** **	**0.0039*** **	**0.0026*** **	**0.0026*** **	**0.0015*** **	**0.0015*** **
	R^2	***0.29***	***0.12***	***0.13***	***0.34***	***0.14***	***0.19***

Source: Thomson Reuters, RBNZ calculations

Finally, we estimate the direct effect of macroeconomic announcements on the exchange rate by regressing exchange rate changes on data and central bank surprises. Table 7 below shows that the effect of announcement surprises on the exchange rate is small but statistically significant in the first minute after release, with an R^2 of 22% for the NZD/USD and 28% for the AUD/USD for all data releases. A one standard deviation positive surprise would be expected to cause around a 0.0004 (4 'pip') increase in the NZD/USD and a 0.0005 (5 'pip') increase in the AUD/USD in the minute after announcement, all else equal.[24] However, for more important announcements, such as US non farm payrolls, the effect is much larger – around a 21 pip move in the NZD/USD and a 27 pip move in the AUD/USD in the first minute. The coefficient on surprises is not statistically significant for either the second or third minutes after release, implying that the market absorbs common knowledge information very quickly – within the first minute. This is generally the case for important data releases like non-farm payrolls, as well as second tier data.

To separate out the two influences on the exchange rate, we run a regression of the exchange rate on order flow and surprises jointly. The equation we estimate is:

$$\Delta ER_{t+k} = \alpha + \beta x_{t+k} + \theta z_t + \varepsilon_{t+k} \text{ for } k = 0,1,2 \text{ minutes after release} \tag{9}$$

The inclusion of order flow as an explanatory variable in Equation 9 increases the R^2 for NZD/USD and AUD/USD significantly compared to the specification which includes only announcement surprises. The increase in explanatory power is particularly pronounced for the second and third minutes. The R^2 increases from almost zero to above 13% for the NZD/USD and AUD/USD in the second and third minutes after release.

Our results imply that the exchange rate reacts very quickly to new information that is common knowledge (as proxied by positive or negative headline surprises), with the exchange rate moving in that direction and dealers buying or selling aggressively in the direction of the headline surprise. Beyond the first minute, order flow continues to be positively associated with exchange rate changes, implying that non common knowledge is incorporated into the exchange rate through subsequent trading activity. Headline surprises do not always fully reflect the underlying strength or weakness of data, which can take time for economists and market participants to decipher – the subsequent trading in the minutes

[24] It is worth noting that on around 9% of NZ data releases and 24% of US data releases there is no trading in NZD/USD in the first minute after announcement – particularly so for second tier data releases like US housing starts and initial jobless claims (results not shown). This contributes to the low coefficient estimate for the NZD/USD. It is possible that the exchange rate adjusts in this first minute after release, but with no trading taking place, consistent with the predictions of the macro approach. However, we find very few occasions of this in our dataset. For the AUD/USD, there is no trading in the first minute after announcement on only 3% of occasions.

and hours following the data releases more accurately reflects what market participants believe is the 'true' information content of the data and what this implies for the exchange rate. Table 11 in the Appendix shows the relationship between the exchange rate and surprises and order flow in the hour after release. The results are broadly consistent with those shown in table 6.

Table 7
News and order flow effects on the exchange rate for all NZ, Australian and US data releases between January 2004 and March 2006
$\Delta ER_{t+k} = \alpha + \beta x_{t+k} + \theta z_t + \varepsilon_{t+k}$ for $k = 0,1,2$ minutes after release

		NZD/USD Minute			AUD/USD Minute		
		1st	2nd	3rd	1st	2nd	3rd
Surprise effect on ER^1	θ	0.0004***	0.0000**	0.0000	0.0005***	0.0000	-0.0001
	R^2	*0.22*	*0.01*	*0.00*	*0.28*	*0.00*	*0.00*
Order flow effect on ER^2	β	0.0052***	0.0028***	0.0025***	0.0024***	0.0014***	0.0014***
	R^2	*0.38*	*0.13*	*0.19*	*0.38*	*0.15*	*0.19*
Effect of both order flow *and* surprises on ER^3	R^2	*0.50*	*0.13*	*0.20*	*0.44*	*0.16*	*0.20*
Surprise effect on order flow[4]	ζ	4.7***	1.5***	0.8***	12.8***	2.8***	1.0*
	R^2	*0.18*	*0.03*	*0.01*	*0.25*	*0.04*	*0.01*

[1] The equation we estimate is: $\Delta ER_{t+k} = \alpha + \theta z_t + \varepsilon_{t+k}$ for $k = 1,2,3$ minutes after releases.[2] The equation we estimate is: $\Delta ER_t = \alpha + \beta x_t + \varepsilon_t$ for $t = 1,2,3$ minutes after releases. [3] The equation we estimate is: $\Delta ER_{t+k} = \alpha + \beta x_{t+k} + \theta z_t + \varepsilon_{t+k}$ for k $= 1,2,3$ minutes after releases. [4] The equation we estimate is: $x_{t+k} = \alpha + \xi z_t + \varepsilon_{t+k}$ for $k = 1,2,3$ minutes after release *i.*
Source: Thomson Reuters, RBNZ calculations

7 Conclusion

Order flow is now widely recognised as an important determinant of exchange rate movements. Order flow helps the market aggregate information relevant to the exchange rate, including information about (1) the current state of the economy, (2) individual market participants' expectations of future macroeconomic variables, and (3) risk preferences. Standard macro models include variables that reflect the current state of the economy, but do not always accurately capture market expectations or prevailing market sentiment, which also drive exchange rate returns.

We extend previous microstructure-based analysis to the NZD/USD and AUD/USD, two widely-traded currencies, with a long and detailed dataset from the Reuters Spot Matching service. We find a strong and positive contemporaneous relationship between order flow and movements in the exchange rates. We find this relationship across a range of frequencies, from one minute to one week, consistent with studies on other major currencies. Our simple order flow model explains around 30-40% of the daily movements in both exchange rates, and closer to 40-50% when we include cross-currency order flow. Our results suggest that order flow in one of the two currencies has a positive influence on the other exchange rate, highlighting the close and integrated nature of the two currency markets.

We also show that order flow helps the market learn what data releases and central bank decisions mean for the exchange rate. Order flow has a larger-than-normal impact on the exchange rate in the minute following data releases, and continues to be positively associated with subsequent exchange rate moves. Our results imply that macroeconomic news is gradually incorporated into the exchange rate through the trading process, in contrast to the predictions of traditional macro models.

References

Berger, D., Chaboud, A., Chernenko, V., Howorka, E., Iyer, R., Liu, D. and J. Wright (2005) 'Order Flow and Exchange Rate Dynamics in Electronic Broker System Data', Board of Governors of the Federal Reserve System, IFDP No. 830

Bank for International Settlements (2004): Why has FX Trading surged? Explaining the 2004 Triennial Survey, *BIS Quarterly Review*

Bank for International Settlements (2007): Evidence of carry trade activity, *BIS Quarterly Review*

Bank for International Settlements (2009): Execution methods in foreign exchange markets, *BIS Quarterly Review*

Breedon, F. and P. Vitale (2004): An Empirical Study of Liquidity and Information Effects of Order Flow on Exchange Rates, *CEPR Discussion Paper 4586*

Carpenter, A. and J. Wang (2003): Sources of private information in FX trading, University of New South Wales, typescript, January

Cheung, Y., Chinn, M. and Marsh, I. (2004): How do UK-based Foreign Exchange Dealers think their market operates?, *International Journal of Finance and Economics*, 9, pp. 289-306

Cheung, Y., Chinn, M. and Garcia-Pascual, A. (2005): Empirical Exchange Rate Models of the Nineties: Are any fit to survive?, *Journal of International Money and Finance*, 24, pp. 1150-1175

Choy, W. (2003): Introducing Overnight Indexed Swaps, *Reserve Bank of New Zealand Bulletin*, 66, pp 34-39

Danielsson, J., Payne, R. and Luo J. (2002): Exchange Rate Determination and Inter-Market Order Flow Effects, mimeo, London School of Economics

Dominguez, K. and F. Panthaki (2006): What defines ‘news’ in foreign exchange markets?, *Journal of International Money and Finance*, 25, pp. 168-198

Eckhold, K. and C. Hunt, (2005): The Reserve Bank of New Zealand’s Foreign Exchange Intervention Policy, *Reserve Bank of New Zealand Bulletin*, 68, pp 12-22

Evans, M. and R. Lyons (2002a): Order Flow and Exchange Rate Dynamics, *Journal of Finance*, 110, pp. 170-180

Evans, M. and R. Lyons (2002b): Informational Integration and FX Trading, *Journal of International Money and Finance*, 21, pp. 807-831

Evans, M. and R. Lyons (2003): How is macro news transmitted to exchange rates?, *NBER Working Paper Series 9433*

Evans, M. and R. Lyons (2004): Exchange Rate Fundamentals and Order Flow, Mimeo, Georgetown University

Evans, M. and R. Lyons (2005a): Do Currency Markets Absorb News Quickly?, *Journal of International Money and Finance*, 24, pp. 197-217

Evans, M. and R. Lyons (2005b): Meese-Rogoff Redux: Micro-Based Exchange Rate Forecasting, *NBER Working Paper Series 11042*

Evans, M. and R. Lyons (2006): Understanding Order Flow, *International Journal of Finance and Economics*, 11, pp. 3-23

Froot K. and T Ramadorai (2002): Currency Returns, Institutional Investor Flows, and Exchange Rate Fundamentals, *NBER Working Paper Series 9101*, August

Gehrig, T. and Menkhoff, L. (2004): The use of flow analysis in foreign exchange: exploratory evidence, *Journal of International Money and Finance*, 23, pp. 573-594

Gereben, A., Gyomai, G. and N Kiss (2005): The Microstructure Approach to Exchange Rates: A Survey From a Central Bank's Viewpoint, *MNB Occasional Papers* 42

Gereben, A., Gyomai, G. and N Kiss (2006): Customer Order Flow, Information and Liquidity on the Hungarian Foreign Exchange Market, *MNB Working Papers*

Gordon, M. (2005): Foreign Reserves for Crisis Management, *Reserve Bank of New Zealand Bulletin*, 68, pp 4-11

Kyle, A (1985): Continuous Auctions and Insider Trading, *Econometrica*, 53, pp. 1315-1336

Love, R. and R. Payne (2003): Macroeconomic News, Order Flow and Exchange Rates, LSE Financial Markets Group Discussion Paper 475

Lyons, R. (2001): *The Microstructure Approach to Exchange Rates*, MIT Press, Cambridge, MA.

Lybek, T. and A. Sarr (2002): Measuring Liquidity in Financial Markets, *IMF Working Papers* 02/232

Madhavan, A (2000): Market Microstructure: A Survey, *Journal of Financial Markets*, 3, pp. 205-258

Menkveld, A., Sarkar, A. and M van der Wel (2008): Customer Flow, Intermediaries and the Discovery of the Equilibrium Riskfree Rate, *Federal Reserve Bank of New York Staff Report No 307*

Neely, C. and L. Sarno (2002): How well do Monetary Fundamentals Forecast Exchange Rates?, *Federal Reserve Bank of St Louis Review*, 84, pp. 51-74

Osler, C. (2006): Macro Lessons from Microstructure, *International Journal of Finance and Economics*, 11, pp. 55-80

Payne, R. (2003): Informed trade in Spot Foreign Exchange Markets: An empirical Investigation, *Journal of International Economics*, 61, pp. 307-329

Rime, D., Sarno, L. and E Sojli (2007): Exchange Rate Forecasting, Order Flow and Macroeconomic Information, Working Paper, Norges Bank

Sager, M. and M Taylor (2006): Under the Microscope: The Structure of the Foreign Exchange Market, *International Journal of Finance and Economics*, 11, pp. 81-95

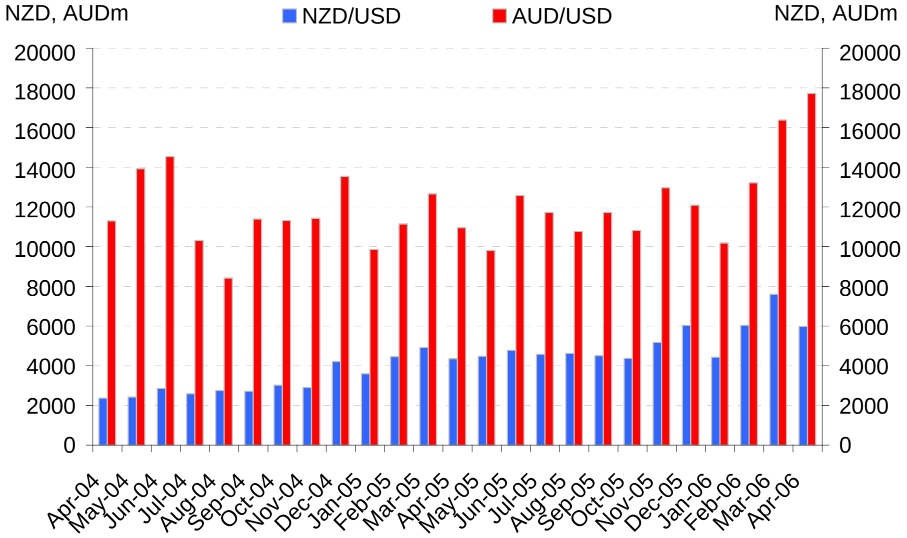
Smyth, N. (2005): Recent Trends in Foreign Exchange Turnover, *Reserve Bank of New Zealand Bulletin*, 70, pp 16-27

Smyth, N. (2005): A Profile of the New Zealand Dollar Foreign Exchange Market, *Reserve Bank of New Zealand Bulletin*, 70, pp 5-17

Vitale, P. (2007): A guided tour of the market micro structure approach to exchange rate determination, *Journal of Economic Surveys,* 21, pp. 903-934

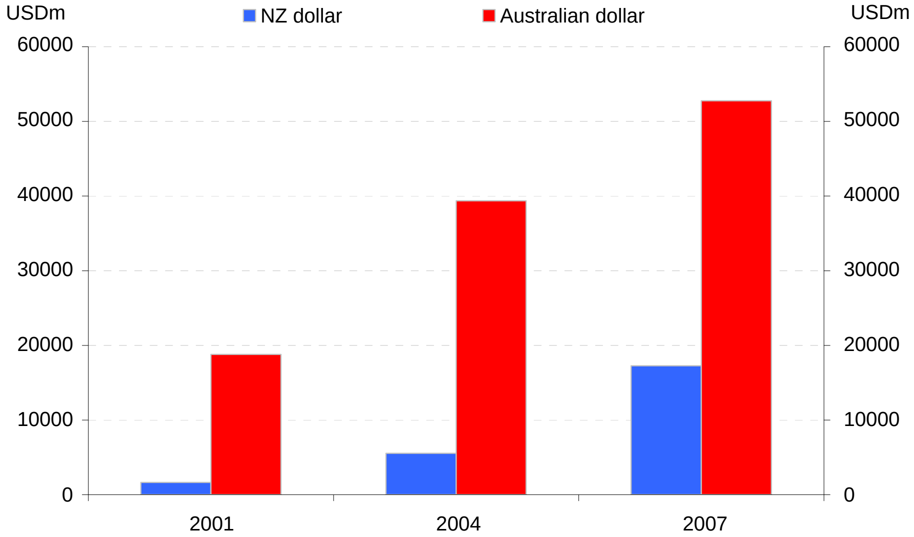
Appendix

Figure 11
AUD/USD and NZD/USD turnover by NZ and Australian based banks



Note: There will be some double counting because sometimes New Zealand-based banks will trade with Australian-based banks, in which case the turnover is captured in both surveys.
Source: RBNZ, RBA.

Figure 12
AUD and NZD turnover from the BIS triennial FX turnover survey



Note: Total turnover in this section differs from the published FX turnover survey results for 2001 and 2004 because it involves all FX transactions involving the NZD and AUD, irrespective of where in the world they occurred. In the published BIS statistics, the BIS only counts trades when at least one party is connected to the country of the currency traded. This data was obtained by request from the BIS. The 2007 data is taken direct from the BIS report so it will understate the total turnover in both currencies to some extent.
Source: BIS.

Table 8
Number of observations for data releases and central bank announcements

Data release	Number of observations	Frequency	Data release	Number of observations	Frequency
New Zealand			**US**		
Trade balance	24	Monthly	Trade balance	22	Monthly
RBNZ cash rate decision	18	6-weekly	FOMC cash rate decision	17	Monthly
Retail sales	24	Monthly	Retail sales ex autos	15	Monthly
GDP	8	Quarterly	GDP	9	Quarterly
CPI	9	Quarterly	CPI ex food and energy	17	Monthly
Current account balance	8	Quarterly	Current account balance	5	Quarterly
Unemployment rate	9	Quarterly	Non-farm payrolls (employment)	27	Monthly
			Initial jobless claims	71	Weekly
Australia			Durable goods orders	25	Monthly
Trade balance	23	Monthly	Philadelphia Fed business outlook survey	27	Monthly
RBA cash rate decision	24	Monthly	Industrial production	26	Monthly
Retail sales	24	Monthly	New home sales	19	Monthly
GDP	9	Quarterly	PPI ex food and energy	14	Monthly
CPI	9	Quarterly	Housing starts	15	Monthly
Current account balance	9	Quarterly	Chicago Purchasing Manufacturing index (PMI)	17	Monthly
Employment	27	Monthly	Conference Board consumer confidence index	16	Monthly
			University of Michigan consumer confidence (Final)	26	Monthly
			Factory orders	16	Monthly
			ISM manufacturing survey	26	Monthly
			ISM non-manufacturing survey	19	Monthly

Source: Bloomberg. Note: Some releases have fewer observations than others, either because some occur at the same time as another release (so they are not included if they are US release), or because there was no trading activity in the 3 minutes after release.

Table 9
Exchange rate changes and order flow in the 3 minutes following US data releases

$\Delta ER_t = \alpha + \beta x_{i,t} + \varepsilon_t$ for $t = 0,1,2$ minutes after release i

		NZD/USD			AUD/USD					NZD/USD			AUD/USD		
		Minute			Minute					Minute			Minute		
Release		1st	2nd	3rd	1st	2nd	3rd			1st	2nd	3rd	1st	2nd	3rd
Trade Balance	β	0.0045***	0.0056***	0.0036***	0.0024**	0.0016**	0.0010**	Industrial production	β	0.0026***	0.0064	0.0036	0.0022***	-0.0025	0.0037
	R^2	*0.28*	*0.47*	*0.32*	*0.36*	*0.33*	*0.14*		R^2	*0.21*	*0.01*	*0.01*	*0.66*	*0.00*	*0.00*
FOMC cash rate	β	0.0084*	0.0055***	0.0059*	0.0066***	0.0058***	0.0064**	New home sales	β	0.0024*	0.0022**	0.0017	0.0010***	0.0019	0.0009*
	R^2	*0.37*	*0.38*	*0.24*	*0.60*	*0.18*	*0.37*		R^2	*0.15*	*0.24*	*0.08*	*0.23*	*0.29*	*0.17*
Retail sales less autos	β	0.0032***	0.0025	0.0042**	0.0019***	0.0042***	0.00056	PPI ex-food & energy	β	0.0061	0.0017	-0.0004	0.0005	0.0022**	0.0007
	R^2	*0.63*	*0.22*	*0.19*	*0.47*	*0.73*	*0.08*		R^2	*0.05*	*0.01*	*0.00*	*0.03*	*0.46*	*0.21*
GDP	β	0.0040**	0.0027**	0.0018*	0.0046***	0.0011***	0.0015	Housing starts	β	0.0009**	0.0024	0.0002	-0.0001	0.0004	0.0023***
	R^2	*0.31*	*0.45*	*0.22*	*0.46*	*0.13*	*0.14*		R^2	*0.06*	*0.47*	*0.00*	*0.00*	*0.11*	*0.49*
CPI ex food and energy	β	0.0045***	0.0018	0.0024***	0.0020***	0.0026***	0.0016***	Chicago PMI	β	0.0010	0.0050*	0.0017	0.0027**	0.0019**	0.0001
	R^2	*0.67*	*0.04*	*0.34*	*0.78*	*0.59*	*0.26*		R^2	*0.02*	*0.17*	*0.06*	*0.46*	*0.27*	*0.00*
Current account	β	0.0153***	0.0094***	0.0038	0.0020**	0.0044***	0.0014	Conference Board	β	0.0042***	0.0016	0.0025*	0.0018***	0.0016***	0.0012**
	R^2	*0.82*	*0.78*	*0.04*	*0.42*	*0.90*	*0.46*		R^2	*0.26*	*0.02*	*0.16*	*0.87*	*0.32*	*0.41*
Employment - payrolls	β	0.0132***	0.0060	0.0021	0.0044***	0.0010	0.0018	Uni Michigan (final)	β	0.0022*	0.0008***	0.0027*	0.0002	0.0024***	0.0024**
	R^2	*0.52*	*0.15*	*0.05*	*0.39*	*0.03*	*0.10*		R^2	*0.16*	*0.57*	*0.11*	*0.01*	*0.36*	*0.32*
Jobless claims	β	0.0045***	0.0056***	0.0033***	0.0015***	0.0012***	0.0009***	Factory orders	β	0.0004	0.0009	0.0005***	0.0003	0.0012***	0.0007**
	R^2	*0.30*	*0.48*	*0.34*	*0.43*	*0.39*	*0.26*		R^2	*0.00*	*0.03*	*0.89*	*0.06*	*0.48*	*0.14*
Durable goods orders	β	0.0076***	0.0042*	0.0006***	0.0012***	0.0026*	0.0015**	ISM manufacturing	β	0.0017**	0.0028***	0.0021***	0.0009***	0.0007	0.0016***
	R^2	*0.46*	*0.18*	*0.40*	*0.20*	*0.13*	*0.18*		R^2	*0.13*	*0.17*	*0.20*	*0.18*	*0.07*	*0.49*
Philly Fed	β	0.0027**	0.0020	0.0037	0.0034***	0.0010	0.0018**	ISM non manufacturing	β	0.0031*	0.0022	0.0011*	0.0011*	0.0010**	0.0016
	R^2	*0.11*	*0.09*	*0.15*	*0.68*	*0.02*	*0.16*		R^2	*0.25*	*0.10*	*0.07*	*0.21*	*0.22*	*0.06*
								All US data releases	**β**	**0.0057*** **	**0.0039*** **	**0.0027*** **	**0.0026*** **	**0.0015*** **	**0.0015*** **
									R^2	***0.29***	***0.12***	***0.13***	***0.34***	***0.14***	***0.19***

Source: Thomson Reuters, RBNZ calculations

Table 10
Order flow and data surprises in the 3 minutes following US data releases

$x_{t+k} = \alpha + \xi z_{i,t} + \varepsilon_{t+k}$ for $k = 0,1,2$ minutes after release i

Release		NZD/USD Minute 1st	NZD/USD Minute 2nd	NZD/USD Minute 3rd	AUD/USD Minute 1st	AUD/USD Minute 2nd	AUD/USD Minute 3rd
Trade Balance	ζ	-9.6***	-1.9	4.7	-25.0***	-5.5	3.1
	R^2	*0.47*	*0.10*	*0.22*	*0.41*	*0.04*	*0.03*
FOMC cash rate	ζ	1.8*	0.2	-0.3	-0.2	2.7	0.6
	R^2	*0.20*	*0.00*	*0.01*	*0.00*	*0.15*	*0.01*
Retail sales less autos	ζ	-12.2***	-3.6	0.4	-4.2	-1.9	-4.6
	R^2	*0.61*	*0.18*	*0.01*	*0.06*	*0.03*	*0.13*
GDP	ζ	-10.2***	-3.6	-2.5	-3.0	-9.2	-5.5
	R^2	*0.80*	*0.32*	*0.23*	*0.02*	*0.21*	*0.17*
CPI ex food and energy	ζ	-4.5*	-2.2	-3.8**	-21.4**	-7.8	-1.3
	R^2	*0.21*	*0.07*	*0.35*	*0.33*	*0.14*	*0.01*
Current account	ζ	0.8	-3.8	-0.0	-2.4	-5.4	8.4
	R^2	*0.15*	*0.39*	*0.00*	*0.06*	*0.11*	*0.17*
Employment - payrolls	ζ	-9.3***	-0.5	3.1*	-32.7***	-3.7	-4.1*
	R^2	*0.43*	*0.00*	*0.09*	*0.50*	*0.03*	*0.05*
Jobless claims	ζ	1.8***	0.8*	0.4	4.3**	1.7	0.6
	R^2	*0.30*	*0.06*	*0.01*	*0.11*	*0.01*	*0.00*
Durable goods orders	ζ	-1.0	-0.4	-0.2	-8.5*	-3.8**	1.4
	R^2	*0.03*	*0.01*	*0.00*	*0.15*	*0.22*	*0.01*
Philly Fed	ζ	-4.6***	1.6	-0.2	-15.4***	0.7	-0.2
	R^2	*0.42*	*0.12*	*0.00*	*0.61*	*0.01*	*0.00*

Release		NZD/USD Minute 1st	NZD/USD Minute 2nd	NZD/USD Minute 3rd	AUD/USD Minute 1st	AUD/USD Minute 2nd	AUD/USD Minute 3rd
Industrial production	ζ	-4.4***	0.2	0.5	-10.1***	1.7	1.7
	R^2	*0.31*	*0.01*	*0.04*	*0.33*	*0.04*	*0.03*
New home sales	ζ	-0.9	0.5	-0.3	-3.0	1.3	-3.3
	R^2	*0.03*	*0.01*	*0.00*	*0.05*	*0.01*	*0.06*
PPI ex-food & energy	ζ	0.1	-0.8	0.0	-3.4	-3.4	-1.8
	R^2	*0.01*	*0.13*	*0.00*	*0.05*	*0.07*	*0.02*
Housing starts	ζ	-0.8	-0.8	-0.5	-5.3*	-2.4	1.3
	R^2	*0.06*	*0.19*	*0.02*	*0.21*	*0.10*	*0.02*
Chicago PMI	ζ	-1.0*	-1.6***	-1.7	-14.1***	-2.0	0.8
	R^2	*0.03*	*0.26*	*0.25*	*0.51*	*0.04*	*0.01*
Conference Board	ζ	-6.7**	-1.2	-2.0**	-32.3**	-5.4*	-2.7
	R^2	*0.42*	*0.07*	*0.13*	*0.58*	*0.16*	*0.00*
Uni Michigan (final)	Z	0.8**	-0.6	0.1	-4.1	-1.9	-0.7
	R^2	*0.15*	*0.13*	*0.00*	*0.22*	*0.09*	*0.01*
Factory orders	ζ	-1.1	-0.1	0.0	-3.0**	-4.5	-3.3*
	R^2	*0.08*	*0.00*	*0.00*	*0.01*	*0.15*	*0.10*
ISM manufacturing	Z	-1.4	-1.8	-1.7	-14.4***	-4.0	-2.4
	R^2	*0.04*	*0.09*	*0.08*	*0.43*	*0.08*	*0.02*
ISM non manufacturing	ζ	-4.4***	-1.2	-2.2**	-8.1***	-1.3	0.8
	R^2	*0.42*	*0.05*	*0.14*	*0.37*	*0.01*	*0.01*
All US data releases	ζ	**-3.4*** **	**-0.8*** **	**-0.6** **	**-10.6*** **	**-2.5*** **	**-0.4**
	R^2	***0.20***	***0.02***	***0.01***	***0.21***	***0.03***	***0.00***

Source: Thomson Reuters, RBNZ calculations

Table 11
News and order flow effects on the exchange rate for all NZ, Australian and US data releases between January 2004 and March 2006 – by hour

		NZD/USD Hour after event	AUD/USD Hour after event
Surprise effect on ER[1]	θ	0.0008***	0.0006***
	R^2	*0.14*	*0.09*
Order flow effect on ER[2]	β	0.0015***	0.0010***
	R^2	*0.28*	*0.49*
Effect of both order flow *and* surprises on ER[3]	R^2	0.34	*0.50*
Surprise effect on order flow[4]	ζ	21.9***	33.9***
	R^2	*0.09*	*0.06*

[1] The equation we estimate is: $\Delta ER_t = \alpha + \theta z_t + \varepsilon_t$ for the hour after releases.[2] The equation we estimate is: $\Delta ER_t = \alpha + \beta x_t + \varepsilon_t$ for the hour after release.[3] The equation we estimate is: $\Delta ER_{t+k} = \alpha + \beta x_{t+} + \theta z_t + \varepsilon_{t+k}$ for the hour after releases.[4] The equation we estimate is: $x_{t+} = \alpha + \xi z_t + \varepsilon_{t+k}$ for the hour after releases.

Source: Thomson Reuters, RBNZ calculations