What Drives Movements in Exchange Rates?

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- *Drawing on both macroeconomic and micro-based exchange rate models, the authors revisit the academic literature on exchange rate determination and summarize the state of knowledge about what drives movements in exchange rates. The focus is on highlighting recent advances in our understanding while identifying promising alternative approaches for future research.*
- *Models of exchange rate determination based on macroeconomic fundamentals have not had much success in either explaining or forecasting exchange rates, possibly owing to the simplifying assumptions employed. Notwithstanding this, researchers at the Bank of Canada have developed an exchange rate equation that has been relatively successful at tracking most of the major movements in the Canadian dollar over the past few decades and has proven to be stable over time.*
- *Micro-based models of exchange rates examine more complex and realistic settings where information is dispersed, investors are heterogeneous, and market trading rules and institutions affect behaviour. This line of research provides better explanations of short-term dynamics in exchange rates and has been found to provide superior forecasts of exchange rate movements over time horizons ranging from one day to one month. One avenue for future research is to apply these micro-based models to the Canadian dollar.*
- *One promising area of research involves uniting the macro- and micro-based exchange rate models in order to explain movements over short-, medium-, and long-term horizons.*

The Canadian dollar has appreciated by about 25 per cent relative to the U.S. dollar over the past two years, rising from 65 cents (U.S.) in January 2003 to over 82 cents (U.S.) in January 2005, and has since remained in this higher range (Chart 1).

This appreciation is noteworthy, not only because of its size, but also because it was the most rapid rise of the Canadian dollar in recent memory. Indeed, as shown in Chart 2, such a large and rapid rise of the dollar is unprecedented in the post-Bretton Woods period. Although there have been other periods when the Canadian dollar appreciated (such as the 1987–1992 episode), it did so at a more measured pace.

This recent appreciation of the Canadian dollar presents a puzzle for economists and policy-makers alike. Traditional exchange rate models are not able to explain such a large and rapid adjustment. From a monetary

Chart 1

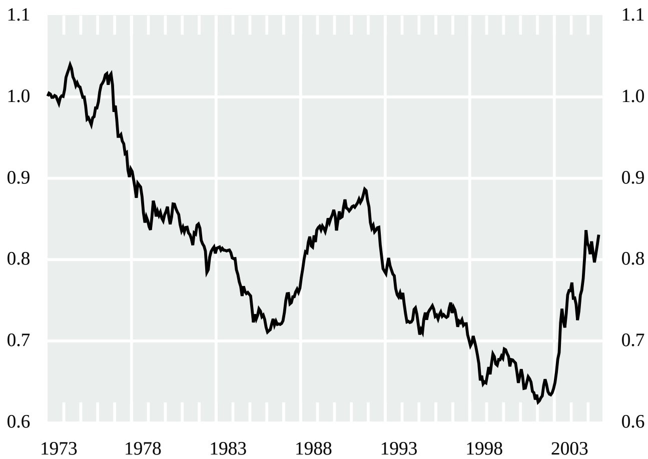
The Recent Appreciation of the Canadian Dollar

Nominal exchange rate (US$ vs. Can$, monthly average)

Chart 2

Broad Movements in the Canadian Dollar in the Post-Bretton-Woods Period

Nominal exchange rate (US$ vs. Can$, monthly average)



policy perspective, it is important to understand what forces are driving the currency, because the causes of the change will have different implications for the Canadian economy and may require a different monetary policy response.[1] For example, the Canadian dollar may be responding to an increase in the global demand for commodities, which would lead to an increase in Canadian aggregate demand. In this case, the monetary policy response would be muted unless some monetary accommodation was deemed useful to facilitate the reallocation of resources between the traded and non-traded sectors. Alternatively, the appreciation of the dollar may simply reflect a general weakening of the U.S. dollar. This case may call for an easing of monetary policy to offset a reduction in the foreign demand for Canadian goods and services. Finally, a movement in the Canadian dollar that is driven by non-fundamental or speculative forces would suggest that monetary policy should react to neutralize the effect of these forces so as to shelter the domestic economy.

With these questions in mind, we revisit the academic literature on exchange rate determination and summarize the state of knowledge about what drives movements in exchange rates, drawing on both macroeconomic and micro-based exchange rate models. The focus is on highlighting recent advances in our understanding while identifying promising alternative approaches.

1. For more on this, see the article by Christopher Ragan in this issue and the speech by Governor Dodge entitled “Monetary Policy and Exchange Rate Movements” given at the Vancouver Board of Trade on 17 February 2005, available on the Bank’s website, www.bankofcanada.ca.

We begin by reviewing macroeconomic models of exchange rates, namely the monetary approach (with both flexible and sticky prices), the portfolio-balance approach, and approaches based on the new open-economy macroeconomics. We then review microstructure studies that highlight the importance of trading mechanisms, information asymmetry, and investor heterogeneity for explaining short-term dynamics in exchange rates. While both approaches have had some success at explaining exchange rate movements over different time horizons, unifying these models to link the behaviour of individual agents with macroeconomic fundamentals remains a significant challenge in exchange rate modelling.

From a monetary policy perspective, it is important to understand what forces are driving the currency, because the causes of the change will have different implications for the Canadian economy and may require a different monetary policy response.

Macroeconomic Determinants of Exchange Rates

The traditional empirical literature on exchange rates is based on a two-country framework where the bilateral exchange rate is viewed as the relative price of the monies of the two countries in question. There are many such models, all of which describe the evolution of the exchange rate as a function of a different set of macroeconomic fundamentals, such as prices, money, interest rates, productivity differentials, government debt, terms of trade, and net foreign assets—typically characterized as intercountry differences.

Main models of exchange rate determination

The monetary approach to exchange rate determination emerged as an important exchange rate model in the 1970s, just as many industrialized countries began to let their exchange rates float.[2] This approach starts from the definition of the exchange rate as the relative

2. See, for example, Frenkel (1976) and Mussa (1976).

price of two monies and attempts to model that relative price in terms of the relative supply of, and demand for, those monies. This model makes several other key assumptions, including that (i) prices are perfectly flexible; (ii) domestic and foreign assets are perfect substitutes; (iii) absolute purchasing-power parity (PPP) holds at all times; and (iv) the uncovered-interest-parity (UIP) condition holds at all times.[3] The assumption that PPP holds continuously is relaxed in the sticky-price version of the monetary model that originated with Dornbusch (1976). In this approach, PPP holds only in the long run, and there are "jump variables" (i.e., exchange rates and interest rates) that compensate for stickiness in prices and account for the fact that exchange rates can "overshoot" their long-run equilibrium levels.

The portfolio-balance model is a second approach to modelling exchange rates.[4] Relative to the monetary models of exchange rate determination, the key modification of this model is that domestic and foreign assets are no longer assumed to be perfect substitutes. The result is that a currency-risk premium intrudes on the UIP condition, and the exchange rate is now determined by the supply and demand for all foreign and domestic assets, and not just by the supply and demand for money.

A third theoretical approach to modelling exchange rates that was initiated in the 1980s, and continued more recently in the context of the development of the new open-economy macroeconomics (NOEM) literature, is to formalize exchange rate determination in the context of dynamic general-equilibrium models with explicit microfoundations, nominal rigidities, and imperfect competition. Early models of this type were referred to as equilibrium models and were essentially an extension (or a generalization) of the flexible-price monetary model that allowed for multiple traded goods and real shocks across countries.[5]

The more recent NOEM models, based on the seminal work by Obstfeld and Rogoff (1995), offer a more rigorous analytical foundation based on fully specified microfoundations. The main disadvantage of using these later models as a basis for empirical work is that the models are often quite sensitive to the particular specification of the microfoundations. For instance, a key hypothesis like pricing to market is assumed in some models, but not others, and is an important factor in exchange rate behaviour (by determining whether PPP holds in the short run). As pointed out by Sarno (2001), this is problematic, given that there is not, as of yet, a consensus in the profession as to the "correct" or "preferable" specification of the microfoundations.

Models of exchange rate determination based on macroeconomic fundamentals have not had much success in explaining, let alone forecasting, exchange rate movements.

A final approach to modelling exchange rates that is worth mentioning is one that accords a central role to productivity differentials in explaining movements in the real exchange rate. The real exchange rate is defined as the nominal bilateral exchange rate for two countries adjusted by the relative prices of goods in those countries. Such models, based on work by Balassa (1964) and Samuelson (1964), relax the assumption of PPP and allow the real exchange rate to depend on the relative price of non-tradables, itself a function of productivity differentials.[6] Empirical evidence supports the view that productivity differentials are an important determinant of real exchange rates, where the link between these variables is typically modelled as a long-run relationship.[7]

Unfortunately, models of exchange rate determination based on macroeconomic fundamentals have not had much success in explaining, let alone forecasting, exchange rate movements.[8] Indeed, as Meese and Rogoff (1983) showed more than 20 years ago in their

3. Absolute PPP implies that goods-market arbitrage will tend to move the exchange rate to equalize national price levels between the two countries. The UIP condition, on the other hand, states that risk-neutral arbitrage will equalize the expected return on a foreign investment and the return on a domestic investment.

4. See Branson and Henderson (1985) for more details.

5. See, for instance, Stockman (1980) and Lucas (1982).

6. The Balassa-Samuelson hypothesis states that differences in labour-productivity growth in the traded-goods sectors of the two countries in question (owing to different rates of technological progress) will cause movements in the bilateral real exchange rate.

7. See, e.g., Chinn (1999).

8. Several authors have found that structural models appear to dominate the random walk's forecastability at relatively long prediction horizons. See, for example, Mark (1995). These results, however, have been questioned by others, notably Killian (1999).

Box 1
The Bank of Canada's Exchange Rate Equation

While several authors have purported to find stable and robust relationships linking exchange rates to various macroeconomic variables, the equations that they have constructed typically collapse soon after they are applied to new, extra-sample data. One notable exception is an exchange rate equation developed by two Bank of Canada economists in the early 1990s (Amano and van Norden 1993). This equation was capable of tracking most of the major swings in the Can$ / US$ exchange rate over the 1973–1990 estimation period. More importantly, its surprisingly good performance continued through most of the next 13 years.

The Amano-van Norden equation (AvN) is based on a simple, error-correction specification. The dependent variable is the *real* Can$ / US$ exchange rate (*RFX*), defined as the nominal exchange rate deflated by the gross domestic product price indices for Canada and the United States. Two world commodity prices—one for energy (*ENER*) and another for non-energy commodities (*COM*)—are used to generate the long-run equilibrium value of the exchange rate, while a third variable—the spread between Canadian and U.S. 90-day commercial interest rates (*INTDIFF*)—is used to capture the exchange rate's short-term dynamics:

$$\Delta \log RFX = \lambda(\log RFX_{-1} - \alpha - \beta_1 \log COM_{-1} + \beta_2 \log ENER_{-1}) + \gamma INTDIFF_{-1} + \varepsilon .$$

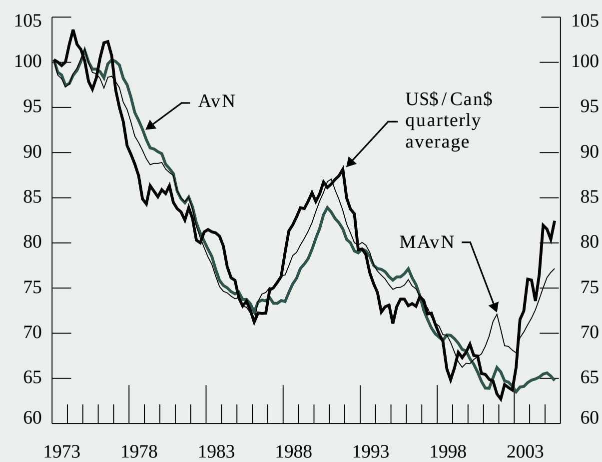
The long-run relationship that was identified between the real Can$ / US$ exchange rate and the two commodity variables has considerable intuitive appeal, since Canada is known as a major commodity exporter. It is important to enter these variables separately, however, as they seem to affect the Canadian dollar in very different ways. While higher world prices for non-energy commodities typically cause the Canadian dollar to appreciate, higher world energy prices are associated with a weaker currency over most of the sample period.

Chart B1 compares the actual value of the Can$ / US$ exchange rate with its predicted value, based on a dynamic simulation of the AvN equation over the entire 1973Q1 to 2005Q3 period.[1] Although the estimated equation is able to trace most of the major movements in the Canada-U.S. dollar up until 2002Q4—three years after the estimation period ends—it fails to explain the most recent run-up from roughly 65 cents (US) to 85 cents (US).

Chart B1

Actual vs. Dynamic Simulation

US cents



Different hypotheses have been advanced to explain the equation's diminished performance over the 2003–2005 period. The first hypothesis starts with the observation that exports of energy products now account for a much larger portion of Canada's trade surplus than they did in the past. Canada's net exports of energy stayed within a narrow range of zero to $3 billion over most of the 1970s and early 1980s. After 1985–1986, they seemed to shift upward and hit a new plateau of about $10 billion until the early 1990s. In 1993, energy exports began to rise dramatically, reaching record highs of nearly $50 billion. Given their increased importance from a trade perspective, it would not be surprising if the nature of their relationship with the Canada-U.S. dollar also changed over the period, with the

1. The parameters were estimated over the period 1973Q1 to 1999Q4.

Box 1 (cont'd)

benefits realized through higher export revenues, increased investment, and greater net wealth offsetting whatever negative factors were at play in the earlier part of the sample period. Chart B1 also shows the predicted value of the exchange rate for a modified version of the AvN equation (MAvN), which includes an extra variable that allows the parameter value on the energy term to change in the second half of the sample period.[2] As shown, the equation is now able to explain a significant proportion of the latest Can$ / US$ appreciation.[3]

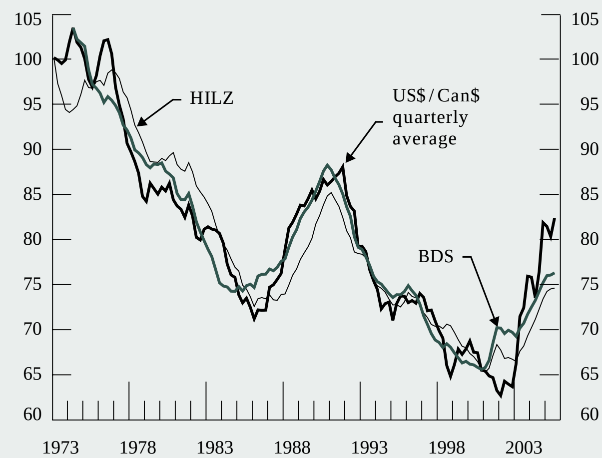
A second hypothesis focuses on global trade imbalances and the trend depreciation of the U.S. dollar against most major currencies during the past three years. This line of research concentrates on the growing U.S. current account deficit and the widespread view that significant realignment of world currencies will be necessary in order to correct it. Although the implications for individual currencies such as the Canadian dollar are not clear, consensus estimates suggest that the U.S. dollar might have to depreciate to put the U.S. balance of payments on a sustainable track. Bailliu, Dib, and Schembri (BDS) (2005) have tested for this effect by including an extra variable in the AvN equation to capture trend movements in the U.S. current account.[4] The dynamic simulations for the BDS version of the equation are shown in Chart B2. This equation outperforms the original AvN specification by a wide margin, and the observed gap between actual and simulated values towards the end of the sample is smaller.

The third and final specification is based on an paper by Helliwell, Issa, Lafrance, and Zhang (HILZ) (2005), and relies on differences in Canadian and U.S. rates

Chart B2

Actual vs. Dynamic Simulation

US cents



of productivity growth to help explain movements in the Can$ / US$ exchange rate. A new variable for the relative labour productivity in the manufacturing sector between Canada and the United States manages to narrow the gap between actual and simulated values of the exchange rate over the 2003–2005 period (the dynamic simulations for the HILZ version of the equation are also shown in Chart B2).[5]

Although these three specifications all show promise and manage to reduce the simulation errors reported over the entire sample period, sizable gaps for 2003–2005 nevertheless remain in every case. Unfortunately, efforts to combine the contributions of each specification and to produce a superior, encompassing equation have so far proved unsuccessful. Perhaps future tests, based on microstructure data, will allow researchers to reduce the errors further and draw stronger conclusions about which of the above specifications comes closest to capturing the true Can$ / US $ exchange rate relationship.

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2. Preliminary testing indicated that 1985–1986 was the appropriate break point for the estimation.

3. For more on the role of energy prices in the determination of the Canadian dollar, see Issa, Lafrance, and Murray (2005).

4. The BDS equation used here, as well as the Helliwell, Issa, Lafrance, and Zhang (HILZ) equation discussed below, are simplified versions of more elaborate equations, presented in stylized form to draw out their major differences. The original equations contain extra variables and, as a result, do a somewhat better job of explaining movements in the Can$ / US$ exchange rate. The main features of the equations are nevertheless preserved.

5. It is important to note that the original HILZ equation used the nominal Can$ / US$ exchange rate, instead of the real exchange rate, as the dependent variable.

study comparing the out-of-sample explanatory power of a variety of exchange rate models, no existing structural model can systematically outperform the naïve alternative of a random walk at short and medium-run horizons, even when aided by the actual future values of the regressors. This key result has yet to be convincingly overturned in the literature, although many studies have attempted to do so.[9] And as Obstfeld and Rogoff (2000) have noted, there is generally a very weak relationship between the exchange rate and virtually any macroeconomic variable—a situation they term the "exchange rate disconnect puzzle." Notwithstanding this, researchers at the Bank of Canada have developed an exchange rate equation that has been relatively successful at tracking most of the major movements in the Canadian dollar over the past few decades and has proven to be stable over time (Murray, Zelmer, and Antia 2000). For more on the Bank of Canada's exchange rate equation, see Box 1.

Why do exchange rates seem to be disconnected from macroeconomic fundamentals?

Four main explanations for the exchange rate disconnect puzzle have been explored in the literature. First, some authors have examined whether parameter instability could explain why macroeconomic fundamentals have so little predictive power. According to this line of thought, the poor forecasting performance of structural exchange rate models may be because the parameters in the estimated equations are unstable over time. There is some evidence to support this view.[10] As discussed by Sarno and Taylor (2002, 135), this instability could be the result of policy-regime changes, implicit instability in key equations that underlie the econometric specification (such as the money-demand or PPP equations), or agents' heterogeneity that would lead to different responses to macroeconomic developments over time.

Second, another avenue explored in the literature is the extent to which forecasting performance based on macroeconomic fundamentals can be improved if the relationship between the exchange rate and its fundamentals is modelled as non-linear. Although there is evidence that the relationship between the exchange rate and macroeconomic fundamentals is characterized by non-linearities (see, e.g., Taylor and Peel 2000), the jury is still out as to whether exchange rate models that incorporate non-linearities will improve the forecasting accuracy of structural exchange rate models.[11]

Third, it is possible that the key assumptions underlying standard exchange rate models are invalid. Two key assumptions that come to mind are PPP and UIP. With respect to the first hypothesis, evidence abounds that PPP does not hold in the short to medium run, although there is some evidence that it may hold in the very long run (i.e., using over 100 years of data) (Taylor and Taylor 2004). Similar evidence characterizes the literature that has tested UIP. Indeed, over shorter horizons, the hypothesis that interest rate differentials are unbiased predictors of future exchange rate movements is clearly rejected in empirical studies, but the results for long-horizon regressions are much more positive.[12]

Finally, Flood and Rose (1995) note that nominal exchange rates are much more volatile (at low frequencies) than the macroeconomic fundamentals to which they are linked in theoretical models. This excess volatility suggests that exchange rate models based on macroeconomic fundamentals are unlikely to be very successful either at explaining or forecasting nominal exchange rates, and that there are important variables that may be omitted from standard exchange rate models. Several potential explanations for this have been explored in the literature, including the presence of unobservable macroeconomic shocks that influence exchange rates, the irrationality of market participants, speculative bubbles, and herding behaviour. Recently, Evans and Lyons (2005a) have proposed an alternative exchange rate model based on microstructure theory that provides better out-of-sample forecasts than a random walk over periods of one day to one month. While the superior forecasting power of this model in the short term is encouraging, it still leaves unanswered the mechanism linking short-term with longer-term dynamics. We turn to this new approach in the next section.

The Microstructure of Foreign Exchange Markets

While traditional models of exchange rate determination have had moderate success in explaining long-run

9. For example, see Cheung, Chinn, and Garcia Pascual (2005), who update Meese and Rogoff's work by comparing the forecasting performance of the major exchange rate models developed in the 1990s.

10. See, for example, Canova (1993) and Rossi (2005).

11. Clarida et al. (2003) are able to outperform a random walk across a range of horizons using a term-structure model of exchange rates based on a regime-switching vector-error-correction model.

12. See Chinn and Meredith (2005) for more details.

trends, they completely fail to predict exchange rates at short horizons or even to explain exchange rate movements ex post (Frankel and Rose 1995; Flood and Taylor 1996). Given this failure, it is only natural, as Frankel, Galli, and Giovannini (1996) point out, to ask whether the problems of standard exchange rate models would be solved if the structure of foreign exchange markets was specified in a more realistic fashion. The microstructure approach to exchange rates has been developed to address this issue.[13]

Micro-based models of exchange rates are important for macroeconomists because they have the potential to explain short-term dynamics in exchange rates and may offer better forecasts of macroeconomic variables that are important for economic activity. But while these models have shown success over time horizons of one day to one month, it is not clear that they will be able to provide explanations of exchange rate movements over 12 to 24 months—the time horizon that is important for monetary policy. Also missing is a synthesis between macro- and micro-based exchange rate models comparable with macro and micro models of the real economy.

Whereas macroeconomic models assume that actors are identical, information is perfect, trading is costless, and the trading process itself is irrelevant, micro-based exchange rate models relax all of these assumptions.

Market microstructure is defined as the study of the process and outcomes of exchanging assets under explicit trading rules (O'Hara 1995). Market microstructure is concerned with the transmission of information among market participants, the behaviour of market agents, the importance of order flow, the heterogeneity of agents' expectations, and the implications of such heterogeneity for trading volume and exchange rate volatility (Sarno and Taylor 2001). A central concept in microstructure is that asset prices need not equal full-information expectations of value because of a variety of frictions. Instead of being inconsequential, market structure and the rules governing the trading process are important variables modifying trading behaviour and affecting the speed and quality of price discovery, liquidity, and the cost of trading (Madhavan 2000).

The microstructure approach to exchange rates begins from a very different set of assumptions than the macroeconomic approach (Frankel, Galli, and Giovannini 1996; Lyons 2001; Sarno and Taylor 2001). Whereas macroeconomic models assume that actors are identical, information is perfect, trading is costless, and the trading process itself is irrelevant, micro-based exchange rate models relax all of these assumptions. These models examine more complex and realistic settings where information is dispersed, and heterogeneous agents have different information sets. The trading process in foreign exchange markets is not transparent and features bid-ask spreads that reflect the costs to market-makers of processing orders and managing inventories. Unlike macro models, where only public information is relevant, micro-based models suggest that some agents may have access to private information about fundamentals or liquidity that they can exploit in the short term. As a result, the trades of better-informed actors may have a greater impact on exchange rate prices than the trades of uninformed actors.

Order flow and exchange rates

One of the key explanatory variables in micro-based models of exchange rates is order flow. Order flow is defined as the cumulative flow of signed transactions, where each transaction is signed positively or negatively, depending on whether the initiator of the transaction is buying or selling, respectively. In other words, it is transactions volume that is classified based on the direction of trading activity. A positive sum over any period indicates net buying pressure, while a negative sum indicates net selling pressure. The explanatory power or informativeness of order flow depends on the factors that cause it. Order flow is most informative when it conveys information about macroeconomic fundamentals that is dispersed among market participants. It is this information- aggregation role of order flow that provides a link between economic fundamentals—such as the state of output, inflation, and other indicators of economic performance—and the behaviour of exchange rates. Order flow is less informative, however, when it arises from the management of inventories by foreign exchange dealers in response to a liquidity shock (Lyons 2001). Distinguishing inform-

13. Summaries of the microstructure literature on exchange rates are provided in Lyons (2001), Vitale (2004), and Sarno and Taylor (2001). The broader microstructure literature is summarized in O'Hara (1995) and Madhavan (2000).

ative from non-informative order flow is a challenge for microstructure research.

Judging from publications written for their clients, foreign exchange market-makers monitor order flow and use it to forecast near-term movements in exchange rates. Academic research has followed, with a large number of empirical studies and a smaller number of theoretical models of order flow appearing over recent years.

Numerous microstructure studies have empirically established the ability of order flow to explain movements in exchange rates at short time horizons.

Evans (2002) develops and estimates a model of foreign exchange trading that demonstrates the relationship between market-wide order flow and exchange rate movements at high frequencies. Evans and Lyons (2004a) subsequently develop a dynamic general-equilibrium model that provides a structural interpretation for the correlation between order flow and exchange rates at longer time horizons. Numerous microstructure studies have empirically established the ability of order flow to explain movements in exchange rates at short time horizons. For example, Evans and Lyons (2002) find that about 60 per cent of the daily changes in the Deutschmark / US$ exchange rate and about 40 per cent of daily changes in the Japanese yen / US$ dollar exchange rate can be explained by daily order flow, with similar levels reported for other currencies.[14] Of greater importance to macroeconomists, Evans and Lyons (2005a) use order flow to explain exchange rate movements for periods up to one month and provide out-of-sample forecasts that outperform both standard macroeconomic models and a random walk.

Micro-based models of exchange rates stress the information role of order flow in a trading setting with heterogeneous agents. In this setting of information asymmetry, order flow is a proxy variable that captures the markets' reaction to macroeconomic announcements and other news that anticipate future shifts in economic conditions. As the macroeconomic fundamentals underlying exchange rates change, traders adjust their future expectations and rebalance their portfolios accordingly, leading to a change in exchange rates. In other words, order flow is a transmission mechanism for public information about fundamentals and private information that affect exchange rates. This view of order-flow data as a tool to learn about the fundamental information of others is supported by a survey of foreign exchange market participants (Gehrig and Menkhoff 2004). It also has empirical support. Evans and Lyons (2003) estimate that at least half of the response of exchange rates to macroeconomic news announcements is transmitted to exchange rates via order flow.

While microstructure researchers emphasize this information-aggregation role of order flow, critics argue that order flow reflects a variety of liquidity effects that are temporary and unrelated to macroeconomic fundamentals, such as momentum trading, trend-chasing behaviour, or other types of feedback trading (Dominguez 2003; Froot and Ramadorai 2005). Breedon and Vitale (2004), for example, develop and test a structural model featuring heterogeneous agents and information asymmetry that allows for both of these characteristics to have effects on exchange rates. They find that order flow explains very little in terms of fundamentals. Instead, they argue that the relationship between order flow and exchange rates is almost totally the result of liquidity effects and not of any information contained in order flow.

Supporters of order flow dismiss the view that order flow represents only temporary liquidity shocks and feedback trading. Payne (2003) conducts an event study of interdealer transactions for the Deutschmark / US$ where the information content of order flow is identified based on the long-run response of exchange rates to trades. His results suggest that around 40 per cent of exchange rate variability is attributed to unpredictable trading activity. Despite this high percentage, order flow continues to have a statistically significant and economically important impact on exchange rates. Even when the possibility of feedback-trading rules is taken into account, order-flow imbalance is still a fundamental determinant of exchange rate movements. Evans and Lyons (2004b) provide more

14. The impact of order flow on exchange rates has been established empirically for the German Deutschmark (Evans and Lyons 2002; Lyons 2001; Payne 2003), the euro (Breedon and Vitale 2004; Evans and Lyons 2005a), the Japanese yen (Evans and Lyons 2002), the British pound sterling (Evans and Lyons 2002), and several other European currencies (Evans and Lyons 2002; Rime 2001). Order flow has also been linked to other exchange rate characteristics, such as bid-ask spreads (Payne 2003), liquidity (Moulton 2005; Breedon and Vitale 2004), and volatility (Cai et al. 2001; Killeen, Lyons, and Moore 2001).

support for the view that order flow aggregates information and reflects agents' expectations for future fundamentals. They find that order flow from end-customer trades provides better forecasts of spot exchange rates than traditional exchange rate models. End-customer order flows also directly forecast macroeconomic variables such as output growth, money growth, and inflation. This finding is significant because it provides a direct link between order flows and macroeconomic fundamentals.

While the research on order flow remains promising, the issue of whether it represents dispersed information about fundamentals or temporary liquidity shocks continues to be debated. It is safe to assume that aggregate order flow arises from both sources, and microstructure researchers are developing methods and models to extract the signal from the noise. Researchers remain cautious, however, since the explanatory power of order flow for forecasting macro variables may vary over time, depending on the focus of market agents at any given point in time. But this line of research remains promising, since it may offer a means to introduce better microfoundations into macro models of exchange rates. At the very least, it demonstrates a link between macrofundamentals and short-term exchange rate movements and suggests that the exchange rate does not simply follow a random walk. And it may provide a means for policy-makers to extract more information out of short-term exchange rate movements.

Market participants and speculation

Another focus of the microstructure approach is on the market participants themselves. Foreign exchange markets consist of three types of agents: market-makers (also termed dealers), brokers, and end-customers. Market-makers are typically traders employed by the large commercial and investment banks who make markets to buy and sell an exchange rate at posted prices for a given size and are willing to take positions in the currencies they trade. Market-makers are portrayed as either risk-neutral or risk-averse agents who manage their inventories carefully and make a large portion of their profits from the bid-ask spread (Lyons 2001). Many of the studies discussed above focus on interdealer trades, where market-makers deal directly with each other. These direct inter-dealer trades represent about half of total foreign exchange trading activity (Bank for International Settlements 2005).[15] Brokers, by contrast, do not make markets themselves but facilitate anonymous trading between counterparties. The traditional voice brokers who transacted by telephone have been increasingly replaced over recent years by electronic trading platforms, such as Electronic Broking Systems (EBS) and Reuters Dealing systems. Evans and Lyons (2005b), for example, distinguish between non-financial customers (such as corporations), unleveraged financial institutions (such as mutual funds), and leveraged financial institutions (such as hedge funds).

Several studies explain short-term exchange rate dynamics with reference to the type of actors who are dominating trading at any given point in time. For instance, the foreign exchange market can be viewed as populated by two types of agents: chartists and fundamentalists (Frankel and Froot 1988). Chartists are assumed to operate on the basis of a mechanical trading rule that is linked to past movements in the exchange rate, whereas fundamentalists are assumed to trade on the basis of changes in macroeconomic fundamentals. Djoudad et al. (2001) estimated such a model for Canada and found that fundamentalists typically dominate the foreign exchange market during more turbulent periods, while chartists have been active during more tranquil periods. This distinction, however, may be less relevant, since modern foreign exchange trading incorporates both approaches, with individual traders choosing how much weight to assign to fundamentals versus technical patterns in the data.

Trading by chartists and other short-term speculative activity may partly explain the disconnect between exchange rate movements and fundamentals, as well as other exchange rate puzzles. Osler (1998) develops a model in which rational, short-term speculation in response to a shock disperses the shock's exchange rate effects over time and generates a response that is more accurately forecast by a random walk than by a structural model. In subsequent papers, Osler (2003, 2005) examines the role of technical trading rules, such as stop-loss orders, in the development of rapid, self-reinforcing price movements (or "price cascades") and increased volatility of exchange rates. Carlson and Osler (2005) develop a model of short-run exchange rate dynamics with heterogeneous agents and demonstrate this model's ability to explain why spot rates do not tend to rise as much as predicted by forward rates (the "forward-bias puzzle"). As well, the authors join other researchers in highlighting the potential relevance of micro-based models for explaining exchange rate dynamics at macroeconomic horizons.

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15. Trades between market-makers and financial customers or non-financial customers represent 33 per cent and 15 per cent of turnover, respectively (Bank for International Settlements 2005).

The most interesting segment of the currency market from a macroeconomist's point of view is the end-customer segment (such as corporations that hedge their exports or imports), since their activity is most closely related to the real economy. Fan and Lyons (2003) provide a description of end-customer activity for a leading global market-maker and find that customer order flow closely tracks exchange rate movements at lower frequencies (for example, at annual frequency). Bjønnes, Rime, and Solheim (2005) provide more evidence of the behaviour of end-customers using a very rich database of trading in the Swedish krona market. They find that non-financial customers are the main liquidity providers in the overnight foreign exchange market, because market-makers do not want to hold risky positions overnight. Their work provides empirical support for the theoretical view of agent heterogeneity in micro-based exchange rate models. Taken together, these studies suggest that understanding the behaviour of end-customers will be important for explaining foreign exchange dynamics over longer time horizons.

Understanding the behaviour of end-customers will be important for explaining foreign exchange dynamics over longer time horizons.

Promising Avenues for Future Research

The research outlined above demonstrates that progress is being made in exchange rate economics, although many intriguing questions and puzzles remain unanswered. The macroeconomic literature has moved forward despite the setbacks identified, and the models have become more complex, introducing microfoundations and rigidities while incorporating a wider range of variables. At the same time, researchers are addressing various empirical and theoretical issues, such as how to model an exchange rate that may have a time-varying or non-linear relationship with macroeconomic fundamentals. While the benchmark for the success of these models remains their explanatory power and forecasting ability, this line of research continues to provide theoretical insights into how the exchange rate behaves. From a macroeconomic perspective, several significant puzzles exist, such as the exchang rate disconnect puzzle, suggesting that more work remains to be done.

The microstructure approach to exchange rates relaxes the assumptions of the macroeconomic models and directs the focus to the information structure, the behaviour of agents, and the role of institutions and trading rules for influencing short-term dynamics. This line of research highlights the importance of order flow as a mechanism for aggregating dispersed information about macroeconomic fundamentals. The inclusion of order flow in exchange rate models provides forecasts that outperform a random walk over time horizons ranging from one day to one month. While researchers disagree on whether order flow reflects information asymmetry about macroeconomic fundamentals or merely transitory liquidity shocks, the ability of order flow to forecast macroeconomic fundamentals directly is supportive of the role of order flow as an aggregating mechanism for dispersed information. Disaggregating the trades of different market participants to distinguish the trades of different agents—such as the order flow of exporters vs. that of financial speculators—may reduce the noise in this order-flow data and provide a clearer link with fundamentals. Finally, research highlighting the role of technical trading rules may explain a number of macro puzzles, such as the excess-volatility puzzle and the failure of UIP to hold (Lyons 2001).

While macro researchers inside and outside the Bank are using the latest macro techniques to model the behaviour of the Canadian dollar, it is noteworthy how little of the microstructure approach is being applied to the same research. This gap may be owing to the lack of data on customer order flow that has been made available by market-makers for other currencies. While lessons for Canada can certainly be drawn from the currencies of other open economies, these micro tools and techniques may offer some insights into the forces driving recent sharp movements in the Canadian dollar described at the outset of this article.

If the exchange rate represents the most important price in an economy, being able to explain price formation and discovery from the level of agents to the level of the economy should be a high priority.

One promising area of research involves uniting the macroeconomic and microstructure approaches to exchange rate determination. If the exchange rate represents the most important price in an economy, being able to explain price formation and discovery from the level of agents to the level of the economy should be a high priority. Work by Evans and Lyons (2004b) and Carlson and Osler (2005) linking microstructure variables, such as order flow and heterogeneous agents, with longer-term fundamentals is a promising step in this direction. While macroeconomic models can explain exchange rate movements at time horizons of several years or more, the micro models currently only explain dynamics at the very short term. If order flow reflects the microrealizations of macroeconomic factors affecting the real economy, it should be possible to explain exchange rate behaviour over longer horizons.

An obvious next step is to develop a model that can explain exchange rate movements over a medium-term horizon that could last from one month to several years. This horizon is known to be important to businesses and households when making savings and investment decisions. It is also the most relevant to monetary policy, as it is the time horizon over which changes in monetary conditions are believed to affect the economy. At a minimum, measures of order flow and more realistic assumptions about the behaviour of agents should provide more realistic short-term dynamics in longer-horizon macroeconomic models. Any models that can help economists to extract better high-frequency signals about the economy from apparently noisy exchange rate movements would be useful. And the ultimate goal remains to provide a well-specified model of exchange rate movements over all time horizons.

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